# Developing a competence audit for technological innovation

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**Title:** Developing a Competence Audit for Technological Innovation
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Technology and the implementation thereof, has helped to develop the human race far beyond its fragile origins. It is technology that enables us to gather and produce our resource requirements such as food, water and other raw materials. It is technology that transforms our society and the way we interact, technology that influences our politics, economics and even in some cases our religion as well.

This thesis focuses on improving an organisation's capabilities to implement technology, particularly with regard to maximising the organisation's success at innovation and specifically technological innovation. It aims to develop a methodology for the auditing of competencies, in innovative organisations. Subsequently organisational strengths and weaknesses are identified vis-à-vis best innovation practises.

The thesis defines the terms 'innovation' and 'technological innovation', and then proceeds towards developing a methodology for improving technological innovation. This requires the development of a standard or benchmark, which will be able to guide organisations in deciding which of its own competencies are strong or weak. Equipped with such a standard in the form of an innovation model, the process of improving the innovation competencies in organisations may begin. This is accomplished by implementing an audit methodology in the form of an innovation audit questionnaire. The questionnaire audits the competencies in the organisation by comparing them with previously defined best innovation standards. This comparison yields a list of 'strengths' and 'weaknesses' that may then be pursued further by the organisation. The goal of this auditing process is therefore to identify and highlight strengths and weaknesses in the innovation competencies of innovative organisations.

The final section of the thesis contains data gathered through the implementation of the developed competence audit for technological innovation. Five organisations were audited. The results correlate well with the expected competencies of their industries. However, the results should not be interpreted in a quantitative manner, for the aim of the proposed audit is not to dictate absolute solutions, but rather to identify strengths and weaknesses in organisations' innovation processes.

**Key Words**: technological innovation auditing, competence based innovation auditing, innovation assessment, identifying innovation strengths and weaknesses, innovation management practises.

# Opsommin

**Titel**: Die Ontwikkeling van 'n Vaardigheidsoudit vir Tegnologiese Innovasie
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Tegnologie en die implementering daarvan het die mens vêr bo sy aardse agtergrond laat uitstyg. Dit is tegnologie wat ons in staat stel om primêre produkte te produseer, te verwerk en effektief te benut. Tegnologie verander die sosiale struktuur, die interaksie tussen mense, die politiek, ekonomie en soms selfs die mens se geloof.

Hierdie verhandeling beskou 'n organisasie se vermoë om tegnologie tot sy voordeel te implementeer, met ander woorde, om die organisasie se sukses met innovasie en meer spesifiek tegnologiese innovasie te verbeter. Dit poog om 'n metodologie vir die oudit van innoverende organisasies daar te stel, deur hoë impak vaardighede, eie aan die organisasie, uit te lig en met bewese goeie innovasie praktyke te vergelyk.

Die verhandeling begin met die definieëring van innovasie en tegnologiese innovasie om 'n basis vir die ontwikkeling van 'n innovasie oudit te skep. Om sterk en swak punte in innovasie te definieer, vereis 'n standaardmodel, waarin bewese innovasie praktyke vervat mag word. Toegerus met so 'n model, kan werklike verbetering van 'n organisasie se innoveringsvermoëns begin, deur sterk en swak punte uit te lig, waarop dan voortgebou kan word. Dit word vermag deur die implementering van 'n oudit metodologie vraelys. Die vraelys oudit die vaardighede, deur dit te vergelyk met bewese goeie innovasie standaarde of praktyke. 'n Lys van sterk en swak punte van 'n organisasie, waarop dan gebou kan word, word so uitgelig.

Die laaste deel van die verhandeling fokus op resultate, na aanleiding van verskeie ouditoetse wat by vyf organisasies uitgevoer was. Die resultate is verkry deur die implementering van 'n ouditvraelys. Die meeste van die resultate het goed met die verwagtinge van die tipiese industrieë ooreengestem. Alhoewel mens geneig is om die resultate op 'n kwantitatiewe manier te beoordeel, is dit nie die doel van die verhandeling om dit so te interpreteer nie. Dit moet eerder op 'n kwalitatiewe wyse gebruik word, waar dit die sterk en swak punte van 'n organisasie se innovering beklemtoon.

**Sleutelterme**: tegnologiese innovasieoudit, vaardigheids gebaseerde innovasieoudit, innovasie assessering, identifikasie van sterk en swak innovasiepunte, innovasie bestuurspraktyke.

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*Business has only two basic functions:*
*Marketing and innovation.*
*Marketing and innovation produce results.*
*All the rest are costs.*

— Peter F Drucker (1985)[1]

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**CHAPTER 4: A TECHNOLOGICAL INNOVATION AUDIT METHODOLOGY**



**CHAPTER 5: DEFINING BEST INNOVATION PRACTISES**



**CHAPTER 6: A PROPOSED COMPETENCE AUDIT FOR TECHNOLOGICAL INNOVATION**

# INTRODUCTION



## 1 Introduction

Innovation has been, currently is and will also be one of the most crucial business practises of all time. Unlike the many remarkable new business concepts that are often only 'flavour of the month' insights, innovation is a constant reminder to business, to improve, renew and change. Recent advances in technology, and a resurgence in business thinking, are raising the development of improvement techniques in areas such as technology management, core competence analysis, customer relations and many others. Innovation, although not exactly a new concept, has often been neglected and left 'to happen on its own'. Managers were heard to say it is too haphazard to manage innovation, and one should be happy when the results are positive. This thinking may be slowly changing as academics and innovative organisations better understand the process of innovation. Coupled to this change in mindset, the discipline of auditing the innovation process, may also become a crucial part in improving innovation.

This thesis focuses on improving an organisation's capabilities to implement technology through the process of innovation auditing. The audit will focus on maximising the organisation's success at innovation and specifically technological innovation by identifying key competencies in innovation. It aims to develop a methodology for the auditing of these key competencies by comparing the best innovation practises, as identified within the innovation discipline, with them.

The proposal to do an innovation audit at any organisation often creates the misconception that a measurement of the outputs of its innovation process will be made. Often auditors are inundated with explanations on the amount, type or successes of the innovations of the organisation over the past year. However, innovation auditing goes deeper than simply looking at the outputs from the innovation process. Rather, it focuses on the steps followed during the innovation process, to better understand and improve the actual process. By focussing on the steps, as well as the competencies associated with them, the innovation audit is able to improve the innovation process, by pointing out strengths and weaknesses in the organisation's innovation process.

Developing a technological innovation audit is not a trivial task. The field of innovation is incredibly wide, and exacerbating this are the many different methods for classifying the field. This may be seen in the many different innovation models and proposals for improving the process, as well as in the volumes of literature and research available on defining different aspects of the process. In the process of developing an innovation audit, this thesis found it necessary to define the technological innovation process, and set a foundation upon which a questionnaire may be built. However in defining technological innovation, reaction is immediately elicited, thus care was taken to outline the reasons for defining innovation the way it was done.

With a working definition of technological innovation in hand, the thesis could proceed towards the development of a methodology for auditing technological innovation. This included finding and categorising best practises in innovation, constructing an audit questionnaire and finding a suitable methodology for implementing an innovation audit in an organisation. However, while researching the best practises of innovation, one came to the realisation of the poor holistic structure in the innovation discipline. Often applicable models or formats in which the best practises of innovation could be structured for conducting an innovation audit do not seem to exist. The conclusion that such a model had to be developed, before an innovation audit was possible, was made. This led to the research and development of an innovation model suitable to form the foundation for a technological innovation audit.

While developing the model for innovation, the author came to the realisation of the duality of the innovation process. Traditionally innovation is portrayed as mechanistic processes and procedures inside an organisation, or conversely as a random conglomeration of processes, to develop a new product. However, all these portrayals clearly disregard the human involvement in the process of innovation, and here is where the possible duality was first discovered. Innovation consists of a *mechanistic causal process* as well as a *human almost random involvement*. By integrating the two, many difficulties are experienced in defining the innovation process. However if these two sides of the same coin are split, innovation becomes much easier to understand and classify.

The realisation of the *duality of innovation* was seen as a breakthrough in the development of an innovation audit. The possibility therefore exists to construct two different methods, one qualitative, the other quantitative for measuring the innovation process. This clearly illustrated the reason why literature on innovation seems to integrate 'soft' human issues with 'hard' procedures. Therefore by measuring the mechanistic process side of innovation in a quantitative way, and measuring the human random side of innovation in a qualitative way, each area could be measured with the best possible method.

A decision was made to concentrate on qualitative measurement of the innovation process, since much research and development has already been done in the mechanistic process side of innovation. Systems engineering and new product development are the forerunners in this development and it was felt that the biggest contribution to innovation might be made in the field of human capabilities, and how to improve them to the advantage of the innovation process.

The focus of the innovation audit in this thesis therefore, lies in the identification and measurement of best competencies for technological innovation, in medium to large organisations.

The proposed model for innovation illustrates the duality of the innovation process clearly. It aims to provide a holistic representation of an observed and temporary reality for the innovation process. Because innovation has no absolute methods that will guarantee success, the model may only portray the observed reality as proposed and practised in innovative organisations. The model serves as foundation for the many different best competencies that may be identified in the innovation process. By creating an anchor point, the model enables the researcher to sort these best competencies and find where, when, and how they should integrate with the innovation process. Therefore by building an innovation model and a best competence field around it, the researcher may be able to construct a temporary best innovation method, which may serve as the standard for the innovation audit.

It is from this standard which incorporates the proposed model and best competencies, that the innovation audit may be constructed. By asking questions on the various aspects of the standard, the auditor may extract the current state of the innovation process at an organisation. Such a process may be formalised in the form of an audit questionnaire, and that is why a questionnaire was developed in this thesis. Although a questionnaire may extract information, a methodology for implementing the parts of the innovation process still had to be developed.

The methodology initially took the form of a financial audit, but soon changed. Due to the quantitative nature of financial auditing methodologies, it was found to be of little practical use. Only some of the causal methods, for finding and analysing the audit data, were used. A much better methodology was found in the form of an innovation audit by Chiesa *et al.*[10] The methodology in this audit focuses on implementing a questionnaire, as well as supplying the answers. By means of a rubric from one to four, these could then be picked by the auditee, and subsequently improve the results from the audit.

With an adequate methodology and an audit questionnaire, the verification of all the proposals made in this thesis, were tested at five South African organisations. Agreement on the innovation model was quite apparent, although some negativity was experienced with the questionnaires. This was attributed to the disinterest shown with innovation, and the amount of time it took to complete the questionnaire. The results indicate that certain industries may exhibit certain strengths and weaknesses. The results also indicated that the innovation audit is relative, and should not be used for calibration, but rather for identifying the strengths and weaknesses of the organisation's innovation competencies.

## 1.1 Overview

The thesis consists of seven chapters and an addendum.

**Chapter two** presents the conundrum of defining innovation, technology as well as technological innovation. Based on the work by Utterback and Abernathy,[1] Freedman,[2] Edosomwan,[3] Drucker,[4] Marquis,[5] Henderson and Clark[6] and others, chapter two focuses on the development of definitions in the fields of technology, innovation, and technological innovation. These definitions serve to qualify the assumptions made later in the thesis, as well as setting some boundaries to the innovation audit. Management practises for innovation and technology are covered as well, since they influence the innovation audit procedures.

A sound understanding of the dynamics of technology and innovation is necessary, to be able to develop an audit for technological innovation. Since different types of innovations are possible, the boundaries to technology and innovation become important. Deciding between radical and incremental innovation can radically alter the questions asked in an innovation audit. Making an informed decision on the type of innovation, as well as the scope of the audit is only possible through knowledge of innovation, technology and the management of both these disciplines.

**Chapter three** discusses the development of different models, to portray complex processes such as innovation, product development or technology management. It dwells on the basic discipline of modelling, and then progresses towards developing a model for the technological innovation process. Legendary models from Utterback[1] and Twiss[7] are displayed, as well as referrals to other more recent ones from gurus such as Tidd *et al*,[8] Edosomwan,[3] Roberts[9], Marquis[5] and others.

Modelling serves the purpose of creating a visible representation of a process, and in so doing sets a standard for future development in the discipline. By modelling the innovation process, one might also identify the relationships between different disciplines within the innovation process. This may lead towards understanding the inner workings of innovation better, as well as integrating these disciplines into a sensible and holistic entity that represents the total innovation process.

A model may serve as structure for the innovation audit. By identifying the key areas of focus in the innovation process, the model enables the audit to target the high impact areas.

The chapter is concluded with an example of adapting the proposed innovation model, to the needs and processes of the organisation. Such an 'organisation specific innovation model', is powerful in its representation of the interaction between elements of the innovation processes in the organisation. It may often be used as a benchmark or an action plan, for improving the organisation's innovation methodology.

**Chapter four** focuses on methodologies for auditing in general, as well as developing a proposed methodology for auditing competencies for technological innovation. Auditing is a method for measuring and validating data from various business processes.[10] Most business processes may be audited, if data is available for comparison, with a certified or known standard. One of the best-established audit disciplines is financial auditing, while others include technology audits, core competence audits, business process audits and many others.

Methodologies for financial auditing have been perfected through trial and error. Over many years the discipline of financial auditing has grown to be a key ingredient in generally accepted management practises. Fortunately these well-tested methodologies may be employed in the innovation audit as well. By actively incorporating financial audit methodologies in the innovation audit, a strong base is formed from where future developments may be done. The thoroughly developed methodologies of financial auditing may also enhance the structure and understandability of the innovation audit.

The possible application of these methodologies in the discipline of innovation auditing is researched in the latter parts of the chapter. Some other examples focussing on innovation audits will also be discussed. Finally the methodology for the proposed technological innovation audit is discussed.

**Chapter five** defines 'best practices' in innovation and aims to set a standard whereby organisations may measure their innovation practises. Defining 'best practise standards' for successful innovation is not a trivial task. This chapter aims to present a non-exhaustive, but high-impact proposal to the best practises in innovation. The secondary aim is to provide a backdrop for the innovation audit questionnaire, developed for use in a competence audit for technological innovation. The beta test version of the questionnaire is included in the addendum. [Appendix B]

The chapter takes its structure from the innovation model developed in a previous chapter, as well as various sources in literature including Thwaites,[11] Student,[12] Tidd *et al*,[8] Chiesa *et al*,[10] and many others. By keeping the model close at hand for easy referral, aspects of the model may also become clearer.

The external environment to the organisation is discussed first, since it is often one of the more generic areas of innovation. The four areas, which form a part of the external environment, may be identified as Technology, Market and Customer, Industry and Political, Economical and Social.

The second part of the 'best practises' in innovation, focuses on business structures and resources of the organisation. By examining the heart of the organisation, including its structures, resources and leadership, one might form an opinion on the organisation's innovation fostering nature. The 'best practise' section on the organisation may be divided into Strategic, Implementation and Fostering Environment.

Thirdly, the individual, an often-unmentioned part of the innovation process is examined and highlighted for best innovation practises or competencies. Innovation will not happen without human involvement and their knowledge, competencies, influences and needs should be taken into account when proposing a 'best practise standard' for innovation. The section on individuals may be divided into *personality and emotions, knowledge, experience and background*, and *interactions.*

**Chapter six** reaches the conclusion of this thesis in the form of an innovation audit. It contains reasons for selecting various questions as well as the questions themselves. Since the questions are based on the best practises in chapter five the chapter only provides the final questions which were used in the innovation audit questionnaire. It would have been impractical to include all the questions which were considered or thought of.

Further more the chapter includes the implementation of the proposed innovation audit questions. A beta test audit process was completed at five South African organisations. During this test period it was possible to test the proposed innovation model, the proposed audit methodology and the audit questionnaire. The audits proved to be successful and enabled the auditor to update and improve the implementation methodology as well as the questions in the audit questionnaire.

The chapter will illustrate the procedures followed to beta test the audit questionnaire. Some of the results from the beta test process will be discussed, as well as their significance for the innovation audit methodology. The chapter will conclude with remarks on the implementability of the questionnaire, and proposed audit methodology as discussed in chapter five. The innovation model and the best practise standards discussed in chapters three and five respectively, will be reviewed on the basis of the beta test as well.

**Chapter Seven** discusses the validity of the proposed innovation audit, model and methodology. It highlights some of the limitations and advantages of the proposed innovation audit. The final section contains a personal opinion relating some of the perceptions and findings of the author.

**The addendum** contains some research on the importance of innovation [See appendix A], as well as the audit questionnaire, which was tested in chapter six [See appendix B]. Innovation models are provided in appendix-D while appendix-E contains the results from the beta innovation audit tests.

## 1.2 References

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# DEFINING TECHNOLOGICAL INNOVATION



## 2 Defining Technological Innovation

This chapter focuses on the development of definitions in the fields of technology, innovation, and technological innovation. These definitions serve to qualify the assumptions made later in the thesis, as well as setting some boundaries to the innovation audit. Management practises for innovation and technology are covered as well, since they influence the innovation audit procedures.

The importance of innovation in creating competitive advantage and improving organisational growth cannot be understated. Appendix A in the addendum contains four viewpoints on how 'gurus' in the field of innovation perceive its importance. Toffler[1] offers his views on the future and what it holds for business, while Drucker[2] identifies the world population contraction as a serious threat. Burgelman[3] and Moss Kanter[4] offer insights into strategic aspects and generating growth for the future.

It is useful to develop a sound understanding of the dynamics of technology and innovation to be able to audit their respective characteristics. Since different types of innovation are possible, the boundaries to the innovation audit become important. Deciding between radical and incremental innovation can radically alter the questions asked in the innovation audit. Making an informed decision on the type of innovation, as well as the scope of the audit, is therefore only possible through knowledge of innovation and technology and the management of both these disciplines.

The word '*innovative*' is much too often used indiscriminately by the media and general public alike. This can often create the wrong impression and understanding of its real meaning. A technological innovation for instance, is not as many people believe, concerned specifically with computers or electronic products such as cellular telephones or international networks. Neither does technological innovation only occur in complex products, processes or systems. Technological innovation does not have to be complex, but it has to be new[10] and aim to implement the technology it embodies, in the marketplace.

For example:

> Bio-engineering and medicine currently represent some of the most advanced fields in technology, yet few people refer to tablets and pills when talking of high technology. Other even more unrecognised technological innovations include agricultural processes, financial services, manufacturing methods, and many others. High technological products, such as the fresh produce on farms throughout the county, rely on high technology for harvesting and protection from pests. These tomatoes, pears, apples, maize and many more, are each high technology products, for without bio-engineering and mechanical harvesters or sorters, these fruits and vegetables would not reach our tables as fresh and free of defects as they do. Technology influences our lives in many ways every day, and by thinking of technology only as electronics or computers, one would be badly misjudging the concept of technological innovation.

The poor understanding of 'invention' and 'innovation' is illustrated in the following example:

> *Laypersons, probably because of the mystique that surrounds science, generally view invention as a relatively rare event and assume that once it has occurred, the process of innovation can be completed in a straightforward manner. In actuality, the converse situation pertains here. All who have worked in R&D will agree that the R&D community is quite prolific in generating inventions, and companies can rarely afford to fund all promising R&D projects. It is the subsequent path to technological innovation that is typically fraught with numerous obstacles to be overcome, if the R&D invention is to be commercially successful.*
>
> —Noori[5]

The development of a working definition on the concept of technological innovation is imperative to the development of an innovation audit. It will be discussed next.

## 2.1 Defining Technological Innovation

To define innovation one might return to the Latin origin of the word. Innovation or *'innovare'*, which means '*to make something new*', leads to several conclusions of its deeper meaning. The Latin concept is quite cryptic and can be better understood when divided into three parts. To make something new one has to:

- Generate or realise a new idea (**invention and creativity**)
- Develop this idea into a reality or product (**realisation**)
- Implement and market this new idea (**implementation**)

The *'to make something new'* refers to replacing old concepts or products with new ones, continually updating and improving them. When introducing a concept such as technology into the meaning of innovation, and defining the term 'Technological Innovation', the following changes to the above occur:

- Generate or realise a new idea, *based on technology, capability or knowledge* **(invention)**
- Develop this into a reality or product **(realisation)**
- *Diffuse*, implement and market this new idea, *technology, capability or knowledge* **(implementation)**

Thus technological innovation is a part of the total innovation discipline. It focuses specifically on technology and how to embody it successfully in products, services and processes. Technology as a body of knowledge might thus be seen as a building block for technological innovation, serving as cornerstone to research, design, development, manufacturing and marketing.

Other definitions of technological innovation may be found in literature, yet they all make some reference to **invention, realisation**, or **implementation.**

For example:

**Invention:**

> *Creation of new idea for a product process or service ... new combination of pre-existing knowledge.*
>
> — Edosomwan[6]

> *... and demonstrating its feasibility*
>
> — Girifalco[7]

> *... covers all efforts aimed at creating new ideas and getting them to work*
>
> — Roberts[8]

> *Organised creativity*
>
> — Ramanujan & Mensch[9]

The advantages of defining innovation as invention, may illustrate the creativity and novelty side of the process. However without emphasis on the implementation of the invention, innovation will not happen. By defining innovation as invention, only half the complete definition is given and no consideration for the total concept of innovation is made.

**Realisation:**

> *Industrial innovation includes the technical design, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product or first commercial use of a new (or improved) process or equipment.*
>
> — Freedman[10]

> *Innovation is the specific tool of entrepreneurs, the means by which they exploit change and opportunity for a different business or service. It is capable of being presented as a discipline, capable of being learned, capable of being practised.*
>
> — Drucker [11]

The advantage of specifically including realisation in the definition of innovation lies in identifying a clear time in the lifecycle of innovation, where the invention progresses from idea to reality. The realisation phase transforms the invention into a producible product and therefore plays a crucial part in the process of innovation.

**Implementation:**

> *Successful exploitation of new ideas...*
>
> — UK DTI Innovation Unit definition (1994)

> *... innovation does not necessarily imply the commercialisation of only a major advance in technological state of the art (a radical innovation), but it includes also the utilisation of even small-scale changes in technological know-how (an improvement or incremental innovation)...*
>
> — Rothwell and Gardiner[12]

> *Innovation is the introduction of a new product, process, or service into the marketplace.*
>
> — Edosomwan[6]

> *... a new technology or combination of technologies introduced commercially to meet a user or market need*
>
> — Utterback & Abernathy[13]

Implementation should be defined in innovation, to indicate the importance to market and the real or perceived need that exists. No invention may claim to be an innovation, before it has been implemented into the market. The acceptance of the invention into the market changes it to the status of innovation. Therefore to define innovation, the following quotes come very close to the truth, as understood in the discipline of innovation.

**Innovation:**

> *An invention is essentially the creation of a new device. An innovation additionally entails commercial or partial application of the new device ... first application of an invention*
>
> — Sahal[14]

> *Innovation is the process by which an invention is first brought into use. It involves the improvement or refinement of the invention, the initial design and production of prototypes. Pilot plant testing and construction of production facilities ... diffusion is the process of the spread of the innovation into general use as it is adopted by more and more users.*
>
> — Girifalco[7]

> *... we look upon innovation as the total process from the inception of an idea through to the manufacture of a product and finally to its ultimate sale. It therefore includes invention and the many stages of implementation such as research development, production and marketing.*
>
> — Berry & Taggart[15]

> *Innovation = invention + exploitation*
>
> — Roberts[8]

This selective and non-exhaustive list of innovation definitions, illustrates the three areas identified in this thesis as the basis for the definition of innovation. They can clearly be seen to occur in the definitions of innovation given by Girifalco[7], Berry & Taggart[15] and Roberts[8]. The fragments [see above] under the headings invention, realisation and implementation illustrate the strong foundation for proposing that innovation consists of these three stages. The definition of technological innovation followed in this thesis, will therefore be a mixture of the above, as they are portrayed in the prominent areas of **invention, realisation**, and **implementation**

Thus the **Proposed Working Definition** of **Technological Innovation**:

- *To conceive and produce a new solution (from a scientific and technological knowledge) to a real or perceived need* ***(Invention)***
- *To develop this solution into a viable and producible entity* ***(Realisation)***
- *To successfully introduce and supply this entity to the real or perceived need* ***(Implementation)***

All definitions discussed above may lead one to the conclusion that technological innovation is a highly personal concept, relying heavily on knowledge, educational standards and intelligence. This also illustrates the difficulty of managing innovation, for how does one manage that which is so oppositely understood. These different ideas about innovation are exacerbated by the media referring incorrectly to any new development or idea as 'innovative', while actually meaning 'inventive'.

The three areas of technological innovation as identified in the proposed definition above, warrant a better description. They form a key part of the innovation auditing process and occur as primal entries in the innovation model, which will be developed later in this thesis. A short introduction to **invention, realisation** and **implementation** follows.

### 2.1.1 Invention

Invention and creativity are very common, and are practised by all of us. Because every human being understands, visualises and communicates information differently, we have no choice in being creative. When learning or reading we transform information into a personalised format to store it better in our brains.[16] This transforming of information into a personalised format, ads a uniqueness to every piece of information and when finally retrieved, manifests itself as new ideas, concepts and techniques. Invention therefore is a natural habit, practised to a greater or lesser extent by all people. This can be proved by the fact that even a simple interaction between two people, usually contains new thoughts, perceptions and even ideas. One of the best ways to improve innovation in an organisation is to hire new, inexperienced people with different perceptions and ways of doing things.

Conversely routine and safety are the suppressers of invention. When routines are formed in our minds, we tend to act along those same paths every day. To break the routine and think more inventive, one should try new things, learn as much as possible and explore continuously. For instance one of Leonardo da Vinci's most valuable traits was his inquisitiveness.[17] He simply had to know everything about anything, enabling him to stay highly creative throughout his life.

### 2.1.2 Realisation

The part of the innovation cycle where ideas are turned into workable and usable products may be referred to as the realisation phase. Engineers, designers and developers may often be found in the realisation phase. These people are realists, practical, goal orientated, hard workers and sure of themselves. Each of these traits play a part in driving and forcing an invention through the difficult stages of development, design, testing and pre-production to a producible product.

Without the realisation phase ideas would always stay 'blue-sky' ideals, hopes and promises. Realisation combines the skills of engineers with researchers, manufacturers and market 'gurus' to design and produce a working prototype, resembling the initial idea. It is important to note that the final prototype might not exactly constitute the initial ideas, since manufacturability, marketability and natural laws abide for every product.

### 2.1.3 Implementation

To implement an innovation means convincing someone to use or buy it from the innovator. Ultimately marketing is about convincing customers that a product is better, cheaper, faster, safer, harder etc. than the competitor's. With a new innovation the same holds true, yet the newness can sometimes be a drawback. Markets resist new products and need to be informed about the features of the new product to be able to understand its advantages. Implementation is therefore about developing and convincing the market, or customer, to buy a new innovation.

### 2.1.4 Conclusion

This concludes the section on the definition of technological innovation. It was found that technological innovation might be defined in a proposed working definition as:

- *To conceive and produce a new solution (from a scientific and technological knowledge) to a real or perceived need **(Invention)***
- *To develop this solution into a viable and produceable entity **(Realisation)***
- *To successfully introduce and supply this entity to the real or perceived need **(Implementation)***

This thesis will follow the definition as proposed above. It will be applied in the development of an innovation model, as well as a methodology for auditing capabilities for technological innovation. To elaborate on the diverse nature of innovation, the different types of innovation will be discussed in the following paragraphs.

## 2.2 Different Types of Innovation

Technological innovation is a complex process of several distinct stages, many of which require different focuses and different management strategies. Typical aspects of the stages of innovation may include the following:

(a) Should the firm start with the inception of an idea (invention)?
(b) Is it more beneficial to take up a well-developed concept and focus on commercialisation?
(c) Should the firm spotlight an existing technology and aim at perfecting or modifying it?

Managing innovation requires the juggling of many concepts and processes to keep each performing at its peak [Appendix A Burgelman]. To understand the complexity of innovation better, some of its elements requiring different management strategies are reviewed below.

Academics and specialists define many different types of innovation. For instance, different applications, degrees, processes and functions all performed in innovation function. The following are some of the more prominent types:

Marquis[18] defines the following different types of innovation:

- **Radical** innovations: ideas that have impact on or cause significant changes in the whole industry
- **Incremental** innovations: small ideas that have importance in terms of improving products, processes, and services
- **System** innovations: ideas that require several resources and many labour-years to accomplish. Communications networks and satellite operations are good examples

Henderson and Clark[19] define the types of innovation as:

- **Incremental**: — incremental innovation refines and extends an established design, but underlying concepts, and links between them, remain the same
- **Architectural**: — the essence of architectural innovation is the reconfiguration of an established system to link together existing components in a new way
- **Modular**: — it is an innovation that changes a core design concept, without changing the product's architecture or primary function
- **Radical**: — radical innovation establishes a new dominant design and hence a new set of core design concepts, embodied in components that are linked together in a new architecture

Types of innovation which will be discussed further include:

- Revolutionary vs. evolutionary innovation
- Modular vs. architectural innovation
- Process vs. product innovation
- Procedure vs. service innovation
- Disruptive vs. sustaining innovation
- Market pull vs. technology push innovation

Although by no means complete, the different types of innovation do give a certain understanding for the complexity of managing the total system. When so many different variables exist in an equation, great effort is needed to solve or just arrive at a sensible answer. In the following paragraphs, some of the more important types of innovations are described, as well as their possible management procedures.

### 2.2.1 Revolutionary versus Evolutionary Innovation

Innovation may be classed into two main categories, revolutionary and evolutionary, or often referred to as radical and incremental respectively. Although some extensions to these categories exist they will be elaborated on at a later stage.

**Revolutionary** or **radical** innovation as it is also known, is accompanied by a high degree of change in human behaviour and paradigms. In essence radical innovators have a completely different way of thinking and doing things. Radical innovation is responsible for most discontinuous product or process changes.

Huiban[20] states that radical innovation typically occurs in small organisations outside the more established industries. This is a contentious issue which many of the bigger organisations such as HP, 3M, DuPont, Pfizer and many others often disprove. What Huiban possibly implies is that disruptive or industry changing innovations often come from outside the industry they disturb. Christensen[23] refers to this type of innovation as the implementation of a disruptive technology. These technologies often find application in niche markets where they 'survive' until a crack or opportunity in the larger market appears. However if the innovation and technology is of sufficient brilliance, these small firms may easily start growing exponentially. The niche market serves as a platform for educating the market and generating resources for further product or technology development. Michelin (steel belt automobile tires) and Apple (personal computers) initially entered niche markets, before they were able to grow to their present size. This afforded them the time and exposure to do the necessary refining and development on their product ranges.

The management of radical innovation is often difficult, since it is prone to failure. Most organisations feel more comfortable to pursue the less risky route of evolutionary or incremental innovation.

**Evolutionary** or **incremental** innovation, on the other hand, is relatively common and occur throughout large and small organisations. It is often the large firms, with well-developed research facilities, that can capitalise most on incremental innovation. By continuously improving they are able to stay ahead of their competitors, and survive another day.

Incremental innovations build on previous radical innovations. They often focus on introducing new features and abilities to current product lines. These innovations can be managed in a formal way, by focusing on creative problem solving and integrating customer needs into future designs. Incremental innovation is the typical run of the mill innovation needed almost every day. It is most often used to keep up with the competition.

Incremental innovation is often the only way large organisations are able to innovate. However a hidden danger lies in specialising in incremental innovation only, for the field of innovation is dynamic and being locked in may mean relinquishing many opportunities to more flexible competitors. Influencing organisational competitiveness and the bottom line.

### 2.2.2 Modular versus Architectural Innovation

The terms modular and architectural innovation have been coined to assist understanding and defining the intermittent ground between revolutionary (radical) and evolutionary (incremental) innovation. The two extreme cases of innovation, as discussed above, do not include innovations such as fusion of technology, rearrangement of units or partial radical innovation. Modular and architectural[19] innovations lie between revolutionary (radical) and evolutionary (incremental) innovation, but are not necessarily simply a fusion of the two extremes. They represent a different approach to innovation and could be used as a methodology for implementing innovation, when revolutionary or evolutionary may not fit.

**A Framework for Defining Innovation**

| Linkages Between Core Concepts and Components | Core Concepts: Reinforced | Core Concepts: Overturned |
|---|---|---|
| Unchanged | Incremental Innovation | Modular Innovation |
| Changed | Architectural Innovation | Radical Innovation |

*Figure 2.1: A Framework for Defining Innovation, Source: Henderson and Clark[19]*

**Architectural innovation** occurs when existing knowledge or hardware embodied in a product, is arranged differently, creating a completely different product and possibly a different market. The function of the product seldom changes dramatically.

A good example might be the innovation of the low-stress chair, commonly used in front of personal computer desks. — The chair consists of opposing cushioned sections for the knees and buttocks. It has no backrest. When one sits in the chair, a crouching position results, with reduced stress on the occupant's lower back. — This chair is not simply an adaptation of a normal chair, but a rearrangement of the back and buttock rests, into knee and buttock sections. The important issue is that the underlying idea of seating a person has not changed, only the way it is accomplished. It may therefore be classified as an architectural innovation.

Implementing an architectural innovation might require scanning and monitoring a wide variety of customer needs and possibly identifying where current organisational technologies or competencies are utilised. Due to the holistic approach required for architectural innovation to happen innovators will require a wide knowledge base with information gathering and knowledge management systems close at hand.

A **modular innovation** usually takes place in complex products or processes with many sub units and functions. This type of innovation can be a radical innovation of a certain part of a total product. A new personal computer may have a new central processing unit, but without accompanying software, interfaces, memory and buffer units, it could not be regarded as a radical new product innovation. In this case a neural network computer or something completely new, would be considered a radical innovation.

Modular innovation is related to radical innovation in the nature of its implementation. As proposed above a modular innovation represents a radical innovation in a single part of a system. Linking modular innovation directly with radical innovation, but in a diminished capacity.

### 2.2.3 Process versus Product Innovation

Innovation at the organisational level involves both the creation of new products, and improvement in the process of producing these products. These two aspects of innovation can be actively managed as different but interrelated entities. However, there is a clear time lag between product and process innovation as described by Utterback and Abernathy[21] in Figure 2.2.

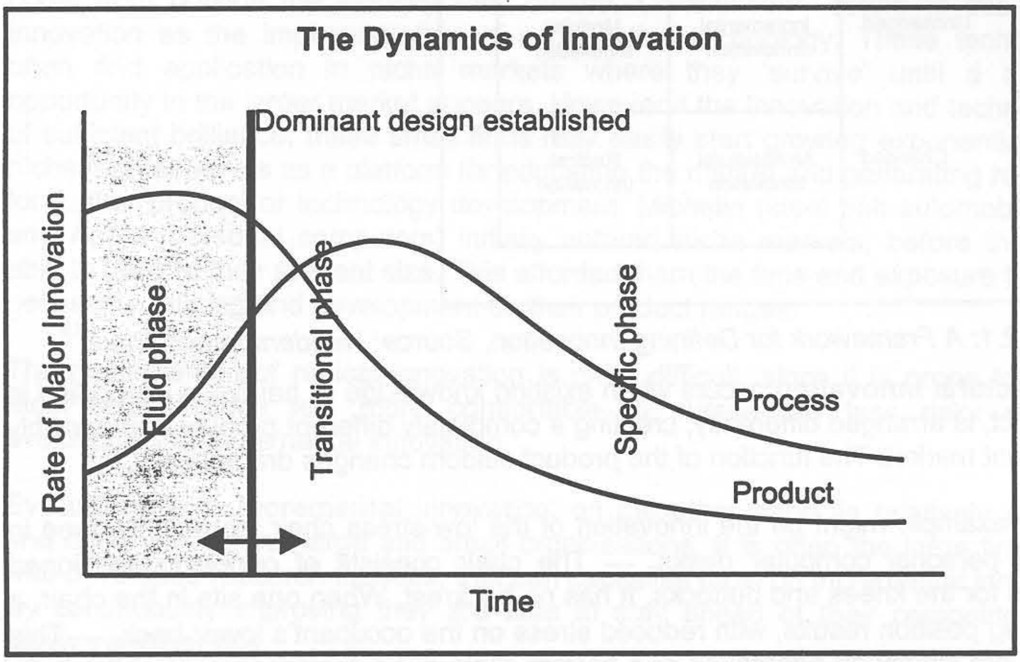


*Figure 2.2: Product vs. Process Innovation Dynamics, Source: Utterback*[21]

The dominant design innovation-cycle in the figure shows the increasing volume of new products in the section where a dominant design has yet to emerge. As shown in the figure a large amount of product innovation occurs until the dominant design is established. This phase is therefore called the ***fluid phase***.

After the dominant design is establishment, the focus shifts to improving the efficiency of manufacturing and production of the product. This results in higher product innovation and is called the ***transitional phase***.

Finally the product enters the ***specific pattern*** in its lifecycle, where incremental product and process innovation occurs. Specialising the product further with regard to customer needs or demands. This phase is highly dangerous since technology lock-in often occurs, resulting in low firm agility, and ultimately no way of adapting to new demands or technological evolution.

The dynamics of innovation in Figure 2.2 are important when strategic innovation planning is done. Organisations need to take the nature of product and process innovation into account, when developing future strategies.

**Process innovation** can be described as improving or changing current procedures and techniques used in the production of products. Any improvement to current manufacturing, delivery, packaging, marketing, project management, etc can be considered a process innovation.

A good example of an operation reliant on process innovation would be Federal Express, the overnight package delivery service. FedEx guarantees that if any package delivered by them arrives late, they will refund 25% of the sending costs per hour of lateness. This means that if an overnight package arrives four hours late, FedEx will receive no money for the delivery and the package thus gets delivèred for free. To be able to offer this incredible guarantee, every person in FedEx has to be committed to delivering every package on time, no matter what the circumstances.

For FedEx to accomplish their guarantee, every department by itself is responsible for their own efficiency. The number of packages dispatched across the world can demonstrate the effectivity of this arrangement. When given the opportunity to improve their delivering times, pilots claimed that flying normal flying hours delayed delivery and insisted on flying 'in the gaps' or outside normal flying hours. This they said gives them the advantage of lower flight densities, with less delay on runways and unloading of their cargo. FedEx researched this notion and saw the advantage to be gained, and today the pilots at FedEx fly in the carefully predicted gaps outside normal flying hours.

Typically this type of innovation can be characterised by an improvement in the pilots working procedures, resulting in an improved delivery system. It is therefore a process, rather than a product innovation.

**Product innovation** is often associated with New Product Development (NPD) and not necessarily with innovation. However, product innovation forms the core of innovative organisation and offers incredible competitive advantage in new as well as established markets. Although related to process innovation, product innovation is much more of a process than a single implementation or improvement. Product innovation is often a shot in the dark with the hope of hitting the right market with the right product at the right price. Good examples of product innovation is not hard to find, but the following is one of the most classical ones:

As discussed by Foster:[22]

> By the late eighteen hundreds the Swiss watch making industry reached its peak in performance and quality. Their workmanship was revered to throughout the world and watches made by them dominated the market. The Swiss however, became too sure in their dominance and failed to spot the possibilities of a certain development. One of their own creative workers in the electronic and crystal impulse generation field started this development. After seeing this new device on a fair in Switzerland, using a crystal instead of a pendulum, Japanese entrepreneurs were ecstatic. They immediately bought the patent from the young designer and set to work on one of the best innovations of the twentieth century, the digital watch. This invention took the world by storm. Suddenly a timepiece made in Japan could keep as good time as an expensive Swiss watch, and at a tenth of the cost. Obviously the Swiss industries collapsed as market share diverted towards the Japanese companies, yet it was the consumer who won in the end. By destroying the Swiss mónopoly and introducing new technology better simpler and cheaper products were póssible.

This example illustrates how easily an organisation may lose track of possible new innovations in their own research laboratories. A consistent focus on incremental product innovation like the Swiss, may result in a mindset which disqualifies alternatives. A mixture of incremental and radical product innovation is therefore necessary to open the paradigms inside an organisation.

### 2.2.4 Procedure versus Service Innovation

Writings on innovation often focus on product and process innovation, and do not include enough research on service and procedure innovation. Although service and procedure innovation is important most strategies and methodologies for product and process innovation respectively hold true for them as well. For the sake of completeness these innovation terms are explained to some extent

**Procedure innovation** (or process innovation) — Innovation that changes the management procedures is a good example of this kind of innovation. This innovation has no direct influence on the products size, shape or features but can cause the process of producing the product to improve. In this way a procedure innovation is a process innovation since it improves the manufacturing or production process.

**Service innovation** (or product innovation) — In a service organisation the product is supplying a service to the client. In this regard the service becomes the product of the organisation, since it generates income. Organisations like banks and repair service stations have many different types of 'packages' they offer, and each of this represent a certain service to the client.

Procedure and service innovation can clearly be incorporated into the larger picture of process and product innovation. But they are often difficult to manage or audit due to their qualitative nature.

### 2.2.5 Disruptive versus Sustaining Innovation

Christensen[23] elaborates on the concept of disruptive and sustaining technologies yet his conclusions and remarks may be applied in the field of technological innovation as well. He proposes the existence of disruptive technologies that have the ability to change the industry paradigm as well as the dominant design. The examples Christensen use, are from the computer hard disk industry where a simple size reduction, had a major influence. In this example he also refers to the sustaining technologies which do not necessarily change the current paradigm.

Christensen describes sustaining technologies as those that fall within the limits and boundaries of the current technology trajectories and therefore only serve to incrementally improve the product. These technologies build upon the previous ones and are mostly well known in every organisation in the industry. Although many resources are spent on advancing the current sustaining technologies, they will not enable the organisation to break free of the current paradigm.

For a paradigm breaking technology Christensen propose doing disruptive technology development. In the Hard Disk Storage industry for instance, the shift from five and a half inch drives to three and a half inch drives, were such an paradigm shift. Christensen defines disruptive technologies, as often simpler and of poor quality, than current technology, yet with a definite niche market. The disruptive technology should also have higher limits than the current one. Then when disruptive technologies are turned into disruptive innovation, they often have the power to unsettle powerful industries.

### 2.2.6 Market Pull versus Technology Push Innovation

In this regard innovation can be seen in two lights, and the distinction lies between listening to the market or the scientists. An innovation starting with an identified customer/market need, is called a **market pull**[33] innovation, while an innovation based on new technology or bright idea is called a **technology push**[33] innovation.

Both these innovations occur frequently but usually in different markets and environments. A technology push innovation, for instance, occurs in a research and development rich environment. On the other hand customer based or service based institutions make mostly use of market pull innovations.

**Market pull** innovation needs a strong customer base and an information gathering mechanism to qualify their needs. Since the customer/market actually asks for a new innovation, little in the form of direct radical creativity is needed. A well-oiled research and development team however, has to translate the needs of the customer/market into practical product proposals. In this regard the organisation doing the innovation has to continually have good contact with the customer/market to ensure the product meets their expectations.

**Technology push** innovation on the other hand needs a strong technology base. By doing basic 'blue sky' research, new materials, methods and techniques are discovered. When these new ideas are incorporated into products, technology push innovation occurs. Although a need for this new technology driven products often exists, there might not always be one. When this happens, the customer/market is often ignorant of the characteristics and advantages of the product, and needs to be educated. A lot of market development is usually required to launch such a technology driven product.

Although technology push innovation can have very high rewards, it is extremely expensive and may fail more often than market pull innovation.

### 2.2.7 Conclusion

The many distinctions between the different types of innovations are one of the reasons why it is difficult to implement a general recipe for innovation. Another, is the many differences between organisations and how they implement their own innovation strategies. To find a sensible and applicable middle road, weighing up the different options correctly will require an enormous amount of research and study, which fall outside the scope of this thesis. The focus will now shift to the applied aspects of innovation, as well as the identification of the key areas defining the discipline of innovation. However the different types of innovation and their management procedures, will influence future conclusions and developments of any kind.

## 2.3 Management of Technology and Innovation

Technology management is becoming an accepted management practice, and in some cases even the equal of current financial management methodologies. With the increase in importance of technology, it is becoming prudent for senior management to be more aware of new technologies. New technologies have the ability to completely disrupt established industries, and make most, if not every, of their competencies obsolete. Conversely, a specific technology identified early enough and developed into a market leader may be extremely profitable.

The management of technology has been developing as a formal disciple over the past decade or two. Compared to other management disciplines it is in its infancy. When one looks at innovation management it is even less developed than technology management as formal discipline.

Many aspects are hampering the rapid acceptance of technology management in industry. One of these is the difficulty of defining technology itself. Another is finding the value technology management adds to the organisation. It is quite difficult to define the value of an 'undefineable' and 'unquantifyable' discipline.

Due to the increased use of technology in the workplace, especially information technology, technology management will in future years become increasingly important.

If the discipline of technology management is difficult to quantify so much more may the discipline of innovation management be. Innovation management as discipline is often confused or combined with technology management. Although it is possible to combine the two as proposed by Betz,[24] in the statement,

> *...the central concept of managing technological change is the idea of 'technological innovation': Technological innovation is the invention of new technology and the development and introduction into the marketplace...*
>
> — Betz[24]

it may often lead to complications in the implementation of technology or innovation. It may possibly be simpler to make a distinction between technology management and innovation management by looking at the processes they are based on.

Technology management is mainly concerned with the interaction of the organisation and the external technological environment. As such licensing, acquisition, technological status, R&D and technological policies could be classified as pure technological management items. While other, more innovation related areas such as new product development, new process development and innovation policies could be classified as pure innovation related items.

The question arises: which one is concerned with the implementation of technology or which one only with the technology itself? There is no doubt that some overlaps between the two disciplines exist, yet few academics are prepared to stake their reputation on drawing the dividing line.

Some of the differences between the two disciplines are relevant to this thesis and will therefore be reviewed in the rest of this chapter.

### 2.3.1 The Management of Technology

One of the possible responsibilities of a technological manager might be to ensure that there exists adequate contact between the organisation and the technological world. Another typical function of a technological management department or office, would be to implement far reaching technological plans with regard to current resources employed, as well as future product development. This may include functions such as information system design, production system planning, technology acquisition planning, technological monitoring and scanning, as well as strategic advice on future developments in the technological domain.

Technology may be defined as 'created capability' in the words of Van Wyk.[25] A cryptic, yet accurate definition, showing a general in-depth understanding of the term 'technology'. However, technology often requires a 'gut feel' definition rather than one in words, and is often best understood over time and through personal research.

One important aspect of technology is its tendency to continuously change; this is often referred to as the dynamics of technological change. The management of technology revolves around the dynamics of technological change. In the following section more detail on this subject is given.

### 2.3.2 Dynamics of Technological Change

The question why and how new technology and innovation happens and how this change manifest itself in reality, leads to the study of dynamics of technological change. A multitude of reasons for change exist yet the limits of technology are often driven by so called barriers of performance. These limits or barriers to technology inhibit the further development of current products and processes. A good example is the limit Intel is reaching in miniaturising their central processing units (CPU's) for new computers. Their CPU's internal architecture is nearing the limit of conductor safety, and therefore they have to investigate other materials or even completely new technologies. This technological limit can be identified as one of the primary drivers in new technology development at Intel.

A complete field of study exists with the specific task of finding and predicting the dynamics of technological change. As with Intel many other technologies have limits, and when these start to impact on development, many new pathways open for managers which need consideration.

As part of these dynamics a renowned Russian economist Nicholai Kondratieff[26,27] discovered a 54-year cycle of commodity prices, which he traced back 300 years. He used this to accurately predict the 1929 stock market crash, three years before it happened. The Kondratieff long wave cycle, as illustrated n figure 2.3, clearly illustrates the cyclic nature of world prosperity. The interaction between economic prosperity and technological innovation is fascinating.

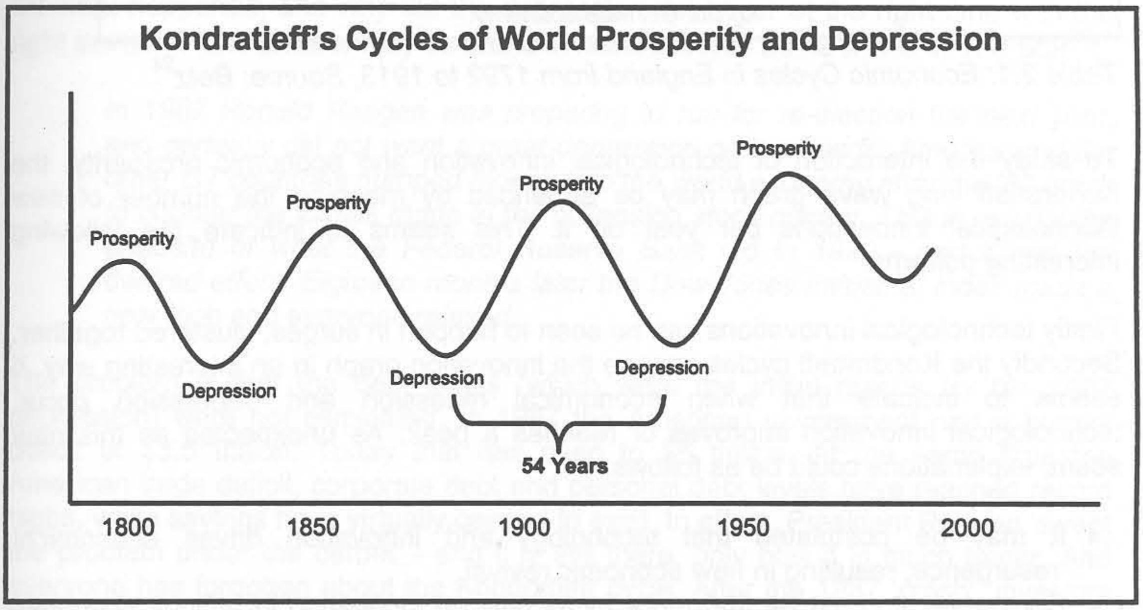


*Figure 2.3: Kondratieff's Long Wave Cycles, Source: Twiss[28]*

| Economic Cycles in England from 1792 to 1913 |
|---|
| *As identified by Kondratieff:* |
| ***First wave:***<br>*1792-1825 Economic Expansion:*<br>*Kondratieff assigns iron, steam power and textile machinery as the reasons for economic expansion.* |
| *1825-1847 Contraction:*<br>*Due to temporary excess in the expansion cycle.* |
| ***Second wave:***<br>*1847-1873 Economic Expansion:*<br>*Due to the beginning of new industries in railroads, steamships, telegraph and coal gas.* |
| *1873-1893 Contraction:*<br>*Again due to over supply and excess*<br>*A temporary economic contraction followed.* |
| ***Third wave:***<br>*1893-1913 Economic Expansion:*<br>*The development of new technologies in chemical dyes, electrical lighting, telephones and automobiles.*<br>*Followed by continued expansion after World War I.* |
| *1930 Contraction:*<br>*Temporary excess as well as war debt of the German economy.* |

*Table 2.1: Economic Cycles in England from 1792 to 1913, Source: Betz*[24]

To study the interaction of technological innovation and economic prosperity, the Kondratieff long wave graph may be enhanced by mapping the number of new technological innovations per year on it. This seems to indicate the following interesting patterns.

Firstly technological innovations can be seen to happen in surges, clustered together. Secondly the Kondratieff cycles oppose the innovation graph in an interesting way. It seems to indicate that when economical recession and depression occur, technological innovation improves or reaches a peak. As unexpected as this may seem, explanations could be as follows:

- It may be postulated that technology and innovation drives economical resurgence, resulting in new economic revival.
- Conversely it could be that more focus falls on innovation in difficult economic times.
- Or that technological development and innovation takes time to develop and the previous prosperity cycle is driving the innovation boom.
- Wars and international disasters can contribute to these cycles yet it is uncertain to the impact they might have.

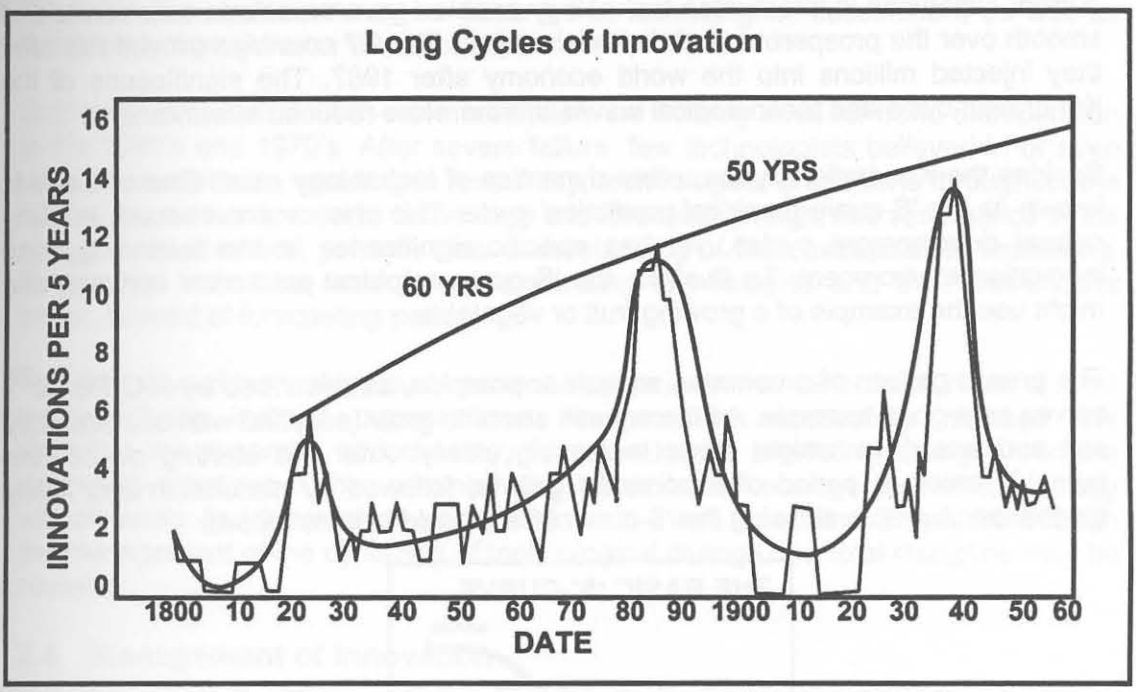


*Figure 2.4: Long Cycles of Innovation According to Mensch, Source: Girifalco*[26]

As the world enters the new millennium it is interesting to note the surge in the economic environment since the stock market 'crash' in 1987. The Kondratieff cycle indicates that if one were to add 54 years to 1929, reaching the answer of 1983, a Kondratieff depression would have been likely around that time. The depression did come in 1987 but not as severe as was proposed by Kondratieff.

So what happened, and why did the depression not occur at the right time with the right severity? The answer may be found in Milne's words as he writes in The Star[29];

> *In 1987 Ronald Reagan was preparing to run for re-election the next year, and certainly did not want a great depression on his hands. America and the other G7 countries pumped money into the world economy after the '87 crash to counter the losses made in the collapsing stock market. This is exactly the opposite of what the Federal Reserve Bank did in 1929 - and it had the desired effect. Eighteen months later the Dow Jones industrial index made a new high and everyone relaxed.*

The problem is that the debt levels (which were the initial reason for the 1987 depression) were not eliminated. In 1987 the American government had a budget deficit of $3,5 trillion. Today that has risen to $5 trillion. At the same time the American trade deficit, corporate debt and personal debt levels have reached record highs, while savings have virtually ceased to exist. In effect, President Reagan 'swept the problem under the carpet' - and it is still there, only now it is much larger. And everyone has forgotten about the Kondratieff cycle. After the 1987 'crash', investors became far more blasé about crashes generally - after all, why worry about a crash if all you need to do is wait 18 months for another all-time high? This attitude, of course, sets us (the world) up for the greatest crash of all time. Ironically, for the Kondratieff cycle to occur, it is necessary for us all to forget about it.

Although these interesting cycles show the impact of technology on economics, and economics on technology, there is no guarantee that they will occur in the future. The current expansion in information technology enables governments to collaborate and smooth over the prosperous and depressive eras. The G7 countries proved this after they injected millions into the world economy after 1987. The significance of the Kondratieff cycle and technological waves are therefore reduced enormously.

Besides the Kondratieff cycles, other dynamics of technology exist. One of these is known as the 'S-curve empirical prediction' cycle. This phenomenon occurs in many natural development cycles, yet has specific significance in the technology and innovation environment. To illustrate the 'S-curve empirical prediction' concept, one might use the example of a growing fruit or vegetable.

The growth pattern of a common squash or pumpkin, as described by A.L. Porter[30], serves as a good example. As the squash starts to grow (supplied with all necessary soil and water) its weight starts increasing slowly. After the starting period, the pumpkin enters a period of exponential growth, followed by maturation and finally stagnation. A graph, showing the 'S-curve effect' could look as follows:

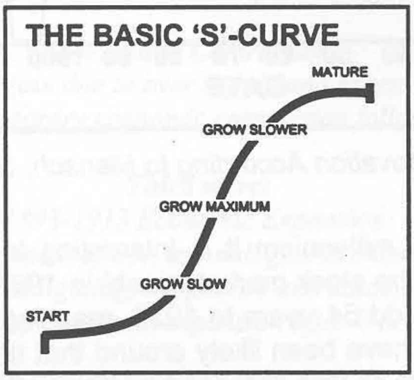


*Figure 2.5: 'S'-curve, Source: Porter[30]*

Interesting parallels between this natural growth curve and dynamics of technology can be drawn. Technology diffusion into a market is one of the more common processes following the 'S'-curve path. The diffusion process of television sets into the American market might serve as an example, as may be observed in Figure 2.6.

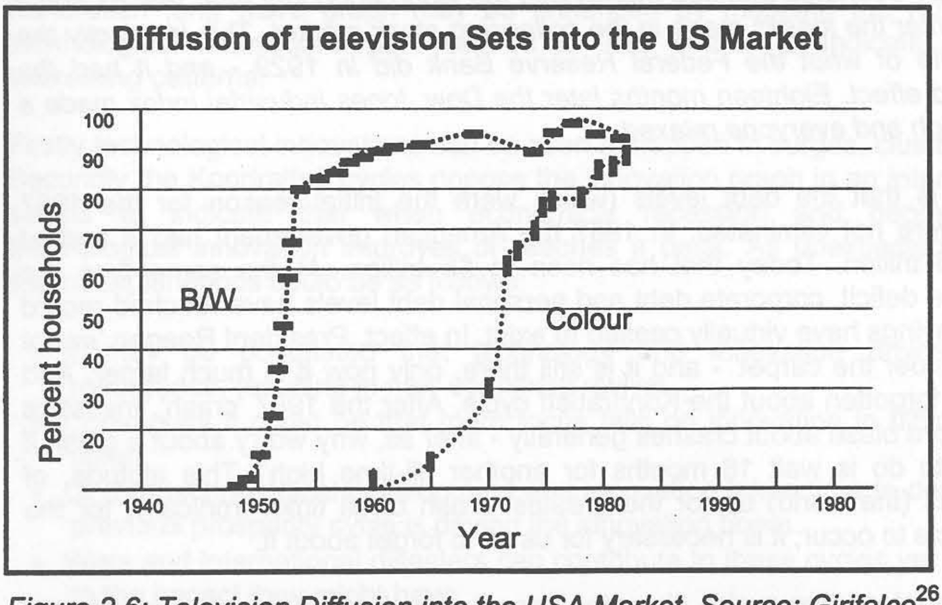


*Figure 2.6: Television Diffusion into the USA Market, Source: Girifalco[26]*

Other 'S'-curve patterns may be observed in technological substitution, as well as technological progress or development.

Both the Kondratieff and 'S'-curve methods were actively used for trend extrapolation in the 1960's and 1970's. After severe failure, few technologists believed in or even used these methods, resulting in few, if any, technological predictions throughout the 1980's. New development in technology and forecasting might see resurgence in the use of these methods, yet with clear understanding of their extrapolation limitations. They might rather be used for understanding technologies and their interactions better, instead of forecasting per sé.

The discipline of technology management may be instrumental in the survival of most technologically inclined organisations. However, to successfully manage this discipline the dynamics of technology form the key to predicting changes and the necessary reactions. Other administrative areas in the management of technology will ultimately find themselves as extensions to these dynamics. Therefore through the management of the dynamics of technological change, the total discipline may be covered.

## 2.4 Management of Innovation

Innovation management is often classified correctly as a discipline separate from that of technology management. However, concerns still surface on the actual implementation of the two disciplines in practise. The question arises: how does innovation management influence technology and what relevance does it have in the high technology organisation of the future?

No easy answer exists, yet the beginning of a discipline may be observed in the writings of academics and specialists such as Twiss[28], Tidd[34], Utterback[22], Chiesa *et al*,[31] and others. Twiss and Utterback have been two father figures in defining innovation management as a discipline. It is through their work on innovation models and definitions that the first beginnings of a discipline were formed. By studying these writings on technological innovation, one may come to understand the bigger picture of the discipline.

Management of innovation is not a subject one can discuss in a brief paragraph or two. Due to the diverse nature of innovation, it often has an impact on a large amount of resources and functions inside the organisation, from strategic decision making to employee attitudes and creativity. As yet few organisations have a formal innovation management programme, increasing the importance of elaborating on the subject in this thesis. Innovation auditing and innovation management go hand in hand.

Technological innovation management and its discipline of implementation can be a contentious issue. Betz[32], for instance implies that innovation management should be part of the technology management discipline, while others such as Noori[33] and Tidd *et al*[34] oppose this. To their reckoning technological innovation management should be a discipline in its own right, and technology management could even be made to fall under the umbrella of technological innovation management. Although both these viewpoints have their merits, this thesis is of the opinion that technology management and innovation management forms two distinct management disciplines, and should be addressed as such. However, this does not propose that no overlap between the disciplines exists, but there is enough evidence to suggest that the differences between the two disciplines are relevant.

To describe the functions required in the management of innovation, the nature and structure of the organisation should be taken into account. Project leaders or managers in the new product development environment, might perceive themselves as innovation managers, yet the management of innovation require a more strategic approach as well. A description such as 'chief innovation officer' might be attached to the person in charge of an innovation management discipline. Such a person should therefore have insight into the long-term organisational strategies and architectures of the organisation.

Six key elements were extracted from the work by Utterback,[21] Twiss,[28] Tidd *et al*,[34] and Cheisa *et al*,[31] and are discussed below. They are proposed to form the basis for the innovation management process, which is followed in the development of a competence audit for technological innovation in this thesis. The innovation management function may focus on these six elements, and by continuously improving them improve the total innovation capability of the organisation.

**External environment:**
Interfacing with technology management as well as marketing and competitive intelligence of the industrial environment, the innovation management function co-ordinates the integration of necessary information for the conception of new ideas and projects, thereby creating an environment rich in knowledge and capable of fostering new innovations.

**Organisation:**
Assisting general management in planning and strategy formulation as well as information capabilities in the region of innovation and new product development. The innovation management group is able to influence the strategic design of new projects as well as new competencies that are required in the organisation. Aspects such as project mix and the aggregate project plan, new product and process development models, technology competence and innovation audits, all form part of the structure and resource environment that is supplied by the organisation to foster innovation.

**Individual:**
Improving personal knowledge as well as encouraging creativity and participation in new innovations, lead to improve effectively and efficiency. The innovation management function should, through interface with human resource management, enhance the capabilities of the employees. Innovation capabilities should also be looked for in appointing new personnel and in this function innovation management might offer guidelines.

**Invention:**
The invention and idealisation process is often the first function people think about when considering the improvement of innovation in the organisation. Although invention is important in its own right, innovation can seldom happen if only one of the three key areas is present. The causality of the three functions: invention, realisation and implementation, relates their significance to each other well. Invention is for instance impossible without market, technology and industry related knowledge, which stems from the implementation of previous innovations.

**Realisation:**
Realisation forms the second part of the causal map in the innovation new product development process. The realisation process requires the input from

the invention process in the form of technology, prototypes and models. These are then used for the creation and building of feasible and high volume production products.

**Implementation:**
Implementation might be considered to be the final part of the causal model drawing on the outputs of the realisation process. This function consists mainly of marketing and market education, as well as after sales service when required. It can therefore generate highly valuable information for the development of new products and innovations, closing the three new product innovation functions into a ever revolving loop.

The last three elements invention, realisation, and implementation can be seen as the heart of a new product or service development process. The first three may be described as the innovation-fostering environment. The innovation management functions, influences each of the six areas and improves them on a continuous basis. Through this, exceptional control on the new product development process is possible, resulting in strategic goals being reached faster with better implementation of resources.

The methodology for the management of technological innovation is still in virgin territory. The proposed six elements above is made on the basis of a innovation model which will be developed in the next chapter. Other sources on technological innovation management were used extensively in constructing the model as well as defining the six elements.

## 2.5 Innovation Management versus Technology Management

The two disciplines of technology management and innovation management have been described above. From these definitions and elements the differences between the two disciplines should be clear. Since the two terms, innovation and technology are understood in a qualitative manner and also on a personal level, there will always be debate on their classifications.

If one regarded technology, it could be classified as a scientific method, discovery or even a certain kind of knowledge. It is not a process like innovation and does not require implementation to be considered a technology. One might think of technology, combined with other methods and ideas, as the input to the innovation process. While the innovation process is where the technology is transformed from static knowledge into practical implemented products.

From the dynamics of technological change and the management of technological innovation, it should be clear that there exits a niche area for both the management disciplines. Some overlap may be necessary but in the end the advantages of splitting technological and innovation management issues, outweigh the advantages of grouping them together.

## 2.6 Conclusion

In this chapter definitions on technological innovation were discussed as well as the management of technology and innovation.

The management of innovation and technology are both relatively new disciplines and are embroiled in much discussion and development. Implementation of these two disciplines will become more crucial as global communications and international commerce remove old continental barriers. The wave of current business practises focusing on competitiveness, will require improvement in methodologies of innovation. Defining the differences between them is therefore of some importance.

The next chapter will focus on the innovation process as well as the environment in which it could flourish. With the help of an innovation model a holistic overview of the technological innovation process is presented.

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Chapter 3

# MODELLING TECHNOLOGICAL INNOVATION



## 3 Introduction

This chapter touches on the discipline of modelling and then progresses towards developing a model for technological innovation. By modelling the innovation process, one might identify relationships and characteristics of the various functions and visually display them to the advantage of organisational management and staff.

As well as being an illustration of innovation processes and functions, a model may serve as a foundation for innovation auditing, without which poor audit implementation would result. A model serves as structure for the innovation audit, and by supplying the key areas of focus in the innovation process, the audit is able to target high impact areas. The holistic overview of the innovation process, provided by the model, therefore serves as guide to the innovation auditing process.

After the development of an innovation model to use in conjunction with an innovation audit, the chapter concludes with an example of adapting the proposed innovation model. The proposed generic model is adapted into several specific models, each representing aspects of the innovation process, tailored to the needs and requirements of an organisation. Such an 'organisation specific innovation model', is powerful in its representation of the interaction between elements of the innovation processes in the organisation. It may often be used as a benchmark or an action plan, for improving the organisation's innovation methodology.

### 3.1 The Importance of Modelling

Most successful managers have a clear sense of direction, as well as the ability to inspire others in this regard. When a typical new product development is started, it is usually accompanied by a business-plan, describing what the product will be, and how it will be produced. A business-plan however is not enough. Nor is it sufficient to improve the subsections of the business-plan to the finest detail.[1] No traditional business-plan can give an adequate overall representation of the direction of the business and its sub-functions. Thus, behind the successful development of a new venture, there should be a process that identifies and integrates the strategies and functions, and link them to the overall business strategy.

New projects need a method for planning, benchmarking and finding direction. In a project, this tool is often called a *project plan* or a *strategic model*. Not using a model to guide and represent milestones, destinations, areas of interest and areas of trouble, may lead to poor management and a disorganised workforce. Models give the opportunity of visually displaying the road ahead, while also showing the current position.

#### 3.1.1 Functional Models and Maps

In every business and every function in the business, there are driving forces that define the critical dimensions of competition.[1] In the marketing of garden tools, for example, an important driving force may be the changing nature of distribution channels, as discount retailers and emerging superstores become the outlet of choice for customers. In the same business, the introduction of electronic control, plastic materials and powerful electric motors, may create product opportunities, that opens-up new segments in the market place. These market and technology drivers, place significant force on tool manufacturing processes, where traditional focus on cost reduction may be in conflict with the need for flexibility and expansion of variety.

Modelling has a clear objective:

> *It captures the driving forces for the process and elements, and portrays their implications for understanding in a graphic way.*[1]

Defined in these terms, functional models have the following distinguishable characteristics:

> *They are visual, graphic displays of the driving forces in the process, and the firm's position along critical dimensions of the model over time.*[1]

The very purpose of a model is to give managers a way to see the evolution of critical dimensions in the process, technology and market. Although good models are based on data and analysis, pulling together that analysis in a visual format, greatly enhances communication and the development of insight.

With a visual, graphic display of the critical dimensions of innovation, a business may collect a set of models that facilitate communication, focus attention, and provide historical context. What is missing, however, is a benchmark — a standard of comparison that creates perspective. Thus, the last requirement for an effective model is comparison with competitors. Finding out 'where we are' and 'where we are going' cannot be done only with internal data. The relevant standards are not past budgets or plans, but what the toughest competitors have accomplished.

Furthermore, seeing what competitors have done, may yield important insights into differences in competitive performance.

Models help to ensure that all functions share a collective vision of where they are going, and of how individual projects contribute to the common purpose. Moreover, modelling facilitates effective mobilisation of all the organisation's resources, capabilities, and skills. Models provide a tool for guiding the development of functional excellence, and they facilitate the strategic integration of that excellence around a common purpose. Additionally, models help an organisation to target its investments. By displaying underlying forces at work in the marketplace, models help to clarify choices firms face, regarding which markets to serve, with which products; which manufacturing facilities to employ; what process technologies to use; and what directions to take in the development of product designs.

Although several different innovation models are used in practice, this thesis will focus on technology based innovation models. The characteristics of these models are discussed in the following paragraphs. The proposed innovation model developed, through participation with industry and adaptation of current models, will be discussed thereafter.

## 3.2 Modelling Technological Innovation

Innovation is a complex and multi-faceted process, changing from application to implementation and process to product.[2] The complexity of innovation lies in the impact it has on every aspect of the organisation. Different types of innovations may range from improvements in base materials, to producing radical new products, to improving services marginally, and each of these may require different strategies, resources and implementation processes.

Focussing on technological innovation narrows the field down a bit and by focusing only on technology as the foundation for the new innovation, the diverse types of innovation may be reduced.

In this regard, this thesis will firstly consider a technological innovation as a *process* containing identifiable parts, and secondly, the impact the *environment* has on the innovation process. The *environment* refers to the *fostering* influences on the innovation process.

The part of technological innovation that may be regarded as a *process*, is possibly one of the more systematic and better-developed areas, as opposed to the *fostering environment*. It is similar to the new product development process, as well as the discipline of systems engineering. At its core it consists of three sequential concepts: *invention, realisation* and *implementation*. These three concepts are the elements most definitions of innovation refer to, when they explain the process of technological innovation.[See chapter 2, Girifalco,[3] Berry & Taggart,[4] and Roberts.[5]]

The *fostering environment*, which forms the second part of the innovation process, is not such a precise or systematic science as the *process* side. This, as well as the limited reference made to this side of innovation in classical definitions of innovation, result in few innovation models actively including the subject in their representations.

Although research by Foster[6], highlighted the importance of the fostering environment, little has been done to actively develop the subject. This, as well as the breadth of the field has conspired against innovation modellers incorporating the fostering environment in their innovation models, leading to the poor state in which innovation models represent the fostering environment.

In this thesis the well travelled road of defining innovation as a process and conveniently forgetting the required fostering environment, will not be followed. By combining both the areas, *process* and *fostering environment* into a single model, this thesis is able to construct a holistic image of technological innovation. Enabling key linkages and interactions to be visually displayed, and improving the comprehension and understandability of the structure of the discipline of innovation.

Although modelling technological innovation as a two-part process, as just proposed, has certain advantages, other models do not necessarily follow this path as boldly, nor do they necessarily model the process in the same way. To ensure the proposal made above is valid and accurate, three viewpoints, where different models are reviewed and their advantages and disadvantages listed, will be elaborated on forthwith. These viewpoints are *linear* vs. *non-linear* modelling, model *representation* level (hierarchical implementation depth), and *generic* vs. *organisation specific* modelling.

### 3.2.1 Three Modelling Viewpoints

In any model or map, certain viewpoints of the author, and his/her ways of understanding of the subject, shimmers through. This is exactly the case with current models in the technological innovation field. The nature of the innovation process is complex and therefore each person makes his/her own conclusions. This gives rise to many different angles on a single process, each having its own advantages/disadvantages as specified by the model's author.

The following three viewpoints were chosen to represent the many different ones in practise. They are not necessarily exhaustive but should hopefully represent the various viewpoints clearly. The three viewpoints include the following.

- *linear vs. non-linear* models
- *hierarchical depth of implementation* models
- *generic* vs. *organisation specific* models

These three fields will be discussed in detail in the following sections, and may include different types of models such as elemental models, strategic models, generic models, organisation specific models, and type of innovation models.

### 3.2.2 Linear versus Non-linear Models

Through the study of innovation models, the diverse nature of the field becomes apparent. *Linearity* and *non-linearity* surface as one possible answer to complexity. Currently almost all innovation models are linear, and therefore a conceptual nonlinear / 3-dimensional / multi-dimensional model was researched. This entails computer-generated graphics and the possibility of constructing a generic model, representing many different aspects of the innovation process.

This modelling method would have several advantages above linear models. One of the most important, is better representation of connections between functions in the innovation process. This would enable the modeller to connect functions to each other, through a matrix in three dimensions, and measure the impact each element in the innovation process has on all the others. The innovation process would finally be represented by a 3-dimensional form floating in space, containing every possible interaction between functions and elements of the innovation process.

More detail and examples on linearity and non-linearity are examined below:

### 3.2.2.1 Linearity

Almost all the innovation models studied as part of the literature review for this thesis, contained a measure of linearity. Causality also plays a big role in the representation of innovation elements. As innovation elements have clear inputs and outputs, they lean themselves towards inclusion into an element or causal model.

The elements and routines of technological innovation can be compared to the new product development process. Although many different types of technological innovation occur, the new product development structure helps to identify the correct elements in the innovation process to model. New product development can be represented as a funnel, where new ideas flow from the market or technological environment, through stage gates and development procedures, into the manufacturing and marketing phases. The funnel is represented as linear, and so the process of new product development is also represented as linear. The funnel,[1] as illustrated in the addendum [Appendix D], of new product development, can be used to represent the elements, and routines in the process of technological innovation. In this regard, new product development and technological product innovation, is very similar. Another linear development process may be found in the discipline of systems engineering.[7] The process starts with the definition of a need, progresses through the various stages of design and ends with product phase-out and disposal.

Noori[8] illustrates a good example of a basic linear innovation model. As Noori explains the process of modelling technological innovation, he refers to two basic linear innovation models. One being, technology *push* innovation, and the other market *pull*.

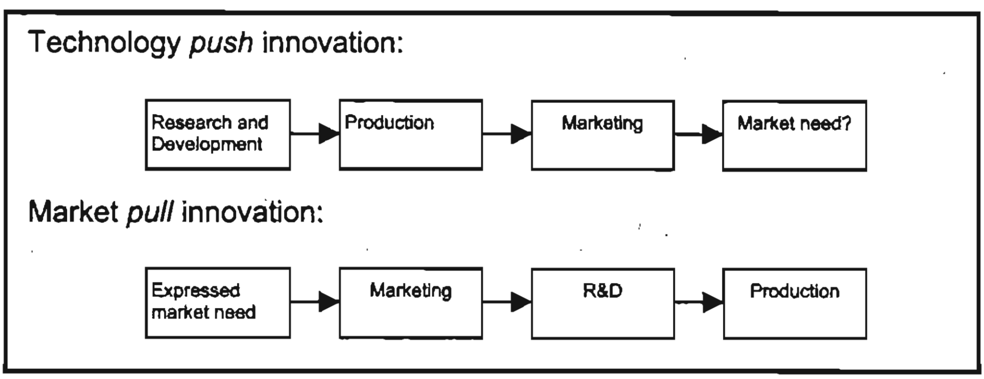



*Figure 3.1: Linear Innovation Models, adapted from Noori[8]*

The Noori models are examples of two different types of innovation. In their simplicity, they do not refer to any other external influences on the innovation process, other than inputs and outputs for each element. If however all the other facets of the innovation process were included in the Noori models, they would not be linear any more.

Other innovation models were found to exhibit measures of linearity as well. Examples of models by Twiss,[9] Utterback,[10] Tidd *et al*,[11] Marquis,[12] Katz[13] and Thamhain[14] are included in the addendum [Appendix D]. These models are only given as examples and not as an exhaustive list of linear models. They therefore serve the purpose of illustrating the concept of linearity.

Linear models list every element in the innovation process sequentially, as they follow upon each other in the process. The advantage in this is the simplicity and ease of understanding of the model. Making it suitable to be implemented in environments where knowledge of innovation is limited.

The negative aspects of linear models do however outweigh their advantages. The innovation process is simply too complex to be illustrated with a linear model. Innovation consists of many levels where processes run in parallel or even in recurring loops. Although some linear innovation models compensate for the complexity, by using branches and feedback loops, these are often added as an afterthought and seldom occur in the same way in practise. Some of the limitations and advantages of linear models are:

The following *advantages* of using linear models exist:

- Understandability
- Ease of implementation
- Clear expression of causality

*Disadvantages* of using linear models:

- Poor representation of required competencies
- Highly specific
- Rigid, and often causal
- Poor representation of multi-faceted aspects of innovation
- Poor representation of links between the different facets of innovation

Linear models attempt to indicate the structure of innovation in a causal fashion. By illustrating the inputs and outputs of different innovation elements, they attempt to create a logical path or recipe to follow when innovating. However the multi-faceted nature of innovation does not lean itself towards such a process, if at all. By disregarding the notion of creating a causal innovation model, new avenues of exploration may appear to the modeller.

The only true representation of the innovation process might therefore be through a higher order model. This refers to a model in three or more dimensions. The advantage of such a model lies in its interconnectivity. Each element is in contact with many other elements of the innovation process. As such, valuable synergies are accomplished, and thus a higher order of innovation becomes possible.

### 3.2.2.2 Non-linearity

Technological innovation does not as a rule follow a neat path, where elements succeed each other, predictably or logically. This is precisely why multi-dimensional models become necessary for representing the process. The advantage of multi-dimensional models lie in their ability to represent processes more holistically than linear models. Interesting examples of multi-dimensional models may be found on the World Wide Web at www.doblin.com,[15] illustrating the viability of seeing innovation as a multi-dimensional process.

Representing innovation as a non-linear multi-dimensional process is not easily accomplished. Many factors directly influence every aspect of the innovation process, and representing each of these influences, can wreak havoc on linear type models.

In this thesis a three dimensional model representing three basic areas (*resources, type of innovation* and *market needs and demands*), that form part of the technological innovation process, is proposed. It should be noted that the three areas are not the only areas and many others may also be used successfully.

In the model, three axes are displayed (*resources*, *type of Innovation* and *market needs and demands*). Each of these represents a facet of innovation, and has direct influences on many aspects of the other two. Although highly conceptual, by modelling innovation in this way, the diverse nature of organisations and their own innovation procedures, can all be accommodated. Figure 3.2 illustrates this model.

To practically use the proposed model it may be used in its three dimensional form, or alternatively by slicing through the model to form an exposed plane, such as illustrated in Figure 3.3, a more specific model may be created. In concept the visible plane should represent a certain innovation methodology in a two-dimensional format, in the liking of the previously illustrated linear innovation models. The proposed three dimensional model contains an infinite number of these planes which may be sliced to illustrate new methodologies for new innovation purposes. An example might illustrate the implementation of the model better.

> For instance:
>
> An organisation might be involved in a stable market, with a well-defined dominant design and be constantly busy with stable incremental innovation to sustain their competitive advantage. The methodology for this type of innovation (sustaining and incremental) would however be different from a methodology for attacking or radical innovation.
>
> Therefore if a sudden change occurred in the stable market such as a paradigm shift, the organisation might have a number of options. It might defend its products by price cutting or better marketing. Alternatively it might consider changing its innovation methodology and becoming more aggressive or radical. If the organisation previously modelled its innovation process as well as its capabilities in the form of a three-dimensional innovation model they might respond in the following manner.
>
> By slicing their three-dimensional innovation model at a different angle they might expose their attacking or radical innovation methodology (linear-model). Thereby transforming the current innovation methodology from sustaining to radical. This model may then help them to innovate more aggressively and catch up or dominate the sudden changes in the market environment.

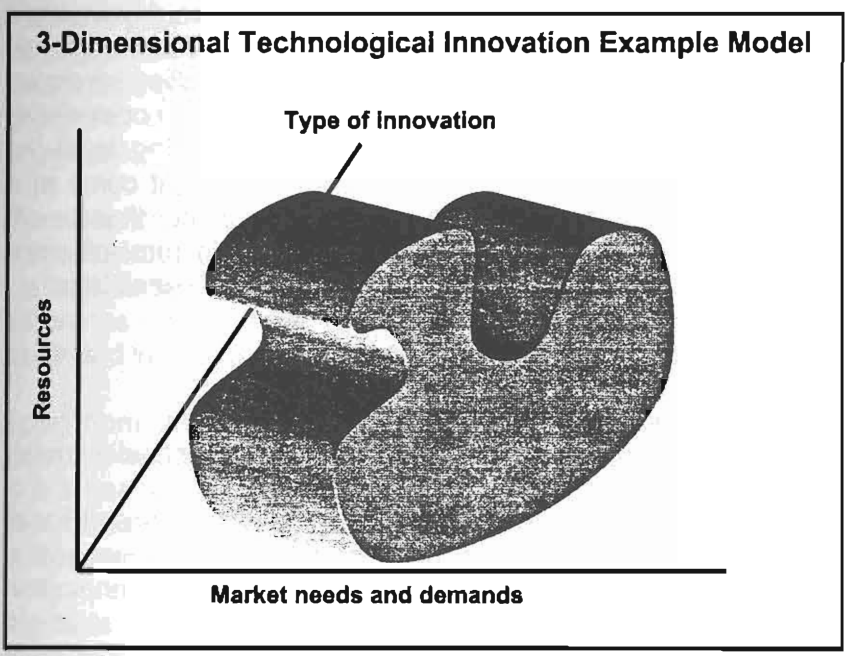



*Figure 3.2: Proposed 3-D Technological Innovation Model*

Although the power of the above mentioned multi-dimensional modelling process is clear, modelling the total technological innovation process, is not so easily accomplished. Three axes are shown in the above example, but many more exist. A myriad of three-dimensional models will therefore have to be constructed to facilitate the representation of the total innovation process. This seems impractical as well as somewhat insensible.

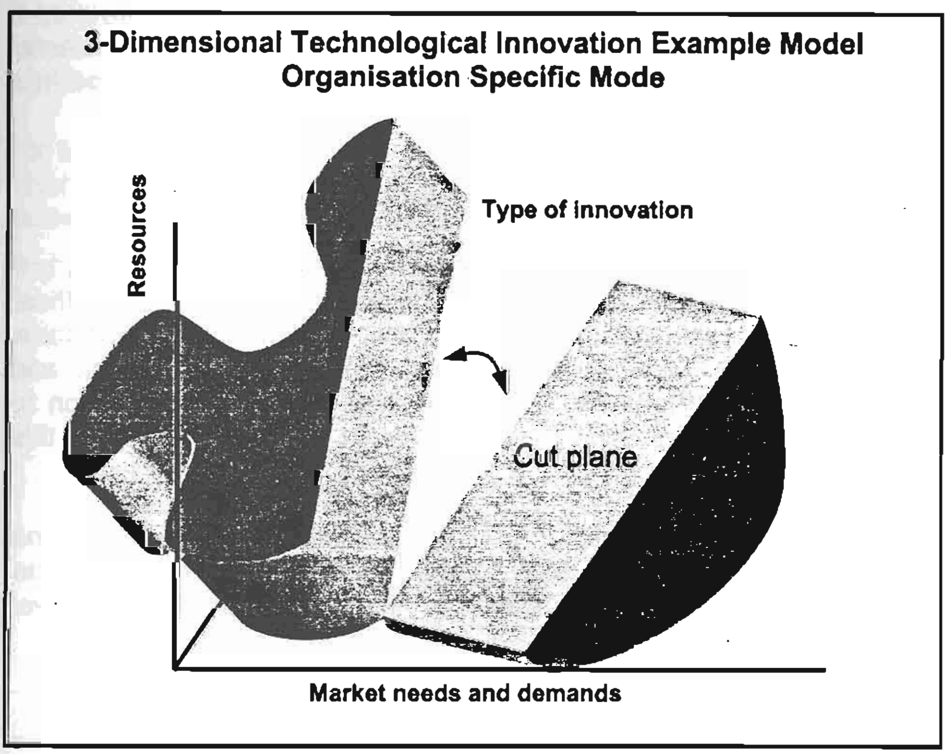



*Figure 3.3: Proposed 3-D Technological Innovation Model in Organisational Specific Model*

The three dimensional modelling of innovation may be augmented into developing a N-dimensional model. Such a model would have 'N' number of different axes and therefore solving the conundrum of the three-dimensional modelling process. Although highly academic as well as possibly impractical there is merit in considering the process of modelling innovation in this manner. Through struggling to fit the multiple pieces of the innovation process into such a model one might come to a better understanding of the inter relations, and the causes and effects these multi faceted parts of innovation may have on one another. This may in turn influence one's ability to represent the innovation process in a more accurate or sensible way.

The following *advantages* for multi dimensional modelling exist:

- High information content
- Strong interconnectivity between elements
- The total innovation process can be modelled (one model includes many different types of innovation)
- By slicing the three dimensional model and implementing the exposed linear model different innovation methodologies might be pursued by means of a single model. This has the advantage of calibrating all the innovation methodologies followed by the organisation, in turn improving the strategic innovation competence of the organisation.

*Disadvantages* for multi dimensional modelling:

- Difficult to model completely
- Difficult to understand the model without assistance
- Very complex

Complex problems have a way of being represented as non-linear multi-dimensional processes. This tendency of modellers to over complicate things, can inhibit the usefulness of models. In such cases, the modeller is often the only person who understands the model completely, as well as the reason why it looks the way it does. This makes non-linear models unfavourable ways of representing systems, even if the systems they are supposed to represent should ideally be modelled in a multi-dimensional way.

#### 3.2.2.3 Conclusion to Linear versus Non-linear Models

The conclusion as to which to use, *linear* or *non-linear* is not a trivial task. Clearly if the process to be modelled is causal and finite, linear modelling would suffice. However, innovation is not causal and neither is it finite, leading to the conclusion that multi-dimensional models might be the answer. Finding a middle road and incorporating aspects of linearity and multi-dimensionality, may offer a solution to innovation modelling. This will be explored in the proposed model later in this chapter.

The following viewpoint on the modelling of technological innovation, discusses the hierarchical depth of modelling. It is one of the three key areas of modelling, as mentioned before, which includes *linear* vs. *non-linear* modelling, *representation level* (implementation depth), and *generic* vs. *organisation specific* modelling.

### 3.2.3 Hierarchical Depth of Innovation Models

Although the representation-level (the part of the technological innovation process represented) of a model has little to do with the actual technological innovation process, it has a lot to do with who will be reading and interpreting the model.

Different people need different information from different models. For instance, a strategic manager would not find a model describing a functional process useful. A model with goals and deadlines and strategic implications might be more to his/her liking. For these reasons, models need to be developed for specific areas in the organisation, pertaining to which hierarchical level they are implemented on.

For simplicity, three hierarchical levels are defined, each with its own distinct characteristics and implications for the innovation process. The first level could be named the *strategic* level, and is possibly the most important, as it has far ranging influences on the other two. They are the *management* and *disciplinary* levels as illustrated in Figure 3.4.

Apart from the levels within the organisation, several others exist outside it. The industry, national and global environments are but a few of these. Each of these levels has an influence on the organisation, and how it operates. Inside the levels there are rules and routines. When an innovation model is designed it is best to try and keep inside these hierarchical levels, to avoid confusion.

The crossing of levels is often done when a generic innovation model is designed. Such models often confuse, and are only truly understood by a very select group. Although the reason for constructing such a model is to cover the total innovation process, it seldom reaches this goal. An example of such a model may be found in the work by Edosomwan[16] as illustrated in Figure 3.5.

The model contains aspects such as *policy formulation, problem solving*, and *resource balancing*, which each represents a different level in the organisation's hierarchy.

The model might be proposed for middle management, yet it offers tasks relating to strategic and disciplinary action. It therefore has to be presented to strategic, as well as disciplinary teams, which may find the model difficult to understand, since it contains so many aspects foreign to their expertise.

For this reason, Figure 3.4 is proposed. Three basic hierarchical levels are defined which may clearly be seen to illustrate where some of the previously discussed models would fit in. Some of the models yet to be discussed are included as well.

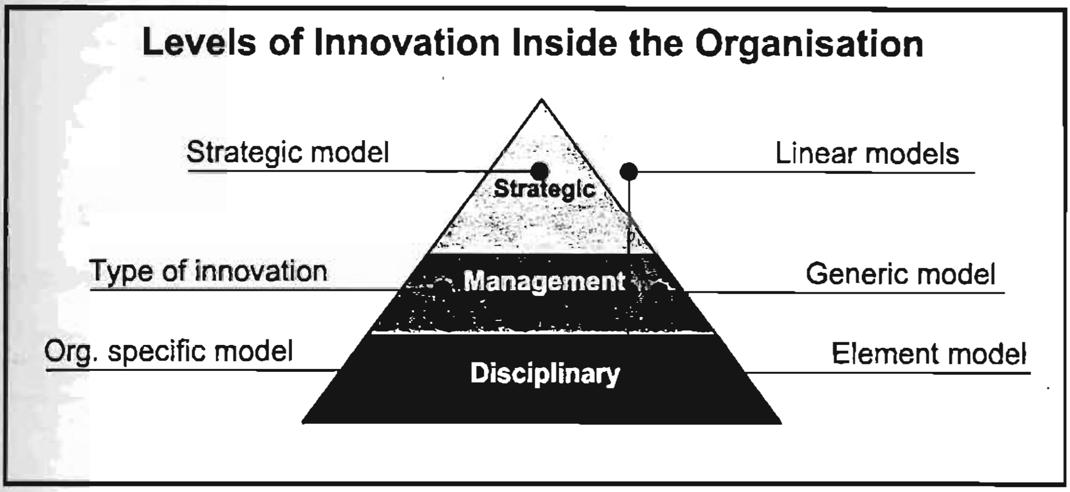



*Figure 3.4: Levels of Innovation inside the Organisation*

The figure illustrates where the different models find their best application. Since many of the models may be configured extensively, the figure is only meant for illustrative purposes. Many models cut across the levels to utilise certain aspects from other levels.

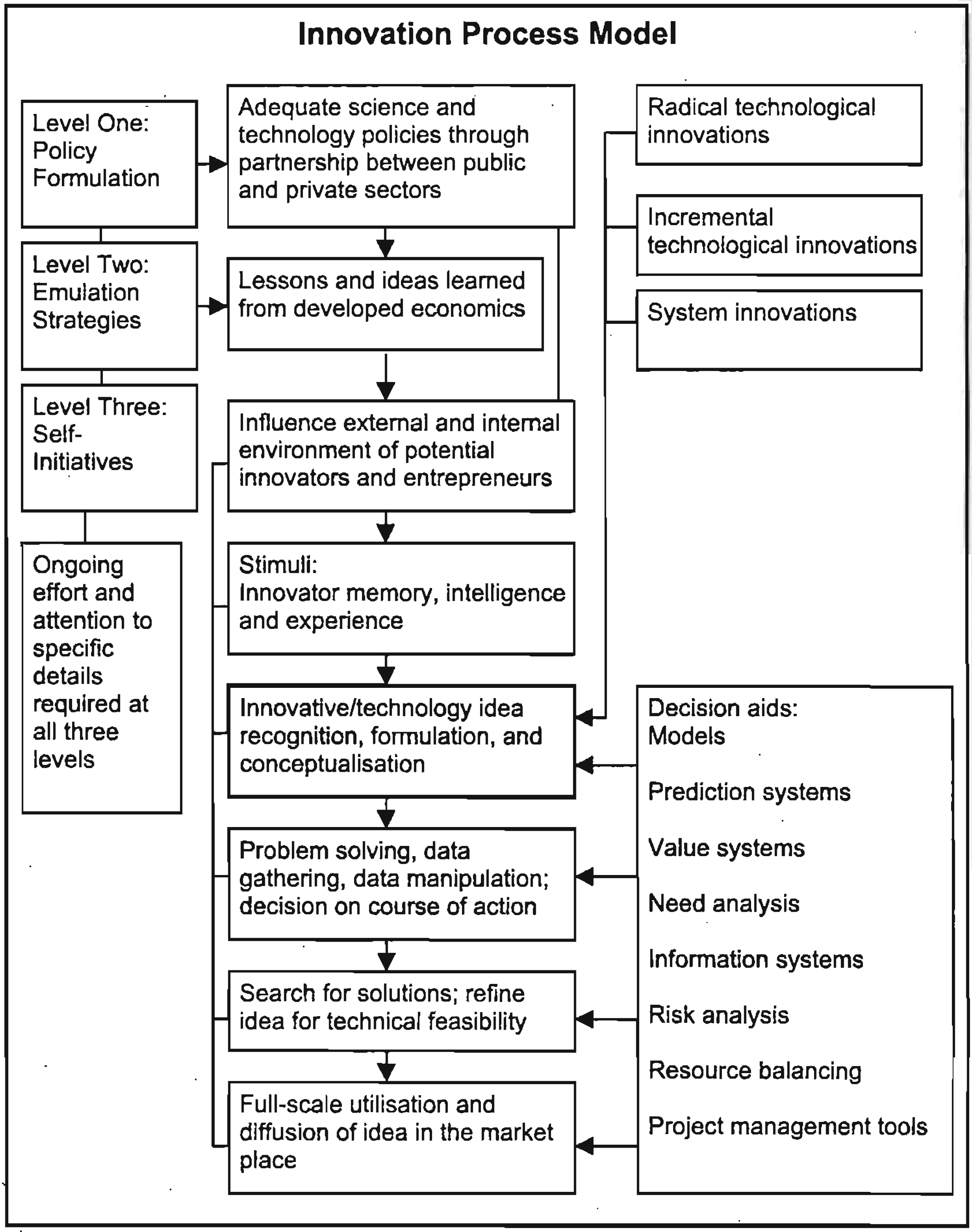



*Figure 3.5: Innovation Process Model, adapted from Edosomwan*[16]

The model by Twiss,[17] as illustrated by Figure 3.10, incorporates some management aspects, such as project champions, project management, knowledge of market needs, and scientific and technological knowledge, yet he also uses elements from the disciplinary level, such as R&D, production, design and marketing. Although these two levels seem to work well together, the model is difficult to apply in any of the two levels, for it excludes a lot of aspects particular to any one level. For instance, in the managerial level, aspects such as resources, tools and systems, information and many others are simply not addressed.

Although the aim is not to discredit the model by Edosomwan,[16] it is important to ask who will ultimately use the model, and how it should be adapted or constructed to best suit that individual.

### 3.2.3.1 The Element Model

The element model is one of the most understandable types of models. It often consists of a checklist of things to do, and or how to do them. To model technological innovation in this way, the boundaries of the model have to be defined very strictly. Will it cover just product innovation or technological innovation, or should it also cover general innovation? To define these boundaries, the interrelations between the elements, may be used. It should however be clear that a certain amount of data would always have to be excluded, to limit the complexity and maintain focus.

An element innovation model contain direct instructions on the required actions in the life cycle of the innovation. The model by Tidd *et al* may be regarded as a element model to a large extent, since it lists the underlying routines in the management of innovation.

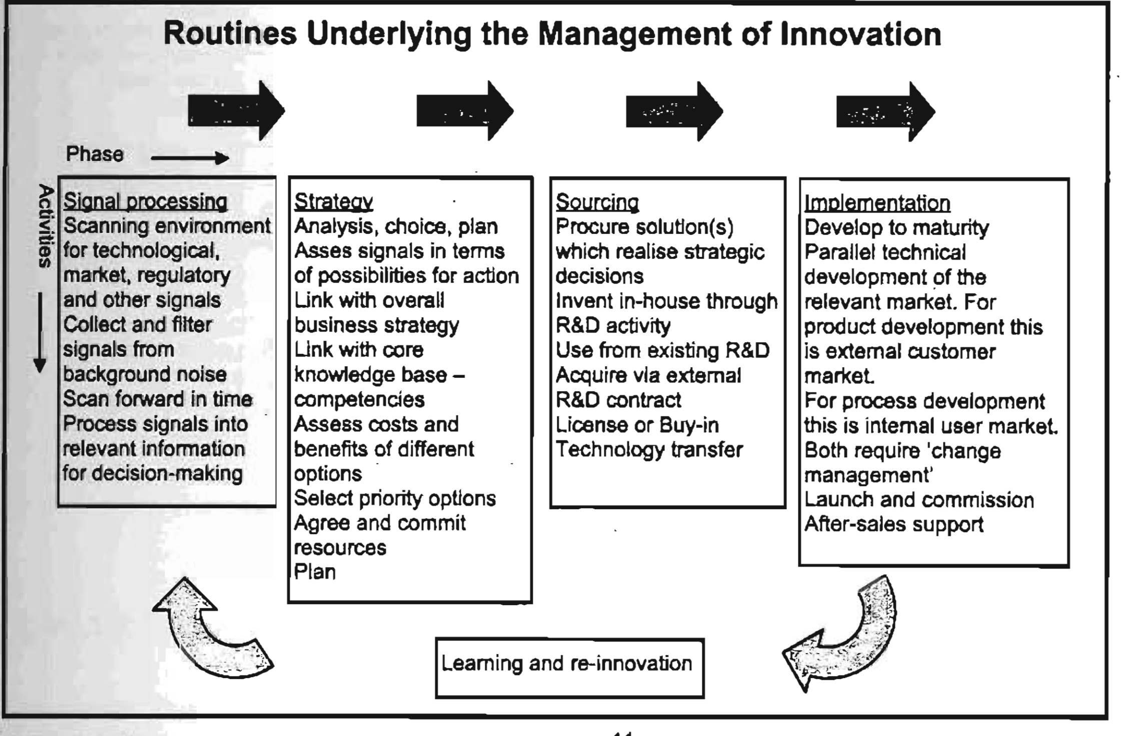



*Figure 3.6: Innovation Model, Source: Tidd et al*[11]

For instance a segment of the model illustrated in Figure 3.6, as proposed by Tidd *et al*[11] contains the following:

- Signal processing
- Scanning environment for technological, market, regulatory and other signals
- Collect and filter signals from background noise

- Scan forward in time
- Process signals into relevant information for decision-making

When implemented, these elements have a direct influence on the innovation process, and can sometimes even be used as a checklist. This is what gives element models their power, and why they can be very useful. When an inexperienced innovator is trying to learn the process of innovation, such a model might prove useful.

A good example of an element-based model, is a mind-map. These models are widely used by educators to help in teaching children to remember and summarise large amounts of data.[18] It works surprisingly well, since connections in the brain are more easily made, than when the information is simply listed.

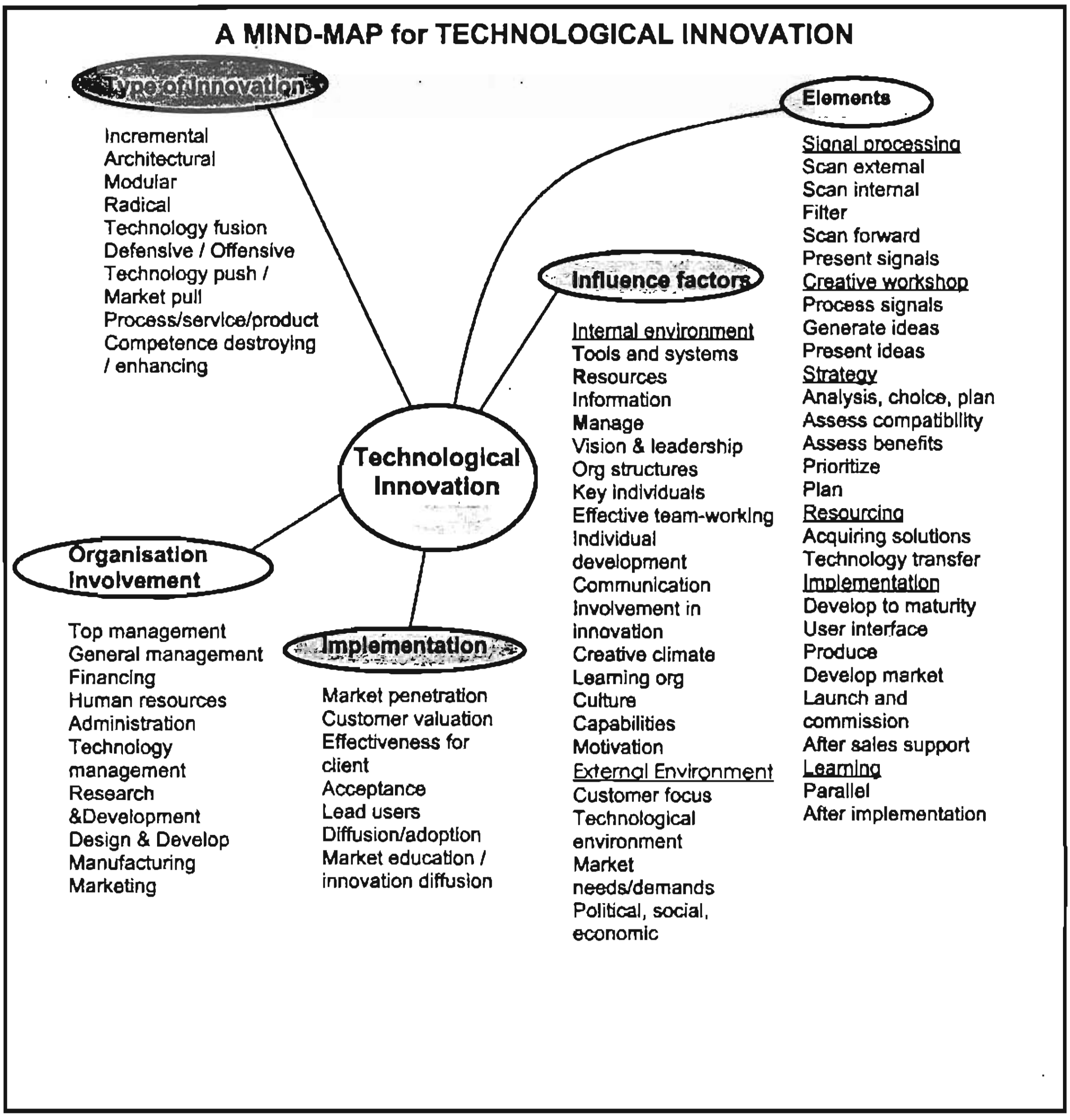



*Figure 3.7: A Proposed Mind-Map Detailing Technological Innovation*

In the quest for understanding technological innovation better, a proposed element model was developed, as shown in Figure 3.7.

Although a mind-map represents information well, it does not really qualify as an innovation model. To construct a model, the mind-map is used as medium for organising the information, before entering it into the final model. The nature of the mind-map ensures that the central aspects of the information are identified, and also the linkages with others. These central ideas or aspects can then become the main areas of focus in an innovation model.

The biggest negative aspect of element models sprout directly from their high focus. When focusing on a single type of innovation, for instance product innovation, the elements apply directly to the process, yet when another type of innovation, such as a service innovation is pursued, the model fails to instruct the user and can lead to poor conclusions or actions. Thus extreme care needs to be taken when constructing element innovation models. And they should not be used to represent a generic method for innovation.

### 3.2.3.2 Strategic Innovation Models

To manage the technological innovation process in an organisation, certain strategic choices need to be made regarding goals, objectives, and avenues of implementation. Although these are not addressed in an innovation model, displaying the correct information for making these decisions can. Factors such as technological strategy, economic impact on new developments or types of innovation, all have a direct influence on the strategic direction of the organisation. A good illustration of a model beneficial to strategy formulation, can be found in the work done by Voss at the London Business School.[19]

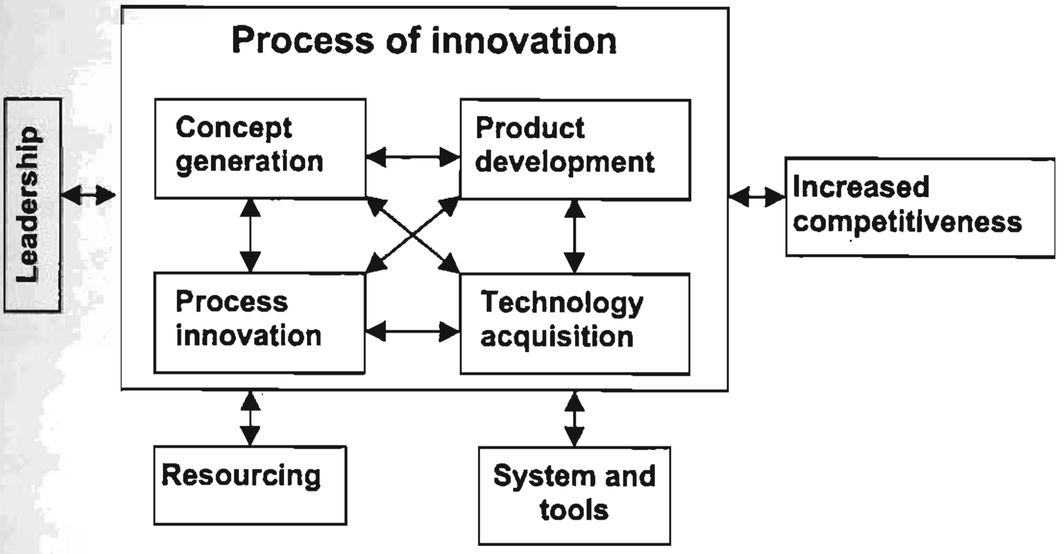



*Figure 3.8: Technological Innovation Model adapted from Voss[19]*

The model, illustrated in Figure 3.8, was developed in conjunction with an innovation audit, and the authors identified two areas of interest: the *enabling* processes and the *core* processes; of which the enabling processes are outside the 'Process of Innovation' rectangle and the core processes inside. Voss proposes that the enabling processes have the greatest significance for strategy formulation, for they influence the innovation process, and need to be linked to the main organisational strategy for optimum functionality. The model indicates the significance of these enabling technologies, and the role they play in the innovation process. This model is discussed in greater detail in chapter four.

The aim of a strategic innovation model is to include innovation in the organisational strategy formulation process, and highlight the innovation aspects of importance. Due to its hierarchical level, it might almost be possible to develop a model focussing specifically on integrating innovation and strategy formulation. This would improve executive management's ability to develop sensible organisational strategies with good innovation related content.

Few strategic innovation models that focus specifically on integrating technological innovation into organisational strategy is available. Although the previously listed models by Twiss[9], Utterback[10] and Edosomwan[16] have some strategic content, they do not devote large amounts of research to the subject. It might therefore be concluded that strategic innovation integration is either unimportant or has yet to be developed into a discipline where modelling is judicious.

### 3.2.3.3 Models Portraying Different Types of Innovation

There are many different types of technological innovation, with various applications and implementation methodologies. Few models have been found to actively differentiate between types of innovation piquing ones interest as to the reasons why. Since different types of innovation such as incremental, modular, radical architectural and others, require different strategies and implementation mechanisms, it is expected that innovation models would focus on certain types of innovation, rather than aiming to represent the whole spectrum.

For illustrative purposes the following types of innovations were identified.

- Radical vs. architectural vs. modular vs. incremental innovation[20]
- Competence enhancing vs. competence destroying innovation
- Technology push vs. market pull innovation[8]
- Process vs. product innovation vs. procedure[33]
- Offensive vs. defensive innovation
- Sustaining vs. disruptive[21]

To illustrate the point of incorporating different types of innovation into an innovation model, a possible example by Schumann *et al*[33] is considered. The model is not strictly a model, but rather a framework for innovation, since its main purpose is to serve as structure for a proposed innovation audit.

| | **Class** | | |
|---|---|---|---|
| **Nature** | Incremental | Distinctive | Breakthrough |
| Product | | | |
| Process | | | |
| Procedure | | | |

*Table 1: Class and Nature of Technological Innovation adapted form Schumann[33]*

The different types of innovation in this matrix include incremental, distinctive, and breakthrough innovation.

> The **class** of the innovation refers to the degree of creativity or newness of the innovation, where incremental is only slightly different, and breakthrough is radically different.
>
> On the other hand the **nature** of innovation refers to where in the organisation the innovation will be carried out, and which field or process it will influence mostly.
>
> All in all the innovation model represents nine types of innovation, each requiring different resources, management skills, and markets strategies.

Although this model can supply some structure to different types of innovation questions, it can not instruct the user where and when to use the different types of innovation. This model is therefore best for identifying the underlining strategies used in the past by the organisation, and giving insight as to possible new strategies to be considered.

It would be interesting to know why the authors did not include other innovation types in their model, since the two fields, *class* and *nature* are certainly not the only types of innovation.

Although a strong case could be made for including different types of innovation into an innovation model, it is often impractical. The highly specific nature of the types of innovation is best left to the application of the innovation model. The aim of an innovation model is not to prescribe to organisations how to innovate, but serve as holistic example which integrates the multi-faceted aspects of the innovation process.

#### 3.2.3.4 Conclusion to Hierarchical Depth of Innovation Models

A tight rope balancing act is necessary when developing an innovation model. Deciding on the level of implementation, only serves to increase the difficulty of deciding on a method for such a model. It is crucial to develop the innovation model for the right audience and ensure their ability in understanding and implementing the example set by the model. In deciding between strategic and disciplinary innovation models, the needs of the recipients has to be remembered and finally delivered upon.

### 3.2.4 Generic versus Specific Models

Many of the models reviewed throughout the literature study were generic, yet some clearly represented organisation specific processes, disciplines or methods. The best reason for modelling the technological innovation process as a generic process, is model implementability. Given most innovations' diversity, models need to include as many aspects of the process as possible, making the model applicable to a wide spectrum of situations. The disadvantage of this is that the model becomes more generic, and thus less definite in application. In other words, generic models require interpretation, and is therefore unable to dictate to the organisation how it should innovate. On the other hand, while specific models may dictate methods best suited to innovation, they are only applicable in very select circumstances.

To illustrate some detail on generic and specific models, the following two sections were developed.

### 3.2.4.1 Organisation Specific Models

Organisation specific models can offer great advantages over generic models, for they are designed to enhance a specific process, and can accurately model specifics, rather than trends or perceptions. The strength of such a model lies in its ability to represent the innovation environment, as well as current organisational routines and structures in operation precisely. Another advantage is the familiarity of specific models. Since the elements used in the specific model occurs within the organisation's structures and procedures, it is familiar to the employees and may find faster application. Specific models might therefore be more applicable to immediate organisational needs and not seen as 'pie in the sky', but as relevant to every step in the innovation process.

A possible example would be a model developed by Ross,[22] as illustrated in Figure 3.9. The model focuses on the strategic side of innovation, but has some specific characteristics Debtek (a division of DeBeers) finds useful.

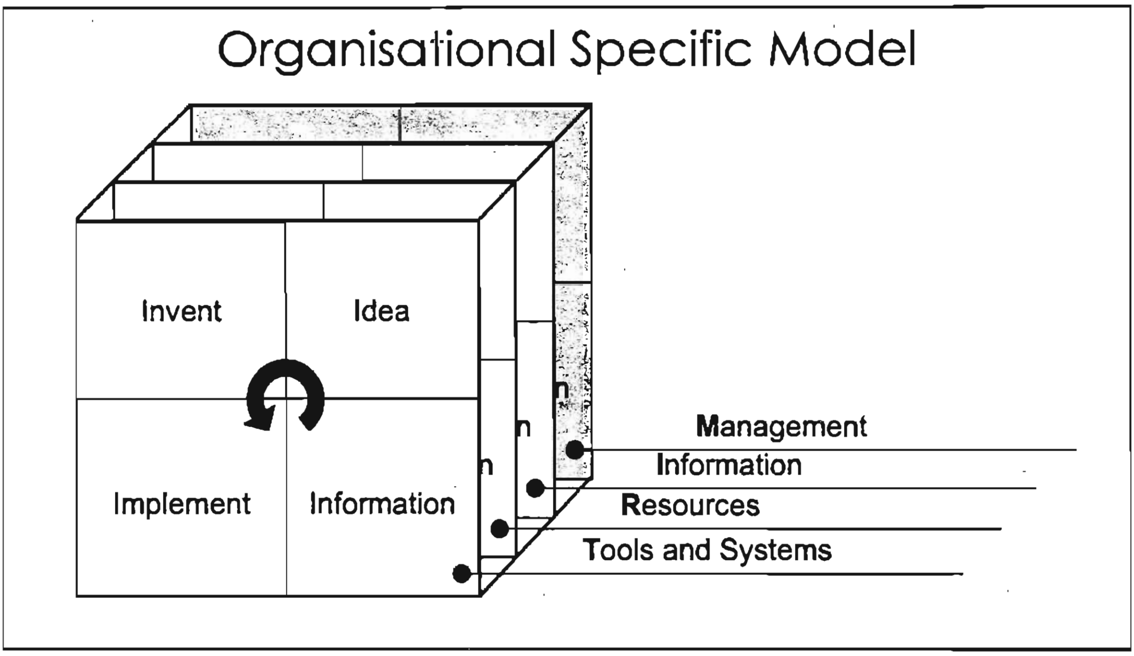



*Figure 3.9: Organisational Specific Model, proposed by Ross*[22]

The model proposed by Ross, although quite generic, describes the areas of particular importance to Debtek, and may therefore be easier to apply than other generic models. By working in conjunction with organisations, innovation modellers may find better application of their proposed models, as well as acceptance in the organisation. This is possibly one of the biggest advantages of specific innovation models.

### 3.2.4.2 Generic Models

The nature of the innovation process and its diversity, encourages modellers to work either highly specific, or very generic. The difficulty lies in the fact that specific models often find themselves excluding such a large proportion of the total process, that they lose sight of new developments, and become very rigid. However by designing generic models with scalable attributes, the conundrum may be solved.

Some good examples of generic models exist, of which models by Utterback,[10] Twiss,[9] Edosomwan[16] and many other innovation specialists form part. As an example, the model by Twiss is quite relevant, as illustrated in Figure 3.10.

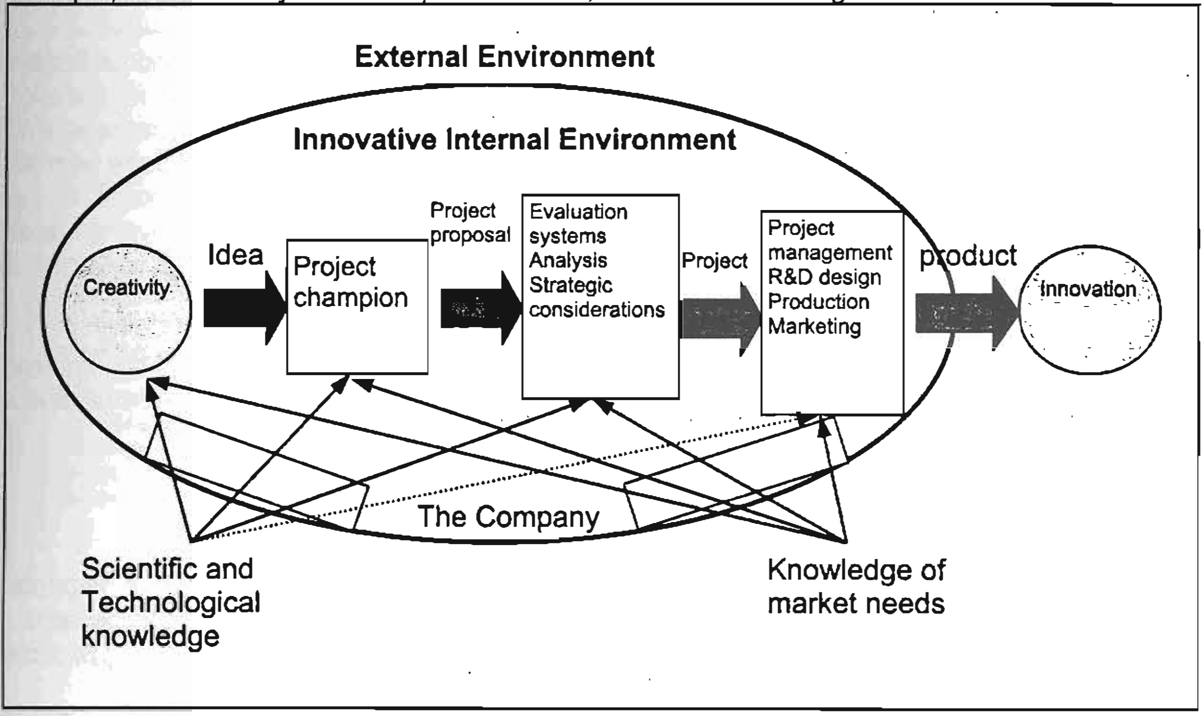



*Figure 3.10: Innovation Model, adapted from Twiss[9]*

The Twiss model is successful at capturing critical parts of the innovation process, while displaying several of the so called *fostering environmental* elements as well. The clear identification of creativity (first dark circle), influenced by the market and technology, explains the origin of innovations well, while the process indicated by the arrows, describes the linear sections following each other in the innovation process. It is these elements referred to in the section about linear models, and also element models previously. When one considers that this model was constructed in 1974, it can be said to be well ahead of its time.

Some of the advantages of the Twiss model include

- Clear identification of many of the key aspects of innovation
- Illustrating the influence the fostering environment has on the innovation process
- Identifying individuals in the innovation process

Some of the disadvantages of the Twiss model include

- The linearity of the model does not accurately represent the innovation process
- Innovation does not necessarily start with creativity as implied
- Many of the multiple facets of innovation such as strategic/market/technological dynamics are disregarded
- The model is proposed to be generic jet contains many specific innovation tasks destroying the uniformity.

Generic models may find their best application as holistic representation of the innovation discipline. They may be used as foundations for auditing, developing new innovation strategies, educating individuals about innovation, as well as further development of more applied or specific models. Generic models may therefore serve their purpose as holistic examples, but should always reflect changes in the underlying discipline which they represent.

### 3.2.4.3 Conclusion to Generic and Specific Innovation Models

To enhance the use of generic innovation models, they are often proposed as flexible enough to be adapted into specific models. In this regard the model in question would offer a generic overview and a focused view after specialisation, representing the best of both worlds. This transforming of a generic model should be done with the organisation and modeller present, since the modeller needs to understand all the organisation's structures and procedures. In a way conducting an innovation audit may be seen as gathering information of an organisation, in order to construct a specialised model for the organisation.

The question whether a choice between generic or specific model should be required is therefore debatable. Since the application of the model dictates the type of model required, it should not be an issue.

## 3.3 Thesis Viewpoint on Different Models

All of the previously mentioned models have positive and negative aspects, concerning clearness of representation, ease of understanding and implementation, as well as modelling perspectives. One might extract from these the most applicable to current requirements, and construct a model based on current literature.

Some of the disadvantages of the models discussed above include difficulty to understand, poor identification of applicable implementation areas, implementation across hierarchical divisions and others. Some of the advantages of the models include good overview, identification of key innovation areas, and illustration of the linkages between different innovation functions.

A factor seldom present in innovation models is representation of individual capabilities. Innovation models often only represent the actions, rather than the source of the actions required. For example: The model by Utterback, as illustrated in Figure 3.11, contains references to problem solving and idea generation, but it refrains from indicating where these capabilities are present in the organisation. If an innovation model is to represent the discipline of innovation, individuals and their skills, emotions and knowledge has to form part of it. After all it is the human factor that makes innovation possible.

It was shown that the type of model is dictated in many cases by the requirements of the organisation. If a model is developed for an organisation, these requirements become of crucial importance. However if modelling is done for scientific clarity or as part of research, the field remains open to the modeller.

## 3.4 Developing a Proposed Innovation Model

From literature one might construct a representative view of the models already in the public domain. By extracting the most relevant parts from these models, an innovation model for auditing may be constructed.

In keeping with the opening statements in paragraph 3.2, two crucial areas in the technological innovation-modelling arena exist. One being the *innovation process*, the other being the *fostering environment*. To illustrate this, reference is made to models by Twiss in Figure 3.10 and Utterback in Figure 3.11, where the innovation process in a linear form, is supported by an environment consisting of technology, science, society and market factors.

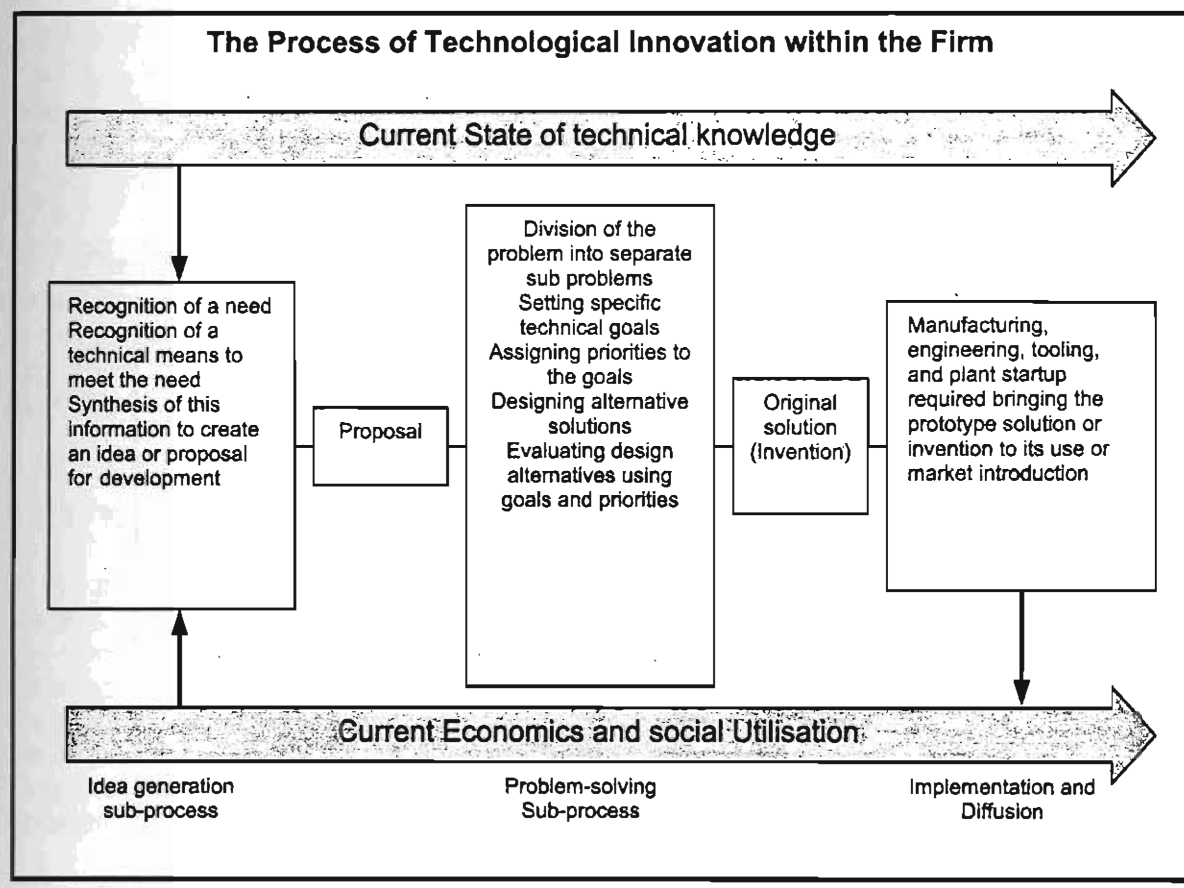



*Figure 3.11: The Process of Technological Innovation within the Firm, adapted from Utterback*[10]

The duality of innovation may be seen in other models as well, yet it is clearly illustrated in the model by Utterback. The *innovation process* is represented in the centre, beginning with the middle left block, and ending with the middle right block. The two arrows top and bottom represent the *fostering environment.* The innovation process and fostering environment are continuously interacting, as shown in the model. It is clear that with either of the two missing or poorly represented, the total innovation process cannot succeed.

The innovation model developed in the following paragraphs relies heavily on the duality, identified in the model by Utterback. The proposed model might take on a different form from the ones listed above, but on closer inspection most, if not every aspect of the models discussed in the paragraphs above, may be identified in it.

## 3.5 The Proposed Innovation Model

### 3.5.1 Model Viewpoint

The aim of the model is to set a clear understandable benchmark for the innovation process inside an organisation, which can be used to focus the innovation audit, and represent its findings. By using a model, many different aspects of a complex process can be represented and used to understand the total process better. By coupling a model of a process with an audit of the process, a powerful tool is constructed for analysis and measurement. The model thus becomes a guide, benchmark and visual representation of the audit findings, and possible recommendations.

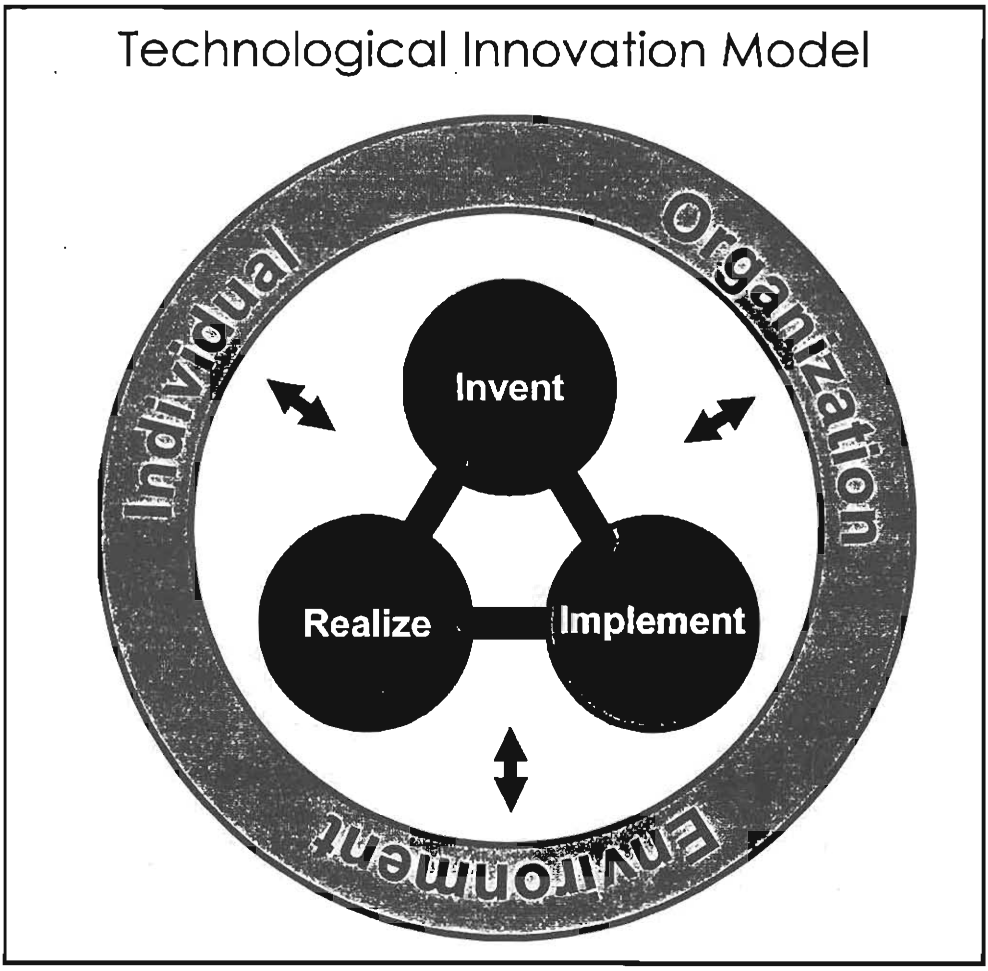



*Figure 3.12: The Proposed Innovation Model*

As noted previously, several different innovation models exist, and they all have their advantages and disadvantages. The proposed model above embraces these models, and extracts from them many aspects to its own advantage. Concepts such as linear vs. non-linear, implementation depth and generic vs. specific aspects, were carefully considered in the process of building the model.

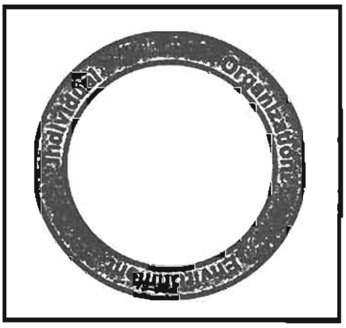
To illustrate the proposed model better, it may be split into two distinct parts. Firstly the innovation *life cycle* or *process*, and secondly the *fostering environment*.

The *life cycle/process* part of the model may primarily be thought of as a linear process, where invention is followed by realisation, which is followed by implementation. The pharmaceutical industry is known for its ability to follow this 'recipe' of new product development quite well.

The *fostering environment* part of the model, is where experience and competencies seated in the organisation are represented. It is often difficult to illustrate how the 'soft' aspects of individuals employed by the organisation influence the innovation process, or where they fit into the framework of innovation. The fostering environment part of the model captures the 'fuzzy/soft' parts of innovation, and integrates them into a sensible, understandable model of innovation.

The following paragraphs will list many of the aspects applicable to *the innovation life cycle/process*, as well as the *fostering environment*. Since the fostering environment is the primary focus in the development of a competence audit for technological innovation, it will be introduced in this chapter and expanded on in a later one. The *innovation life cycle/process* is discussed in some detail.

### 3.5.2 The Innovation Fostering Environment



In the model the ring, enclosing the innovation life cycle process, represents the fostering environment. The three key terms inside the ring, each represents a part of the fostering environment. The terms **individual**, **organisational**, and **environmental** are representative terms to describe the fields of the fostering environment. They are representative but not absolute, since overlapping between the various fields often occurs.

Why is the fostering environment important?
How does the fostering environment influence the innovation process?
Where does the fostering environment fit in?
What does the fostering environment contain?

These and others are all issues that have to be addressed to understand the importance of the fostering environment.

The fostering environment is important because it influences every aspect of the innovation process. Invention, realisation and implementation rely heavily on the capabilities, leadership and resources seated in the fostering environment. An exceptional fostering environment may often go a long way in improving a poor innovation process. Kanter[23] uses the example of an United States firm, that actually has to lock its office doors over weekends, to deny employees entrance into the building, and consequently their work. The company is able to create such interesting assignments, and such an excellent working environment, that its employees refuse to leave. Just imagine what it would be like to work in such an exiting environment, capable of motivating employees so well!

Organisations consist of employees, and employees are human beings. This fact is often overlooked when innovation models and methodologies are developed. Unfortunately, innovation is primarily a process initiated and completed by humans. Innovation relies on human creativity, drive, leadership and problem solving abilities. The innovation process can therefore only improve if these 'abilities' of the humans are improved. The fostering environment has as primary goal the construction and supporting of an environment that would be able to improve these and other abilities.

Many papers on culture and social aspects of the organisation have been written. Few of these have the innovation process in mind when defining the extent and ramifications of their findings. Unifying these studies with others in the field of innovation may improve the way organisations perceive the fostering environment. Yet before the findings of such studies are accepted, the place of the fostering environment in the organisation will be difficult to define. Ideally an innovation manager might look at improving the fostering environment, or alternatively it might fall under the auspices of human resources or general management. However until a consistent effort has been made to implement a plan for improving the fostering environment, little if any improvements may be forthcoming.

To illustrate some of the aspects of the fostering environment, the three terms defined in the innovation model are discussed below.

### 3.5.2.1 Individual

Humans are important! Even though every innovation, idea, insubordination or huge success originates with human beings, innovation models seem to discount them as unimportant. Innovation models may imply the importance of the individual, yet it is necessary to indicate where individual, group or organisational competencies are needed in the process of innovation. Finding and assigning the best individuals with the correct competencies to the correct tasks in the innovation process, may often be as important as the task itself.

Innovative companies all state the importance of freedom, creativity and non-conformity, yet all of these aspects are uniquely human. One of the crucial departments in an organisation trying to be innovative, should be its human resources and employment agency. For instance how can managers rely on, and trust employees, if the typical people hired by the employment department are ones with no self-motivation or drive. By hiring employees 'that fit in', the organisation may often create a homogeneous mixture of competencies, with little or no ability to be different.[24]

Entrepreneurs and intrapreneurs are some of the most valuable individuals in the organisation. These individuals have the ability to motivate themselves, as well as the vision and drive to reach their own idealistic goals. Other individuals such as 'sponsors', 'leaders', 'gatekeepers' and 'weirdoes' may play key roles in the innovation process. These individuals often form the backbone of the fostering environment, giving advice and training to novice employees.

> A *sponsor*[25] may for instance provide authority and resources to a blue-sky idea, without the explicit knowledge of the board. Enabling the new start-up to progress to a stage where viability may be proven.
>
> *Leaders* and *entrepreneurs*[26] are able to gather individuals into groups, and excite them about a new project; afterwards following through on the development of a new innovation idea.
>
> *Gatekeepers* are sources of information and may be consulted on a regular basis for advice and information.

While *weirdoes* are the ones stirring the pot of innovation, making sure nobody stagnates in his or her own thought-process.[24]

The method for dealing with change and new technologies, are often influenced by the culture and perceptions of the people in the organisation. If a culture of secure and lethargic job positions have established itself, change will become incredibly difficult. However when employees feel challenged, entrepreneurial and act individualistic, change is less disruptive and is often seen as a new opportunity. Thus through a strategy of continuos change, organisations may keep fit, mentally and capability-wise. This section will be discussed in more detail as part of the innovation audit in chapter and five the audit questionnaire in the addendum.

#### 3.5.2.2 Organisation

The successful application of innovation does not only rely on diverse, creative or brilliant employees, but requires leadership, structure and goals as well. The organisation may assume the role of 'mother' and 'guardian' for new innovations, and therefore act accordingly [See addendum appendix A, Burgelman].

To define a clearer picture of the organisation's tasks, the following elements may be identified:

- *Formal environment setting* — creating an environment where innovation might be born, developed and finalised.
- *Structure* — inventors, scientists, and sales people are not known for their adherence to project management, and a certain measure of structure will enable these employees to reach their goals faster and with less turbulence.
- *Vision* — the leader of innovation is traditionally the one with the VISION, and as such the organisation supports this leader, thereby enabling the continuation of the innovation projects.
- *Mission* — a holistic mission should be defined by the organisation, assigning a place to the innovation inside the diverse aggregate of projects pursued by the organisation.
- *Resources* — a crucial task of fostering an innovation is utilising the correct resources. Even though resources do not make an innovation, the timely access to required ones, does improve innovation speed.

Idealistically an organisation may be defined as a group of individuals, working together to reach a common goal to the advantage of all. In such an environment, the above mentioned aspect would often be easily accomplished, to the advantage of the innovation process. This is seldom the case, for organisations often have pre-conceived structures and methods of operation, with bureaucracy being the innovation exterminator. This section will be discussed in more detail as part of the innovation audit in chapter five and the audit questionnaire in the addendum.

#### 3.5.2.3 Environment

The environment is characterised by the interaction between the organisation and everything outside the organisation. Areas such as technology, religion, politics, social norms, world occurrences, the market, and many other factors have a role to play in the operations of organisations. Of these, the ones that may have a pivotal influence on the organisation may be grouped into *technology, market, industry and P.E.S.* (politic, economic, and social).

*Technology* has enabled the human race to improve their living and working standards enormously. Without breakthroughs in medicine, agriculture, internal combustion, electronics and social sciences the world would probably still be in the middle ages.

As technology changes, so does the *market* in its needs, beliefs and desires. One may only glance towards one of the building blocks of the American World Wide Web environment, only to find that an incredibly large percentage was built on pornographic web sites. Clearly the market need existed, yet who would have expected the explosion of odorous material that would ooze from this concoction. Evidently the market changed from relatively innocent girlie magazines to hard core sexual intimacy.

The *industry* norms and standards dictate competition and competitiveness. To be able to compete in national and international market, organisations often try to comply or surpass the industry standards. Obtaining adequate knowledge of competitors is crucial, as well as benchmarking one's own operations against the best in the industry.

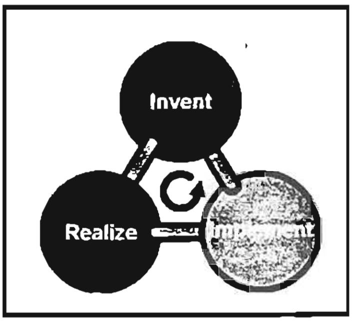
*P.E.S.* (politics, economics and social) may influence the organisation in various ways. Economical, political and social crises have different influences on the organisation, yet when they occur simultaneously, as they often do, unfortunate things happen. Poor social control, natural disasters or political upheavals often precede economic disaster. Even if these do not directly influence the organisation, the economic realities soon will. Few organisations are able to weather high interest rates, or reduced sales for extended periods of time. The P.E.S. factors are important and should not be disregarded.

Networking is part of the process of interaction with the external environment. Knowing the right people in the right places is often a key ingredient to finding the best opportunities, as well as hearing about the threats beforehand. Individuals with the good contacts outside the organisation, may often be valuable, for they are often able to find exciting opportunities through these contacts

The three areas highlighted in the fostering environment are to a certain extent present in every organisation, regardless of its innovative capacity. Just as every person has some creativity and can learn to improve this[27], so do organisations posess the possibility to learn and become better at innovation. By improving the fostering environment, organisations will improve in their innovation efforts, and might find other aspects of the business, such as customer relations, also improving.

The fostering environment is highlighted extensively in the innovation audit questionnaire, and accompanying documentation included in chapter five and the addendum. The other side of the coin in the *innovation process* contains the recipe-like, innovation life cycle development tasks. *Invention*, *realisation*, and *implementation* are common tasks performed in organisations with strong new product development divisions. These organisations include the likes of 3M, DuPont, Intel, as well as pharmaceutical giants such as Merck & Co., Pfizer, Inc., Schering-Plough and others. The following paragraphs will highlight these three new product development sections.

### 3.5.3 The Innovation Process Life cycle



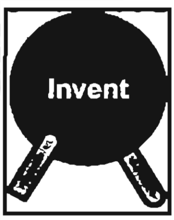

In the proposed model, three equally important spheres represent the linear new product development innovation process. The process starts with **invention** then progresses to **realisation,** and ends with the **implementation** phase.
Although the spheres overlap in practise, it is sensible to split them in the proposed manner. This notion is supported by literature as illustrated by these two examples in a non-exhaustive list.

> *'The innovation process has three major components. The first is invention — getting ideas, The second is development — turning ideas into reality. ... The third stage is getting the product on the market and making it a huge success'.*
>
> — Wiersema [28]
>
> Model concepts:
>
> *'Idea generation sub-process, problem solving sub-process and implementation and diffusion'*
>
> — Utterback[10]

In the model the spheres each represents a part of the innovation process, yet they do not actually represent the true-life situation. A more accurate picture should include overlap and synergies between these units, fusing them together into a continuous process.

Each of the spheres is composed of several key aspects, regarding their main area of focus. It is interesting to note that these aspects might change when different organisations are modelled, and thus the model leans itself toward customisation and better implementation. Some examples of customising the model are proposed at the end of this chapter.

To illustrate the inner workings of the model, the three fields will be discussed below. *Invention* may often be the first process in an innovation, followed by *realisation* and then market *implementation.* However when a product improvement innovation occurs, the implementation phase or market may be the initiator, followed by invention, realisation and implementation.




#### 3.5.3.1 Invention

The process of invention is one of the most fascinating parts of the innovation process. It is here where creativity, luck and 'guts' play a major role in the daily task of people such as researchers, developers and inventors. People have gone as far as saying invention is a non-rational process.[29]

The invention process may often seem to be discontinuous and chaotic, and then at another time linear or even predictable. From a distant perspective invention may seem chaotic and highly unpredictable, yet many factors are responsible for good invention practise. By focussing on these aspects the chaotic areas of invention may be isolated. And after these chaotic areas have been identified, projects may be managed with less associated risk. However, brilliant ideas will never occur on demand, and one should not base planning on the assumption that an idea will be forthcoming.

In this regard, one might then propose that invention is not just about ideas. Such a belief would deliver nothing but crazy, unreachable plans. Invention is about getting ideas and developing them to a demonstrable format for further development.[30] As such, an invention should be proven to minimise risk and reduce setbacks or redevelopment time.[1] Some key elements in this part of innovation include:

- *Signal processing* (contact with external and internal environment)
  To form creative and sensible ideas, the right people, atmosphere and way of looking and thinking about things, are crucial. Without knowledge and some experience, ideas would be frivolous and highly unreachable. Therefore the right technological and market interaction is essential to good idea generation for new innovations. Not only does good contact with the environment stimulate ideas, they are also more in line with what the customer wants at the end of the day. Consider the following example:

  > *One firm spent a good deal of money to develop a special welding torch, for use in repairing automobiles. Not one was sold. Puzzled, the management representatives visited potential customers to find out why. Only then did they learn the torch could not be used on the auto body with the upholstery already in place. The torch would have been a fire hazard. Obviously, the management could have avoided this failure, had it checked with potential customers, before developing such a product.*[31]

  By purposeful analysis of technological trends and market needs, organisations can improve their alignment with reality, and ensure more competitive products in the long run.

- *Ideas workshop* (need recognition and idea generation)
  Ideas always happen. It is how we utilise or promote these ideas that really matter. In the corporate world as many as 80%[32] of all pursued ideas are failures, yet if the process is managed, it is possible to reduce this number. Organisations such as Cisco, Sybase, Hewlett Packard, 3M, Kodak, GE, DuPont, and others clearly indicate their willingness to innovate, by allocating millions of dollars to developing methods and incentives for better innovation.[33] Idea generation forms the starting point of any innovation, and therefore by managing this point, endless futile hours of work and spending of resources, can be tempered.

- *Solutions* (finding solutions for ideas via internal and external channels)
  Finding solutions to problems is where everyday creativity and open mindedness enters. Employees with an aptitude for problem solving especially in creative ways should be cherished by the organisation. Problems are often sources of ideas and by turning problems into solutions into advantages is the prerogative of the highly innovative organisation.

- *Development* (assuring viability of idea and possible continuance of project)

The importance of formal development and verification of ideas and new technologies cannot be overstated. Hewlett Packard uses a system whereby new technologies, which have been proven, enter a system of 'Pizza Bins' where they are stored for inclusion into new products.[34] However to be admitted to this pre-product inclusion storage bins, technologies first have to prove their stability and implementability. A massive amount of research and development is a requirement for any of these new technologies to reach this stage.

Science and research based organisations may often be classified as inventive. These organisations specialise in research and development and seldom produce tangible products for the consumer market. They focus on intellectual products such as test results, new methods, ideas and technologies. These often take the form of patents and publications. These organisations often require external funding, yet provide a valuable source of new information to the world.

**Links**
Strong ties in this area of innovation should exist between the organisation and the external environment, especially technology and market needs. The invention arena is one of the most fragile parts of the innovation process, and therefore requires the right organisational and social environment.


### 3.5.3.2 Realisation

Bringing together training, skills, experience and technology, the entrepreneur or organisation has the ability to transform the inventor's idea and change it into reality. This stage has realisation as goal, and nothing else. Although engineers, entrepreneurs and leaders play a large role on this area, all functional people need to be present to influence the development of the idea. Concurrent engineering is the 'buzz'-word used in this phase. In keeping with this, team structures become highly important as methods for bringing together the right people at the right time.

Systems' engineering is the clear and logical choice in detailing the realisation of innovation. Per sé an innovation does not need to be all new. In complex systems, only parts of the total could be new inventions, while many standard components stay in use. System engineering enables the engineer to construct a solution to an identified need, by fusing inventions and current technologies into a single product. The common term used for this is technological fusion, and a good example is the integration of current cellular telephony, Internet connection, or even personal computers, Internet connectivity and television entertainment. Although some new inventions do play a part in these new products, much of the old stays in place, therefore requiring complex systems integration of old and new.

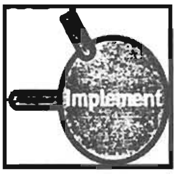
A detail discussion of systems engineering falls outside the scope of this thesis. However some facets of the discipline is discussed in the addendum [Appendix B] to illustrate the process of realising an innovation.

This concludes the section on realisation, and the importance of the section may be observed in its detailed discussion in the addendum [Appendix B]. When innovation is discussed, the hard work and hours of intense design and development are often poorly planned. Taking an idea and transforming it into a product with exciting attributes at a producible cost, is difficult in the extreme. Without a highly competent realisation team, organisations will never see their blue-sky ideas realised in practise.

Some of the disciplines involved with the realisation process, might include engineers and project managers. Interaction between the engineers, project managers and other role players such as customers, suppliers, and manufacturers are crucial, and should not be neglected in this phase.

**Links**

The realisation of the innovation ties strongly with organisational structures and routines, on how to design, develop and produce a new product. Individual involvement is crucial, as a great number of goals and deadlines need to be met within budget and on time. Interaction with the market and technology is strong, but in a supply of information and technological know-how, rather than new trends or needs.




#### 3.5.3.3 Implementation

Manufacturing and marketing are unlikely bed partners, but this phase of the technological innovation modelling process focuses on producing, introducing and selling new innovations.

In recent times developments in automated manufacturing and outsourcing of non-core processes, created the ability for organisations to split the production side of the product away from the innovation process. Production has become such a specialised field, that it often serves the organisation better to outsource the high volume production of a product, than to try and do it themselves. This has the advantage of reducing organisational diversity, as well as the upkeep of huge manufacturing plants with large overheads. Processes such as laser cutting specialised machining and die pressing may all be safely and profitably outsourced. This affords organisations low overheads and no worries about keeping up with new manufacturing technologies.

Marketing forms an integral part of innovation. It is here that the product needs to be implemented and shown to work. Marketing has long since passed the era of selling appliances from door-to-door. Current day marketing is a high-powered monitoring and knowledge-based industry, with sophisticated advertising of products over a range of media types. Even with all today's tools and toys, the marketer, with the right product at the right place and time, often has the advantage and will have the best results.

Diffusion of innovation into the identified market share, can be a very expensive, as well as frustrating task. Barriers to entry and consumer apathy have to be overcome, in developing and teaching new users. In the quest for knowledgeable users Von Hippel researched and identified many characteristics of lead users.[35] These users are often technical with the persistent need to improve their current tools. By looking at the changes these people make to their current apparatus, ideas for new developments may be found. Lead users are often used for beta testing new products to determine the possible success value of the product.

Marketing and strategies aimed at specific segments, are some of the keys to the diffusion of new innovations. A totally new concept might still take years to become an accepted method or product. A good example in this case is the APS device developed by Tech-pulse South Africa.[36] Gervan Lubbe, the patent holder and director of the business, spent five years testing, marketing and persuading potential customers to use the device, before it became accepted.

> The APS (Axio Potential System) device induces electromagnetic pulses between two electrodes, and if placed on a human body or muscle, will induce electromagnetic waves. This results in the human body producing natural pain killing endorphins, which naturally reduce the pain. These endorphins are the body's natural painkillers, and are therefore much safer than painkillers.

The point in case being it took the inventor of this system five long years to educate the market enough to be able to sell the product. Since the market is also included in the external environment, it will be discussed further in the audit questionnaire.

Some of the most common participants in the implementation part of the innovation cycle are market research organisations and advertising agencies. Other businesses such as distributors, marketers, supermarket chains and other general retail stores are all part of the implementation of innovation.

**Links**
The production side in this section has strong efficiency and new methods linkages with the technological environment, but almost no market related interface, where as the marketing side concentrates on the moods and demands of the market, and needs to be highly in tune with future customers. This section does not require as much organisational structure or backing as the other innovation areas, yet it is responsible for interaction with them, to ensure the market needs are realised and addressed.

### 3.5.4 How the Model Works

From the previous section it should be clear what each of the concepts in the proposed innovation model represents, and where they fit into the innovation process. It is important to understand that the model can be implemented on several levels in the organisation, be it strategic, management or disciplinary. Thus to use the model effectively, it should be accompanied by an innovation audit, measuring specific aspects of the innovation process in the organisation. These measurements may then be represented as bar charts in referent to the elements in the innovation model. To illustrate how the model could work, the following scenarios are proposed:

> **Strategic**:
> The South Africa organisation the CSIR (Council for Scientific and Industrial Research) was a basic research institution, supported by the government for a long period of time. Since 1994 several changes in South Africa have resulted in their funding being drastically reduced. This forced the CSIR to look at other sources of income, and specifically at improving the marketing of their services as well as some of their current products. On an industry level the CSIR could be regarded as an **inventive** organisation, trying to improve its **realisation** and **implementation** areas. It could be said that the CSIR should try to improve the realisation and implementation aspects of its business, but this is not necessarily the best option. If for instance other organisations in the same industry as the CSIR found its best markets to be for inventions, the CSIR would be at fault when improving its realisation and implementation areas. They could rather improve their inventive capabilities and serve the best market, which might be the USA Basic Research Council.

What it boils down to, is that innovation is not a clear-cut process with neat inputs and outputs. Often the innovation model only serves as a basic foundation for a much more detailed innovation process. Therefore, finding the specific blend between invention, realisation and implementation for each organisation to best serve its market and utilise its resources, may be done with the model as foundation and its possible extensions, as proposed in paragraph 3.6, as directions.

**Management level**:
The organisational level representing this area the best is the project management level. In this environment projects are continually started, developed and implemented and the model finds its best application here. The 'aggregate project plan', as discussed by Wheelwright[1] plays a role in deciding the type of projects chosen, and how they fit into the innovation model. For instance an organisation might face a choice between improving its production process through a new innovation, or developing a new service enhancing its current products, or developing a totally new product. Each of these projects has a different map on the innovation model, and the organisation should choose the best fit. This ensures that the organisation has the best chance of being successful in the new project. This method of fitting projects to the company's capabilities, ties in with new technology and core competencies, where new technologies are bought to fit the needs of the organisational strategy and future development focus.

**Disciplinary level**:
Individual employees can easily feel like cogs in a wheel of a big turning machine. To improve efficiency and innovativeness in employees, the innovation model may be used. Each employee has his or her own way of thinking and doing things, but by encouraging them to adopt the innovation model, their lesser developed skills may be improved. In problem solving for instance, the three areas *invent*, *realise* and *implement* play key roles in certain stages of the solution. By consciously ensuring aspects in the innovation model are met, a better chance exists for improved solutions. By focusing on the environment of the employee, the model helps in improving innovation climates and cultures.

It should be understood that the specific aspects and elements of the model would change considerably when implemented on the different levels within the organisation. For instance: when the strategic level is modelled, the external environment on the model would change significantly, and so would other aspects specifically connected with the industry environment. This would differ from the innovation development level, where the term **organisation** in the model would either change or possibly fall away. In the individual level the model would change to exclude individual, since it is this that is being modelled.

Until now the focus in developing an innovation model has been one of setting a standard for the innovation auditing process. However, different innovation strategies are necessary in different industries, and developing the innovation model into an organisational specific one, would prove useful. The following paragraphs will show some examples how the model might be customised to the organisation's needs. These examples proposed here are pure speculation, for it is the organisation itself and not the modeller that should define the specific elements in these models.

### 3.6 Proposed Implementations for the Proposed Innovation Model

The innovation model will ultimately prove its validity and importance in the application of the model. To illustrate the possible expansion and customisation underlying the model, two examples will be illustrated.

Innovation models often attempt to capture some degree of structure, as well as contents of the innovation process. The model developed in this thesis does not contain any content of the innovation process. Rather it contains the 'headings' of the contents of the innovation process, and may therefore be expanded showing the underlying body of innovation. Considering the model to be a master for a much deeper development of information enables the innovation model to be customised to a specific organisation, or even one innovation project alone. The model may be extended as shown in Figure 3.13.

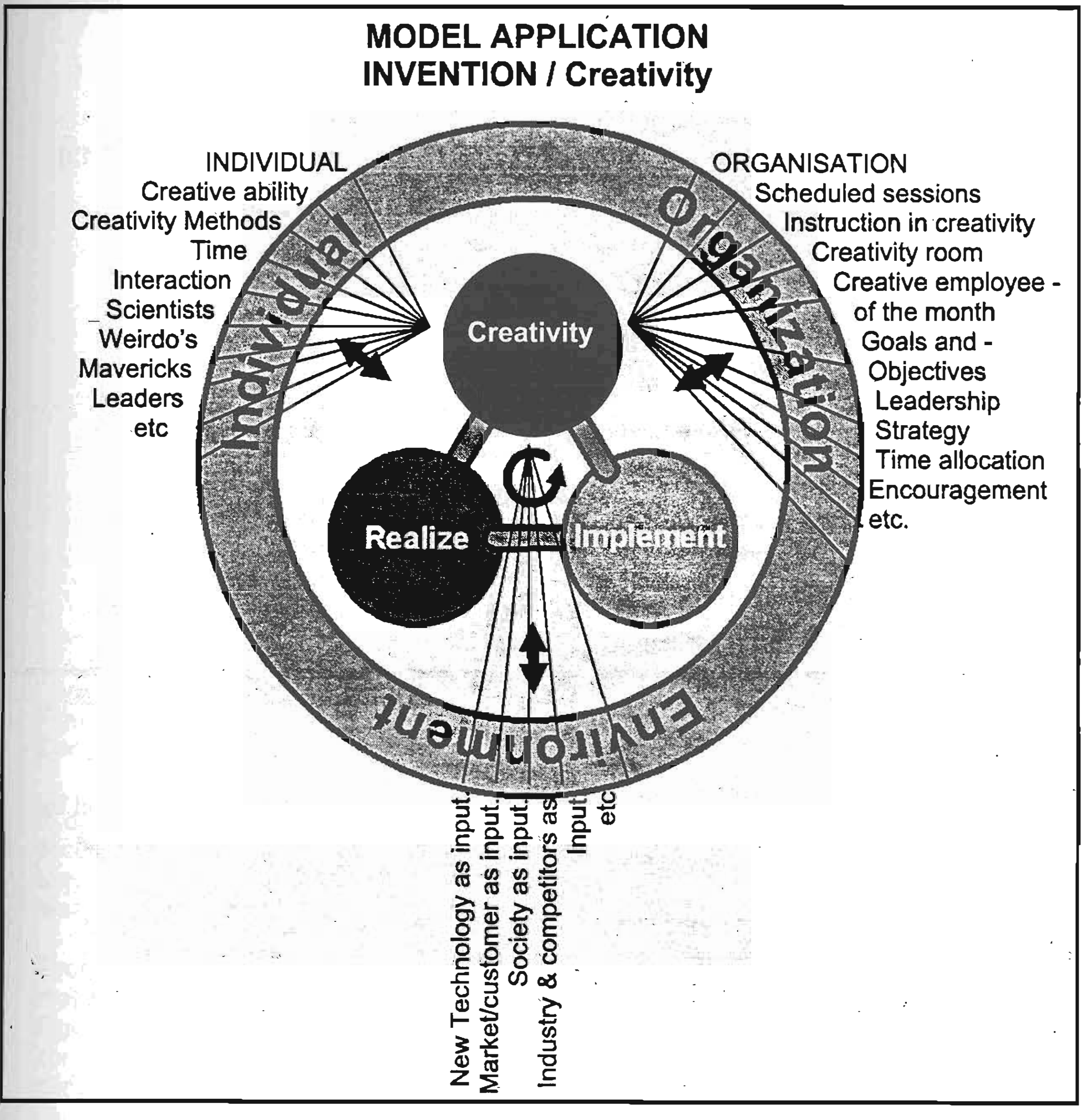



*Figure 3.13: Innovation Model showing Sub-Section Invention, and Focussing on Creativity*

Each of the three main innovation functions, *invent, realise,* and *implement* may be split into subsections, containing the more specific steps of innovation. For each of these sub-sections, the model may then be developed to suit that particular field. Figure 3.13 illustrates a single subsection of the invention function. The creativity sub-section requires specific individual, organisational and environmental characteristics to function optimally as part of the innovation process.

This subdivision of the model makes it complex, but far more flexible than many current innovation models. There might be some difficulty in assigning values and meaning to every proposed sub-section, but the goal is not to iron cast a model of the innovation process inside the organisation, but rather to stimulate thought and a holistic understanding of the innovation process.

Other sub-sections that may possibly be used in the model may include the following: (This is not an exhaustive list)

**Invention**

Interaction —Contact with technology / market
Creativity —Creative idea generation / need recognition [Figure 3.13]
Research — Find solutions to ideas
Test & model — Develop solutions to demonstrable format
Licence — License out or develop further

**Realisation**

Initialise — Program initialisation
Approval —Filter, prioritise, choose
Resource — Assign resources
Plan — Plan and specify
Acquire — Technology acquisition
Design — Design and develop to maturity [Figure 3.14]
Test — Test the systems
Pre-production — Production concerns

**Implementation**

Produce — Full-scale production
Develop — Market development / customer development
Commercialise — Innovation commercialisation / diffusion
Support — After sales support

Example 2, as seen in Figure 3.14, illustrates a possible application of the model in the realisation sub-section, with the focus falling on design:

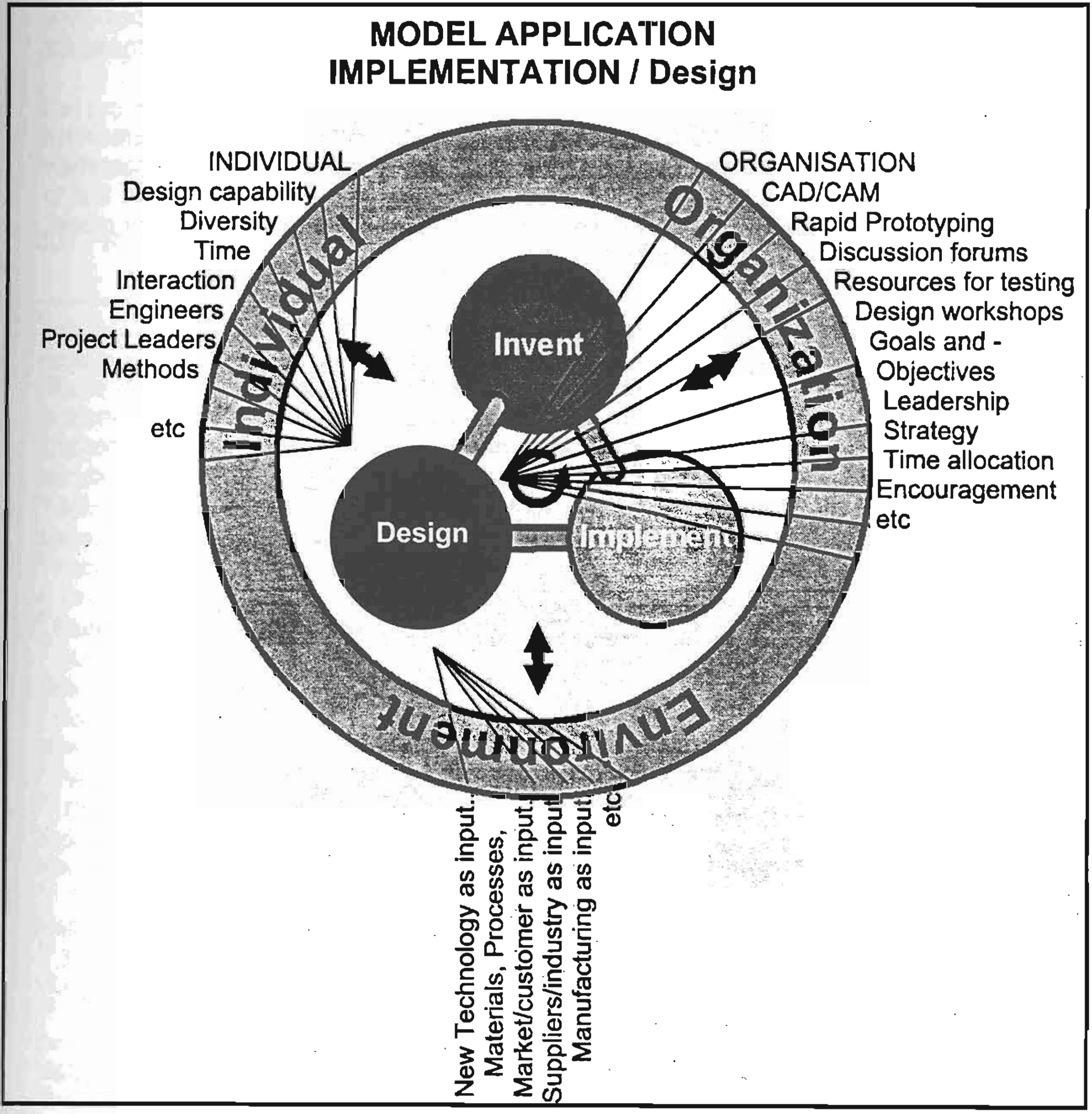



*Figure 3.14: Innovation Model showing Sub-Section Realisation, and Focusing on Design*

In order to model an organisation with this model, each of the above mentioned sub-sections should be classified in terms of individual, organisational and environment terms. The proposed sub-sections each requires unique interaction with the three areas, as can be seen in the two example models provided.

Every innovation process can thus be divided into many sub-sections by following the master model. By integrating the many two-dimensional models as illustrated in Figure 3.13 and Figure 3.14 into a single three-dimensional innovation model, consisting of two-dimensional slices, a comprehensive innovation model may be constructed.

Many links between the different sub-sections of the innovation process exist, and they emerge when comparisons are drawn between the various two-dimensional models. These links may prove to be one of the key areas where organisations differ from each other. Possibly even the place where the essence of their methods for applying innovation lies.

Further development of the model is beyond the scope of this thesis. It remains a field where successful research and application may be done. To successfully develop the model further, some practical trials, where organisations would like to customise the model, would prove useful. The development of a 'best practise model' may serve as a starting point in this regard.

## 3.7 Pros and Cons of the Proposed Model

The proposed model does not claim to be the best, nor exhaustive in its representation of the innovation process. It does try to offer a holistic impression on a fragmented discipline. The implementation of the model may hold some interesting possibilities, yet is left open for further development. Organisations may find, by using the proposed innovation model, that they might be able to restructure their innovation process more sensibly.

The following advantages and disadvantages are evident:

Disadvantages:
- The model is very generic and difficult to understand at first glance
- There are few elements of innovation in the model
- No mention is made of different types of innovation
- There is too much emphasis on the individual
- The model is too simplistic for a highly complex industry
- The market is neglected
- Manufacturing is neglected

Advantages:
- The model offers an holistic view of the innovation process
- The model identifies key aspects of the innovation environment
- The fostering or 'soft' aspects of innovation is accurately depicted

It is not easy to develop a model for a diverse field, such as innovation. Through consultation with industries, the model developed above has been validated. Not one of the industries consulted reported any problems, disagreements, or invalid aspects of the model. Although this does not guarantee the validity of the model, it does enhance its stature.

## 3.8 Conclusion

This chapter reached a conclusion in the development of a generic innovation model with the advantage of being scalable for specific applications. It was observed that many aspects influence the development of an innovation model, but the area of implementation ultimately dictated the best possible model to use. Therefore since the model in this chapter was developed to serve as a foundation for a competence audit for technological innovation, it included a holistic overview of the *innovation process* as well as the *fostering environment*.

In the following chapters the proposed innovation audit will make extensive use of the proposed innovation model. However, it will not implement the further developments proposed in customising the innovation model as discussed in paragraph 3.6. Each of the proposed audit sections will be based on the three areas identified in the fostering environment.

The proposed innovation model was developed to serve as structure and foundation for the innovation audit. The following chapters will show the development of an audit methodology and also how it conforms to the proposed innovation model.

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Chapter 4

# A TECHNOLOGICAL INNOVATION AUDIT METHODOLOGY



## 4 Audit Methodologies

Auditing is a method for measuring and validating data from various business processes. Most business processes may be audited if data is available for comparison with a certified or known standard. One of the best-established audit disciplines is financial auditing, while others include technology audits, core competence audits, business process audits and many others.

Methodologies for financial auditing have been perfected through trial and error. Over many years the discipline of financial auditing has grown to be a key ingredient in generally acceptable management practises. These well-tested methodologies may be employed in the innovation audit as well. By actively incorporating financial audit methodologies in the innovation audit, a strong base is formed from where future developments may be done. The thoroughly developed methodologies of financial auditing may also enhance the structure and understandability of the innovation audit.

This chapter will start by discussing some aspects of the financial audit methodology, and then progress to the possible application of these methodologies in the discipline of innovation auditing. Some other examples focussing on innovation audits will also be discussed. Finally the methodology for the proposed technological innovation audit is discussed.

## 4.1 A Financial Audit Methodology

The financial audit process (as opposed to other audit processes) is possibly the most widely recognised and best understood concept held by the general public. In this context an audit may be described as a measuring activity, involving the comparison of data to current set standards and policies. As such financial auditing can be defined in the following general terms:

> *Financial auditing is the process by which a competent, independent person accumulates and evaluates evidence about quantifiable information related to a specific economic entity, for the purpose of reporting on the degree of correspondence between the quantifiable information and established criteria.*[1]

Developing a basic understanding of the processes involved in financial auditing may be instrumental in dealing with the process of innovation auditing. These financial principles are discussed below.

**Quantifiable Information and Established Criteria**[1]
To 'do' a financial audit, information in a verifiable form and standards by which the information can be verified, is necessary. Quantifiable information can and does take many forms such as financial statements, the amount of time spent by an employee on a task, the total cost of a contract or an individual's tax return.

Criteria for evaluating quantitative information can also vary. Financial accounting does however rely on standardised practises and historical accounting principles. For customisation some organisations require criteria based on the standards inside their environment. This often happens where more strict criteria than in usual accounting practises are needed.

**Economic Entity**[1]
When an audit is commissioned, its scope must be made clear to the auditor. By defining an economic entity such as a company, department or even an individual, the range of the audit is set. Furthermore a time period defining the duration of the operation to be audited should be set. This period is usually one year, yet monthly and quarterly audits can also be done. In defining these boundaries, the auditor can be certain of his/her responsibility and complete the task effectively.

**Accumulating and Evaluating Evidence**[1]
Evidence is the necessary information for validating any conclusions and recommendations, as well as ensuring the accurateness of the auditing process. Thus any information used by the auditor to validate quantifiable information in accordance with established criteria, can be regarded as evidence. Evidence takes many forms including written or oral testimony, observations and written communication with outsiders. When auditing, deciding on the volume of evidence to gather, is one of the important tasks. The ideal would be not to waste time on collecting too much evidence, yet

finding enough to satisfy the audit criteria. As such gathering evidence is one of the primary auditory functions.

**Competent Independent Person**[1]
'Competence' and 'independence' are unscientific terms and can therefore not be defined in absolute measures, yet typically competent auditors are qualified individuals that understand the criteria for the audit, as well as the evidence needed to make proper conclusions. An unbiased opinion is necessary, yet often difficult to maintain. As such an auditor always strives towards an independent mental attitude. This does however become exceedingly difficult, when the auditor is also a company employee.

**Reporting**[1]
The final output from the audit is the audit report — i.e. the communication of the findings of the audit to the organisation. Audit reports differ from auditor to auditor, yet they all have the same basis, on informing readers as to the correspondence between quantifiable information and established criteria. Different audit subjects might also warrant different types of reports. An audit on an individual might require a verbal 'OK' while a corporation might require a formal, highly technical statement.

Financial auditing is a well-defined profession, based on standards and the measurement of conformance to these standards. To formalise these standards and introduce them as common business practise, GAAS (Generally Accepted Auditing Standards) have been compiled. Although others exist, this standard is widely used and accepted by most accounting institutions. By following these standards a better understanding of the auditing discipline is possible.

### 4.1.1 General Standards in Financial Auditing[1]

The quality of work done by the auditor is of great importance. Not only can this impact on the organisation being audited, but also on all parties relying on the audit information. Setting general standards of technical training, human independence and professionalism become necessary. A non-exhaustive list of these may include.

*Adequate technical training and proficiency* — Technical competence is a necessity in financial auditing. Formal University education, practical training and experience, as well as continued education are expected from all auditors.

*Independence in mental attitude* — This relates to the nature of the auditor and his/her ability to distance him/herself from the organisation being audited. It is important that no mental attitudes influence the auditor's objectiveness and cause him/her to misinterpret or represent findings as part of his/her duty.

*Due professional care* — Professionalism is required in many professions and is expected from the auditor as well. This requires the auditor to act in good faith and not be negligent while conducting an audit.

#### 4.1.1.1 Standards of Field Work in Financial Auditing[1]

Conducting an audit at a client's place of business, requires a high standard as well as professional behaviour from the audit team. Such standards pertain primarily to the client, but should in general include adequate planning and supervision, understanding the internal control structure of the organisation and obtaining sufficient competent evidential matter. These may be discussed as follows:

*Adequate planning and proper supervision* — to ensure effectivity and efficiency audit planning is required. Since assistants with limited experience often execute major portions of audit programs, planning and supervision should be on site to guide, and ensure adequate audit quality.

*Understanding the internal control structure* — the internal structure of the client's organisation has an influence on the validity and accurateness of the financial information. Understanding the controls and procedures that are in place, enables the auditor to assess the accurateness of the financial data.

*Obtaining sufficient competent evidential matter* — the heart of the audit relies on expressing, with a reasonable bias, the accurateness of financial data presented to the auditor. In this regard evidence and professional judgement is necessary. However, determining the amount and quality of evidence needed, rely on the auditor's experience as well as professional judgement.

#### 4.1.1.2 Standards of Reporting in Financial Auditing[1]

Reporting comprises the outsets of the audit and standardising this format improves evaluation purposes. Four standards need to be met in reporting and they include statements presented in accordance with GAAP (Generally Accepted Accounting Practise), consistency in the application of GAAP, adequacy of informative disclosures and expression of opinion. These may be discussed as follows.

*Financial statements presented in accordance with GAAP* — the auditor identifies the GAAP standard as the factor for evaluating management financial statement assertions.

*Consistency in the application of GAAP* — the consistency in following the GAAP standard is highlighted. If not, deviations from the standard can be noted and no report is necessary.

*Adequacy of informative disclosures* — the adequacy of notes to the financial statements is expressed. If no deviations or insufficient notes are apparent, no report is necessary.

*Expression of opinion* — as final standard the auditor is required to express an opinion on the financial statements taken as a whole. Several standard opinions are available for appropriate inclusion to the report.

This concludes the introduction to financial auditing. It sets the foundation to build and elaborate on methodologies for the innovation audit. The following sections will contain more relevant information on innovation auditing procedures.

### 4.1.2 The Adapted Financial Audit Methodology

Adapting the financial audit methodology to the requirements of an innovation audit may prove valuable. The innovation auditing discipline is relatively new and as yet few standards or formal procedures have been defined. The formality of the financial audit process serves in providing guidelines and definitions that may be adapted. One of these is the definition of the innovation audit. By changing some of the terms in the financial audit definition, a workable innovation audit definition may be derived. It does not claim to be the best nor the only, yet it might hold some merit towards formalising the innovation auditing process.

A proposed innovation audit definition:

> *Technological Innovation Auditing is the process by which a competent, independent person(s) accumulates and evaluates evidence about the process of innovation, related to a specific entity, for the purpose of reporting on the degree of correspondence between the innovation process and established best known practices in the innovation environment.*

The definition touches on many interesting points, which may be applied in the implementation of an innovation audit.

Some perils exist in directly translating the financial audit into an innovation audit. Aspects such as quantifying and finding established criteria as illustrated in the application of GAAP (Generally Accepted Accounting Practise), in the practise of accounting, or GAAS (Generally Accepted Auditing Standards), in the practise of financial auditing, might prove difficult for an innovation audit. However, by adapting the most useful areas in the financial audit methodology, such as the accountability, professionalism, planning, and gathering of data to the innovation audit methodology, improved auditing may be expected. Some of the advantages and disadvantages of adapting the financial audit methodology to the innovation audit methodology, are illustrated in the following paragraphs.

**Quantifiable Information and Established Criteria**
The difficulty in qualifying innovation in absolute terms is a severe drawback to the process of auditing it. Presently no 'ideal innovation recipe' can be relied on to guarantee success. The reason for this is the amount of human involvement necessary to innovate, as well as the ever-changing nature of new innovations.

However, it is possible to audit many aspects of the innovation process effectively, yet with a slightly different methodology than financial auditing. Innovation practises, although less quantifiable and absolute than financial practises, may be audited by means of 'best practise criteria'. Finding these best practises criteria falls to the researcher in the field of innovation. By identifying the reasons why certain organisations are better at innovation than others, certain practises and methods may be extracted. It is these methods that may form the basis for best of breed practises.

Best of breed practises are not always the same for innovation processes in different industries. They may vary in impact on the innovation process as well as the practises themselves. The researchers' and auditors' dilemma lie in finding a set of standards to be used in auditing that will fit all industries well. Alternatively, designing customised best practises for each industry which suit their innovation processes best.

**Specific Entity**
As is the case with the financial audit, the innovation audit needs specific boundaries and scope. The diverse nature of innovation can cause poorly defined audits to escalate into very large projects, requiring many resources. By defining a specific group of people, department or process to be audited, the audit procedure becomes more manageable, and delivers better results.

Different methods in auditing innovation inside an organisation could include the following:

- Auditing a previous innovation/product from inception to implementation
- Auditing a management team for their leadership skills in leading innovation
- Auditing a department and the part it plays in the innovation-chain within the organisation
- Auditing a complete organisation and how it approaches and ensures new innovation

The above mentioned list is not exhaustive for other possible specific entities may be defined for auditing.

**Accumulating and Evaluating Evidence**
Evidence does not play as important a role in innovation auditing as it does in financial auditing. The reason for this lies in the nature of the innovation process and the information extracted from it for auditing purposes. Since the information mostly consists of human perceptions and notions, it is virtually impossible to evaluate quantitatively. The only evidence available is the hard facts of good or poor product performance. Yet this has no bearing on any of the issues influencing innovation, such as creativity, motivation, knowledge, drive, leadership, technology, market needs and many more.

**Competent Independent Person**
It is crucial that any person responsible for an innovation audit has adequate understanding of the subject. Since the innovation auditing process is so new, many years of implementation and developed will be necessary before competent independent auditors will be available. The best option at the moment may be to employ individuals knowledgeable in innovation. These auditors should, however, be able to respond to almost any situation and understand the implications it may have for the innovation process.

Internal innovation auditing can be quite risky since few individuals are absolutely biased towards their present employers. By contracting an external audit person or firm, more independence and sometimes more credibility are attached to the audit. This seems to be the better scenario.

**Reporting**
The output from the audit may take on many different forms or degrees of detail. Audit outputs should highlight strengths and weaknesses and leave any future planning to the organisation. They might include recommendations on which aspects of the organisation to change, as well as the best procedures to follow. However, it would be prudent of management to be cautious of audits prescribing certain actions. It is not the auditor's place to prescribe improvements or remedies, but rather to measure and report. It falls to management to plan and act on findings from the auditor's report.

In conclusion innovation auditing may in certain cases borrow methods from financial auditing. There does however seem to be a difficulty in identifying quantifiable information as well as criteria for the measurement of the information as part of the innovation audit. Rather than following the financial audit process blindly, only the most useful areas in the methodology will be applied.

## 4.2 Possible Technological Innovation Audit Methodologies

The financial audit methodology introduced some basic terms for inclusion into the innovation audit. These terms were identified over many years of auditing and empirical testing. The discipline of innovation does not have such a history, and neither have success factors been identified with complete certainty.

Although literature on management of technology and management of innovation often contains informal proposed innovation audits, they are seldom tested in practise. The example audit, as illustrated in paragraph 4.3, is one of a very select group of innovation audits, which have been implemented and tested in the British manufacturing industry.

The following paragraphs highlight three possible viewpoints on innovation auditing. They include auditing the competencies, processes or performance of the innovation process. Two of these are discussed in an audit, which was developed by Chiesa *et al.* This audit will be reviewed as an example audit after the audit viewpoints.

### 4.2.1 The Competence Innovation Audit

Human competencies may or may not form the basis for innovation. However, little research on human innovation competencies has been done. Research on culture and other social aspects have made some progress, yet the core of human innovation competencies has yet to be defined conclusively. Not only do the human competencies influence the innovation process, but also the organisation's competencies. Structures and resources provided by the organisation may go a long way in improving the innovation process. The model developed earlier in this thesis leans heavily towards the importance of identifying the competencies inside the organisation. Some of the reasons for this viewpoint might be found in the dynamic times we live in.

The nature of technology is that of relentless change and transformation. Organisations active within the high technology environment are often acutely aware of this, yet often find itself trapped when unforeseen technological changes occur. To cope with these changes, organisations have to have a base to fall back on which has little to do with their disciplinary knowledge. Innovation competencies may be such a base.

If an organisation encouraged its employees to specialise further and further into their fields of expertise, they might easily become redundant when a technology paradigm shift occurred. These employees would not have any generic knowledge or tools that would work in the new environment. This would severely impair these employees in times of change.

However, if an organisation were to educate its employees in the discipline of innovation, they would be better at innovation as well as better prepared for change. A technology paradigm shift might be just such a change they would have to be prepared for. In the event of a paradigm shift disciplinary knowledge easily becomes obsolete forcing employees and organisations to change. By educating its employees in the discipline of innovation the organisation is able to give them some generic tools useful in many different paradigms. These employees would therefore be better equipped to deal with change and might even welcome it due to the many new possibilities associated with it.

By building competencies in innovation, organisations might build a knowledge base applicable to new opportunities, changes or threats, resulting in a highly valuable generic competency which cannot be destroyed by change.

The competence innovation audit focuses on the innovation competencies of the organisation, its resources, structures, leadership, management and employees. By determining the ideal competencies embodied in these elements, the competence innovation audit may find its application.

By examining the technology, market and networking competencies, the organisation and its procedures, and the individual employees of the organisation, a clear measure of innovation competence may be obtained. A competence audit could therefore identify strengths and weaknesses in the innovation environment, inside the organisation.

### 4.2.2 The Process Innovation Audit

Where the competence audit focuses on the environment created for fostering innovation, the process audit focuses on the step-by-step actions necessary to develop and implement an individual innovation. Systems engineering and new product development processes both find its application in this discipline. Detailed measures of these processes have been developed as part of the new product development processes. They are therefore more accessible and quantifiable than the competence measurements. This facilitates auditing and the identification of clear strengths and weaknesses. An example methodology for process auditing may be found in an excellent audit developed by Chiesa *et al*[2].

The Chiesa *et al* audit, as illustrated in section 4.3, focuses on dual aspects of the innovation process. The two sides are described as performance and process. Process can be understood as the outputs or results obtained when innovating and by looking at these, strengths and weaknesses can be identified. The process audit is a general auditing method, and addresses the holistic attributes such as culture, creativity, structures, implementation and others forming part of innovation. When auditing in such a way, all employees can offer significant value in completing the audit questionnaire. These responses can, however, be emotional and not always reflect the true state in the organisation. They are often answered on 'gut feel', reducing the audit to possibilities and perceptions rather than facts.

### 4.2.3 The Performance Innovation Audit

Different to the process audit the performance audit moves away from all the 'soft' emotionally driven innovation attributes, cutting directly toward the factual process of new product or process development. The performance audit requires the identification of metrics (units of measurement) whereby processes, methods and involvement is measured and equated with another measurable entity, usually money or time.

The process audit may be quite difficult to implement, since few if any clear metrics exist in the innovation process. Long discussions as to good or poor metrics may lead to unacceptably high implementation time for the audit. The process audit has the added drawback of high level implementation, often excluding lower level employees from participation. As tested by Chiesa *et al,* this audit is sometimes regarded as too difficult to implement, resulting in a shift of emphasis towards finding the best metric.

Although the performance audit has its niche of implementation, it tries to measure a qualitative process by applying a quantitative measure. In the world of financial auditing this is possible, for there quantitative data is compared with quantitative measures, resulting in a quantitative outcome. When trying to compare qualitative and quantitative data with each other difficulties may be expected, and since innovation is by enlarge a qualitative process this may often occur. This makes the performance audit a difficult audit methodology to implement.

### 4.2.4 Conclusion to Technological Innovation Methodologies

The three proposed audit methodologies proposed above is not an exhaustive list, and should not be interpreted as a total representation of the field of auditing. However since innovation auditing is new few explicit methodologies have been defined and the above mentioned is therefore only a beginning.

Competencies are from this audits perspective valid measuring aspects in the innovation process. Competencies of organisations represent the skills, processes, procedures and perceptions of an organisation, and by measuring these the audit methodology is able to hit at the core of organisational practises.

The following section will give a opposing view from the one of competence auditing, in the example of an innovation audit by proposing a *process* and *procedure* audit.

## 4.3 An Innovation Audit Example

**A Technical Innovation Audit Developed by Chiesa *et al.*[2]**

The need for innovation auditing is steadily being recognised as a good management tool for increasing and improving the innovation process. The United Kingdom Department of Trade and Industry, encourages the development of an innovation audit as it sees technological innovation as one of the drivers of national competitiveness, and sought a means of getting companies to develop and improve their innovation management processes and performances.

A dual approach to innovation auditing is followed by the Chiesa *et al* audit. Innovation performance and innovation processes are split to form outcomes based and best practise audits.

> The *process audit* (best practise audit) focuses on such questions as whether the individual processes necessary for innovation are in place, and the degree to which best practises are used and implemented effectively.
>
> The *performance audit* focuses on the measurable outcomes of each core and enabling process of the overall process of technological innovation. Concerned with results and outputs from the innovation process, the performance audit looks at quantitative results, facilitating the comparison between current performance and expected or required performance.

In developing the audit, a general model of the technological innovation process is constructed. This model consists of 'core processes' as well as 'enabling processes'. The core processes, of which there are four, form the main focus of the model, while the enabling processes form part of the innovation environment, and interact with the core processes. This may be observed in Figure 4.1. The model creates the basis of the innovation audit, and both the performance and process audits draw their representation of the innovation process, from this model.

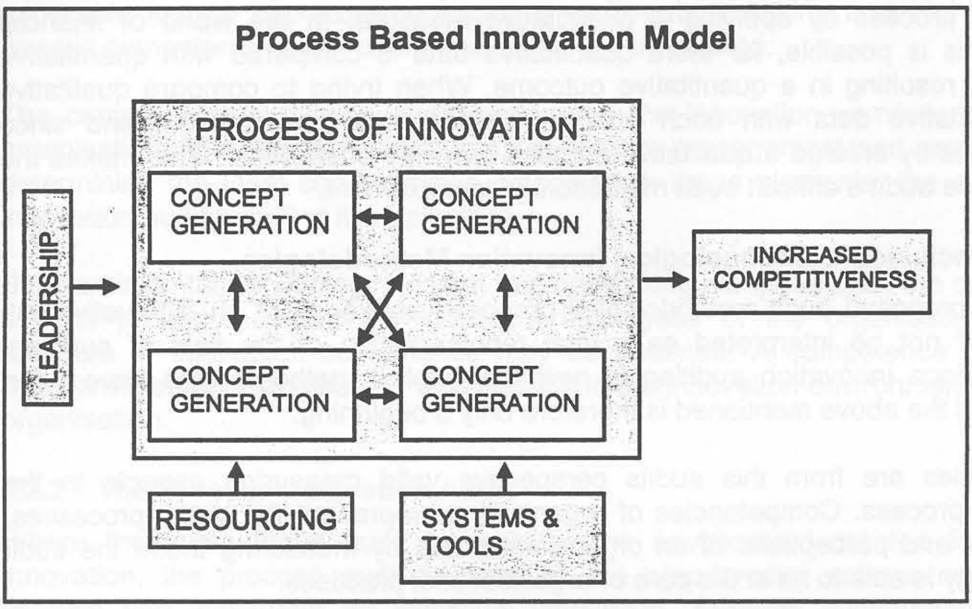


*Figure 4.1: A Process Based Model for Innovation, Source: Chiesa et al*[2]

By building on the model, a detailed innovation audit may be constructed. Such a comprehensive approach to auditing a firm's technical innovation competence, should encompass a means for:

- assessing the current innovation practise and performance;
- identifying the gaps between current and targeted practise and performance and the reasons for gaps;
- defining the action plans needed to close these gaps.

### 4.3.1 Process Audit

A process audit of a firm's innovation competence requires reviewing the practises adopted to mange the innovation process. The following are noted by Chiesa *et al*:

- the degree to which there are appropriate business processes in place;
- the deployment of good practises — the breadth of use in the company;
- the degree to which each practise meets known 'best in class' or world standards.

Due to the perceived and real complexity of the innovation process, organisations often require various assessment methods. The Chiesa *et al* audit proposes the use of an in-depth audit as well as an overall assessment scorecard approach. The scorecard, as based on the model, would serve as a rapid assessment method, identifying areas of high and low importance. The outputs from these high or low areas could then be used in the in-depth audit, reducing the amount of in-depth testing necessary.

In developing the model as well as the scorecard, an extensive literature review was conducted by Chiesa *et al*. This was necessary in order to identify, as well as quantify the best practises in the discipline of technological innovation. An integration of literature from several sources yielded a strong foundation in identifying best, as well as worst practises. These were then applied to the innovation scorecard as part of the innovation audit.

The scorecard was constructed using a general four point ranking, where each of the four points represents an improved state, from poor to exceptional. As these all involve some sort of description of the particular process, care is taken to be general, yet topic specific. The scorecard requires the participant to select the description best resembling the organisational innovative actions. This can significantly improve total participant understanding.

### 4.3.2 Performance Audit

The focus of the performance audit is on measurable qualities of the innovation process. This differs from the process audit, where best practises are used for measurement. The performance audit requires the definition of metrics that can be quantified and measured unbiased. The metrics needs to be defined by the organisation, as they are highly specific. To facilitate the definition process, the innovation auditor might propose the following areas wherein metrics might be defined:

- *Concept development* — the number of innovations, new product ideas, number of new product based ventures, averaged product lifecycle, product planning horizons
- *Product development* — time to market, product performance, design performance
- *Production process innovation* — effectiveness, speed, development cost, continuous improvement
- *Technology acquisition* — R&D/technology acquisition cost per new product, R&D projects that lead to new or enhanced products, number of licences, number of patents, cost benefit of R&D projects
- *Leadership* — number/percentage of members from technical functions/product development in the main and subsidiary/divisional boards, percentage of employees aware of innovation policies and values, number of pages in the annual report devoted to innovation and technology
- *Resourcing* — personnel in product development who have worked in more than one function, percentage of projects delayed/cancelled due to lack of funding, percentage of projects delayed due to lack of human resources
- *Systems and tools* — percentage of designers with access to CAD screens, percentage of products on CAD database, percentage of designers trained to design for manufacture, percentage of teams trained in creativity techniques

Metrics is specific to organisations, although some similarity might occur between companies in the same industry. Metrics offers the innovation auditor a precise method for measuring. This may lead to identification of areas for improvement, as well as gaps between current and expected performance. It may even be used for comparison of performance, against goals set by the company or the competition. Future performance standards may be set, based on final outputs from the performance audit.

The single biggest drawback of the performance audit is the nature of the process it proposes to measure. No innovation is ever the same — as per its definition —

assigning performance measures to parts of this process, assumes one innovation will be comparable with the following. In certain special cases this might be true, yet for the majority of innovations, few if any repetitions are present.

### 4.3.3 Example Review

The Chiesa *et al* audit focuses on dual aspects of the innovation process, namely the performance and process sides. The process side may be understood as the outputs or results obtained when innovating, and by looking at these, strong or poor practises may be identified. The process auditing method addresses the holistic attributes of innovation such as culture, creativity, structures, implementation and others. When auditing in such a way all employees are able to participate and offer their assessments and perceptions. Since the questions are understandable and most employees may have some experience at the fields in question. However these responses may in some instances be emotional and will not always reflect the true state in the organisation. They are often answered on 'gut feel', reducing the quantifyability of the audit results.

The performance audit mentioned in the Chiesa *et al* example focuses on the quantitative measures in the innovation process rather than the 'soft' human innovation attributes. It focuses on identifying quantifiable and measurable entities inside the process of new product development. The performance audit requires the identification of metrics (units of measurement) whereby processes, methods and employee hours may be measured against money or time. The process audit is often difficult to implement, since few if any clear metrics exist in the innovation process. The performance audit has the added drawback of high level top down implementation requirements, due to the definition of metrics and associated control that is necessary to measure them accurately. This excludes and disempowers lower level employees who may often be the main innovators of the organisation. It was concluded in the results of the beta tests conducted by Chiesa *et al* that this audit is often regarded as too difficult to implement.[2]

Although other audits have been proposed by Shumann *et al*,[3] Tidd *et al*,[4] and Burgelman *et al*[5] they have yet to be implemented. These efforts were considered in the development of the proposed model and innovation audit methodology but will not be discussed at this time. They often consist only of proposed questions to ask and seldom includes a methodology for implementation.

The example audit by Chiesa *et al*, as well as the proposals made by Shumann *et al*, Tidd *et al*, and Burgelman *et al*, indicate some of the difficulties and advantages associated with different types of innovation audits. Although the field of innovation auditing literature is insufficient to make adequate conclusions on the best method for innovation auditing these offer some guidance. The difficulties and advantages will be of value in the following paragraphs where a proposed audit methodology is discussed.

With the aim of building on the work by Chiesa *et al* the proposed competence audit for technological innovation developed in the next paragraphs, focuses on enabling and fostering innovation, through identifying and measuring competencies. Many of the themes and aspects highlighted by the Chiesa *et al* audit, can be followed through as competence measurements. The proposed audit methodology focuses intently on the 'measurement of human and group competencies', hoping to facilitate and coach organisations to the factors crucial for technological innovation.

## 4.4 A Proposed Audit Methodology (based on a competence audit framework)

Innovation auditing is an emerging discipline. As yet, few organisations have tried to implement such a process. The audit methodology proposed here, draws on ideas and literature in the fields of auditing, technology and innovation. Interaction with key people in the industry, as well as the academic environment, helped to clarify and validate many proposed audit questions and ideas. A 'prize', in the form of an innovation audit was found in an article by Chiesa *et al*. This had a significant effect on the proposed methodology of this thesis.

As stated before the proposed audit methodology focuses on competence analysis of technological innovation process in the organisation. The proposed audit methodology builds primarily on the model developed in earlier chapters of this thesis, as well as on the competence audit methodology discussed above in paragraph 4.2.1. The model is integrated with the innovation audit in such a way that it provides structure, and ensures that all the necessary parts of the innovation process are covered. Due to the diverse nature of innovation, it is easy to leave out some aspects when auditing. Since the model theorises to represent the entire field of innovation, it enables the audit to identify and target the strengths and weaknesses in the organisation in short order.

### 4.4.1 The Fostering Environment Methodology

Innovation is often referred to as a very sensitive process,[4] easily undermined or compromised by uninformed people. Therefore to 'get innovation going', a special environment with open inviting structures, knowledgeable people and available resources are necessary. To attain this in the innovation process, organisations will have to change the way they look at innovation. Innovation does not happen on demand and neither can management 'drive', command or require innovation from employees. Without vastly improving perceived advantages of being a creative and innovative person in the organisation, few employees will be prepared to accept the risk of failure, inherent in the innovation process. Therefore innovation will only occur consistently when all the correct procedures, as well as reward possibilities are in place. Conversely, innovation will almost never happen before every obstacle has been removed.

This concept of total compliance, or unification in innovation, may be observed in many innovation models,[6,7] as well as in actual organisations. For example: 'At Pfizer there is an institutional memory that supports the way we solve problems and organise our work.'[8] This accumulated knowledge and institutional awareness act directly to the advancement of innovation at Pfizer, thus making it one of the most successful pharmaceutical organisations in the world. It is therefore clear that unification and working towards a common goal can have powerful influences on the innovation process.

The innovation model developed in an earlier section of this thesis is based on the dual areas of the innovation process, and it forms the basis for unifying the innovation process. The model describes the new product development process as well as the fostering environment.

Although the new product development cycle is and will always be a key part of the innovation process, it has been studied and analysed extensively. The audit in this thesis therefore avoids the new product development process in its methodology. It rather focuses on the fostering environment, where small improvements may still have large payoffs.

Due to the nature of innovation and its current management procedures, little analysis has been done on the innovation-fostering environment. This creates the opportunity for measuring and implementing best practice models in this environment, deriving significant advantage to innovative organisations. By adding some structure to a field of 'soft' issues, improvements in understanding are possible. Without structure and understanding, learning is not possible and without learning organisations are unable to improve this discipline.

The methodology for auditing the organisational competencies by focussing on the fostering environment might initially look one-sided, but on deeper inspection one will find all functions of the innovation process covered. Is it not true that the competencies of an organisation lie in its individuals and procedures? And is this not precisely what the innovation model proposes to measure? Saying the audit is one-sided from a new product development point of view, may have some merit, yet when one observes the total innovation process, this is no longer the case. Innovation auditing is a broad and difficult process, which has to be customised for each and every organisation. However the kernel of knowledge used in the innovation audit stays the same for all, because in essence the competence to innovate has more to do with individuals, processes and procedures, than with in-depth scientific knowledge.

A proposed methodology for auditing an organisation is discussed in the following paragraphs. A flow diagram was also developed and is illustrated in Figure 4.2. Some resemblance to the discipline of financial auditing may be seen, however, elements of other audit methodologies are also present. The methodology starts by introducing the concept of standard for the innovation process, and is concluded in the application of findings of the innovation process.

### 4.4.2 General Standards

No general standards exist in the discipline of innovation. Unlike the discipline of financial auditing, generally accepted innovation practises do not exist, and neither might such practices be easily defined in the near future.

The only solution to finding standards is to look at the field of best innovation practises. These pseudo-standards may temporarily serve as a benchmark for the innovation process; that is until better ones have proven themselves. The innovation audit therefore strives towards capturing the best practises in the discipline of innovation and adopting them as temporary standards.

The next chapter will focus on identifying many of these best practise standards. Based on these a beta test innovation questionnaire was developed and may be viewed in the addendum [Appendix C].

Although best practises are a solution to the dilemma of defining standards for the innovation audit process, it by no means guarantees that the standards are correct. This means that an audit developed for a specific industry might not be applicable to another. Therefore the discipline of innovation auditing will always require specialised consultants with experience in innovation and its possible permutations. Without the trained knowledge of these individuals, organisations may find that even by scoring high on a 'do it yourself' innovation audit, the innovation process of the organisation might still be weak.

Defining standards in innovation will always be a contentious issue. Through experimentation and learning, organisations might find 'that which works best' for them, yet always remembering they operate in competition with others, and the ones with the best standards are the ones with the best innovation competencies.

### 4.4.3 Audit Boundaries

When a new project or measuring activity is started, certain boundaries have to be laid down. This too is crucial in the innovation auditing process, since innovation can often occur in many diverse forms throughout an organisation. Technological innovation forms part of the discipline of innovation and may be used as boundary. Other areas, as highlighted in previous chapters, such as the type of innovation, product, process or service, as well as different business units, management, employees or other groups may also be successfully used to define audit boundaries.

In the proposed innovation flow diagram, illustrated in Figure 4.2, the sources of data are identified as *management*, *key innovative people* and *employees*. Other classifications may be utilised, depending on the required results of the innovation audit.

Choosing the audit group sets the first boundary on the audit process. The flow diagram shows only three group selections. Different ones are possible. By choosing the audit groups carefully, a *management*, *general* or *specific* innovation audit may be conducted. These may be used for different purposes, such as *strategic planning*, *department restructuring*, *fault diagnosis*, *human resource management* or even *technology* strength and weakness assessments.

The boundary between technological innovation and innovation is obtuse at best. Betz[9] goes as far as implying technology and innovation are one and the same, while Noori[10] clearly distinguishes between technological innovation, invention and creativity. For the purpose of this thesis it is proposed that the boundary between technological innovation and innovation is defined by the 'technology'. Technological innovation would not include financial, management, political, social or other non-scientific innovation. It would focus on innovation related to technology and science, rather than non-scientific based procedures and processes.

Other boundaries may be set in consultation with the organisation, and the outputs required from the innovation audit. This would incorporate the current procedures in the organisation and how they innovate and utilise technology. It should also include what the organisation wants to achieve in the future, and the typical changes that might be necessary to achieve this.

### 4.4.4 Defining the Audit Group

Defining the correct audit group is important for many reasons. Every element of the audit is influenced by the perception and understanding of the auditee, especially if the audit is based on qualitative rather than quantitative measures. By selecting groups with approximately the same level of perceptions, knowledge, hierarchical position and influence on the innovation process, a representative data sample may be obtained.

One possible method for choosing a representative audit group or groups may be by studying the organisational structure. Through this structure various groups with similar competencies may be identified. It is also a good idea to work in conjunction with senior management to identify the various groups.

The different audit groups may be selected to represent the different hierarchical levels within the organisation. They may also be selected by vocation. Or they may be grouped into *invent*, *realise*, and *implementation* groups as discussed in 'the proposed innovation model', in chapter 3.

Grouping the organisation before auditing is important yet a large group audit, which covers virtually every employee, may not be such a bad idea. The questionnaires received from such an audit may be sorted into groups afterwards. However, this generalises the audit and applied explanations of questions are impossible in these situations.

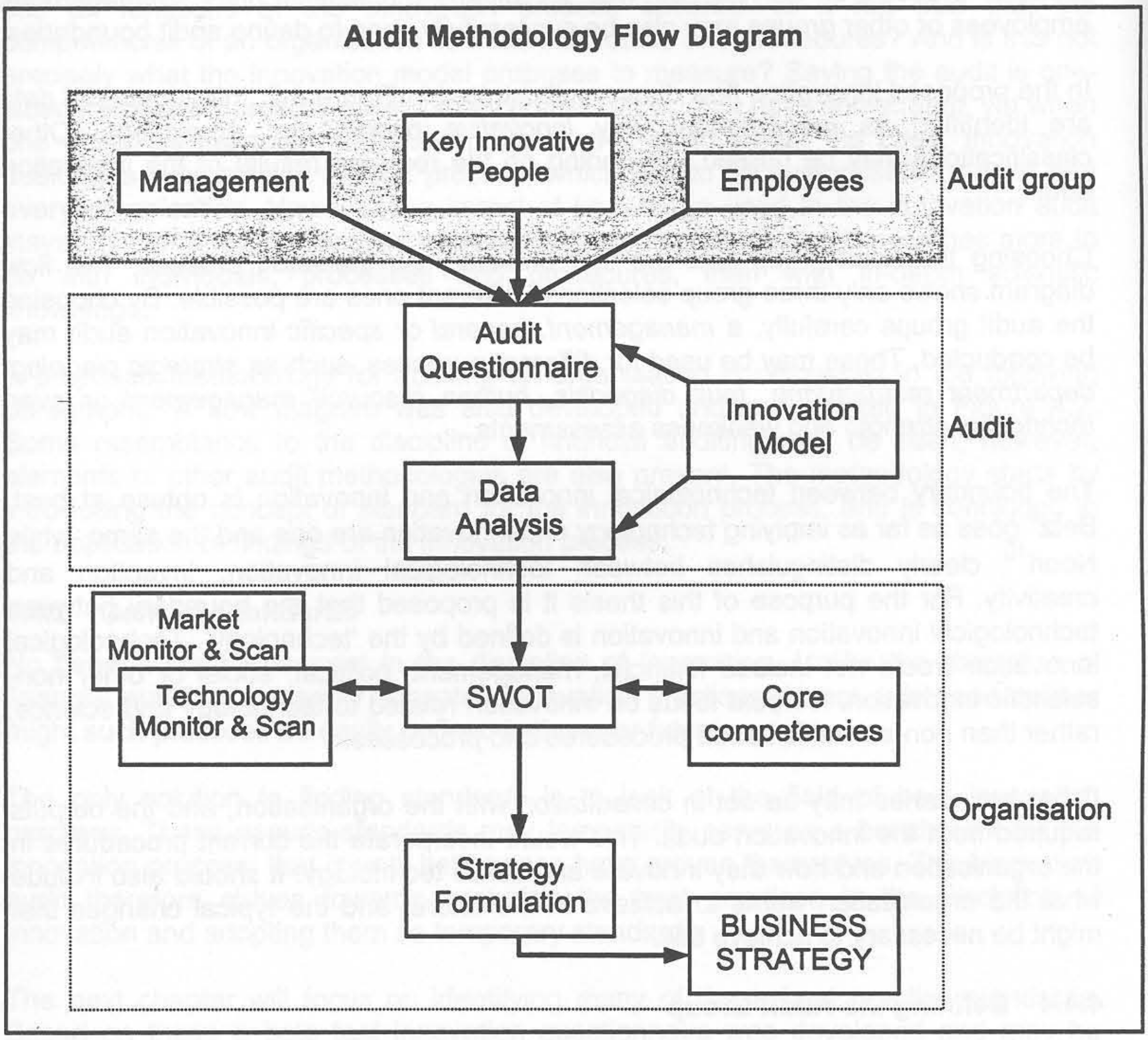


*Figure 4.2:Proposed Audit Methodology Flow Diagram*

The advantage of smaller and better-focused audit groups lie in the applied advice and explanations the auditor may give at the audit occasion. This facilitates understanding and reduces the possibility of ruined audit questionnaires.

The number of employees in a group becomes significant if an individual is able to influence the results significantly. The ideal would be to ensure that at least ten participants complete the audit questionnaires. However, this is often difficult when smaller organisations are audited, or when a group, representing top management, completes the questionnaire. In these instances care should be taken to discuss and explain each question in the audit questionnaire, thereby reducing the chance for misinterpretation and distortion of the answers.

Without due care and consideration, the audit groups may severely influence the innovation audit process. Direct consultation with the groups is advantageous, but not essential. The audit groups have to be chosen in accordance with the results required from the organisation, be they strategic, disciplinary or elementary.

### 4.4.5 The Audit Questionnaire

The questionnaire forms the front end of the innovation audit. By using the questionnaire, responses to issues on innovation may be gathered from an audit group. Through the use of a questionnaire, a large amount of data may be gathered. When analysed, this data would represent the organisation's abilities relative to best practises in innovation.

The proposed audit questionnaire developed in this thesis was compiled from the 'proposed innovation model' as developed in chapter 3. Other literature on innovation case studies, models and management methodologies, was also used in the compilation of the questionnaire. The innovation audit is therefore an extension of the innovation model.

The questionnaire consists of three sections, which each consists of three to four subsections. The sub-sections contain the questions. Each sub-section contains five questions. In all there are 50 questions. The questionnaire is included in the addendum and may be consulted there.

The questions take the form of asking a question on a single subject, and then proposes four separate answers. The answers are arranged from best to worst. However, there are no correct or incorrect answers, for the questions form part of a measurement tool and not a prescription tool. By supplying the audit group with four possible answers per question, their responses may be measured more formally. This improves the data analysis process as well.

Each person identified in the audit group, receives an audit questionnaire and is asked to select one of four answers for each question. These are later calibrated as part of the analysis process.

### 4.4.6 Data Analysis

In analysing the data, the four proposed answers for each of the questions are numbered from one to four, with one being the worst possible answer, and four being the most ideal. The chosen answers are then individually entered into a database for further analysis. If groups were defined beforehand, the data should be kept in this format.

At this stage the data of each questionnaire is still treated individually. However, by summing and unitising the answers of the individual questionnaires, a representative answer of the total audit group may be found. With this step, the many audit questionnaires are combined into one, which represents the total audit group. This may be done with the whole audit group or with groups identified inside the bigger audit group. A management sub-group may be one ideal group to keep apart.

This formatted data from the audit questionnaire may be analysed and presented in different ways. High-level organisation strengths or weaknesses may be presented as trend lines, bar charts or other graphical images, while specific weaknesses may be highlighted by comparison with 'best in category' results.

The data may be formatted into **individual, sub-sectional,** and **sectional** sectors.

**Individual**
Each of the questions in the innovation audit questionnaire addresses a part of the innovation process, and therefore indicates a particular strength or weakness. These may be analysed in conjunction with the other questions or individually.

Commonly the individual answers would be analysed after the key strengths and weaknesses have been identified in the sub-sectional and sectional sectors. When reasons for strengths or weaknesses are required, the individual questions may be analysed.

In analysis, if a particular answer was to diverge greatly from the others, misunderstanding, ignorance, or impatience in the audit group may have been the cause. These individual questions should be discussed with management and a decision on their place in the audit made.

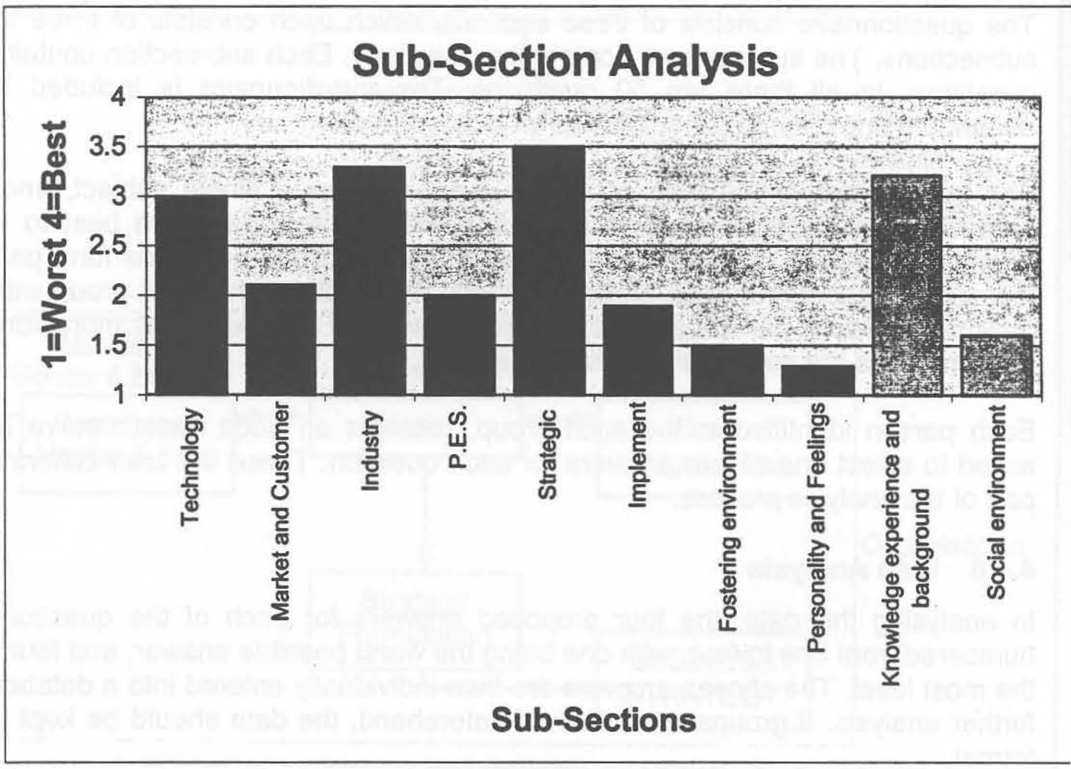


*Figure 4.3: Example of Sub-Section Analysis Results*

It is not sensible to represent each question on a chart. The sub-sectional and sectional analysis do however lean themselves to bar chart representation.

**Sub-sectional**
Each of the sub-sections addresses a part of the three innovation model sections, namely *environmental, organisational,* and *individual* as discussed in chapter 3. As such they represent key areas where focus is necessary in the innovation process.

After the section analysis process has identified a poor section, examining sub-sectional results will indicate which of them influenced the section the worst. When a sub-section has been identified, plans and procedures may be implemented, to improve the section as a whole. By looking at individual questions in the sub-section, the detail problem areas may be identified.

**Sectional**
Formatting the data into sectional areas of strengths and weaknesses may offer a holistic view of the innovation process. This data may be used effectively in strategizing the development of the *environmental*, *organisational*, and *individual* areas of the innovation process.

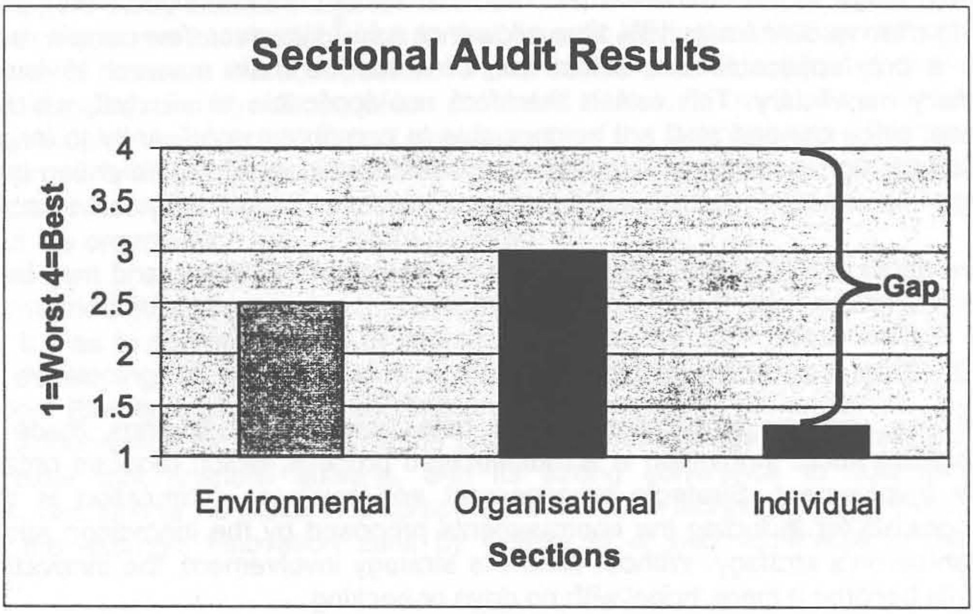


*Figure 4.4: Example of Sectional Analysis Results*

The three sections discussed above represent the findings of the innovation audit in a graphical way. By measuring the relations between the bars, organisations are able to focus on improving the weaknesses. The 'gap' between the top of the charts and the best possible score, may be used in defining the growth possibilities in innovation for the organisation, as illustrated in Figure 4.4. Through identification of strengths and weaknesses, as well as growth potential, the innovation audit results represent a valuable tool to top management. It offers them a holistic view of the current innovative competencies in the organisation, as well as identifying where improvements may be required. Offering a plan for improvement may ultimately reduce the amount of mystique surrounding innovation, and actually improve the organisations' abilities.

> *Auditing goes beyond measuring: it builds on this to identify gaps between current and desired performance, to identify where there are problems and needs, and to provide information that can be used in developing action plans to improve performance*
>
> — Chiesa *et al*[11]

The audit data may also form a benchmark for future innovation competence audits. By implementing an innovation audit in a yearly fashion, the previous data may calibrate the amount of change over the past year. Improving the ability of top managers to understand the current and future of the discipline of innovation within their organisations.

### 4.4.7 Strengths, Weaknesses, Threats and Opportunities (SWOT)

SWOT-analysis is often used in organisational analysis and strategy formulation. By integrating the results from the innovation audit with this analysis, advantages of understanding and familiarity may be gained. The SWOT-analysis methodology may also contribute to the credence of the innovation audit findings.

Care should be taken to implement findings from the audit throughout the whole organisation. Many of the competencies addressed by the audit, are specific to a certain stage of the innovation process, and should not be implemented randomly. 3M is often quoted for its 15% time allowance rule.[8] However, few people realise this rule is only applicable to a select few, of which the main research division is the primary beneficiary. This rule is therefore not applicable to all staff, which makes sense, since general staff are seldom able to contribute significantly to innovations, based on high technology. Organisations should be wary of implementing innovation proposals without strategic consideration of where they might be most valuable.

More detail of SWOT-analysis is beside the theme of this thesis and may be studied at a later stage.

### 4.4.8 Business Strategy Formulation

Business strategy formulation should take note of the findings made by the innovation audit. Innovation is a multi-faceted process, which requires organisation wide involvement. Strategic management and business formulation is therefore responsible for including the improvements proposed by the innovation audit in the organisation's strategy. Without business strategy involvement, the innovation audit results become a mere 'hope' with no drive or backing

### 4.4.9 Advantages and Disadvantages of the Proposed Audit

The proposed competence audit for technological innovation is able to identify strengths and weaknesses of the innovation environment within the organisation, and represent these strengths and weaknesses in such a manner that action may be taken.

It is also capable of improving the understanding of the innovation process and culture inside the organisation, improving management decisions and strategy formulation. This is possibly the greatest advantage held by an innovation audit. It being a source of knowledge on the competencies of the work force, to reach certain goals, and their ability to innovate.

However, the audit is not suitable for identifying quantitative measures of the innovation process. It is based on qualitative factors of the organisation, such as *perceptions, competencies, cultures, leadership,* and *interaction*. To identify quantitative measures of the innovation process, another type of innovation audit will have to be developed. However, due to the qualitative nature of innovation, such an audit may prove to be difficult to implement in practise.

Due to the nature of innovation, no standards are available. The audit makes use of best practises for standards and in this lie the audit methodology's predicament. Identifying the 'correct' and 'best', best practises can become the number one activity in developing an innovation audit, reducing the significance of a formal methodology. For if the best practise standards are correct, almost any methodology will do. However, if the best practise standards were actually not best practises, the best audit methodology in the world would not help.

Since the audit methodology has yet to be thoroughly tested in practise, further advantages and disadvantages is difficult to define. Chapter six will discuss a beta-test of the audit questionnaire, and may be able to identify some implementation problems.

## 4.5 Conclusion

There are many ways of improving the innovative competence of an organisation. Often managers study literature and research articles on entrepreneurship, creativity and culture to address the shortcomings in their specific environment. Even though a large volume of literature exists, it does not mean the literature is applicable or even correct for applying to a specific problem. As stated before, innovation is a 'holistic' business principle, meaning that almost every aspect of the business can influence it, and to improve it, the whole business has to change. Better practises in managing innovation and incorporating it into a holistic approach towards strategy development throughout the organisation are therefore required.

The audit methodology proposed in this chapter does not claim to be the best nor the only one. It tries to define an order of implementation to the audit questionnaire, as well as developing a holistic concept of the innovation process, within the organisation. Elements of financial auditing and one example of an innovation audit, serve as a foundation for constructing the proposed methodology framework. But it became clear that financial auditing, and its strong adherence to quantitative measures, has little or no place in a competence audit for technological innovation. However the example innovation audit by Chiesa *et al* was applicable in many instances.

Innovation auditing is based on best practises, and therefore variable in nature. Measuring the organisation's competencies against these best practise standards, are unfortunately the best available option, although it may never be perfect. Therefore the identification of the correct standards, play the most important part in developing an innovation audit; resulting in different audit methodologies, being able to do the job. In consequence, diminishing the development of a formal innovation audit methodology.

The next chapter will discuss the best of breed standards, used in developing the innovation audit questionnaire. As mentioned above, these standards are crucial for developing a valid innovation audit and were therefore studied in detail.

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# DEFINING BEST INNOVATION PRACTISES



## 5 Defining Best Innovation Practises

Defining 'best practise standards' for successful innovation is not a trivial task. This chapter aims to present a non-exhaustive, but high-impact proposal to the best practises in innovation. The secondary aim is to provide a backdrop for the innovation audit questionnaire developed for use in a competence audit for technological innovation. The beta test version of the questionnaire is included in Appendix C.

The chapter takes its structure from the innovation model developed in a previous chapter. By keeping the model close at hand for easy referral, aspects of the model may also become clearer.

The external environment to the organisation is discussed first since it is often one of the more generic areas of innovation. The four areas, which form a part of the external environment, may be identified as **Technology, Market and Customer, Industry** and **Political, Economical and Social.**

The second part of the 'best practises' in innovation focuses on business structures and resources of the organisation. By examining the heart of the organisation, including its structures, resources and leadership, one might form an opinion on the organisation's innovation fostering nature. The 'best practise' section on the organisation may be divided into **Strategic, Implementation** and **Fostering Environment.**

Thirdly, the individual, an often unmentioned part of the innovation process is examined and highlighted for best innovation practises or competencies. Innovation will not happen without human involvement and their knowledge, competencies, products. The lesson of not just buying but further development is clear, as portrayed by current eastern countries increasingly developing their own technologies.

In auditing technology as part of the innovation process, the key aspects relating to its building function, must be identified. As initiator of typically *radical* or technology *push* innovation, technology is seen as the cornerstone for new development in a particular field. As such, the content and implementability of technology, has grave consequences for the time span of a new innovation's development. A rule of thumb indicates that innovations with more than two breakthrough technologies are more likely to fail than succeed, helping managers to choose between different proposals. As such, the readiness of technology, according to dynamics of technological change, influences the outcome of most innovations.

#### 5.1.1.1 Dynamics of Technological Change

Technological innovation takes time to diffuse into the market, especially when radical or poorly understood technology is being implemented. For example the basic oxygen steel making process took twenty years to get to the 90% implementation point in the United States. Earlier processes took even longer. Other technologies do however penetrate markets faster. Television for instance took only 10 years to penetrate the market in excess of 90%.[1]

A major task in the management of technology, is the understanding and description of the possible diffusion period of a new technology. When addressing the rate of technology adoption by the market, two elements may define the field: the *extent of use* and the *time*.

> That is, the *extent* of technology in use as a function of the *time*.[1]

To employ these two elements some definition of terms is required. A description of the diffusion of technology should start with the following:

- A definition of the technology
- A specification of the population or its proxy within which the technology diffuses
- A choice of a parameter which measures the extent of diffusion

By defining these aspects of the diffusion process, initial values are obtained for use as a foundation in future analysis.

To illustrate diffusion of technology, several models have been developed over the years. The 'S'-curve evolutionary model has found the most acclaim and is widely used in the forecasting of diffusion and substitution of technology.[2] As shown in chapter three the 'S'-curve may be used to forecast several different processes, of which technology diffusion is one.

The importance of technological adoption and diffusion can be astronomical for the innovation process.

> Firstly technological innovation requires a source of available technologies for instant inclusion into products or processes.

> Secondly if diffusion of technology and innovation into the marketplace is slow, large amounts of investment capital is needed to finance the product

and marketing campaign, often resulting in other innovators passing the initial highly indebted innovator.

Thirdly if diffusion is too slow, next generation products, often better and more suitable to the market, cannot be developed for a lack of funds and other funding institutions' interest.

For these reasons, technological innovation may often be a process where large amounts of resources are needed. To compete, companies need large resource piles and an ever-present vigil in the innovation environment. Others, without the resource availability, have to produce products under license and often renounce innovation to the struggle for survival.

#### 5.1.1.2 Key Technologies

Organisations implement corporate strategies in order to ensure long term growth and survival. Generally the focus falls on products and the supply thereof to current and future customers. Technology and innovation seldom feature as prominently in strategic planning as they should, often with far reaching effects. One reason for not including technology or innovation into the strategy might be because the returns on investment on technologies and innovations are often difficult to calculate. To remedy this, key technologies, in the same manner as core competencies, have to be identified and classified. For the purpose of this identification and classification, a technology *balance sheet* might be used as proposed by De Wet.[3]

The process starts by developing a framework for the product market interaction. The matrix morphology, as shown below, contains the different markets where the organisation's products find their application. This presents a clear picture to the management of the company.

**Market Matrix**

| Markets \ Products | P1 | P2 | P3 | P4 |
|---|---|---|---|---|
| M1 | X | | | X |
| M2 | | X | X | |
| M3 | X | X | | X |
| M4 | | X | X | |

*Figure 5.1: Market Matrix, Source: De Wet*[3]

Additional information such as *market share, market sizes, market dynamics, product maturity* and *competitor behaviour,* should be used in conjunction with the matrix. This immediately indicates 'where we are', 'where to go' and 'when to get out' clearly.

When technology and process information are added to the matrix, a more detailed explanation of organisational status is reflected. It is here that *key technologies* need to be judged and entered into the organisational framework.

**Technology Balance Sheet**

| Key Technologies: T1 | T2 | T3 | T4 | Markets / Processes | Products: P1 | P2 | P3 | P4 |
|---|---|---|---|---|---|---|---|---|
| | | | | M1 | X | | | X |
| | | | | M2 | | X | X | |
| | | | | M3 | X | X | | X |
| | | | | M4 | | X | X | |
| X | | | X | PR1 | X | X | | X |
| | | X | X | PR2 | X | | | |
| | X | | | PR3 | X | X | X | |
| | | X | | PR4 | | X | | X |

*Figure 5.2: Technology Balance Sheet, Source: De Wet*[3]

Key technologies are defined as those capabilities in the form of *information, methods, artefacts* or other, enabling the organisation to execute individual processes. And similarly the processes are defined as the 'value addition activities' in the organisation, capable of producing products or services. This 'technology balance sheet' integrates key technologies with market sectors, illustrating the current position of the organisation clearly. An example may be observed in Figure 5.2.

Organisations build their products on core competencies as well as key technologies. Without a good knowledge of these technologies and how to effectively utilise them, organisations will seldom reach the desired focus to stay ahead of competition. Only by identifying internal, as well as external key technologies, and pursuing those to the ultimate, can organisations stay innovative.

### 5.1.1.3 Predicting Future Technologies

*The future was predictable but hardly anybody predicted it.*

— Allan Kay [Apple]

Technology is never only about the here and now, but mostly about the future. Technological forecasting has in recent times won back its appeal, since the time it was developed. Managers do however now realise that forecasting is not the alpha and omega and apply it therefore only as a guide.

Five of the more common methods used in technology forecasting includes *monitoring, expert opinion, trend extrapolation, technology trajectories*, and *scenario analysis*. Some of their characteristics will be discussed below.

**Monitoring**

*Monitoring is to watch, observe, check and keep up with developments, usually in a well-defined area of interest*

— Coates *et al*[4]

Patent monitoring and scanning is one of the common technological forecasting techniques used. Others areas which may be consulted include published sources such as annual company reports, articles and press, various journals, various databases, symposium and conference proceedings, and many more. Unpublished sources such as trade shows, exhibitions, tours or conferences as well as industry contacts or friends may yield valuable information as well.[5]

Ashton *et al*[6] define the steps of monitoring as:

- Define user needs
- Prepare a monitoring plan,
- Acquire source materials,
- Analyse results,
- Disseminate monitoring products,
- Review monitoring performance.

As example a patent analysis process may be discussed:

> The advantage of studying different patents is the detailed information they contain. Many different inventions and innovative companies may be studied through the patent office, hence its popularity in the field of competitive intelligence gathering. By statistically analysing large numbers of these patents, broad patterns or trends that may be significant to the development of new technology paradigms may be identified.
>
> As technological indicators, patent databases represent some of the more direct sources of information. Other indicators such as organisational R&D expenditure, number of scientist or engineers and number of scientific papers and technical publications, may be used for competitive intelligence analysis as well. These are not used so often, yet they represent a fair source of information on new technology. Despite some shortcomings to patent scanning, by examining R&D expenditures as well as patents in a particular industry, economic benefits of technology developments may be statistically proved,[7] making patent searches a worthwhile forecasting technique.
>
> Different outputs from patent analysis can be utilised in technology forecasting. Patents can provide insight into an organisation's strategies for exploiting technologies internationally. This information can then be used to make judgements about the economic potential of an individual organisation's inventions. Since patent protection in many countries is expensive, the more countries in which protection is sought, the higher the economic potential of the patent and technology.

Patent analysis is by no means the only method used in monitoring and scanning. Monitoring and scanning does however play an important part in the discipline of technology management and the assessment of threats and opportunities, requiring the implementation of all relevant methods and sources.

**Expert opinion**

Expert opinion is often used in the field of technology forecasting. Institutions such as the IPTS (The Institute for Prospective Technological Studies), focus on providing relevant technological forecasting information, in this way acting as an expert in many fields. Experts may often offer insights easily overlooked by technological monitoring and scanning, for they know their field intimately and can make deductions on the importance of different technologies.

**Scenarios**
Scenario planning and development is a key component to strategic planning. It is often coupled with technology, because of the impact technology has on the future. Technological intensive organisations often construct complex technological development scenarios to improve their planning for the future. Examples include Motorola, NEC, Intel and many others. Figure 5.3 illustrates an example from NEC.

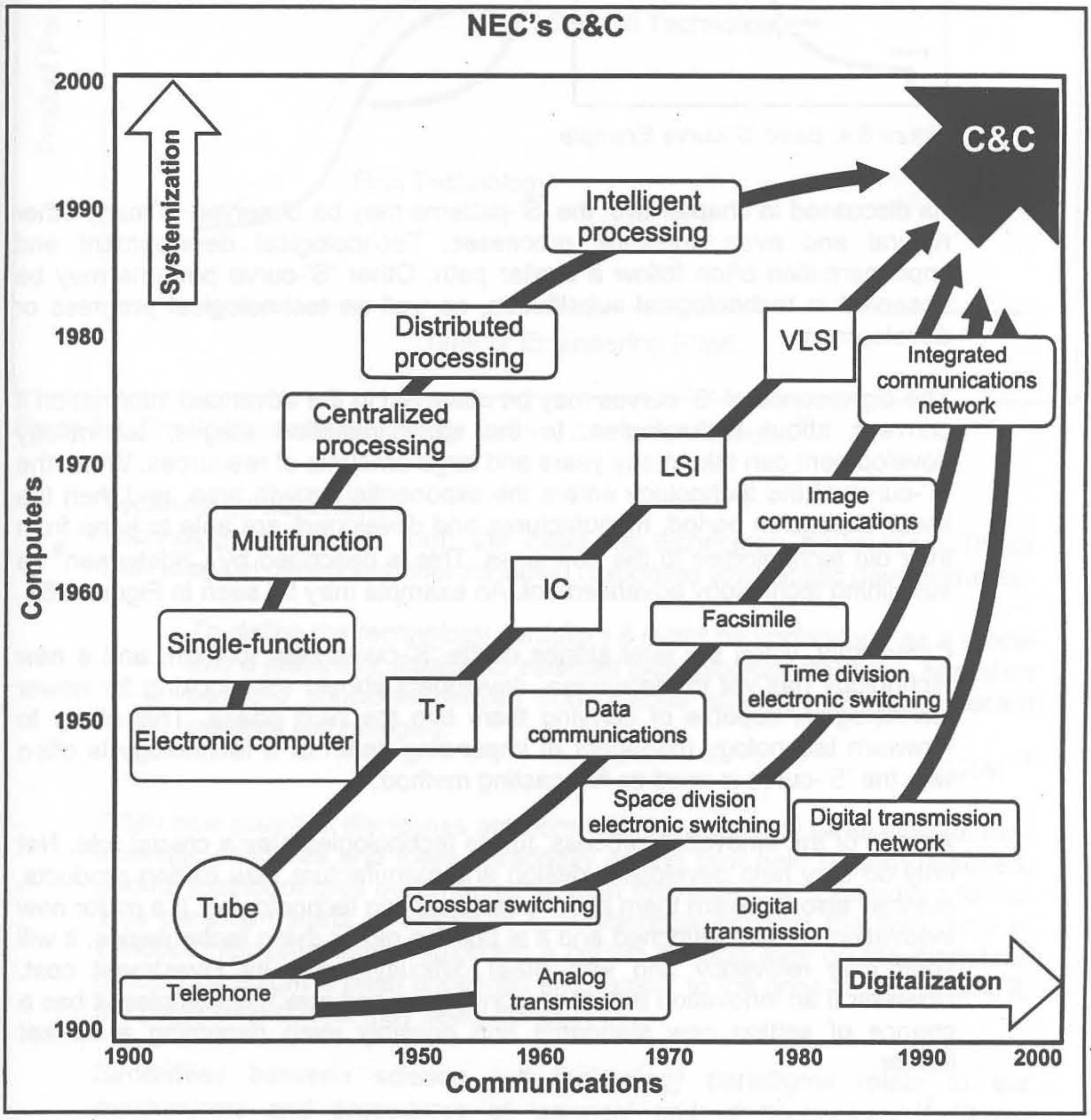


*Figure 5.3: NEC's C&C,. Source: Koji Kobayashi*[8]

With the help of future scenarios as shown above, organisations may lead into the future instead of passively waiting for the future to happen to them.

**Trend extrapolation**

'S'-curve analysis forms one of the corner stones in technology trend analysis. This technique is based on mathematical analysis of technology development and the correlation it seems to have with natural growth patterns. Figure 5.4 illustrates the principle.

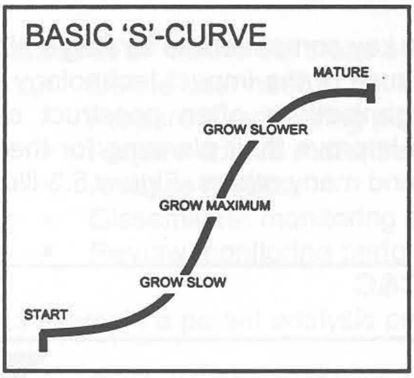


*Figure 5.4: Basic 'S'-curve Example*

As discussed in chapter two, the 'S'-patterns may be observed in many other natural and even unnatural processes. Technological development and implementation often follow a similar path. Other 'S'-curve patterns may be observed in technological substitution, as well as technological progress or development.

The significance of 'S'-curves may be observed in the advanced information it conveys about technologies. In the early inception stages, technology development can take many years and large amounts of resources. When the 'S'-curve of the technology enters the exponential growth area, and then the linear expansion period, manufactures and developers are able to jump from their old technologies to the new ones. This is described by Christensen[9] as sustaining technology advancement. An example may be seen in Figure 5.5.

Conversely, when the later stages of the 'S'-curve start to form, and a new technology has yet to materialise, developers should start looking for newer technologies, capable of carrying them into the next phase. This ability to forewarn technology managers of impending death of a technology is often why the 'S'-curve is used as forecasting method.

As part of the innovation process, future technologies play a crucial role. Not only do they help developers design and manufacture new exiting products, but they also forewarn them about possible dying technologies. If a major new innovation is to be launched and it is built on old or dying technologies, it will soon lose relevancy and with great difficulty repay its investment cost. However if an innovation is built on converging and new technologies, it has a chance of setting new standards and possibly even becoming a market leader.

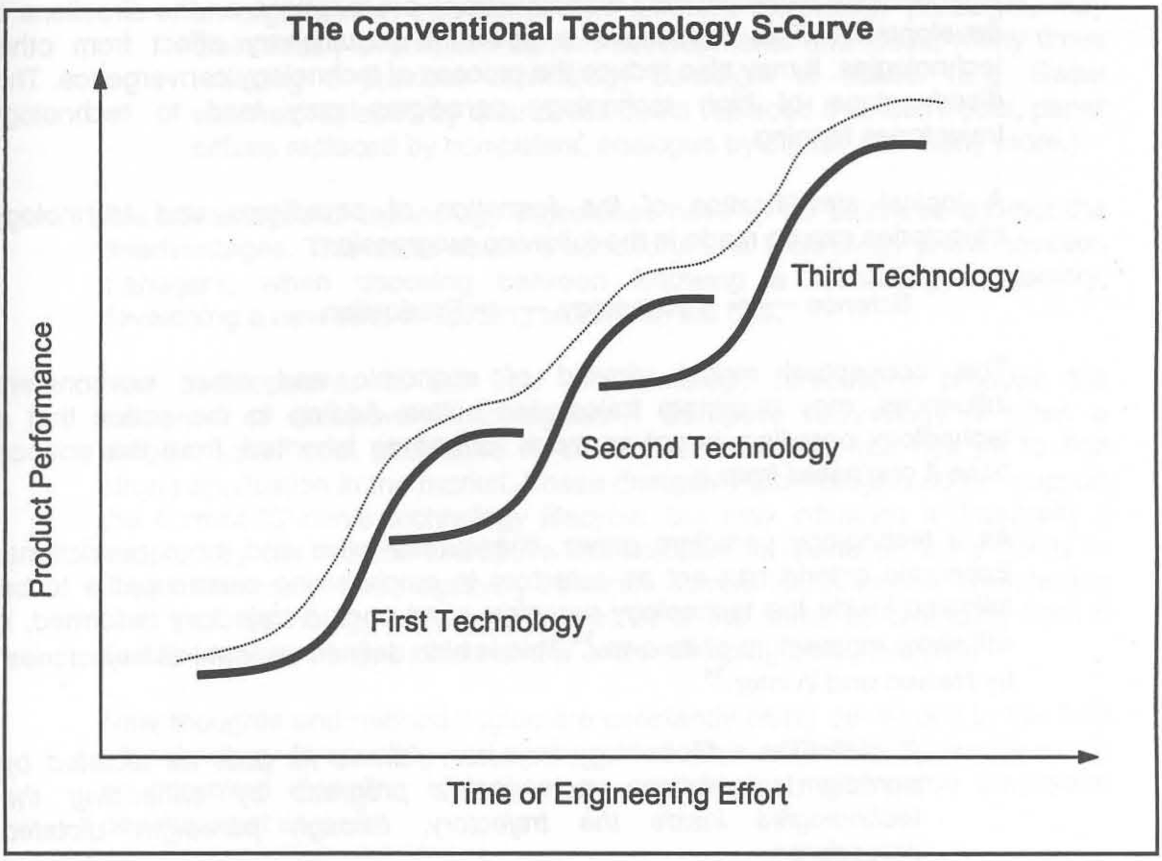


*Figure 5.5: The Conventional Technology S-curve, Source: Christensen*[10]

**Technology trajectories**

Technology paradigms form the basis for technology trajectories. These technological paradigms offer intriguing responses to scientific developments.

> *To define the technology paradigm it might be understood as a model and a pattern of solution of selected technological problems, based on selected principles derived from natural sciences and on selected material technologies.*
>
> — Dosi [11]

Often new scientific disciplines are born with the discovery or analysis of new scientific principles and ideas. Gradually as the new field is acknowledged, and its methodologies become ingrained in the discipline, a paradigm forms. This paradigm starts to dictate to new scientists entering the field, how to conduct their procedures, enforcing a certain methodology on the discipline. Since a paradigm is often undefined and 'logical' to the ones trapped inside it, the previous proposal may seem harsh.

Similarities between science and technology paradigms relate to the mechanisms and procedures of 'science' and of 'technology'.[12] These paradigms often lock the fields of study or research into particular directions, procedures, methods and ideas. Many new technologies are born in science laboratories, and it is important that the science paradigm present in the laboratory does not instil its limitations on the new technology.

A technology paradigm may embody strong prescriptions on the directions of development. This may have a powerful exclusionary effect from other technologies. It may also reduce the process of technology convergence. This disadvantage of high technology paradigms may lead to technology trajectories forming.

A logical simplification of the formation of paradigms and technology trajectories can be made in the following progression:

Science → Technology → Production

This conceptual model, devoid of economic and other environment influences, may illuminate trajectories better. Adding to the notion that a technology paradigm is not so much formed as inherited, from the science base it originated from.

As a technology paradigm grows, it assumes more and more restrictions. Economic criteria can act as selectors in emphasising certain paths to be followed inside the technology paradigm. And once a trajectory is formed, it will show momentum of its own.[13] This is also defined as 'natural trajectories' by Nelson and Winter.[14]

> *In definition a technology trajectory follows its path as dictated by paradigm restrictions, and shows progress by enhancing the technologies inside the trajectory, through paradigm dictated procedures.*
>
> — Nelson and Winter [14]

A technology paradigm may contain numerous restrictive variables. The following ones are some of the more common:

- Economic, institutional and social factors
- Technological history, fields of expertise
- Institutions specific variables such as public agencies, military and others
- Cost or labour saving capabilities
- Economically defined 'needs' from suppliers or customers

These are but a few, since most variables will have some effect on the paradigm, whether discarded or incorporated as restrictions.

As part of the innovation process, technology paradigms and trajectories influence the innovation process *positively* or *negatively*.

> The *positive* contribution is towards keeping 'noise' (useless information) limited and therefore enhancing development and project completion time. Another advantage is the specialisation inside a technology trajectory, which enhances products and new ideas in many ways.
>
> On the *negative* side, innovation is supposed to be about developing 'new' products or processes and can never be truly new if contained in a bound environment, no matter how diverse. Secondly by innovating inside a technology trajectory, the chance of outside intervention from

an organisation in a completely different technology paradigm, may disastrously overwhelm current developments and ideas; many times reducing a previous technology paradigm to ashes. (E.g. Swiss watches replaced by quartz, sail boats replaced by steamboats, paper offices replaced by computers, analogue by digital, and many more.)

The advantages of technology trajectories have to be balanced against the disadvantages. This could create a conundrum for technology and innovation managers, when choosing between following a technology trajectory, developing a new one, or splitting of from an old one.

New developments in the field of technology forecasting propose the existence of disruptive technologies. A disruptive technology is often a simpler, lower cost alternative to current technologies, but has jet to find strong application in the market. These disruptive technologies do not support the current 'S'-curve technology lifecycle, but may influence it drastically if adopted by the market. Disruptive technologies have the uncanny ability to 'break the mould' and negatively influence current technologies. Transferring from one technology paradigm to another is the same as changing from a sustaining technology path, to a new and developing disruptive one.

New thoughts and methodologies are constantly being developed in the field of technology forecasting and extrapolation. This will hopefully lead towards an improved discipline of technology management, and better innovation development as well.

#### 5.1.1.4 Conclusion to Technology

Technology plays an important role in the total process of innovation, from ensuring the correct technology is available, to manufacturing a part, to providing personal computers to type the documentation for product support. Yet, even organisations with the best and most up to date technology will not automatically be able to innovate. Too many other external and internal factors influence the innovation process, one of which includes the product market. Without a strong market even the best and most creative organisation may flounder, yet the market more often than not commands the bottom line.

The following section will look at the *customer* and *market* and their influence on innovation. The importance of good market interaction will be highlighted.

### 5.1.2 Market and Customer

Customer relationships are increasingly becoming more important in marketing, as well as in the whole innovation process. The ability to build meaningful customer relationships will enable organisations to interact and gain valuable knowledge from customers, with the aim of improving new product development. In both innovation and marketing there is no substitute for understanding and knowing the customer[15].

However, not every customer wants or is prepared to build a long-term relationship with the developer. Many customers may provide one-time only sales-opportunities, representing a field of information where little emphasis is currently placed. Transactional efficiency and one time customer satisfaction, could become a large component of marketing, as global marketing strategies impact on once remote market sectors. In the field of innovation, better monitoring and information gathering techniques will have to be developed to compensate.

To better understand and identify the best innovation practises in marketing, the implications of the market may be discussed under subjects such as purchase and *consumption behaviour, competitive environment, market trends* and others. These are discussed below.

### 5.1.2.1 Purchase and Consumption Behaviour

Strong marketing capabilities are based on an intimate understanding of purchase and consumption behaviour. Managing the purchase and consumption environment requires careful analysis of consumer characteristics and behavioural trends, as well as the social influences and environmental factors that influence behaviour. In the era of communication and global marketing, these characteristics and trends need to be understood on local, regional and global level.

Two types of decisions are required from customers, namely: *extended problem solving*, and *limited problem solving*. Since technological innovation often results in complex products, an extended problem solving decision is often required.

> Extended problem solving has a great deal to do with the perceived risk. When buying a computer for instance, there might be a risk involved with buying the wrong one. The difference between Apple and IBM for instance is great, and factors such as compatibility and future product support, play an important role. When the importance of unseen issues is high, customers need more information when making a decision on the worth of a product. A customer is 'said to be involved' if a particular product is important enough to warrant further investigation.

The importance of understanding the needs and requirements of the future market is important to every organisation. Purchase and consumption behaviour forms one of the keys towards understanding one's market, and its associated dynamics.

### 5.1.2.2 Competitive Environment

Competitive intelligence is often accompanied with thoughts of secrecy and espionage, yet most successful organisations use 'clean' competitive intelligence. There is seldom the need for crime in the information environment, if well-managed gathering and analysis are in the order of the day. Through patent information and direct or indirect signals, competitors may be monitored. This often provides early warning of new products or radical breakthroughs.

By methodically collecting and sorting key pieces of information, excellent competitive intelligence may be gathered and stored. This information can and does improve strategic decision making, as well as new product development. More discussion on competitor analysis will follow in section 5.1.3 on industry analysis.

### 5.1.2.3 Future Market Trends Foresight

Current market literature focuses on existing markets and how to serve them best. Through *segmentation analysis, industry structure analysis* and *value chain analysis*, marketing departments try to gain competitive advantage for their organisation's products. However, how does one analyse a market that does not yet exist? This is often one of the predicaments when introducing a new technological innovation into the market. Within an established market, most of the rules for competition have already been set, yet in emerging areas the rules are waiting to be set.

Managers and organisations focus a lot of attention on the problem of getting and keeping market share. Many believe market share is the primary criterion for measuring the strength of a business' strategic position.

From an innovation perspective the following questions arise:

- How does one calculate the meaning of market share in markets that barely exist?
- Can business maximise market share in an industry where the product or service is undefined, customer segments have yet to solidify, and customer preferences are still poorly understood?

> *'Competition for the future is competition for opportunity share, rather than market share'. The question that therefore must be answered is, given our current skills or competencies, what share of future opportunities are we likely to capture? Which in itself leads to others: Which new competencies do we need to build to reach or capture more opportunities in the future, and how would our served market have to change?'*
>
> — Prahalad and Hamel[16]

In the race towards the future, top managers have to be just as concerned with maximising current market share, as they are with maximising future opportunities, or as yet non-existent markets. However, few market managers are equipped to deal with radical shifts in customer behaviour or societal change, yet if Toffler[17] has anything to say about the future, it will be one of miraculous upheaval and change.

#### 5.1.2.4 Interaction

Strategic alliances can have a significant impact on organisations and their business environment. Companies with small domestic markets often find alliances with global players very lucrative. Not only can international alliance partners improve sales, they may also incorporate research, development and patents into their own products, generating valuable licence revenues.

The following three conditions as defined by Yoshino *et al*[18] have to be met in forming a strategic alliance:

- The two or more firms that unite remain independent, subsequent to the formation of the alliance.
- The partner firms in the alliance share the benefits of the alliance and performance of assigned tasks.
- The partner firms contribute on a continuing basis in one or more key strategic areas, e.g. technology, products, and so forth.

Strategic alliances are enablers of new technology development. In the initial undefined beginning of a new technology, many different approaches are necessary (start of the 'S'-curve). When alliances are formed, even between competitors, common development can be achieved. This reduces the amount of time and money necessary for developing technologies, until they become economically viable. At this point however alliances are broken and each organisation starts to compete with its own products, yet often using the same underlying technology as the previous alliance partners.

Many current alliances exist today throughout the global business environment. Through the development of technology and improvement of total value chains, these alliances are great incubators for innovation. Although alliances seldom form to develop a single product, they often generate enough technology, incentives and possibilities for new innovation that after the alliance splits up strong new products flow from the previous alliance members.

5.1.2.4.1 Market and Organisation Interaction

It would be logical to assume that with an improvement in communication technology, interaction between organisations and customers would improve. This is exactly the case in marketing and the direction of changes in this field. Marketers challenge themselves to act in a more holistic way, incorporating diverse aspects previously unconnected with the discipline. All these changes have one goal in mind, and that is better interaction between all parties.

*Interactive relational network management* can be described as improving the bonding between existing and new parts of the value chain. It is the task of the marketing department of a organisation to help every individual in the value chain network to think of every customer they serve as an individual. In this way they will improve understanding as well as better workmanship on products and services, enriching the total innovation process.

*Cross-functional activity management* involves the task of making sure everyone, no matter how small the task he or she performs, makes a valued contribution to the total success of the innovation to his/her best ability. Marketing may often be seen as a group of cross-functional activities requiring everyone to manage a sub set of the total range of marketing activities. Thereby the whole can become more than its individual parts.

*Information management* is and will play an increasingly important role in innovation as well as marketing in the future. New database software enables organisations to apply predictive models to customer data and improve market orientation. Information management technology, increasingly enable organisations to interact with their customers on a one to one basis; subsequently improving relationships as well as mutual understanding.

*Acquisition and retention management* is based on the principle that retaining customers is more profitable than attracting new ones. Keeping and teaching current customers is advantageous to innovation, once the lead user principle can be applied. Better information about new and current products can also be obtained from retained customers.

*Transaction and relationship management* does however play almost as an important part as retention of old customers. Focusing specifically on the immediate needs of the customer and disregarding the potential of him/her becoming a regular customer, will teach organisations to satisfy customers the first and only time. This trend impacts negatively on the amount of information obtained from customers and often also on innovation.

Customer interaction has an extremely important function in the technological innovation process. It is important to realise that marketing departments seldom understand direct contact between customers and engineers or innovators (as can be seen in above-mentioned marketing jargon). Innovators however receive validation and motivation from customers, as well as new ideas. In return customers are educated (about a new product or idea) to a degree, and when the innovation finally appears on the market, it is more easily accepted.

5.1.2.4.2 Market/Customer Influence (Market/customer development)

There are many environmental issues shaping customer behaviour. Individual characteristics also play a role in defining customer needs and requirements. With the aim of diffusing a new innovation into a new market, these individual and environmental issues have to be used to the innovator's advantage. Although individuals have their own individual characteristics, these are malleable and can be influenced if approached correctly or for a long enough duration of time. The most common way of influencing individuals is through the environment they live in.

Shaping the human living and working environment is fast becoming one of advertising's major purposes. Some parts of New York for instance are so plastered with advertising that the visual environment is almost totally controlled by advertisers. Besides advertising other avenues of influence exist and some of them might include *culture*, *social class*, *personal influences*, *household influences* and *situational influences*. These will be discussed below.

**Culture** plays a significant role in most populations. Common values, attitudes and meaningful symbols help individuals interpret, communicate and evaluate their worlds as members of a certain culture group. By understanding the culture in a specific market segment, its advantages and pitfalls may be identified. This in turn leads to more appropriate marketing techniques as well as total innovation processes.

**Social class** can affect the implementation of innovation in a direct way. Brand names play an important part in defining a social class and this can be exploited. By instilling a specific brand as an upper class identifier, such as Cartier, Rolex, Rolls Royce and others, ridiculous profits can be accrued. It is however extremely important to adapt the innovation process to these specific classes, since brand names will never be able to support poor quality innovation.

**Personal influences** are the most crucial when diffusing an innovation. Knowledge of specific individual characteristics in a market can often be spotted in lead users. These users are often technically inclined and know a great deal about the operation of the product. They can successfully be used for testing and evaluation purposes. By monitoring their responses, specific likes or dislikes can be identified and implemented in the final product.

**Family and household influences** have a unique area where information and decisions are sometimes left to specific individuals. When identified these individuals can prove extremely profitable. They often play a gatekeeping role of gathering information and influencing communication on proposed products. If a new innovation for toddlers is launched, the appeal should not be directed at the toddler only but the parent as well, since she/he is the one with the purchasing power.

**Situational influences** can many times result in prolonged diffusion for innovation. It may also improve the diffusion process. The South African market has seen a profusion of 4x4 vehicles in the last couple of years, and has become a test environment for new 4x4 automobile models. Due to the natural environment and the perceived requirements of the South African driver, 4x4 technology has been adopted faster and with more zeal than in many other countries. The situational influences clearly enhance the testing and introduction of new 4x4 technologies in the South African market. Other situational influence factors may include the *purchase environment* and situation, the *communication* situation, and the *usage* situation.

Advertising has major cost implications and developing a market for a new technology may often cost more than an organisation is willing to pay. First to market, or fast follower strategies, play an important role in implementing new technologies. Choosing the best one to follow may be a solution to a resource-depleted organisation. By deciding on a fast follower strategy and waiting for another organisation to spend the millions in market development, the fast follower may be able to capture market share with less resource intensive advertising campaigns. In so doing reducing the risk and cost of failure if the market does not like or appreciate the new product.

#### 5.1.2.5 Conclusion to Marketing

Many non-technology oriented managers and organisations, feel the market is the ultimate judge and source of competitive advantage. Although this viewpoint has many years of success and research behind it, one flaw exists. Markets are unable to need or ask for new things. Sure they often require improvements on current products or services, but seldom if ever do markets have the ability to define a new paradigm. For how could someone desire or need the undefined? The only true paradigm shifters are the individuals busy in the field of experimentation and discovery, for through discovery new knowledge is created which may lead to new innovation pursued.

Listening and testing the market undoubtedly improves innovators' understanding and ability to satisfy their needs. The innovation manager therefore has to ensure that the total innovation function has as much interaction with the market as possible. This does not only improve the innovation, but the understanding and worth the market assigns to the hard work done by the innovation team

### 5.1.3 Industry

Current business strategies emphasise the importance of core competencies and competitive advantage for the future survival of organisations in a globally competitive environment. These activities are said to form the heart and brain of the modern technology based organisation. This is often possible through outsourcing certain non-core functions to specialists. Alliances with other firms are thus becoming increasingly important in modern business. When managed correctly, this focus and outsource strategy may help the organisation to reduce its overheads, and improve the current capabilities. This often results in a more streamlined and competitive organisation.

In the era of take-overs and growth by acquisition, many large ungainly international organisations were established. These oligopolistic entities often grew to improve synergies between functions, thereby improving vertical integration in the industry. By acquiring businesses in the value chain, thereby shortening it, these large organisations were able to control the product from the raw materials stage, right through to sales and after service. In the early parts of the twentieth century the Ford Motor Company owned large tracts of pine plantations with the aim of using this wood in their Model-T Fords. Thus taking the methodology of vertical integration to the extreme. Today however, the difficulties in managing such a huge process have become more apparent, and few organisations are brave enough to try their hand at it.

The promise of greater profitability and synergy between disciplines are some of the reasons why vertical integration is still seen in modern organisations. But, as Peters[19] states:

*Synergy is a snare and a delusion…*

— Tom Peters

...and should therefore not be followed blindly in the hope of managing the total value chain. The easy road of growth by acquisition may often lead to death by restructuring for many or most of today's large oligopolistic firms, possibly as soon as five years[20] after they went on the acquisition spree. These firms, in the aim towards managing the total value chain, are seldom capable of managing the complex and extensive diversion of functions contained inside their new oligopolistic organisations.

It is often said that in large organisations, with every new employee being appointed, the organisation's effectivity improves with an ever-diminishing amount. While the administration and overhead costs increase with an ever-increasing amount. This leads to the logical conclusion that the smallest number of people with enough knowledge and experience to 'do the job', is also the most effective amount. It is this empirical observation that often results in small organisations stealing market share from large organisations. It surely enabled a small company like Apple (in the early days), to severely influence and steal market share from the much larger IBM Company.

In large organisations the amount of revenues lost, due to slow reaction time, and poor cultural fits between the core organisation and the newly acquired one, may lead to shedding all non-core assets and capabilities.

#### 5.1.3.1 Alliances and Industry Analysis

Industry analysis and competitive intelligence often conjure up images of romantic, sometimes dangerous and often illegal acts of espionage and spying, so clearly portrayed in films of the seventies and eighties. The fact of the matter is that an established discipline of totally legal competitive intelligence gathering exists, with strong links to most of the top 500 global companies. Not only does this discipline include competitor analysis, but other aspects such as *benchmarking*, *structural industry analysis*, *regional and governmental benefits* as well as *international advantages*.

The discipline of structural industry analysis was greatly expanded by Michel Porter and his development of the five competitive forces model.[21] This model as Figure 5.6 illustrates is the basic industry structure found in the value chain of a product, comprising the *organisation*, its *suppliers*, potential *new entrants*, *substitutes*, as well as *buyers*. These are the players capable of commanding the attractiveness of returns, differentiating the highly profitable industries from the low profit ones.

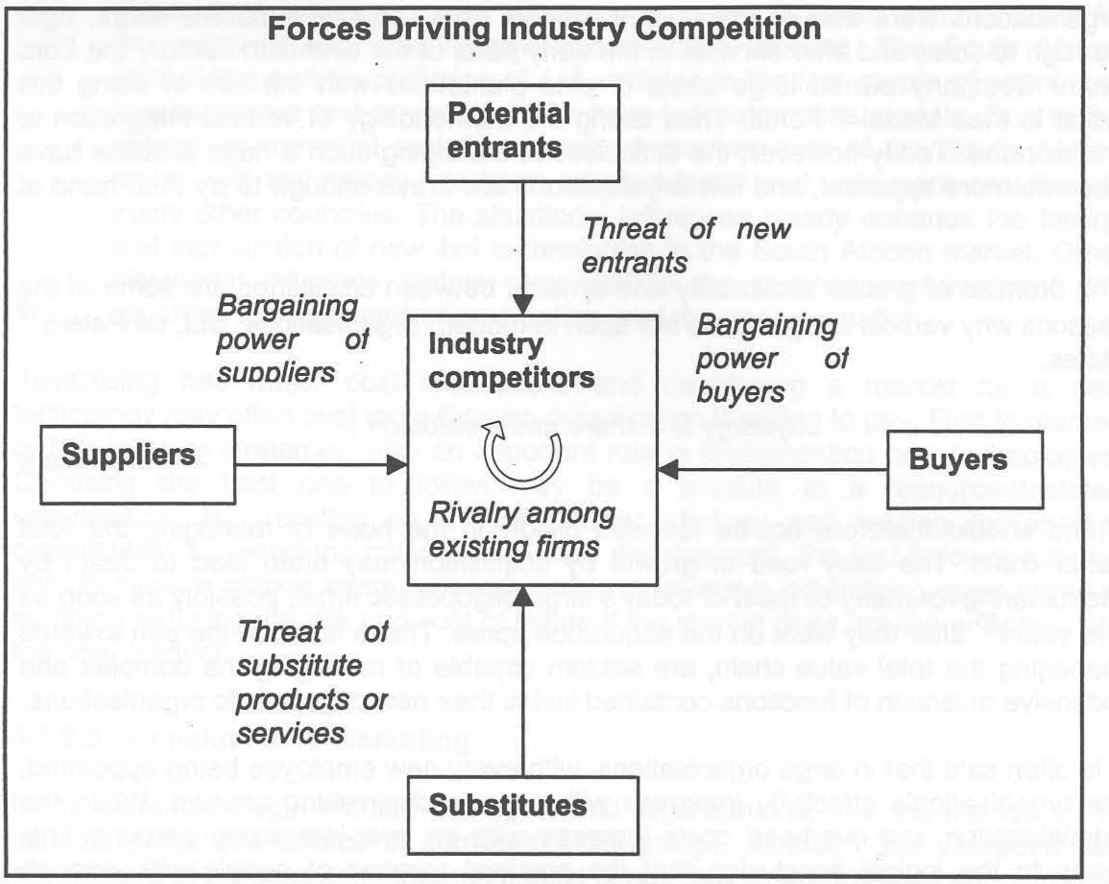


*Figure 5.6: Forces Driving Industry Competition, Source: Porter*[21]

Profitability and competitiveness may be improved, through collaboration between the organisation and its suppliers, as well as its buyers. By focussing on the supply side offering mutually beneficial advice as well as assistance, the organisation may be able to improve the service, reliability, production processes, and products received from the supplier. In turn this could improve the organisation's own position, by enabling it to shift towards better materials requirements planning options such as JIT or Kan-Ban systems.[22] For example the surge in SAP™ and Baan™ software implementation in recent times, are proof of the benefits that can be derived from strong interaction between parties in the value chain.

Strong connection between the organisation and the customer, may improve not just the amount of goods sold, but offer other advantages as well. Involving select groups of buyers in the new product development process may enhance the overall acceptability of the final product. The involvement will also improve understanding on the buyer's part of the reasons for including certain unknown attributes to the product. Concurrent engineering is one of the disciplines advocating early involvement of all relevant parties, including suppliers and buyers. If the organisation is able to influence these groups, much may be gained in the areas of competitiveness and profitability. The statement by Porter[23] holds true: 'The ultimate aim of competitive strategy is to cope with and, ideally, to change those rules *(that define the industry structure)* in the firm's favour'.

Some of the methods discussed next enable the organisation to improve as well as influence its industry environment.

#### 5.1.3.2 Benchmarking

Benchmarking is a tool for identifying 'best practises' at various companies, with the aim of adapting and implementing these towards own improvement.

Benchmarking follows a four-step approach. The Shewhart or Deming cycle[24] is the basis for this fundamental quantifying method, and consists of the following four steps:

- Plan
- Do
- Check
- Act

*The first step* includes planning the benchmarking study, defining the necessary processes, as well as the measures of process performance. Additionally the organisation's ability at their own processes, and the companies that the study will use as a benchmark, should be identified. This is illustrated in Figure 5.7.

Questions such as 'What should we benchmark?' and 'Whom should we benchmark?' form the basis of the first step.

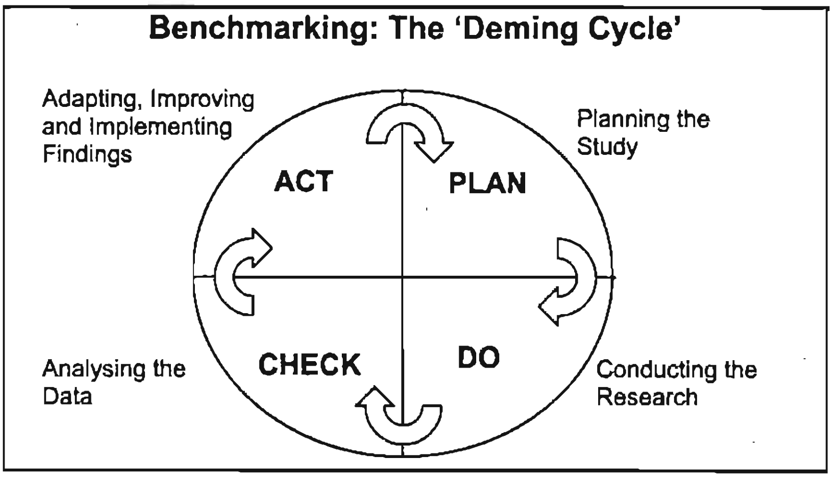


*Figure 5.7: The Deming Cycle, Source: Watson*[25]

*Step two* consists of the primary research, which includes investigating public disclosures about the particular processes of the target companies. It is important to learn as much as possible, before making direct contact with the target organisations, since many are unaware of what has been written about them in the press and trade publications. When direct contact is made, it can be in the form of telephone, written or site visits to make detailed observations.

*The third step* in the cycle is the process of analysing the gathered data, and determining the studies findings and recommendations. The analysis consists of two processes. Determining the discrepancy between the companies, by using the metrics as defined by the planning stage, and identifying the processes that facilitated the performance improvements at the leading companies, which formed part of the benchmark.

*The last step* in benchmarking involves the improvement, adaptation and implementation of the appropriate benchmark enablers. With the aim of changing an organisation, benchmarking has a built-in bias for action. It goes beyond just conducting a business process study, or obtaining a relative measure of business performance.[26]

As part of the innovation process, benchmarking can help weak and poorly innovative organisations improve their innovation success rates. Benchmarking for innovation can, apart from traditional benchmarking, have some interesting advantages. By benchmarking for innovation, the ability to adapt innovation procedures from any organisation, and not only those within one's own industry, becomes possible. This magnifies the ability of innovation benchmarking, to find the best of the best, and apply those processes on the home front. Since different industries tackle innovation differently, by searching for unique techniques and processes, organisations can extract only the most effective ones, and adapt them as world leading methods in their own organisations. This expands the benchmarking principle, by removing current barriers that exist when benchmarking in a specific industry.

#### 5.1.3.3 Competitive Environment

The competitive environment is about knowing one's adversaries, and when to close in battle, or to form temporary alliances. Strategies for defence and attack form a large constituent of this discipline. Methodologies in the field of technological interaction include aspects such as predator-prey, pure competition and symbiosis of technologies, as proposed by Pistorius and Utterback.[27] These interactions between technologies are just as applicable to the interaction between innovations. It is therefore important to understand the actions and reactions of competitors.

When analysing competitors, the unwritten rules guiding their actions should be investigated. These rules often point towards their destination in the development of new products, and may be used for anticipating their future activities. With this knowledge in hand strategic responses may be constructed beforehand to the advantage of one's own organisation. The following as proposed by Burgess[28] may be of assistance when analysing competitors and their possible future moves:

**Mission and objectives** — *find out about the future and past in the competitors annual reports and other documents.*
**Satisfaction** — *does the competition seem satisfied with their own performance.*
**Motives and drives** — *remuneration and long or short term results. Do they want to become industry leaders or are they content?*
**Current strategy** — *what is the current strategy, and is it reachable? How does this compare to our own?*
**Future objectives** — *does foresight and future planning form a large part of strategic planning? Is there a vision of the future?*
**Market served** — *what market segment does the competition service well? Which segments contribute the largest part of sales? Which would be defended strongly or poorly?*
**Globalisation** — *is globalisation a priority and are sources of demand and supply being globalised?*

**Resources** — *what is the organisations cash position? Trends in financial results? Key people?*
**Management style and intro-organisational conflict** — *how is the competition's management perceived? Do they encourage entrepreneurship and innovation? Are they authoritarian? How do employees perceive the business environment inside the firm? Is conflict and failure accepted and managed well?*
**Empowerment profile** — *does diversity exist in the organisation? Are rights and religious days of minorities observed?*
**Response profiles** — *how does the competition respond to threats and opportunities? Does it over or under react?*
**Transitional product rollout strategies** — *how is the firm likely to introduce its products into foreign markets?*
**Countries of origin effects** — *what perceptions exist about the competitor's country of origin and how do this affect them? Communism or wars severely influence the global perception of countries as well as their products.*

Many other measurements of competitor capability and characteristics exist. By methodically collecting and sorting key pieces of information, excellent competitive intelligence may be available. This information can and does improve strategic decision making as well as new product development.

#### 5.1.3.4 Ultimate Leadership

Although ultimate leadership is idealistic it has a very important goal. As the global business environment shrinks, many organisations will find themselves attacked heavily in all national and international markets. There can no longer be such a term as a local market, for international organisations increasingly enter all emerging markets with the aim of gaining global dominance.

#### 5.1.3.5 Conclusion to Industry

The industry environment holds many different threats and opportunities. Identifying these to the advantage of the organisation, is what industry analysis is all about. Aspects such as competitive intelligence, alliances, benchmarking and learning from each other, offer organisations in an industry the ability to survive and prosper, if correctly applied.

### 5.1.4 Political, Economical and Social (P.E.S.)

The political environment and the trends therein have an impact on technology and technological innovation[29]. Although politics and technology influence each other, certain global trends may be identified as drivers. To a certain extent these trends do not necessarily drive the direction of individual technologies, but create the means and opportunity for their development. For example the United States of America created a strong incentive in the form of grants and motivation when the 'Space Race' was on. Currently emphasis falls on biological research and thus government grants are increasingly made available in this domain. It can be clearly seen that certain technology areas are of more importance than others, and it is crucial to most organisations to be aware of possible grants, tax incentives and other political, social and economical advantages. With this in mind, it makes sense to have close links with national, as well as international governments, in order to capitalise on incentives in the fields of technology or innovation.

The economic world is possibly one of the strongest drivers of technological development. Competitive advantage and money drive most organisations, which in turn drive the development of technology and new innovations. As time and distance disappear in the new millennium, so will the demand for commodities (mining, manufacturing and agricultural products) become less important[30]. Instead demand for information, services, knowledge and intellectual capital will build. This can clearly be seen in the enormous rating placed on current 'Internet Stocks', like *America on Line* and *Amazon.com.* These information and service providers are valued much higher than mining, manufacturing or agricultural organisations, simply on the fact that they are build on intellectual capital and service, as well as offering enormous growth possibilities. Therefore, being on the right side of economical development and investor perceptions, may prove extremely advantageous for technological development and new innovations.

Most organisations would attribute a large part of successful innovation to segmenting and entering the correct markets. Undoubtedly this is correct, yet markets are driven by certain forces of which one is social beliefs, actions and needs. For example a social change in the market had a disastrous effect on the Ford Motor Company. Ford designed and developed the new 'Edsel' for young upcoming couples, yet they misjudged the social needs of the population segment so badly, that the 'Edsel' was probably their biggest disaster ever. Ford had to go back to the drawing board and completely redesign the vehicle, better directing it at the newly emerging market.

Technological innovation can sometimes occur without serious consideration for social needs, this however, is only possible if the technology is strong enough to influence a social change, as can be seen in the information revolution. When such a change is made, many opportunities for new innovation in that particular field become available, advancing technological development.

By identifying and pursuing relevant innovation enhancing factors, organisations may be able to substantially improve their development and innovation resources. By keeping a lookout for influential national and international parties, cultivating links with national and international governments, and deriving ultimate advantage from national and international innovation incentives, may significantly improve organisational innovation abilities.

Although the P.E.S. factors do not always directly impact the innovation process, they do play a role in organisational survival. As Kondratieff proposed in his discussion on the interaction between the economic environment and technology development one may see the result that one has on the other, as discussed in chapter 2. Organisations disregarding these environmental forces may find themselves in deep trouble when technology, politic, social or economic paradigms shift. For the business environment is never in absolute equilibrium, offering many threats and opportunities, as it changes.

## 5.2 Organisational Issues

### 5.2.1 Strategic

Every modern organisation, large or small, can no longer rely on exogenous factors for competitive advantage. Innovation and dedication to technology and customers, will be the driving forces within the twenty first century. The information age enables a process, whereby knowledge can accumulate, to the advantage of Science and Technology; almost forcing civilisation to discover or develop incredible new concepts. All this impact directly upon the modern organisation, by reducing its knowledge base and underscoring its products. One thing is absolutely clear. No complacent, tradition bound organisation will be able to survive the twenty first century.

To grow into the new all different global environment, understanding and preparing for the future becomes most important. Foresight and vision are two of the strategic terms emphasised by business schools and academics, for they are the barometers to the business environment and its possible needs. The term 'foresight' dominates in an exiting management book by Prahalad and Hamel,[31] describing precisely the methods and processes crucial to competition in the future.

#### 5.2.1.1 Strategic Planning

Strategic planning is based on identifying corporate objectives for the future, in response to perceived threats and opportunities by understanding the company's strengths and weaknesses.[32] Strategic planning provides a framework to guide the choices that determine the future direction and nature of an organisation. As such it provides the basis for all long range and operational planning. It is the highest level of decision-making concerning a company's basic direction and purpose, in order to assure long term health and vitality of the organisation. A strategy is broad in scope and concerned with goals and the means of attaining them. Strategic decisions should be non-routine, important, complex, holistic, and future oriented. Without strategic planning, organisations stumble along in a state of masked chaos, offering no chance for purposeful technological innovation.

> *The reality of strategy lies in its enactment, not in the pronouncements that appear to assert it.*
>
> —*Burgelman and Rosenbloom*[33]

Strategy is emphasised as the determining factor in directing organisations towards a higher pace in technological innovation. For industrial firms, competing in the technological environment, a combination of factors in three domains is crucial:

1. The development of new ideas, products and processes;
2. The adoption of new ideas, products and processes developed elsewhere;
3. The successful marketing of the output of the new product development program.

The technological innovation process relies on exceptional organisational strategy for underlying direction and support. Without a strategy that includes innovation as the means towards reaching the future, technological innovation will not be accomplished.

#### 5.2.1.2 Active Foresight Programme

Tradition, complacency and success are some of the enemies of modern day organisations who want to stay innovative. Another one and possibly even the greatest, is a lack of foresight. Most CEO's (Chief Executive Officer), MD's (Managing Director) and others involved in the management process, will agree that change is happening more rapidly today than ever before. They may also agree that the rate of change may increase as information technology enables humans to be more effective. The logical conclusion from this would be that managers would be spending more and more time anticipating change and future threats or opportunities. However, this does not seem to be the case,[31] and one wonders why not.

Prahalad and Hamel[31] aptly describe an analogy to the amount of time spent on serious consideration of the future. They state that they often find managers on average spend 40% of their time looking outside the organisation, and 30% of that time on looking three, four and five years into the future. Of the time spent looking into the future, as little as 20% is spent on attempting to build a collective view (with other employees and colleagues) on the future. This results in a staggeringly small amount of 2.4% that the typical organisation spends on building a collective perspective of the future. This fuels the debate on realisation of future threats and opportunities, and how an organisation may possibly be able to capitalise on, or defend against such actions.

The obvious question at this time is where does this foresight come from, or how can it be obtained. Since no crystal balls with glimpses of the future exist, the basics of constructing a foresight strategy take time and creativity. Developing foresight requires more than scenario planning; it requires a will to make something happen. It often starts with what could be and then works backward to what should happen for that future to materialise. This type of foresight is unique, for it is active. Instead of reactively predicting the future, organisations are shaping themselves to be part of the construction and final outcome of the future. This type of future building is what the Motorola Company embraces. They are totally committed to satellite based personal communications for instant world-wide data interchange. This is also the foresight, which drove JVC in the development of the VCR as well as Bell Atlantic's view of information, entertainment, and educational services made available to every home in its service area.

A deep understanding of trends in lifestyles, technology, demographics, and geopolitics supports industry foresight. Yet ultimately it requires more than sheer knowledge, it rests on imagination and a sense of curiosity. 'Foresight is the product of eclecticism, of a liberal use of analogy and metaphor, of an inherent contrarianism, of being more than customer-led, and of a genuine empathy with human needs'. Prahalad and Hamel.[31]

Foresight, if correctly implemented and thoroughly entrenched throughout the organisation, can be a driving force behind innovation. For innovation to flourish, organisational goals specifically requiring innovation, is necessary. In this, foresight plays the crucial role, for foresight not only proposes a future, but also requires the organisation to make that future happen. Foresight and innovation are partners, and one without the other can never be as potent as in their combined form.

#### 5.2.1.3 New Generation Products in Accordance with Foresight

When studying new product development, literature teaches the importance of product platforms and incremental improvement. Modern competitive environments require differentiation in the extreme, nullifying the concept of incremental improvement. For organisations to overcome incremental differentiation, radical innovation becomes necessary. Radical innovation, although costly and risky, does create enormous possibilities.

*You don't leap a chasm in two bounds.*

—*Chinese proverb*

Tom Peters[34] goes so far as stating 'You can't improve your way to success', meaning incremental innovation can no longer be a strategy towards success. Even though the concept of Kaizen,[35] as practised by many Japanese organisations, strive towards perfection through incremental changes, perfection for perfection sake can be disastrous. Inadvertently it boils down towards avoiding fundamental change and only improving marginally upon yesterday's paradigm.

*Incrementalism is innovation's worst enemy.*

—*Nicolas Negroponte, MIT Media Lab*

As crucial as it may seem, the fragmented view of only pursuing radical or chasm bounding innovation, cannot easily happen in a vacuum. For organisations to make the 'leap across the chasm', a foresight or future plan is necessary.[36] By means of such a plan, goals and requirements might be set in preparation for the 'leap across the chasm'. The Motorola Company is well known for its vision of the future, and how they plan to, affect or conform to it, to position themselves in the most advantageous position possible. Yet Motorola will not simply 'leap' on faith alone, they carefully plan and build enough competencies, through alliances and current product ranges, to be able to snap into action the moment all criteria for final chasm jumping are met. In this, incremental innovation can play the part of preparation for shifting to new paradigms and radical new products. Incremental innovation should not be misjudged as a strategy capable of delivering sustainable competitive advantages.

### 5.2.1.4 Foresight and Business Strategy Link with Innovation

Organisations with poor technological innovation records may often try to improve the process through motivation, and requiring more innovation from their brightest and best employees. Often the required innovation is stated in vague terms, leaving it up to the innovator to 'be creative' and find something new. The same might happen in a process environment, where management requires new ideas on improving the process, yet send out vague requirements about innovation or new ideas. It therefore comes as no surprise when employees, in an effort to be creative and inventive, come up with ideas directly opposed, or even completely removed from the organisation's business strategy. An example in the packaging industry in South Africa, where management asked employees to be creative and think of entrepreneurial or new innovations, delivered amazing results. One of the employee's proposals was so far removed from the business as to propose (innovate) a new fishing hook design.[37]

> The *first step* in improving ideas in the organisation is making employees aware of the organisational strategy. Even though most employees often know the strategy, it seldom impacts directly on their daily activities. Emphasising areas of the strategy where innovation is required and focusing on goals and objectives can generate better ideas and more useful creative activity.
>
> The *second step* and the more strategic one is linking the innovation strategy with the corporate business strategy. Goals and objectives set in accordance with the corporate and foresight strategy will bring the innovation process to a keen focus. This will empower creative and entrepreneurial employees in improving their idea submissions, reducing the risk of being turned down, as

well as the mental frustration of knowing a good opportunity is sliding out the door. Administration wise, managers will be freed of turning down the ridiculous proposals, and freer to evaluate the better-focused ones. By cutting out the ridiculous and finding the strategically focused proposals, the evaluation committee will not be forced to turn down so many proposals, improving employee and innovation related activity morale.

Innovation strategy is possibly the most crucial part of the process of managing innovation. Without such a strategy, no organisation will be able to develop new products, without straying from their core competencies.

#### 5.2.1.5 Selecting the Correct Structure for Innovation

Organisations commonly employ different structures when managing new projects. Just as some project structures are better to use for certain projects, innovation team structures may have different advantages. Innovation team structures are borrowed from the project management discipline, for a new innovation is often structured and implemented under the auspices of project management.

Certain structures work better for certain projects or innovations. Four dominant structures, as identified by Wheelwright and Clark,[38] can be shown to enhance or debilitate particular forms of innovation.

The four project structures as proposed are the *functional team structure*, *lightweight team structure, heavyweight team structure* and the *autonomous team structure*.

In the *functional team* environment, people are grouped principally by discipline, and managed by a functional or discipline manager. This structure is conducive to incremental innovation, since few cross-disciplinary actions take place.

The *lightweight team* structure incorporates a project manager, who co-ordinates different disciplines through liaisons. These do not influence the disciplines directly and only the liaisons get information from other disciplines. This structure is more conducive to incremental innovation, with some free ranging creativity.

When *heavyweight team* structures are used, a strong project manager leads the project, and interacts directly with all participants in each discipline. This enhances information flow, leading to better ideas and more creative innovation.

Tiger teams or *autonomous teams* are almost small businesses in their own right, including their own employees, and financial systems. These teams are best for radical innovation, or developing new technology not yet adopted by the organisation. They are however dangerous since their autonomy give them an elevated position compared with other organisation employees. This may often result in envy and negative competition between the tiger team and the organisation[39].

In essence the organisational strategy is there to provide the innovation process with the necessary resources and strategy. By creating an atmosphere where direction and means are provided, the strategic side of the organisation may fulfil its obligation to the innovation process.

#### 5.2.1.6 Conclusion to Strategy

Top management influence the innovation process through the strategies, plans and visions they create for the organisation. How else could one expect innovation in an organisation without specific strategic incentives in place to foster it? Innovation is often regarded as a wild and unpredictable process, yet many organisations have shown this is not the case. By including directives and goals for the innovation process in the organisation's strategy, methodical innovation will occur more and more frequently. Even though breakthrough innovations will only come once in a while, by improving and innovating consistently, the chance for the one great breakthrough is much improved.

### 5.2.2 Innovation Process Implementation

New technology and its acceptance by non-technical people, is of great importance to the technology manager in the organisation. Innovation often embodies technology, and is therefore affected by the difficulties of changing human perceptions and actions. Even inside the organisation it may sometimes be difficult to convince employees of the advantages of a new innovation. Being unable to change management's or accounting's negative ideas on a new innovation, may end up by sinking a possible new innovation project.

'Change' management plays an important part in the implementation of new technology. To skilfully manage change inside the organisation, Student[40] identifies five factors:

1. The *influence* and how this is applied,
2. The amount of *familiarity* employees or recipients of the implementation has,
3. A basic period of *testing* before implementation,
4. The amount of associated *stress* accompanying the change required,
5. A *chance* variable, allowing for a measure of luck.

**Influence** forms the focal element in any successful change process, and can either be employed advantageously or negatively. By forcing or requiring participants to change through domination or fear, negativity will surface immediately. Participation, when used as change technique, may also fail, for participants may soon feel manipulated and become negative towards the change. This brings us to the crucial point, that if individuals are forced in any way to change, they will resist, regardless of how much sense it may make. People do not resist change; they only resent being changed.

Conversely people seldom resist change when it comes in the form of creating or being part of something. In this regard people tend to support things they helped to create, as well as processes or implementations they have influence over;[40] or if the employees were consulted in the decision processes, that resulted in a change. Any of these procedures strengthens the behaviour in people to accommodate change and newness.

Through participation, an added advantage is motivation to ensure successful completion of the change, therefore reinforcing the decided upon course. When employees have influence over the outcome and prescriptions of their tasks, work can become more meaningful, contributing towards an overall feeling of well being.

**Familiarity** underscores the importance of time as an element of change. The human brain has a tendency to reject sudden changes, yet slow and methodical introduction of ideas can have a marked effect on the acceptance of radical new things.[40] Time must pass for ideas to become acceptable, and employees to forget how they worked in the past without the new concepts. Familiarity breeds comfort and acceptance, and wherever possible, innovation should be implemented on a pilot basis in carefully chosen parts of an organisation, before putting it into a system.

**Testing** acknowledges the fact that participants will test the soundness of the innovation and the degree of support it will receive from other important participants. Most people are naturally curious and willing to experiment, they also have need for stability and predictability. Through testing, the change-implementers offer the participants a chance to evaluate and become familiar with the change, as well as the option to compare it to current procedures or systems. This, in turn, empowers the participant in making a choice of acceptance or rejection, without it reflecting negatively on his/her person. When implementing new ideas, a necessary response to 'we are different — it won't work here', is to allow for a period of testing to create acceptance.

**Stress** acknowledges the fact that facing the unknown is a fundamental and disquieting threat. Behavioural change challenges an individual's adequacy, and is far more complex than merely acquiring new intellectual skills from classroom training or programmes. In such a scenario, self-esteem is easily threatened before change, and it is only after successful change implementation, that a sense of self-confidence and well being can improve again.

Another aspect of stress can occur when slack is reduced, and members of a department are asked to work differently or more efficiently. The probability that an organisational change will cause stress, is directly related to the degree of behavioural change required for adoption of the innovation

However, stress in some cases can be quite positive. The presence of stress, prior to change, might signal the need for change, as well as improve the possibility that some action will be taken. In such a case, stress elicits initial co-operation, if the proposed change is perceived as a means of reducing the stress. During the changing process, stress may help speed acceptance of change along, in this way. If stress is too great, withdrawal and aggressive behaviour will result, impacting negatively on organisational performance.

**Chance** is ever present and may add problems as well as opportunities to a new innovation implementation. Since change impact on human capabilities and routines, one should never expect the logical, and be prepared for problems as well as opportunities.

#### 5.2.2.1 Adoption of Technology and Innovation

Technology adoption is crucial in small and large organisations. Every organisation while trying to survive and grow into the future, needs to consider the amount of technology and innovation required, to be successful. This implies that, without correct management of new technology and innovations, organisations will not be able to adapt to changing new circumstances.

Without these new skills, technologies, peoples, methods and ideas, corporate environments can become stale, formal and bureaucratic, resulting in cultures where little or no scope for innovation exists. Innovation cannot happen in a vacuum and needs support from resources, culture and management inside and outside organisations.

With continued adoption of new innovations the added bonus is that people, including managers and employees, inside the organisation, become accustomed to change, increasing their potential to accept new and strange stimuli. Frequent adoption also stimulates learning, for adopting new innovations require new procedures and knowledge, therefore forcing participants to study continuously. Therefore frequent innovation and technology adoption can become a strong driver for human resource improvement in the field of creativity.

#### 5.2.2.2 Timing and Implementation Speed

Fourteen years ago, Tushman and Nadler postulated:

> *...in today's business environment there is no executive task more vital and demanding than that of sustained management of innovation and change...to compete in this ever-changing environment, companies must create new products, services, and processes; to dominate they must adopt innovation as a way of life.*
>
> — Tushman and Nadler (1986)[41]

Today, companies are faced with the additional demand of responding fast to this ever-changing environment. Timing has become one of the crucial aspects of innovation implementation and development. Having the correct timing and the capability to react fast enough, enables companies to launch and introduce products in the correct market window, enhancing their possibilities for success.

Timing of innovation adoption is not only crucial to companies producing and selling innovations, but also to firms busy adopting certain new innovations. The criticality of timing and innovation adoption can be seen in the effect it has on every part throughout the organisation. As such it becomes a multi-functional strategic, managerial and operational issue.

The timing of implementing innovation is influenced by many factors, of which strategy forms an important part. The problem with research in this area however, lies in the fact that it has often been undertaken with little consideration for previous studies, and is therefore extremely fragmented. A large amount of research has been done and through synthesis, key areas can be identified.

As a first stem towards this, Table 5.1 is supplied, where the vast literature in the field is divided into parts. This can be seen as a representation of current knowledge on the timely introduction of new innovations.

**FACTORS — SUPPLIER'S SIDE**

**Environment and industry specific factors**
**(e.g. reputation, technology standardization, market dynamism)**

**Firm specific factors**
**(e.g. competitive strategy, product policy, customer/market orientation, technology strategy)**

**Pre-launch activities**
**(e.g. R&D allocation, collaboration with customers, technology gatekeeping, proficiency in critical succe factors in development, NPD in networks)**

**Launch activities**
**(e.g. mode of exploitation, marketing proficiency, identification of lead users)**

**Selling centre**
**(e.g. capitalise on relationships, customer orientation)**

**The innovation and its characteristics**
**(e.g. decision process, information flow, adoption process)**

**Buying centre**

**Organizational/managerial factors**
**(e.g. structure, employee characteristics, communication, attitude to risk)**

**Economic factors**
**(e.g. technology strategy, technological diversity, production technology)**

**Firm specific factors**
**(e.g. product/market strategy, competencies)**

**Customer market focus**
**(e.g. diversity of customer base, demand, receptivity to innovations)**

**Environment and industry specific factors**
**(e.g. competitive intensity, barriers to entry, stage of industry development)**

**FACTORS — ADOPTER'S SIDE**

*Table 5.1: Factors Affecting Adoption of Technological Innovations, Source: Tzokas and Saren*[42]

### 5.2.2.3 Ultimate Advantage of Available Resources

People, technology and money are possibly the key resources in the development of successful new innovation. For organisations to grow and be successful, they often focus on these resources as measure and control instruments. This may be observed in the strong financial control process present in most organisations today. Implementation of innovation requires the setting aside of some of these 'strict control systems', by allowing ideas and new projects to develop through their 'difficult' times, where they often consume copious amounts of man hours and finances.

It is in this stage that 'skunks' and 'bootleggers' have their greatest influence. By inhabiting a corner out of the way of the normal business operations, they are often able to defy some of the 'red tape' associated with new ventures. They often work on small budgets with limited resources, resulting in the notion of getting the basics right the first time. For example: Whittle's prototype jet engine was conceived, developed and first tested in just such an environment.[43] Clearly illustrating the importance of sometimes letting the strict monitory and resource control systems, slip a bit.

#### 5.2.2.4 Balanced Repertoire of Product Development, Production and Distribution

A part of the new product development, as well as resource allocation process, is to decide on the best mix of innovations, or proposed new products, to develop further. Wheelwright and Clark[44] refer to this as the organisation's 'aggregate project plan'. This plan organises the type and risk involved with new projects, into a manageable model, where resources might be assigned with care, in contrary to current practise, where resources are often awarded on the bases of which new project presentation looked the best. In such an aggregate plan, the risk reward ratio might be adjusted to include 'hi-risk high-reward', as well as 'low-risk moderate-reward' projects.

#### 5.2.2.5 Early Involvement of all Players

Technology 'push' and market 'pull' innovation are often the subject of debate on the best methodologies, when considering new innovations. Although these differ significantly, they both require early involvement of all 'players' in the innovation game. The notion of concurrent engineering[45] has found great acclaim in the engineering environment, yet often these new methods do not include users or scientists, whom are many times crucial to the development of new technological innovations. Even if these groups are included, few engineers and new product developers know how to interact with them, to the advantage of the project. It is therefore critical to include all 'players' into a communicative environment, to encourage the transferring of ideas and knowledge. Gillette clearly understands the valuē 'knowledge about the customers' may have on the innovation process. Every working day 200 American males lather up at Gillette's South Boston plant, to test out new products and ideas.[46] In this way Gillette is able to stay one step ahead of competitors, with innovation after innovation.

#### 5.2.2.6 Conclusion to Innovation Process implementation

With the best strategy in the world, but not the ability and competencies to implement it, innovation is bound to stay a pipe dream. Organisations have to change continuously, and the implementation of new technologies, to help the innovation process in the organisation, may sometimes prove difficult. Settled employees, unaccustomed to change, may hinder any form of innovation, by being unable to cope with their new tasks in the innovation process. The innovation manager has the task of streamlining the innovation process, and constantly improving individual competencies. Enabling them to better innovate. Therefore by getting the right information to the right people, at the right time, so that they can take the right action, may be of prime importance in the implementation of innovation.

### 5.2.3 Fostering Environment

Every organisation has a certain feel about it. When one enters the front door a feeling of wealth, professionallity or tradition may often be pervasive. The environment and the way people dress, speak volumes about their capabilities and emotional state. By controlling these, an organisation may go a long way in improving, or hampering, the environment for successful innovation.

Spescom, a JSE listed South African organisation, for instance, allows some of their more creative employees, the freedom to wander around bare foot and dress almost any way they like. Only when interaction with clients are necessary, will these employees be asked to dress 'neatly', to portray a professional image. However, if these employees were forced to wear ties and suits in their daily tasks, their creative spirit might be corroded, and they would probably be inclined toward looking for alternative employment.

When trying to build an organisation with highly innovative capabilities, one will have to create a physical and social environment for an innovative 'culture' to flourish. Although some control in the form of direction and structure is required in this, it should enhance, instead of debilitate.

### 5.2.3.1 Four Factor Theory

Research into climate and innovation, led West[47] to believe four factors were of major importance. A review of the literature proves these as consistent with many teams, and therefore relevant. The four factors observed by West may be described as a model for work group innovation. A brief listing of the four factors include: *vision, participative safety, task orientation* and *support for innovation.* These are described in more detail below:

**Vision**

*Vision is the idea of a valued outcome, which represents a higher order or goal, and a motivating force at work*

—West and Farr[48]

Groups with clearly defined focus, and objectives, are more likely to develop new appropriate methods for reaching these. West asserts that work group vision has four component parts: *clarity, visionary nature, attainability*, and *sharedness*.

*Clarity* refers to the degree the proposed vision has a valued outcome to individuals in the group, and thus reinforces their commitment to the group goals.

*Sharedness* refers to the extent the vision gains widespread acceptance with individuals within the team.

Further visions should be relatively attainable, if they are to initiate innovation, since if the goal cannot be reached, it may be demoralising and negative for total innovation.

**Partcipative Safety**

*Participativeness and safety are characterised as a single psychological construct, in which the contingencies are such, that involvement in decision-making is motivated and reinforced, while occurring in an environment, which is perceived as interpersonally non-threatening*

—West and Farr[48]

The more people participate in decision making through influence, interaction, and sharing information, the more likely they are to invest in the outcome, and offer new ideas for new products and improved ways of working. The essence of this principle is therefore based on participative safety, which influences the group interactions wherein the predominant atmosphere is one of non-threatening trust and support.

**Task Orientation**

'A shared concern with excellence of quality of task performance in relation to shared vision or outcomes, characterised by evaluations, modifications, control systems and critical appraisals'

—West and Farr[48]

Within groups, the task orientation factor is evident by emphasis on individual and team accountability; control systems for evaluating and modifying performance reflecting upon work methods and team performance; intra-team advice; feedback and co-operation of opposing opinions; constructive controversy; and a concern to maximise quality of task performance. This factor hence describes a general commitment to excellence in task performance coupled with a climate, which supports the adoption of improvements to establish policies, procedures and methods.

**Support for Innovation**

*...the expectation, approval and practical support of attempts to introduce new and improved ways of doing things in the working environment.*

—West and Farr[48]

Support for innovation varies across teams, to the extent that it is both articulated and enacted. Employees more accustomed to change and improvements will be more inclined to accept innovation.

An aspect of the organisational environment is the identification of key people that form part of the innovation process. Thwaites,[49] and Maidique[50] refer to champions of the innovation process and making them 'visible' to less experienced employees taking part in the innovation process. This enables the employees with the specific competencies in innovation to be utilised by many of the innovation projects to the advantage of the organisation.

Another aspect of the fostering environment is the philosophy of developing skills in innovation. By constantly improving the competencies of employees in the workplace chief executives are able to lift the aggregate innovative capability of the organisation. Quin,[51] as well as Thwaites[49] state the importance of organisational learning, and not just from external sources but from trials and tribulations inside the organisation. Management should set an example to innovation teams where failure is followed by vigour for success in stead of hopelessness.

*'To encourage reward and recognise innovative individuals...'* writes Nicolson[52] on the organisation 3M. He is referring to the methods used by 3M to harness the competencies settled in their employees to the full. And rightly other organisations should listen to the methods employed by 3M for they have been heralded as one of the most innovative organisations in the world. Through a mixture of freedom, forced innovation and listening to their customers 3M was able to create 30 percent of sales from products no older than four years. This means 3M has to stay focused and keep innovating for every year that percentage of sales has to be filled with new products, illustrating the seriousness 3M takes innovation.

3M is possibly the landmark when researching or writing on innovation. Through their creative strategies and formal innovation programmes they are able to improve the organisational fostering environment immensely. It is not as many people think only the 15-minute free time that makes the difference but the total culture and environment where innovation is expected, required and encouraged.

#### 5.2.3.2 Conclusion to the Fostering Environment

Nurturing and building an organisation's environment, able to foster innovation, may easily be disregarded by the lucky few who posses them. In many organisations such a culture does simply not exist, and probably never will. Changing attitudes, habits and methods in an organisation is virtually impossible. As Peters[53] state it is often easier to kill the old, and start from scratch, building the correct environment from foundation upwards. Some of the measures discussed above, may improve an ailing environment, as well as keeping a working fostering environment healthy; for ideal environments may decay of their own accord, if left unchecked or maintained.

## 5.3 Individual

Innovation can not consist of only technology and business, but requires the active involvement of individuals[54] as well as the management of each of these three aspects. Many biases are deeply ingrained in the very threads of corporate fabric. People naturally tend to listen to others 'like them', and disregard those who are 'unlike them'. Changing this dynamic requires placing as much emphasis on the human aspect of innovation as is placed on the technological and business aspects. Corroborating the importance of the individual in the innovation Znaiden may be quoted.

> *My approach recognises the human factor as the single most important element for innovation. Nothing else really matters.*
>
> — Znaiden[55]

And although managing humans might be considered diametrically opposed to managing a manufacturing process, for instance, innovation can not succeed without human participation. This brought the author of this thesis to the realisation of the possible gap in the discipline of innovation auditing and modelling, namely the involvement of the individual.

Few, if any, innovation models, or even innovation audits, currently contain human related issues. This thesis therefore aims to propose the subject as initial inclusion to the innovation audit process. Due to the newness of the inclusion, some aspects might not be as structured or all inclusive of the discipline of human management and understanding, as might be expected when conducting formal innovation audits. None the less the following three sections were found to have high influence on the innovation process, and were included for testing and learning about this aspect of innovation.

### 5.3.1 Personality and Emotions

The question, why employees are in their current job positions, and their enjoyment of their daily tasks, may be judged by a 'lottery question'. The question builds the scenario where the employee or individual wins the lottery, and then receives a large monetary prize. By thus removing the one key ingredient from the employment environment, that of money, true reasons and attitudes for working, might come to the surface. Although the question may be unfair, it does illustrate an interesting point, when the importance of financial gain, and its influences, are revealed. It also relates directly to motivation and the possibility of encouraging employees to be creative and innovative in their environments.

If employees work 'for the money' they will seldom if ever be compelled to be as creative as possible. Especially if few monetary rewards are available, and the environment is one of stagnation and complacency. In this regard, employees often find themselves in an environment of monotonous daily tasks, with no scope for creativity. Getting out of this rut requires persistent focussing on creativity, as well as scheduling specific creative tasks, or creativity sessions.

An important part in motivating, and fostering innovation, is communicating the strategic organisational goals to all employees. This, as well as describing the part each employee may play, may serve in motivating employees to contribute creatively to reaching goals and strategic missions. Many studies show that, if given some leeway as well as a reachable goal, most employees will be more creative, yet remove this target and bureaucracy, and mediocrity may push under even the most brilliant employee.

Personal psychology is, as Znaiden[55] states, the single most important element to innovation. It is true that the inspiration for innovation cannot be brought about through resources, organisation, money, environment or processes imbedded in the organisation. It is the self-motivation, and determined psychology of the human employees, responsible for innovation.

The rate-limiting factor for innovation is not as stated the environment, organisation or lack of resources. It is more likely to be the way employees think of themselves and their own innovation perceptions. If innovation can be cultivated inside people's heads, they can go a long way, with minimal resources or organisational support. The biggest rate-limiting factor to innovation, will always be the perception and thoughts of the employees, and not any other external factors. This is also why leadership, rather than management, forms a key component of growth and development, which can only occur through innovation.

If such an understanding and leadership environment is present in an organisation, some key areas may be addressed to improve total innovation output.

> A **fierce sense of independence** needs to be instilled in each employee. This not only helps with individual creativity, but also ensures groups do not start following the leader, resulting in less than effective creativity and innovation.
>
> **Self-motivated** people are essential. Although difficult to teach or instil in an employee, clear discretion should be made when employing new people, to find well motivated enthusiastic candidates.
>
> Making sure that **self-direction** play a role in the development and future prospects in, and around, the working environment.

The concept of self-direction could be one of the most interesting and best indicators of employee innovativeness there is. As corporations become less concerned about employment security, and more directed towards growth, employees need to take care of themselves, by thinking of what they are doing for themselves. Employees need to become more selfish to survive.

In the last twenty years of the twentieth century, many changes took place, with advances in medical, electronic and political environments. One change that has been silently brushed over by many, has been the growth of self-reliance, expected from society and especially working people. The amount of freedom that is allowed to any employee today, is staggering, if one looks back to what it was like only thirty years ago. Yet this freedom comes at a grave price. Just as firms were more rigid and bureaucratic in the sixties, so were they much more concerned with the welfare of their employees. It was not uncommon for a person to work for one firm throughout his life, and enjoy high job security throughout this time. The drive towards quality, growth, efficiency, and effectively, changed all this. No longer can organisations afford to keep redundant workers or managers, and as such, many restructuring have take place. Being lean, mean and efficient, means under no circumstances does employees have job security

We are very fortunate to live in a society where any idea may be actively expressed, without being shouted down, or burned at the stake. Even though ideas are not always believed, or rejected, by old paradigms, they can at least be brought out in the open and looked at for advantages. In South Africa, for example, we are seeing a revolution in music, sex and fashion, and these are many times the silent drivers of new reform in business and commerce. Some of the new development in South Africa has already been felt in the blooming information technology industry, where strong organisations such as Didata, Comparex and Datatec, embark on expansion, here and abroad.

Freedom and reform are however not always positive. Through added freedom, and a search for growth, individuals many times get run over and their worth demoted to rands and cents. Therefore, when organisations merge and diversify, many individuals are misplaced or even expelled, for not fitting or simply being redundant. Therefore, with increased freedom, a severe decrease of employment security is common, changing many individuals' lives and security.

Based on this decrease in security, individuals need to understand the need for life long education, and learn to work for themselves. No longer should we strive towards working for someone but rather strive towards working for ourselves even if working in a large organisation. This might seem to be a contradiction in terms for how may one work for a large organisation and *still* work for yourself? Easy, working for yourself requires only that you set your own goals and reach them in your own environment, by aligning your own goals with those of the organisation you may work for a large organisation and yourself as well. This does require a mind shift towards self-improvement, but when accomplished it improves the reason for working and the satisfaction obtained form it. Improving ourselves should therefore be central to everything we do, for if we do not improve ourselves, no one else will. Questions such as what are you doing every day, to best position yourself for change?, 'what are you doing day in and day out, to gain maximum control over your future, and have the greatest freedom of choice?', 'what are you doing for yourself?'. In each of these questions we need to determine how loyal are we to ourselves; how dedicated, committed and hard working are we for ourselves? This is a legitimate response to a corporate environment that seldom cares for employees, as they did in the past.

When working for a large or even small organisation, this selfishness leads to other unique capabilities. No longer do resources or time constraints restrict self-directed employees. More and more these employees are seen to be creative and innovative in their work. For their work is being done for themselves, and innovation is almost natural to the self-motivated individual. Understandably, to improve and learn, and be ready for change, one makes sure innovation forms part of the daily routine. For innovation has been the source of learning and discovery for mankind over the ages.

Thus to motivate employees to be more innovative, their basic belief in themselves needs to be addressed. They need to be encouraged towards individuality, self-motivation, entrepreneurial behaviour, which all stems from the self. These concepts need to be supported by real life circumstances, and strong leadership, helping and motivating towards reaching personal and company goals. In these circumstances, a capable leader can clearly have a remarkable affect and success ratio, for fostering more innovative thoughts and actions.

### 5.3.2 Knowledge, Experience and Background

The field of knowledge management and intellectual capital is starting to make major inroads into management practises of high technology organisations. Human and organisational competencies are receiving a lot of attention in the form of core competence management, technology management and knowledge management. This is the result of global competition between high technology businesses, which requires a constant development of new ideas and better products. And the only source of new ideas and better products, is highly capable human beings. Finding, keeping, and improving these organisational assets will influence the capabilities of organisations to stay competitive. Cognitive styles of different individuals play a role in how they solve problems. Organisations may be one step further on the road of building a competitive human resource base, by identifying those employees best suited to innovation.

Cognitive style, and problem solving, can have a marked effect on the creativeness of people. Recently, researchers have given increased attention to specific dimensions of these cognitive styles and methods. Kirton[56] proposed that individuals can be located on a scale, between those who can do things 'better', to those who can do things 'differently'. Conversely Jabri[57] conceptualised creative thinking and problem solving as composed for two independent modes of thinking: 'associative' and 'bisociative'. Associative meaning to use set routines, habits, adherence to rules and use of rationality and logic, while bisociative means to overlap separate domains of thought simultaneously, and a lack of following rules or disciplinary boundaries, with an emphasis on imagination and intuition. Typically then, associative thinkers would do well at systematic problems, with bisociative thinkers being better at intuitive problem solving. The intuitive problem solver, is therefore able to process information from various fields and different paradigms, and is therefore more likely to generate a novel problem solution.[58]

Neither of these styles is necessarily preferable in problem solving, yet the application of problem-solving style to task and work orientation, could have a positive influence on projects.

One may therefore expect an organisation with mainly 'learning by doing' or 'associative' employees, to be more comfortable in the arena of incremental innovation. While an organisation with mainly 'academic' or 'bisociative' thinkers, would excel at radical innovation.[59]

Touching on the same subject are the ways employees 'learn' how to perform in their working environments. Often a high degree of repetition exists in daily tasks, which negatively influence the human brain. This 'way of doing things' and the structures policies and procedures, may be so strong in an organisation, as to mould its employees into carbon copies of one another. They often are incapable of change or interpreting problems outside the letter of the organisational charter. Organisations with these kinds of environments will find innovation extremely difficult.

A great deal of research on knowledge management is currently being done, and should be studied to isolate the implications to the innovation process. This is bound to become an important field as part of innovation, for the individual and his/her competencies are supremely important.

### 5.3.3 Interactions

At the individual level, climate is a cognitive interpretation of an organisational situation and may be labelled as the organisation's 'psychological climate'[60]. Components of psychological theory postulates that individuals respond primarily to cognitive representations of environments, rather than to the environments per sé.[61] The climate represents signals individuals receive, concerning organisational expectations for behaviour, and potential outcomes of behaviour. And this information is then used to formulate expectancies or conceptions.[62] People respond to these expectations by regulating their own behaviour, in order to realise self-evaluative consequences, such as self-satisfaction and self-pride.[63]

Consequently the following hypothesis was proven:

> *The degree to which individuals perceive dimensions of the organisational climate as supportive of innovation is positively related to their innovative behaviour.*
>
> Scott and Bruce[64]:

Hence, the critical relation between organisational climate, and innovative and creative behaviour can no longer be misjudged.

As social psychologist K.E. Weick[65] postulates: 'The organisation is the sum of its personal interactions of its members, and these interactions are conditioned by the inability of people to process all of the information they receive'.

As part of Weick's understanding, inside the organisation employees and managers act and make decisions on previous experiences, as well as interactions in their peer group. There are, however, discontinuities, differentiation and other variations in these, which do not lead to an immediate solution or route of action. These may be isolated and examined at a later stage.

Solving isolated problems without previous experience, can be done by drawing on heuristics and causal maps. Causal maps are particular sets of attributed causal relationships between remembered events, which make sense of current conditions. If used in problem solving, those that make sense will be selected, while others discarded. Through this, organisations may reduce ambiguity in decision-making, and reach common understanding of the thought process used in reaching the decision. By modelling these causal decision-making sessions, others may digest the decisions reached, leading to better organisational understanding of the common goal.

This process of internal negotiation and decision-making can result in the members of the organisation having a perceptible similarity of outlook, on certain issues. This could be suggested to be the reason for saying an organisation has a certain 'culture'.

By encouraging and appointing 'mavericks' or 'weirdoes' in the organisation, similarities in outlook may be avoided. Although culture is pervasive, 'mavericks' and 'weirdo's' help to bring variety in decisions, developments and general business practices.

Another study on the social aspects of innovation, Nemeth[66] comments on the mechanisms of social control, utilised by organisations, which may directly oppose creative innovation. Often, some of the 'most admired' companies emphasise mechanisms of social control, rather than innovation. They know the power of clear goals, worker participation, consistent feedback, a cohesive work force and a motivation system that underscores desired behaviours and values. This may lead, as Collins and Porras[67] note, to a 'cult-like' atmosphere, which includes a fervently held ideology, indoctrination, high degree of fit or uniformity, and elitism.

It is true that these social control systems work, otherwise these visionary organisations would not exist as they do today, for they enhance morale, loyalty, and security. The power of approval of peers can, and is, one of the most established findings in social psychology. When people are faced with a majority viewpoint, they are very likely to adopt the majority judgement, even against their personal convictions. Literally hundreds of studies have documented these findings.[68]

In the light of these findings on peer pressure and 'cult-like' cultures, how could a difference of opinion be possible? And who would venture such an unpopular action, if rewards and social censure might hang in the balance? It has been documented that even when employees know better, they allow their bosses to make mistakes.[69] This directly influences the innovation process, for until creative and new ideas are born, little if any, innovation is possible.

Directly opposed to this line of argument, run the findings by Zien and Buckler.[70] They examined the social aspects of innovation, and found that highly innovative organisations pride themselves on their stories of starting out, and making successful ventures into new arenas. These stories are not there, just for fun, but support and reinforce the principals of innovation and company identity (therefore a unified culture). By telling stories, myths, teaching parables and legends, new recruits get to know the spirit of the organisation, while long-time employees revel in attention of previous ventures. Many organisations have specific people collecting stories, and publishing them for all to read and enjoy. According to Zien and Buckler these stories foster innovation, by setting an example and motivating employees to strive towards innovating more.

The thesis by Nemeth, Scot and Bruce[70] however, opposes this view. They postulate and demonstrate, to a degree, the importance of diversity and individuality in being creative and innovative.

It is not surprising to find opposing views and understandings of the effective and ineffective actions to be taken, when trying to foster innovation. Many organisations correctly and incorrectly postulate their innovativeness, and therefore studies can only be as good as its underlying assumptions and data. With the diverse implementation and understanding of innovation, finding the best advice and procedures to follow, often rest on the shoulders of consultants and advisors, capable of pointing out the pitfalls in different strategies.

## 5.4 Conclusion

This chapter offered a non-exhaustive outlook on defining best innovation practises. A huge amount of research is still needed to complete the development of a representative list for these best practises. This might be accomplished with the help of many people and is subsequently not attempted in this thesis. The hope is that the areas addressed in the chapter illustrate the questions asked in the audit questionnaire and help to set a foundation for further development.

Setting standards for the innovation process is near impossible. Every organisation has its own methods and processes that work well for them, and are often reluctant to change these. However, some of the different methods and competencies of different organisations correlate with one onother. It is these that were discussed in this chapter. Based on the framework of a proposed model in chapter three, the best innovation practises were arranged in three sections, each comprising various subsections. In this manner the many different innovation standards are easily understood as well as incorporated into the innovation audit.

The following chapter will focus on a proposed audit questionnaire. The questions are based on the standards discussed in this chapter and should prove representative of each section.

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# A PROPOSED COMPETENCE AUDIT FOR TECHNOLOGICAL INNOVATION



## 6 A Competence Audit Questionnaire

This chapter will introduce many of the questions as well as reasons for including them in the audit questionnaire. It draws on literature in the field of innovation management, social behaviour, industry analysis, as well as technology to name but a few. Several studies have been done on identifying key aspects in the field of technological innovation and many of the questions find their origin here. Other questions were developed on the foundation laid by the innovation model proposed in chapter three.

The following questions were compiled for the implementation and testing in an audit questionnaire. The actual test questionnaire, illustrated in the addendum [Appendix C], was compiled for the purpose of beta testing the questions proposed in this chapter. As such the questionnaire covers many different aspects of the innovation process, touching on things such as culture, creativity, flexibility, management style, and many others. Innovation is a diverse process and no one single best avenue for success exists. It is often a coming together of many different disciplines, all effectively partaking in the innovation process, which has the greatest influence. This means that the management of innovation per sé will become increasingly important as globalisation and competitiveness increase.

The chapter will be concluded with the implementation of the test questionnaire and the discussion of some of the results obtained.

## 6.1 Identifying Representative Questions and Answers

Innovation consists of many linear and non-linear processes, yet ultimately it has a beginning and an implementation or end. This may be observed in innovation models as defined by Noori,[1] Twiss,[2] Utterback,[3] Marquis,[4] and Katz[5]. To represent every aspect of this process as well as possible, this thesis proposed a model in chapter three and this will form the foundation and structure for identifying representative questions.

Not all questions were considered. The focus fell specifically on publications, books or databases with strong research backgrounds and high professional standing. Other published sources with thorough research and implementation of the findings were considered as well. Few if any of the questions were simply 'thought out', but all were adapted and changed to suit the audit style and implementation methodology. Often some of the accompanying literature was used to formulate the proposed answers as included in the audit questionnaire.

Many reasons existed in deciding between including or excluding audit questions. But these were reduced by the well laid out innovation model and best practises proposed in chapters three and five respectively. The questions simply reflect these boundaries set beforehand through thorough research of the field of technological innovation. However some of the more obvious reasons for including or excluding a specific question are listed below:

Reasons for including questions in the audit:
1. Proven or thoroughly researched questions.
2. If the question targeted a key area in the innovation process without which it may easily fail.
3. If the question fell into a specific area of the proposed innovation model which lacked sufficient representation.
4. Questions aimed at competencies required for innovation in stead of metrics or steps in a process.
5. Representative questions which would be generic enough to enable a wide audit application field.
6. Questions aimed at medium to large organisations with established innovation processes, rather then small or micro enterprises (entrepreneurship questions were avoided).
7. To make sure a holistic representation of the innovation process is conveyed through the questions and their implementation.

Reasons for excluding questions from the audit:
1. Questions with poor correspondence with the audit topic.
2. If too high a concentration were found in certain areas of the proposed innovation model.
3. Questions with too much of an applied nature.
4. Duplicate questions were consolidated into single ones.
5. Questions not aimed at competencies but rather at metrics or process steps.
6. Questions aimed at small or micro enterprises.
7. Questions requiring a high degree of knowledge or background in innovation which would not be understood by the auditees.

## 6.2 Proposed Competence Audit Questions

Considering the above mentioned criteria as well as all the previously discussed innovation best practises in chapter five, the following questions were selected. They offer a holistic view as proposed by the audit model in chapter three and should represent its different sections. However, due to the limited nature of this masters thesis a claim of total comprehensive representation of the innovation discipline is not made.

### 6.2.1 Interaction with the External Environment

#### 6.2.1.1 Technology

1. Is dynamics of technological change a priority for strategic and general management, in deciding what new innovations to pursue, and where the company is heading?

| Yes, always | Often | Sometimes | Almost never/ not yet |
|---|---|---|---|
| | | | |

2. Is there an ingrained knowledge throughout the organisation of key technologies and how they contribute towards strategy and core competencies? *(Key technologies are those which the organisation's bottom-line depends on, with the greatest influence on efficiency, capabilities and are process oriented, or improve development.)*

| Yes, almost everyone | Most of the organisation knows and understands our technologies | Probably only senior management knows this | I don't know our key technologies or how they contribute |
|---|---|---|---|
| | | | |

3. Is licensing of technology, in and out, actively pursued and are the criteria clearly stipulated? (*selling patents, licensing in (buying) of technology, licensing out (selling) of technology*)

| Yes licensing is often used when applicable | Licensing is used only if we are unable to do it ourselves | Licensing almost never used + criteria unclear | I don't know about our licensing procedures |
|---|---|---|---|
| | | | |

4. Do you use exploratory techniques to identify and predict future technologies for subsequent implementation into your foresight program? *(e.g. technology scanning and monitoring, scenario analysis and Delphi)*

| Yes, active monitoring and scenario planning are done in conjunction with the organisational strategy | Changes are being implemented from technology scan with some positive improvements visible | A technology scan has been done yet nothing changed | Little or no technology scanning is done |
|---|---|---|---|
| | | | |

5. Do your broad organisational technology trajectories (as outlined in the strategy for future development) foster innovation?

| | | | |
|---|---|---|---|
| Strong scientific R&D components + long term technology development | Some scientific and unique research yet most emphasis on scale | Future technologies focus on cost cutting and reengineering | I don't know about our future technology needs |

### 6.2.1.2 Market and Customer

1. Is there an intimate knowledge of the market/customer and its needs, preferences or demands with every person involved in new projects/innovations? *(Each function, from R&D, to design, to manufacturing, to after sales service, knows the needs and preferences of customers and how this product will satisfy them? "These guys really thought before designing this!" "This is a well designed product!" "This is beautiful and so useful, it's just what I needed".)*

| | | | |
|---|---|---|---|
| Yes, there is an intimate knowledge built through personal contact and observation of product use | A strong knowledge of market needs exists, yet products sometimes miss expected markets or initial user needs | Customer needs difficult to translate to actual work done in organisation | Market not yet well identified, yet information from marketing agency used extensively |

2. How strongly does the market/customer influence the characteristics, introduction price, operating procedures and final outcome of the project? *(Does the customer have a say in the features of the product, its safety, its reliability and its "looks". Does a feedback system exist for customer comment on current products?)*

| | | | |
|---|---|---|---|
| Customers part of development team, as well use of screening with customer groups | Customer needs and preferences used throughout development, yet little direct contact between project team and customer | Customer input used, yet often irrelevant since customer doesn't know what he/she wants | Market needs used as identified by marketing department |

3. Are criteria for market/customer development clear? *(Is the market developed before launching a new product; is advertising or similar development techniques used effectively.)*

| | | | |
|---|---|---|---|
| Strong market development with design and R&D giving input to marketing | Some market development done by advertising and personal contact with customers | Little market development done, just product advertising | Little or no market development is done |

4. Is the development capability of lead users (consumers that usually buy the first of almost everything) fully exploited? *(These consumers can give valuable critique on the product when in final development stage, since they usually have a good technical knowledge. E.g. Netscape launching a beta browser version and asking the lead users to find any bugs.)*

| | | | |
|---|---|---|---|
| Yes, lead users are identified and used extensively | Some preference made between customer test groups with emphasis on technical and non-technical people | Customer test groups are identified at random | No lead users are identified |

5. Do you use exploratory techniques to identify and predict future market trends in line with the strategic foresight of the organisation? *(e.g. market positioning and trend analysis, scenario analysis and Delphi)*

| | | | |
|---|---|---|---|
| Yes, active monitoring and scenario planning are done in conjunction with the organisational strategy | Correlation between strategy and market analysis with some benefits starting to occur | Market analysis is done, yet it is not linked to strategy | Little or no future market analysis done |

### 6.2.1.3 Industry

1. Do you encourage suppliers to develop their systems and products to deliver a higher quality and overall better product to you? *(Strong relationships between you and suppliers can improve delivery, quality, price, and add to the total value chain)*

| | | | |
|---|---|---|---|
| Yes, direct contact and deliberation on new products with emphasis on best supplier possibilities | Lots of encourage-ment as well as pressure | Some encourage-ment | Little or no contact with suppliers on such issues |

2. Are your motives for collaborating with other companies in the industry made explicit, and related to subsequent outcomes? *(Do industry work groups exist to develop certain basic needs for the industry. — e.g. Japan's industries stand united against the world, yet compete fiercely on national level.)*

| | | | |
|---|---|---|---|
| Yes, direct contact and collaboration with clear motives and outcomes | Lots of collaboration | Some collaboration | Poor relations with competitors and other role players |

3. Is benchmarking used in your industry on a national and international scale? *(how does your organisation compare with the best in the world)*

| | | | |
|---|---|---|---|
| Yes, regular benchmarking used nationally and internationally | Regular benchmarking used | Some benchmarking used | Poor relations with competitors and no benchmarking used |

4. Compared to your competitors, does a strategy exist that will result in your ultimate leadership in the industry (niche), through development and innovation? *(secrecy, accumulated tacit knowledge, product complexity, complementary assets, learning curve, standards, patents, lead times and product support )*

| | | | |
|---|---|---|---|
| Yes, our strategy takes competitors into account and will try to lead to leadership | Some competitor trends included in strategy | Knowledge of competitors, yet their development not included in strategy | Competition's strategies not known neither our own future development |

5. Do you learn from the competition, and is competitive intelligence used? *(R&D and reverse engineering, licensing, hiring, information collection)*

| | | | |
|---|---|---|---|
| Yes, good intelligence of competitors available and is used as learning tools | Regular intelligence and learning activities are undertaken | Some competitor intelligence available | No or little knowledge of competitors |

### 6.2.1.4 Political, Economical and Social

1. Do you specify and communicate your education and training needs to local and leading providers? (*Universities, Technicons, or NGOs*)

| | | | |
|---|---|---|---|
| Yes, continuous contact with short courses and research programmes | Regular contact yet little input or direction given | Some contact no input | None or little contact with such institutions |

2. Are all parties influential to new projects or innovation, captured by your information network? (*national and international "gurus" in the political, environmental ("green"), economical, social and government arena*)

| | | | |
|---|---|---|---|
| Yes, continuous contact with strong benefits | Regular contact and some benefit derived | Some contact little benefit | None or little contact with such parties |

3. Do your links with government provide early warning of relevant regulation, promotion and mechanisms that would have a positive or negative impact on your organisation?

| | | | |
|---|---|---|---|
| Yes, many links with strong benefits | Many links with some benefit derived | Some links exist | Little or no such links |

4. Are potential advantages, that may derive from the national environment, effectively used and implemented? *(Tax breaks, special development areas, science base, input prices, workforce skills, market demand, support industries, and other.)*

| Yes, all available advantages are employed | Many advantages used | Some advantages used | Don't know of any |
|---|---|---|---|
| | | | |

5. Is action being taken to benefit from foreign systems of innovation? (*Foreign investment, joint ventures and alliances, trade agreements, suppliers and customers, licensing, reverse engineering, public research*)

| Yes, all available advantages are employed | Many advantages used | Some advantages used | Don't know of any |
|---|---|---|---|
| | | | |

### 6.2.2 Organisational

#### 6.2.2.1 Strategic

1. Does an active foresight programme exist, looking five to ten years into the future, complementing the strategy in reaching the future of your organisation?

| Yes, foresight and strategy, shape our future focus | A foresight study has been done | Some future planning is done | Don't know of any |
|---|---|---|---|
| | | | |

2. Are new generation products and technologies planned and developed in accordance with your foresight and strategy formulation? *(number of new generations of products planned in advance)*

| Yes | Most new projects are strategic and in accordance with the foresight | Some projects are strategic | No or I don't know |
|---|---|---|---|
| | | | |

3. Does the overall foresight and business strategy, link with innovation and innovation management throughout the organisation? *(Are clear goals for innovation set, and is innovation seen as a method for gaining a competitive edge over competitors.)*

| Yes, mostly | In certain cases | Marginally | No or I don't know if it does |
|---|---|---|---|
| | | | |

4. Is the correct structure for a particular innovation determined, be it tiger teams, multi-disciplinary teams, functional participation, or matrix based, with strong leadership and early involvement by future members of the chosen structure.

| | | | |
|---|---|---|---|
| Yes, best possible team structure chosen with early participation of all functions that are present in the team throughout the innovation lifecycle | Task team as well as good concurrent engineering practices | Some flexibility with better involvement of innovation parties | Only one formal structure with functional participation as project reaches each stage in the lifecycle |

5. Do you clearly identify potential new company technological competencies — corporate visions, technical judgements, product-technology matrices, incremental trial, error and learning?

| | | | |
|---|---|---|---|
| Yes, all available advantages are employed | Many advantages used | Some advantages used | Don't know of any |

### 6.2.2.2 Implementation

1. Is your organisation able to extract the ultimate amount of advantage from available resources, and previous experiences? *(Learning (project review) and realising new possibilities for current resources, can significantly reduce an organisation's overhead costs i.e. Japan)*

| | | | |
|---|---|---|---|
| Yes | Mostly | Sometimes | Not really |

2. Do new innovations/ventures have a balanced repertoire of product development, production, and distribution? *(If compared to a three-legged chair, if any one is not present, consequences can be disastrous.)*

| | | | |
|---|---|---|---|
| Yes | Mostly | Sometimes | Not really |

3. Is there a measure of elapsed time, from the first funding of a new innovation and the time it takes to recover the investment through market sales of that particular innovation? *(Time for ROI)*

| | | | |
|---|---|---|---|
| Yes, clear metrics and measurements for new developments are in place | Mostly | Sometimes, yet generally little track is kept | Not really |

4. Is there early involvement (while still planning) and concurrent working by as many functions as possible, within the new product development system?

| | | | |
|---|---|---|---|
| Yes | Mostly | Sometimes | Not really |

5. Are there formal procedures for reviewing new product development progress against a series of stage 'gates' throughout the innovation lifecycle?

| Yes | Mostly | Sometimes | Not really |
|---|---|---|---|
| | | | |

#### 6.2.2.3 Fostering Environment

1. Do career structures and skill improvement courses, include learning about creativity, core competencies, technology and innovation and how to implement it practically in each employee's working environment?

| Yes, almost all employees learn of these concepts | Most management people | For some employees | Not that I know of |
|---|---|---|---|

2. Are key individuals identified, advertised, recognised and supported by management, to make the necessary information and experience available to entrepreneurial employees, in your organisation?

| Yes, we have an active key peoples network | Mostly | To a certain degree | Not that I know of |
|---|---|---|---|

3. Is your organisation capable of actively learning, as well as learning faster than competitors, from each new product innovation, even if the innovation was unsuccessful?

| Yes | Mostly | Sometimes | Not really |
|---|---|---|---|
| | | | |

4. If a new product fails, is there a feeling of total dismay and hopelessness concluded in shutdown of the project, or does quick learning occur from the experience, followed by renewed vigour for succeeding and making the project work better? *(Few first innovations are immediate success stories. New product market expectations are always difficult to judge, and the only way is by actually launching a product and learning from the reaction.)*

| Yes always | Mostly | Sometimes | Not really |
|---|---|---|---|
| | | | |

5. Does management or leadership expect innovation and creativity, and strive's to create a truly friendly environment for new ideas and expectations to be discussed and pursued?

| Yes, management leads the way through excitement and example | Innovation expected, rewarded and fostered but not by all | Innovation expected but little done to create the environment | Not really |
|---|---|---|---|

6. Does a flexible incentive scheme exist, with rewards that have a real influence on employee innovativeness? *(Base pay with bonus opportunities doubling or even tripling the base salary)*

| | | | |
|---|---|---|---|
| Yes, a good formal and informal incentive schemes exist | A formal innovation scheme exists | Year-end bonus scheme exists | Not really |

### 6.2.3 Individual

#### 6.2.3.1 Personality and Feelings

1. If you win the lottery tomorrow with a total prize of $10 million, would you?

| | | | |
|---|---|---|---|
| Invest the money and continue working | Take a long vacation but stay on in your current position | Resign after completing immediate tasks and responsibilities | Immediately resign and do whatever you like |

2. Do you feel compelled to be as creative as possible when solving problems, or starting with a new project? (*Do rules and regulations exist limiting your creativity or inhibiting controversiality.*)

| | | | |
|---|---|---|---|
| Yes | Mostly | Sometimes | Almost never |

3. Do you as an individual experience the strategic goals of your organisation (as set by the foresight and strategy of your organisation) as motivational?

| | | | |
|---|---|---|---|
| Yes | Mostly | Sometimes | Not really |

4. When pursuing or suggesting an innovative avenue, do you at any stage feel threatened (promotion wise, to be showing disrespect, being ridiculed, feel foolish, seem to be naïve, fear of failure, not wanting to stand out, being branded as different, or losing social standing) by management or colleagues?

| | | | |
|---|---|---|---|
| Yes, I often feel threatened in some way | Many times especially in the company of superiors | Sometimes | Not really, the culture is very open and most things go down well |

5. Do you as an individual feel like you are making a significant contribution to your organisation's strategic and foresight goals, or do you feel like a cog in a huge machine?

| | | | |
|---|---|---|---|
| Yes, I often feel significant | In many projects I have felt significant | I sometimes feel significant | Not really |

### 6.2.3.2 Knowledge, Intelligence, Experience and Background

1. When starting a new project, are you and your colleagues made aware of the common goal for the project, as well as the significance to the organisational strategy? (common goal = total project goal = successful market penetration = reaching planned strategic future)

| Yes, always | Mostly, depending who is involved | Sometimes, yet depending on who is involved | Seldom or not really |
|---|---|---|---|
| | | | |

2. Are you creative in new projects or do your years of experience inhibit crazy ideas, - possibly childish or ridiculous? (Do you use creative techniques in your own work and in group situations?)

| Yes, I always try | Mostly, if time allows | Sometimes, depending on the project | Seldom, I just try to finish the project on time in 'spec' |
|---|---|---|---|
| | | | |

3. Do you often study inside and outside your field to improve your knowledge base, enabling you to adopt different approaches, when solving problems? (Self motivation to grow and learn)

| Yes, I try to broaden my knowledge on many aspects | Mostly if time allows | Sometimes | Not really |
|---|---|---|---|
| | | | |

4. Are you aware of the key people (champions, gatekeepers, entrepreneurs, mentors) in your organisation to contact if a new idea occurs to you, even if it is completely outside your department's field of expertise?

| Yes, I know all the key people and how to get in contact with them | I am aware of most key people | I am aware of some key people in my department | Not really |
|---|---|---|---|
| | | | |

5. Do your family and home environment support you in entrepreneurial efforts you make at the office, even if it may result in a negative outcome?

| Yes, my family is part of my work and is prepared to adjust as I am for them | Mostly | As long as the changes do not impact to severely | Work and home do not mix |
|---|---|---|---|
| | | | |

### 6.2.3.3 Social Environment

1. Do you have a relationship of communication and understanding with at least one person in each of the functional departments of your organisation?

| | | | |
|---|---|---|---|
| Yes, I have a relationship in each of the functions and it always broadens my perspective when discussing new projects with them | I know most relevant people in the different functions | Some relationships, yet they are not specifically in certain departments | Not really, I am not that social |

2. Does a spirit of innovation and dedication prevail throughout your organisation, recognising and celebrating employees brave enough to propose new innovations or whom are creative and resourceful in their daily tasks?

| | | | |
|---|---|---|---|
| Yes | Mostly | To a certain degree | Not really |

3. Is it possible that everybody in your organisation essentially thinks in the same way (is the workforce predominantly engineers/ economists/ lawyers/ doctors) or are diverse thinking really present? *(Do most employees follow and agree with the leader or manager and form a sort of herd around a single person, without giving their opinion, or sometimes not even having an opinion of their own?)*

| | | | |
|---|---|---|---|
| Yes, it is quite possible | It is mostly possible | To a certain degree, yet we are quite diverse | No, we are an extremely diverse group of employees, ranging from many different countries, as well as occupations |

4. Are there any mavericks or 'weirdoes' in your organisation, and are they sort of accepted in the social structure of your organisation. *(They are often catalysts for different thinking and breaking the herd mentality* )

| | | | |
|---|---|---|---|
| Yes, mavericks are purposefully hired and made to feel welcome, as any other employee | Some mavericks are hired, yet they seldom fit in | Most new employees are hired to fit in, yet the few who slip through, are accommodated | Not really, no weirdoes |

5. Is there a person or persons in your organisation that tells and embodies powerful and purposeful stories, with the aim of imbedding in the identity of the organisation's past legends, faiths, myths, and stories relating to innovative activities and highly successful past and future activities?

| | | | |
|---|---|---|---|
| Yes, we have many storytellers | Some do exist, yet their value are not recognised by management | Few active story tellers, but stories in the form of rumours do occur | Not really |

## 6.3 Conclusion to Audit Questions

The aim of the audit questions is to extract a representative view from the auditee on the competencies seated in his/her organisation. By arranging the questions in sections as proposed by the innovation model in chapter three, this was accomplished.

The diverse nature of the innovation process may require many more questions than the ones proposed above. However, by balancing the advantage of adding more questions to the audit questionnaire against the supposed improvement they may introduce, should limit the number of audit questions. Making the questionnaire as user friendly as possible and not too long, also impose a severe limit on the amount of questions that may be asked. These two factors were the determining factors in limiting each section in the questionnaire to five or six questions only.

By asking generic and holistic questions the audit is able to identify strengths and weaknesses in various areas of the organisation. The results from the audit questions and the identified strengths and weaknesses may be included in a threat and opportunity analysis, with subsequent strategy formulation for the organisation.

## 6.4 Testing the Proposed Competence Audit

To test the proposed innovation model, the proposed audit methodology and the audit questionnaire, a number of South African technology based organisations was approached. Successful audits were completed at a total of five organisations in the regions of Pretoria and Johannesburg. Various hierarchical audit depths including management level audits, operational level and disciplinary level audits were tested at the audited firms.

The following paragraph will illustrate the procedures followed to beta test the audit questionnaire. Some of the results from the beta test process will be discussed, as well as their significance for the innovation audit methodology. The chapter will conclude with remarks on the implementability of the questionnaire, and proposed audit methodology as discussed in chapter four. The innovation model and the best practise standards discussed in chapters three and five respectively, will be reviewed on the basis of the beta test as well.

### 6.4.1 The Beta Test Procedures

To test the audit questionnaire the decision was made to follow a beta test methodology. Beta testing offers the advantage of testing a relatively new process or product in an undefined and unstructured discipline or industry, through a limited number of tests. Since innovation auditing is still in the development phase beta testing seemed the best option.

The audit questionnaire was developed from the innovation questions discussed in the first section of his chapter and the best practise standards discussed in chapter five. The questionnaires were then presented to the organisations by means of the following steps:

**Beta Test Audit Procedure:**

Select organisations where innovation is, or should be, a core process.

There is no sense in selecting organisations where innovation barely exists. These organisations are often so busy with other business practices, that they would not think innovation auditing could help them.

Contact the MD or technology manager of the selected organisations.

Innovation auditing is a strategic management tool. It therefore requires management approval, before implementation is possible.

Explain innovation auditing and its advantages.

Many organisations implicitly manage innovation, and have not yet thought of measuring their own innovation capabilities. The notion of innovation auditing must therefore be explained, in effective yet understandable terms.

Explain the audit implementation procedures.

Managers need to judge the impact of the innovation audit process on their business, and the procedures for auditing therefore become necessary. Time allocation and the depth of the audit, contribute to the duration of auditing.

Obtain the go ahead to proceed, as well as the hierarchical audit depth allowed.

Strategic management approval will enable the auditing process to proceed, and empowers it to schedule meetings, and audit sessions.

Subdivide the organisation into audit groups.

Before auditing can start, manageable audit groups should be identified. These could be business units, disciplinary units, teams, departments or any divisions made inside the organisation. At this stage the depth of the audit should be made clear, and the number of employees taking part, identified.

Briefing of leaders to each audit group.

Just as the strategic management needs to know the purpose of the audit, so should the audit group leaders or managers.

Explain innovation auditing and its advantages.

To introduce the concept of innovation auditing, a model of the innovation process inside an organisation will be discussed.

Explain the audit implementation procedures.

Auditing is done in groups on the same social and employee level. Innovation involvement also plays a key role in selecting the groups. Each person in the group completes an innovation audit questionnaire. The auditor should be present to facilitate the audit process, and answer any questions if uncertainties arise.

Conduct sessions of auditing.

Introduce the innovation audit to the group, and ensure they understand the innovation model as basis for the audit. Answer any questions on the questionnaire. Create an environment where honesty and personal perceptions may be measured.

Collect and digitise data from each audit session.

Enter the answers to the audits into a database.

Analyse and integrate data with the innovation model.

Divide and modify the data from the groups if necessary.
Integrate the data into sensible outputs that illustrate the 'strengths' and 'weaknesses' clearly.

Construct audit outputs for the organisation as a whole, as well as for each audit unit.

Create any number of bar charts or strength and weakness charts, applicable to the organisation's need.

Hold discussion sessions with senior management.

Discussion on the findings of the audit with senior management, may be the first step in revealing the audit scores. More discussion with audit groups may be required if senior management queries the reasons for the findings, or would like more information on certain strengths and weaknesses.

Hold discussion sessions with audit groups (management backing auditor up).

Report audit findings formally in the form of a document, including audit procedure, results and actions taken, as well as timeframe for next audit

Evaluate positive and negative aspects highlighted by the beta test procedure.

Beta testing excels in test situations where many uncertainties still exist. It requires direct contact between the tester (auditor) and the tested (auditee) to facilitate comments and queries on the test. By following a beta test methodology, the audit questionnaire was successfully tested in various organisations with good response by all. Some of the comments and queries on the proposed innovation questionnaire will be discussed next.

### 6.4.2 Audit Test Selection

To test the proposed audit questionnaire different industries were considered. Due to the high technology nature of the electronic business environment, as well as the availability of these industries in the Pretoria/Johannesburg area, most of the tests were done at electronic and information technology related organisations. One of the audit tests was conducted at a medical development facility to add a measure of diversification.

**The first audit** was done on management level at an arms manufacturing organisation.

Nature of Business

The organisation in question is involved in the manufacturing of guided weapons for the South African National Defence Force, as well as the international market. After the trade embargo against South Africa was lifted its once stable market disappeared. This lead to downsizing and numerous retrenchments, negatively affecting the morale of the whole organisation. Their current trade consists of international and national contracts, but an uncertain future in the arms industry looks likely.

Innovation Practises and Competencies

The organisation consists largely of highly qualified engineers and scientists. They are involved in various projects with enough freedom to be creative and innovative within the parameters of the project. To try and stimulate innovation, top management allowed new ventures to be started. However, these often diverged from the core business and failed miserably. Currently focus falls on the core business and formal innovation in identified fields where new technology paradigms are forming.

The Audit

One to one contact was possible between the auditor and the four auditees. The audits were done in the form of interviews to enhance the preliminary questions through explanation. Since this was the first audit, unnecessary questions were still part of the questionnaire. These were removed afterwards. This led to some inaccuracy of the results in the first audit. The auditor noted the poor understanding of many facets of innovation during the audits. Other aspects such as a lack of trust in leadership, a poor outlook on the future and a generally negative atmosphere were quite obvious in some of the older auditees. The only positive auditee was quite young and still full of ambition. This led the auditor to the conclusion that the organisation was finding the adjustment from mainly national to international trading, strenuous. The audit results will be discussed later in this chapter. The raw data from this audit is included in the addendum [Appendix E, Table E.1 and E.2].

**The second audit** was performed at an electronics/software systems engineering organisation.

Nature of business

The organisation was formed by systems engineers with the aim of providing high technology systems solutions to defence and commercial clients, nationally and internationally. They specialise in defence systems, energy systems and security systems. Some of their competencies include, artificial intelligence, digital electronics hardware design, software design, computer vision, aeromechanical services and weapon guidance. The organisation consists of scientists as well as systems engineers and computer programmers.

Innovation Practises and Competencies

The approach to innovation is from the 'rationalist' perspective as proposed by Tidd *et al.*[6] It focuses on design and development on a systems engineering methodology on a reactive basis. The organisation develops systems for clients to their specification, rather than free-standing products to be sold into the market. This enables the organisation to concentrate on developing and testing the product, until it meets every standard or specification required.

The Audit

It was possible to audit a large group, incorporating individuals from scientists to management level. The industry in question is well positioned for growth in the future and innovation related activities and employee perceptions were expected to be highly positive. The audit took the form of a group session and less direct interaction between the auditor and auditees were therefore possible. A highly professional environment, as well as positive responses to the innovation audit created the impression of a highly effective organisation, based on strong leadership.

**The third audit** was done at a small software company, which forms part of a larger holding company listed on the Johannesburg Stock Exchange.

Nature of business
Knowledge management is becoming an important aspect of successful business management. The organisation in question specialises in the development of software and systems in this field. It is a newly formed unit and with the backing of its listed holding company, could reach great hights. Currently the organisation produces and sells to the national and international knowledge management market.

Innovation Practises and Competencies
Since the organisation was just recently incorporated they have yet to form tradition bound procedures. This enables them to be free and creative, as often expected from software development organisations. Strong leadership and good interaction between the employees and management seem to improve the possibility of strong innovation practises being established.

The Audit
Individuals with high involvement in the innovation process were identified and asked to complete the questionnaire. An environment of excitement, dedication and innovation was found to be present in the organisation. Direct interaction between the auditor and auditees was possible. Five individuals completed the questionnaire, including the managing director.

**The fourth audit** was conducted on a one to one basis with employees at a medical research facility.

Nature of business
The institute in question provides testing and research services to private as well as governmental institutions. It is currently part of the University of Pretoria but might be transferred to the government. This may lead to disruption in their ability to perform their services.

Innovation Practises and Competencies
The medical research institute plays mainly a role of service and has a low product development priority. The institute does basic research on various chemical, virological and other medical ailments. It may therefore be classified as a research organisation and should not be compared with the other audits performed during the beta test phase. Some of the differences will be quite apparent in the discussion of its results later in this chapter.

The Audit
The auditor experienced a mixture of emotions from hostility to exuberance. This may be ascribed to the uncertain environment at the organisation since its future operations hung in the balance of government downsizing. Direct interaction between the auditor and auditees was possible, and a total of six questionnaires was completed.

**The fifth and last audit** measured the capabilities of a large group consisting of engineers, managers and marketing employees.

Nature of business
This was possibly one of the most successful organisations which formed part of the beta test group. The organisation is involved in the development and

distribution of pre-paid electricity metering devices. They have contracts both nationally and internationally with a strong presence from Africa and Australasia to South America and Europe.

Innovation Practises and Competencies
Since the organisation claims to be the leader in their field, the auditor perceived them to be quite innovative. A strong view of the future exists with emphasis on new development and improvement in the product. Since the product and related technology are still in the growth phase, it is expected that the organisation would be continuously busy redefining and developing the product. A definite dominant design has yet to be established, but the organisation in question has a good chance of setting current and future standards.

The Audit
A bright future is expected for the organisation, although their current working environment may lack some amenities. The general social climate was tense and could be ascribed to a high priority on time management. Due to the large group, there was limited interaction between the auditor and the auditees. However, since this was the last group in the beta test process the auditor had gained some previous experience in discussing the topic. It may therefore be seen as the most reliable results obtained.

The interaction between the auditor and the audit firms was valuable in teaching the limitations of academic ideas and the implementation thereof. It became clear to the auditor, while in the process of auditing, that a large amount of knowledge and understanding needs to be settled in the auditor himself/herself, since he/she has direct influence on the outcome of the innovation audit.

On the organisation side, the beta test process showed the lack of strong and well-developed innovation strategies, a fact which will have to be addressed in the new South Africa.

The following section will discuss some of the findings from the beta innovation test. The organisations' names are omitted as requested by them, but they are identified by their industry type. The raw data from the audits is included in the addendum [Appendix E, Table E.1 to E.10].

### 6.4.3 Beta Test Findings

Before discussing the results from the beta test audit, some comments made by the auditees will be discussed. This improves the understanding why the results are what they are and calibrates the reader's perceptions to a degree. While auditing the auditor noted many positive and negative aspects, which might influence the audit results. These will be discussed in this section as well.

The audit questionnaire included a sub-section where the auditees were given the chance to review the questionnaire. Some of the comments they made are listed below.

**The response to:**

Does the audit, to your experience cover every aspect crucial to the innovation process?

*What about technical competence we often appoint somebody without a full appreciation of technical skills?*

— Divisional Manager

*To a certain context, yes.*
*Are salaries market related?*

— Project Manager

*The questionnaire does not address the relationship between innovation and meeting mindset constraints.*

— Defence Systems

*In our industry there is no time to really innovate, due to massive pressure to meet milestones so that more can get generated. Management, especially MBL/MBA managers don't, or seldom understand engineers/technical people/intellectuals and their needs. This affects motivation, which in turn affects innovation.*

— Systems engineer

*More contact with outside world*

— Systems Engineer

*Management skills and attitude towards innovation*

— Systems Engineer

*Innovation requires time (often company time), how it is allocated and how much. Innovation requires exposure, are the right tools in place or available (Internet, etc.)*

— System engineer

*Feelings on effectiveness of management. Feelings on practical approaches used to solve serious problems / crisis.*

— Engineer

*Ability to work flexitime as most ideas happen when there is silence.*

— Software design engineer

*Pretty comprehensive, maybe too much emphasis on the technical (development) side. Innovation = Product + commercialisation*

— Director & Business Manager Defence Systems

*Yes - touches issues crucial for innovation but sometimes not seen as crucial. Bringing your background/networking and experience with in an organisation that aids innovation i.e. have the guys in the teams "been around" done things, experience + gone through a few innovation cycles. Therefore innovating people create innovative atmosphere but some should be old hands otherwise the young guys just fall around.*

— Senior design engineer

*It appears to cover most of areas, but there are a couple of apparent deficiencies. Difficult to choose a one to four answer. A scale from 1 to 10 would have been easier. No account has been taken of the respondent's experience or length of service.*

— Project manager

*The audit seemed to cover all aspects of the model and I was able to relate nearly all of the questions to our organisation quite easily.*

— Manager

*Suggest you talk people through each question. Questions need to be more user friendly or need to be talked through. I am not confident that my answers will be as meaningful as possible.*
*Informality, lack of rigid structure and rules.*

— Engineering Manager

*Is there time to be innovative?*

— Software development manager

*Go/no go decisions and the decision making process*

— Business development Manager

*The audit appears to be well structured and at first pass addresses most I can think of.*

— Managing director

General comments

*We live in a vertical market and as such follow one path. The current path is for reliability based on experience. Innovation is therefore not so much at the forefront. Innovation is however extremely valuable*

— Product management

*Once a product is designed developed and implemented there is an innovation process, which should happen in the actual production of the product. I.e. processes and systems are put into place or improved to make it cheaper and more cost effective to produce the product. This aspect is not covered very well. A large part of staying ahead with a particular product is in how smartly do you produce the product.*

— Manager

Trends may be identified in the aggregate of comments received from the auditees. For instance the comment/question: '*Is there time to be innovative*' occurs in various forms in several of the comments. It relates to the question of how an employee perceives his/her everyday task, and to what extent it forms part of an innovation process. If the employee does not feel involved with innovative processes, his/her perception may be faulty or there may actually not be any innovative activities in process. Creativity is not innovation and employees should not think since they were not very creative in their task that they did not innovate. Innovation has many non-creative parts yet employees have to be made aware of this.

However, without a persuasive drive for innovation including allotted time and resources, management may not expect employees to innovate on their own. On the other hand employees should not expect an hour every other day when they may sit around 'innovating/idealising', although they might think this is how it should be done.

Another recurring comment which ties in with: '*enough time for innovation*' is the competency of the organisations' management. If the employees do not feel management is competent in innovation or even in their other management tasks, the process of innovation will immediately suffer. Innovation is a process, which absolutely requires leadership. When such a person is not involved, the process seldom reaches its goals and reverts to a state of mediocrity.

The comments also seem to indicate that the proposed innovation model (on which the audit questionnaire was based), is valid to a certain extent and since few negative comments were made, may be designated as a valid innovation model. Although further development of the proposed innovation model is necessary, this 'validation' enables further research to concentrate on detail and not question the basic foundations laid by the model.

The true meanings of the comments are often obscured by the many different sources they refer to. It is difficult to qualify a comment when the true context of the comment is not understood. For this reason the above mentioned comments will be regarded as guidelines for improving the innovation audit, but will not effect fundamental change.

Many lessons and a greater understanding may be gained from the proposals above. The aim of the innovation questionnaire is to extract innovation related information from the individual, as effectively as possible. By heeding the proposals made against the questionnaire, it may be improved to be more user friendly and understandable.

Due to the depth and complexity of the innovation process the above quoted comments on the validity of the innovation questionnaire are not as influential as they might appear. The organisations, which were tested, do not research the methodologies of innovation and may therefore have a narrow-minded approach to the subject. To expect in-depth comments in such a short period does seem a bit unfair and one should not be too harsh on some of the responses.

It is clear that the most appropriate test for the validity of the proposed questionnaire may be found through the application thereof, as part of an innovation audit. Secondly, the total proposed innovation audit model, methodology and questionnaire may only show its validity once implemented. If actions taken due to the audit proposals result in organisational improvements, the audit will be validated, however if actions taken result in poorer performance, the audit may not be so accurate. Thus the only way to truly test the innovation audit, is to measure the advantages derived after its implementation.

#### 6.4.3.1 Findings Noted by the Auditor

During the beta test process the author learned much about the behaviour and characteristics of small and large groups of people. The applicability of the questionnaire, was also reviewed. The following conclusions were reached:

1. Direct involvement (person to person) between the auditor and the auditees improves the understanding of the questions and therefore the answers. While less interaction (auditor to group) may give results without any of the biases from the auditor influencing the auditees. It is therefore difficult to determine which of the two will ultimately give the best audit results.
2. A serious drawback to questionnaires is that questions are open to individual interpretation and often misunderstood if on difficult subjects.
3. Few individuals in the organisation are knowledgeable enough in the discipline of innovation, to understand the questions and their implications. This severely limits the validity of the answers, as they are based on limited understanding. Clearly to

answer a question sensibly, one requires background knowledge on the field in question. Education in the field of innovation is therefore a crucial aspect of building strategies for innovation.
4. There are so many aspects to a successful innovation process that one audit questionnaire could not possibly cover them all. Fitting complex concepts and processes into a limited number of questions, complicates the questions and degrades the results of the innovation audit. It would be better to split the audit into a master audit with several sub-audits, enabling the organisation to audit their weak spots and find the areas where improvement would offer the largest advantage first.

It is clear that much applied research is necessary to define the different methods for implementing an innovation audit, and defining where and when they should be used. This thesis found that an audit questionnaire offers some advantages, yet many disadvantages are apparent as well. Through future years of innovation auditing, these methodologies will however be resolved.

To illustrate some of the results from the beta testing of the innovation audit questionnaire, they are discussed in the following section.

## 6.5 Results From the Beta Test Process

The results will be discussed in two main categories. Firstly, the results for each organisation may be compared with other organisations inside, as well as outside the industry, if they completed an innovation audit of their own. For the purposes of this discussion, the five organisations which completed the beta test audit questionnaire, will be compared. The sections that may be compared includes overall industry analysis, organisation analysis and innovation sub-section analysis.

Secondly, a single organisation will be examined and some discussion on its strengths and weaknesses provided. By representing the audit data in this way, the organisations are not only able to judge their own strengths and weaknesses, but also how they compare to other organisations. The data from the audit questionnaires are included in the addendum [Appendix E].

### 6.5.1 Comparative Analysis

Benchmarking has found large implementation and application in the business environment.[7] Most organisations realise the advantage of benchmarking their processes against the others in their industry and so learn about their strengths and weaknesses. In the discipline of innovation this has not been possible, and developing measures to enable the benchmark process to include innovation, is important. This thesis and the proposed innovation audit, may be a step in this direction. By comparing the audit results from different organisations in the same industry, their innovation competencies may be benchmarked. The following graphs from the innovation audit testing procedures, may serve as examples.

Due to the perceptive nature of the innovation audit (it is based on perceptions), discrepancies might occur between an organisation's innovation output, and its ranking as obtained from the innovation audit. It should be remembered that the results from the beta test audit questionnaires represent general organisational perceptions and may be influenced by many factors. Factors such as audit group size and composition, successfulness of current practises, the organisational culture, and many more have a direct influence on the human perceptions and feelings of the innovation process, thus colouring their responses on innovation. The results should therefore not be seen as absolute, but rather as a measure whereby the organisation's perception of its innovation capabilities, is compared with others in the same industry.

Three graphs will be discussed, ranging in explanation and audit depth. The first illustrates the total innovation audit results, while the others include more detail on innovation specific competencies.

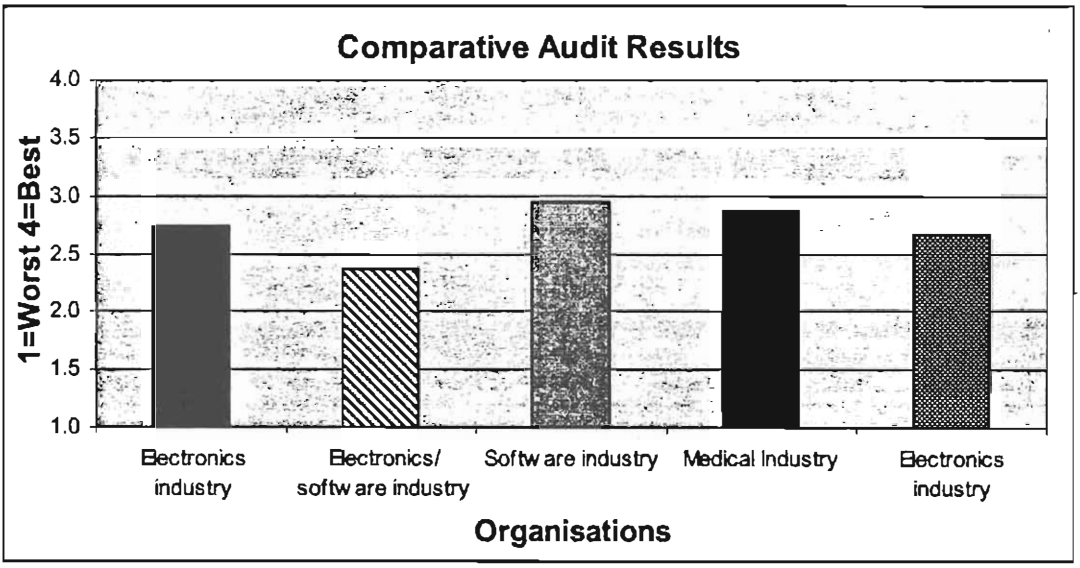


*Figure 6.1: Comparative Organisational Analysis (The competence audit's combined results)*

The calculations displayed in the bar-chart in Figure 6.1 entailed summing and averaging the respective answers from each question of all the questionnaires. This created one master questionnaire for each of the five organisations audited. By summing and averaging each of the master questionnaire's questions in the sub-sections, averages for each of the sub-sections were obtained. The sub-section averages were then summed and an average for each of the sections calculated. By summing and averaging the sections a final score for each of the organisations was determined. These scores are illustrated in the bar-chart in Figure 6.1. All the relevant data is incorporated into the Addendum in Appendix E, as well as a more detailed explanation of the calculations.

Figure 6.1 shows the five organisations which took part in the beta testing process. It illustrates five separate organisations active in the electronics, software and medical industries. The graph was constructed by finding the average of all the questions in the innovation questionnaires completed by each of the organisations. The bars represent the average score for each organisation, with a score of one being the lowest and four the highest. As discussed in paragraph 6.4.2 the first bar, on the left, in Figure 6.1 represents the first audited organisation, the second represents the second audit, and so forth, ending with the last bar, on the right, representing the fifth audit. These shades and patterns will continuously represent the results from the same organisations in the next paragraphs.

In Figure 6.1 the organisation in the software industry, third bar from left, perceived their competencies as very innovative, while the electronics/software integration organisation, second bar from left, was found to be less competent at innovation. It is interesting to note the high score in the medical industry, second bar from right, which may be due to the large development component of that particular organisation. Both the most left and most right bars illustrate an average score which may be ascribed to the underlying organisations' formally developed innovation processes.

The results in Figure 6.1 give a measure of the perceived innovativeness of the organisation. As such it may be used to fuel ideas and look deeper into the reasons why certain organisations are more positive on their innovation capabilities than others. This may also be correlated with the amount of new innovations in the product range, to calibrate the innovation audit findings. For instance, 3M's management set the goal that 30 percent of all sales has to come from products that had been around no longer than four years, possibly resulting in making them one of the worlds most innovative organisations.[8]

The results from the innovation audit may therefore be treated as the 'inside' information on why certain organisations are more innovative than others. And the innovation outputs as the outside or visible results from the organisation's innovation efforts. By using both these measures organisations may be accurately compared with one another on their innovative ability.

To understand the reasons why certain organisations score higher than others in the comparative analysis, one may consider some more detail. The sectional analysis and comparisons are able to reflect differences between organisations in the environmental, organisational and individual sections of innovation.

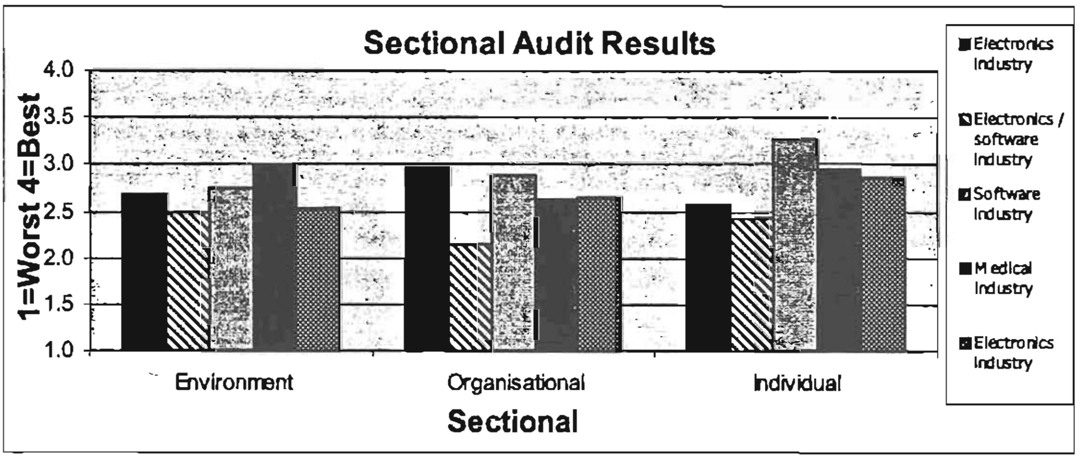


*Figure 6.2: Organisational Analysis*

Figure 6.2 illustrates the sections of the innovation audit questionnaire for the five organisations that were audited. The three sections, environment, organisational and individual form the foundation of the audit questionnaire and comparing these sections with each other may highlight respective strengths and weaknesses. The graph enables organisations to compare the different sections with other organisations who also completed the audit questionnaire.

In Figure 6.2 it is interesting to note that the organisation in the software industry, is stronger in the individual section than any of the others, while the organisation in the medical industry is strongest in the environment section. This may be attributable to the focus of the different organisations. The software organisation clearly relies heavily on individual competencies and creativity, while the medical development organisation relies more on professionalism, and the correct research and development of a new substance.

It is apparent that the electronics/software integration organisation, second bar from left in each of the three sections in Figure 6.2, was found to be less competent at innovation. This may, however, be an anomaly. Since the innovation audit is based on perceptions, it is possible to find an organisation with a strong or weak perception of its own innovative ability, irrespective of its 'real' ability in comparison with others.

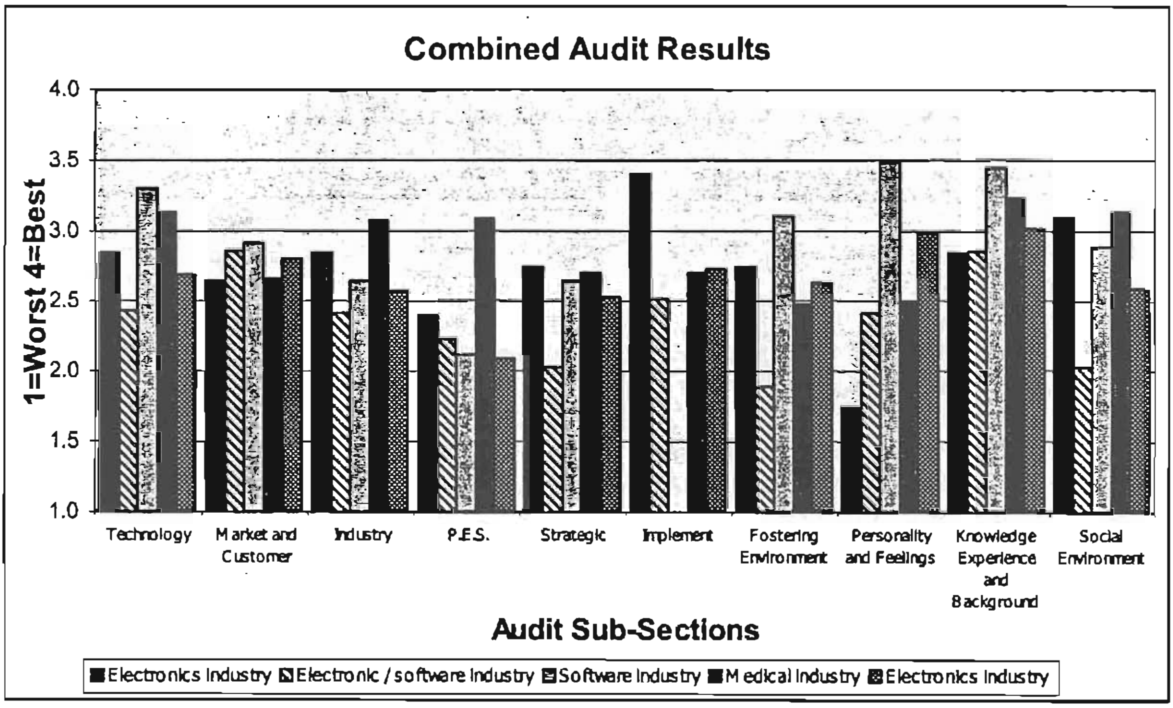


*Figure 6.3: Organisation Sub-section Analysis*

Even more detail is illustrated in the sub-sectional analysis of the different organisations, as illustrated in Figure 6.3. Each organisation is still represented in the same patterns and shades as in Figure 6.1. The bars represent the average of all the questionnaires for each sub section completed by each of the audited organisations. By comparing the sub-sectional results, in-depth knowledge on the strengths and weaknesses of organisations in relation to others, may be identified.

In the Figure 6.3, one may find the specific reasons why some organisations scored better than others in the preceding Figures 6.2 and 6.3. As illustrated in Figure 6.2 the organisation active within the software industry scored top marks. Thus Figure 6.3 can illustrate which of the three sub-sections in the individual section is the reason for the high scores. It is apparent that 'Personality and Feelings' and 'Knowledge, Experience and Background', are both top scores. While the 'Social Environment' is more in line with the other organisations' scores.

The previously mentioned low scoring organisation in the electronics/software industry, may likewise be analysed. Figure 6.2 illustrates this organisation's poor performance in the 'Organisational' section and the more detailed explanation in Figure 6.3 illustrates the reasons. One may conclude from Figure 6.3 that this organisation perceives its 'Strategic', 'Implementation' and 'Fostering Environment' as having poor competencies for innovation.

After identifying the specific areas where underperformance or overperformance were achieved, the organisations may investigate the reasons why, and then plan strategies to remedy the situation. It would be highly advantageous to both above mentioned organisations (software and electronics/software), if they could identify the reasons why the perceptions were so positive or negative, and then change or improve them in order to bring them in line with the other competencies of the organisation.

The comparative analysis enables the organisations who took part in the innovation audit to benchmark their competencies against each other, without giving away any proprietary information. This is ideal for many organisations with sensitive data and projects. Although the audit may not identify specific actions to be taken, it does identify the holistic areas where strengths and weaknesses lie. To advise in any other way, the audit would have to do in-depth analysis of organisational procedures and processes. The audit does therefore not try to prescribe, but serve as a method for self reflection and identification of an organisation's own characteristics. By pointing out areas of strength or weakness, the audit reaches its goal and enables the organisation itself to identify the specifics in improving their own processes and procedures.

It should be remembered that the audit is based on perceptions and this may lead to organisations with a high opinion of their own abilities, scoring generally higher than others. The results as illustrated in Figures 6.1 to 6.3 are therefore not absolutes, and may not be compared in this manner.

As more and more innovation audits are completed certain profiles for different industries may emerge. This would occur if some sub-sections were found to be more important than others for successful innovation in a specific industry. I.e. the medical organisation with a high score in 'Technology', but a lower score in 'Market and Customer' as may be observed in Figure 6.3, may be indicative of the industry specific requirements. Others may include a high score in the 'individual' section where extensive creativity and individualism is required. By applying these profiles to certain industries, better comparisons may be drawn than those illustrated in Figures 6.1 to 6.3. This may then lead to accurate assessment of industry structures, as well as reasons why some industries are more innovative than others.

### 6.5.2 Organisational Analysis

The results from the innovation audit may not only be used for comparative analysis, but also for identifying strengths and weaknesses inside individual organisations. Every organisation has to a greater or lesser extent innovation competencies in each of the sections identified by the organisational audit. However to be as successful as possible, the sections need to be balanced, as indicated by Tidd *et al.*[9] Successful innovation requires a balanced score-card for all its many diverse sections and subsections. Even though many perceptions of innovation focus on the brilliance required in the invention stage, without equally brilliant realisation and implementation, few if any, innovations will occur.

Analysing the separate sections of the audit results, with a subsequent refocus on sub-sections, enable organisations to identify their strengths and weaknesses in relation to their other competencies in innovation. The following two figures will illustrate the sections and sub-sections better. They represent a single organisation.

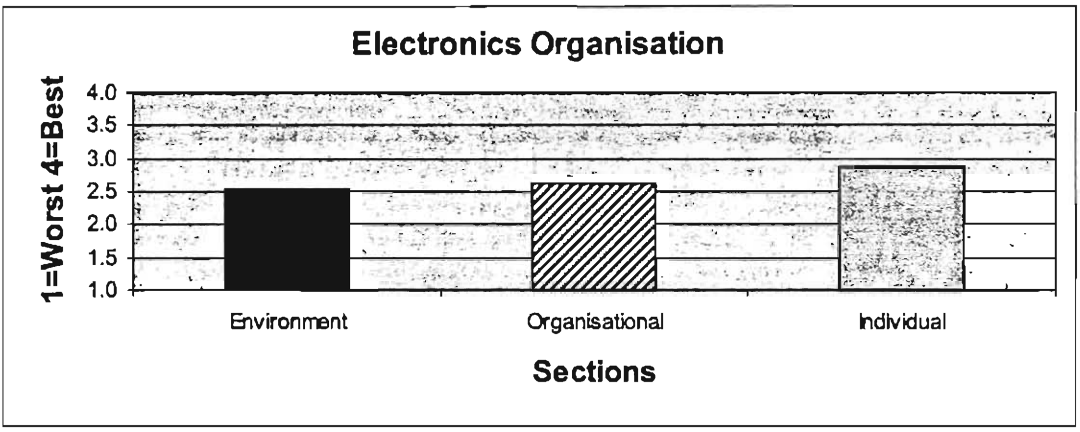


*Figure 6.4: Organisation Innovation Section Analysis*

Figure 6.4 illustrates the three sub sections as reported by the innovation audit questionnaire. The same calculations were made as for the comparative analysis in paragraph 6.7.1. All the relevant data is also incorporated into the Addendum in Appendix E, as well as a more detailed explanation of the calculations.

Figure 6.4 illustrates the 'Environment', 'Organisational' and 'Individual' sections for a single organisation. The 'Environment' bar, left in Figure 6.4, appears to have the lowest score, while the 'Individual' bar highest. All three sections scored between 2,5 and 3 making them average to near above average.

It is interesting to note the relation between the 'Individual' and 'Environment' scores. Although the reasons why these differ, may not be found in these results, the figure with the sub-section results will prove to be more informative. However the organisation would be prudent in researching why their environmental competencies contribute less to the innovation process, than the others.

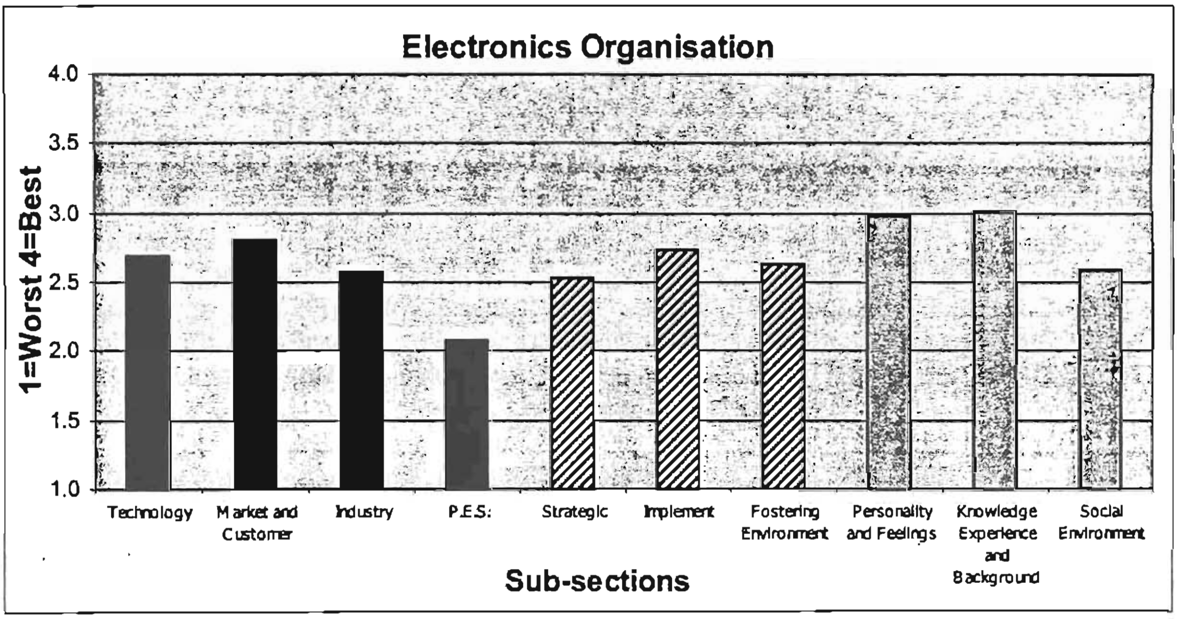


*Figure 6.5: Organisational Innovation Sub-section Analysis*

The results displayed in Figure 6.5 indicate the specific areas where the innovation process in the organisation lacks the necessary competencies. The 'P.E.S.' (Political, Economical, Social) attracts immediate attention on the low side, while the 'Personality and Feelings' and 'Knowledge Experience and Background' sub-sections, attract attention on the high scoring side.

It is interesting to note the low score the organisation attains in sections relating to social interaction and fostering environments. The sections, 'P.E.S.', 'Fostering Environment' and 'Social Environment' generally scored the lowest in its respective sections, with the exception of the 'Fostering Environment'. This is an indication that some work on the culture in the organisation may be overdue, and may make a significant impact on the innovation process, if improved.

The two strong sub-sections illustrated in Figure 6.5, lie in the 'Personality and Feelings' and 'Knowledge Experience and Background'. This may be ascribed to the type of employees employed by the organisation. They are all highly qualified engineers or scientists with strong personal motivation and a will to achieve success. This influences their response to their own capabilities and competencies boosting the two sections.

The organisation illustrated in Figure 6.5 may improve its innovation process dramatically, if they followed the proposals made by the results from the innovation audit, viz.

1. They have a strong human capability / competency capacity illustrated by the 'Personality and Feelings' and 'Knowledge Experience and Background' scores. This means they should be able to teach their employees new skills or improve their competencies through new projects.
2. They may improve by increasing the focus on the social interaction environment, as well as the fostering of new innovations.
3. They may improve through greater interaction between the organisation and the industry, as well as the political, economical and social environment (P.E.S).

These are but a few of the measures the organisation may consider. Analysing the specific questions in the innovation audit in more detail, the reasons for specific strengths or weaknesses may be discovered.

It is only natural for organisations that would like to improve their innovation processes to focus first on the things they 'know how to do', or 'are good at'. This often results in an unbalanced innovation repertoire with poor end results. The strength of the innovation audit lies in identifying the areas where improvement is most necessary, or may have the greatest impact. The audit is able to point out the areas where improvement will contribute much or little, enabling organisations to focus their competency development processes better.

Ultimately the innovation audit aims to create a balanced scorecard of innovation competencies in the organisation by identifying the imbalances between the various sub-sections. It secondly proposes the improvement of the total scorecard to enable the organisation to better compete within its own industry. Organisations may therefore employ the innovation audit, not only to identify strengths and weaknesses in their own operations, but also in its associated industry.

## 6.6 Conclusion to the Beta Test Process

The beta tests were resoundingly successful in identifying problems and improvements in the innovation questionnaire and implementation methodology. Through discussion with organisations, the proposed innovation model was also validated to a certain extent.

The audit results illustrated the expected nature of the proposed innovation audit well. The proposed innovation audit does not aim to identify specific practises or methods that should be followed in order to be successful at innovation. It neither prescribes actions to be taken to improve or change the innovation process. The audit has one goal in mind and that is to identify strengths and weaknesses in the innovation competencies of the organisation, and then let them determine how to improve these. The results from the audit tests prove the ability of the audit to capture perceived competencies and illustrates them in a sensible manner. It is able to clearly illustrate the strong and weak areas of the organisation's innovation process, enabling the organisation to take action.

The only true way to validate the innovation audit is through application in as many organisations as possible. Then with the findings of the audit implemented, the results in the innovative ability of the organisation, will prove the worth of the audit. If organisations do not improve due to the innovation audit and its identification of strengths and weaknesses, one may regard the audit as a failure. However, in identifying strengths and weaknesses the audit does succeed as clearly illustrated by the graphs in this section.

## 6.7 Conclusion

This chapter introduced the final part in the development of a competence audit for technological innovation. Many questions from various literary sources, as well as personal opinions as expressed by individuals in the industry, were discussed. These were then incorporated into an audit questionnaire for use in the implementation of an innovation audit, with the aim of identifying strong and weak competencies in organisations.

The chapter included reasons why various questions were included or excluded. The primary reason was often the limited nature of the questionnaire, and since innovation has so many facets, not every question could be included.

The chapter concluded with the beta testing of the questionnaire, as well as the proposed audit methodology and proposed innovation model, as discussed in previous chapters. The results were found to be subjective but largely conforming to expected industry and organisational perspectives. The tests did, however, clearly illustrate the ease with which strengths and weaknesses were identified by the audit, not only when organisations were compared with each other, but when their own competencies were compared as well.

## 6.8 References

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Chapter 7

# CONCLUSIONS AND RECOMMENDATIONS



## 7 Conclusion and Summary

A golden thread runs through this thesis, with the end goal in mind of developing a competence audit for technological innovation. It starts with the development of an innovation model as foundation, and then progresses to the development of a methodology for implementing an innovation audit. The methodology, in chapter four, is followed by an extended discussion in chapter five on best innovation practises. These practises form the foundation for the final audit questionnaire. The goal of the thesis is reached in chapter six, where a number of questions are proposed to establish a final audit questionnaire.

One should be cognisant of the fact that the auditing of competencies for technological innovation, does not lie in the implementation of an audit questionnaire only, but that every part, from modelling, to implementing a methodology based on best practises, through the means of a questionnaire, constitutes an innovation audit.

Although the innovation audit proposed is probably not the best or the final version, a firm foundation in the proposed innovation model, has been set. As stated before, the heart of the innovation audit lies in identifying the most practical standards to use when auditing. In the diverse discipline of innovation, this often looks like an impossible task. However by splitting the various subjects into the areas as proposed by the innovation model, a holistic picture of the innovation process may emerge.

A lot of research is still necessary to identify which 'best practise standards' have the greatest influence on the innovation process. The audit questionnaire succeeded in narrowing some of the key aspects down, yet their ability to influence the innovation process, has not been confirmed. Through trial and error and over many years of innovation auditing, this may develop into a formal standard, to be used in all innovation audits.

### 7.1 Audit Validity

Is the competence audit for technological innovation, as proposed in this thesis, valid?

This is a very difficult question to answer from a pure academic perspective. Although field-testing has been done to improve the proposed model, audit methodology and audit questionnaire, the validity of the competence audit for technological innovation lies in its application. It is only through the application of the proposed innovation audit in industry, that the finer details will be ironed out. One may expect the same measure of competence and professionalism in innovation auditing only after years of implementation, similar to that of financial auditing practises.

Some of the current limitations to the proposed model, audit methodology, and audit questionnaire, are discussed below.

### 7.1.1 The Proposed Innovation Model (Chapter 3)

To develop a sensible audit the construction of a model for the process to be audited was found to be imperative. Although other models in the field existed, the author felt it would be unethical to use them directly in an innovation audit. A decision was made to first study many models to better understand the method of innovation and possibly reach some conclusion to its improvement.

The proposed model is a combination and adaptation of current models available in literature. Aspects from models by Twiss[1] and Utterback[2] may be directly identified in the proposed model, while others such as Tidd *et al*,[3] Marquis,[4] Katz[5] and Thamhain[6] contributed significantly. The model is therefore not without foundation and although it may look new, it actually represents many proven innovation practises, as well as some of the more recent and radical ideas.

One part of the model is new and seldom found in other innovation models. The explicit introduction of the 'individual', focuses the proposed model on the competencies and capabilities of the organisation, rather than the products or processes employed. It breaks away from the more traditional outlook on innovation as being a causal and linear process, as proposed in models by Twiss,[1] Utterback,[2] Tidd *et al*,[3] Marquis,[4] Katz[5] and Thamhain.[6] The author feels the need to explicitly include the individual, due to the clear abundance of human involvement in the innovation process. New developments in the field of knowledge management, that clearly tie in with the subject of organisational competencies, also had an impact.[7]

The model was discussed and offered for criticism to many organisation managers, and although some remarks on the inclusion of minor aspects to the model were made, not one of the individuals disagreed with its representation of the innovation process. This gave the author the reassurance to proceed with developing an audit methodology and audit questionnaire, both of which were based on the model and its possible application.

### 7.1.2 The Proposed Audit Methodology (Chapter 4)

The audit methodology was largely developed with the aid of financial audit practises and the work by Chiesa *et al*.[8] Few innovation audits have been implemented or developed up to date. Finding relevant methodologies in this area therefore proved difficult. The decision was made to base the methodology proposed in this thesis on implementing the innovation model, and then measuring the organisation against this.

Much research is still required in developing methodologies for implementing innovation audits. Aspects such as the time frame between audits, the extent of the audit, the hierarchical depth of the audit should all be addressed in collaboration with the organisation, before starting the actual audit. As the discipline of innovation becomes more critical in years to come, developing methodologies for improving innovation, will become more important as well. Although this is a slow process, the time for innovation auditing may come sooner than expected. Hopefully the methodology in this thesis illustrates some of the aspects for the development of better and more user-friendly innovation audits.

### 7.1.3 Defining Best Innovation Practises (Chapter 5)

Chapter five aims to identify and illustrate a holistic overview of current innovation practises employed by organisations. Its goal is to give a non-exhaustive, but as representative a view as possible, on the best practises in innovation. Due to the nature of innovation and its multi-faceted diversity, the chapter cannot claim to be absolutely comprehensive. It does, however capture and explore many of the aspects of the innovation process, as well as the proposed innovation model developed in chapter three.

From the many aspects addressed in chapter five, it was possible to construct questions to use in a proposed audit questionnaire. The chapter therefore succeeded in creating a foundation for the measurement of innovation and the developing of a innovation audit.

### 7.1.4 The Proposed Competence Audit for Technological Innovation (Chapter 6)

Chapter six encompasses the proposal of various key questions to the development of a successful technological innovation strategy. The validity of these questions are also tested as part of a beta test.

The questions included in the audit questionnaire possibly received the greatest amount of criticism, as compared to the proposed innovation model developed in chapter 3. Although this was expected, many truths and limitations to the questionnaire were revealed.

During the beta test phase, the lack of understanding of the questions in the innovation questionnaire, became apparent. Other aspects such as truthful answering, and rushing to finish also played a role in affecting the final results. Although the questionnaire is ideal for large groups of people, it would be much more sensible to conduct direct interviews where small audit groups are concerned. The intimacy and ability of the interviewer to explain the questions, may lead to more accurate answers. Ultimately this would ensure representative audit results.

The author does not postulate that the audit questionnaire is the ultimate or final version in developing an innovation audit. Many different possibilities such as interviewing, group sessions, facilitation and others may find application in an innovation auditing. The best way for auditing will be discovered through trial and error and may look completely different from the neat academic proposals made in this thesis.

## 7.2 Recommendations

The audit was tested in the South African environment and is therefore subject to conditions experienced in South Africa. Many of the following positive and negative aspects observed, while testing the audit, are a direct result of the South African environment. However, some of the organisations have strong foreign interests and they should therefore offer a better international perspective.

Since the proposed innovation questionnaire is greatly influenced by perceptions and human ideals, many factors may influence the auditees' answers. Although the questionnaire was developed with this in mind, therefore the four answers per question, negative or positive perceptions on innovation or the organisation, will influence the questionnaire greatly. Some of these include:

Positive aspects fostering innovation in South Africa:

- Highly creative people
- Many opportunities
- Some world class organisations
- Good background in research and development especially in the arms industry
- Improved business environment after elections (1994)
- Stable business environment with many exchange rate advantages
- Good tertiary education facilities, starting to include innovation and technology as main study directions

Negative aspects suppressing innovation in South Africa:

- A generally poor knowledge on the implementation of innovation in practise
- A poor understanding of the complexity of the innovation process
- Biases against the relevancy of innovation modelling
- The amount of research still necessary to formulate an audit discipline, as compared with financial auditing
- The difficulty in defining best of breed practises.
- The multi-faceted aspects of innovation and their required management
- Poor linkage between innovation process and strategic planning
- Not enough innovation improvement programmes
- The importance of the individual is misjudged
- The narrow focus many organisations have with regard to innovation
- Poor leadership and bad management of innovation
- Encumbering organisational structures
- The poor national market and difficult international market environments
- Lack of foresight
- Lack of importance attached to innovation
- Diversification away from core competencies

One of the greatest stumbling blocks facing the successful development of a innovation culture in South Africa, is the lack of education. Innovation absolutely requires higher education and without even basic education being a standard in South Africa, many years of difficulty may be expected. South Africans should realise that when they try to sell their products in the international market, they are in direct competition with the best in the world. And competing with the best in the world means the organisation requires a workforce equal to, or better than, the best in the world. Therefore the country with the best-educated population will ultimately be the most prosperous. Unfortunately the World Competitiveness Report indicates South Africa as the country with the lowest score in the field of population,[9] clearly illustrating South Africa's enormous disadvantage to other first world countries.

Some other aspects of the innovation audit that have to be developed further, may include the following dichotomies:

**Open Ended versus Set Questionnaire Auditing**

The above mentioned influences on the perceptions of the South African population have to be factored into the innovation audit in some way, or otherwise removed from the responses by the auditees. In this regard a more open-ended audit may work better. If a process of asking open-ended questions, rather than set questionnaire questions, was followed, auditees may be asked to motivate their answers. This would then indicate any negative biases or other influencing factors, which could be factored out at a later stage. This may result in more truthful answers to the key points on innovation. However, how does one quantify open ended answers and is it therefore possible to sensibly perform an open ended innovation audit? This has to be researched in further development of innovation audits where the advantages between formal questionnaire based audits may be weighed against informal open-ended audit methodologies.

**Qualitative versus Quantitative Auditing**

Even though the audit methodology proposed in this thesis focuses on the qualitative aspects of the innovation process, some valid reasons exist for focussing on quantitative measures. Control, clear unbiased standards, efficient measures, and reproducible answers are the measures traditional auditing are based on. To be able to say unbiasedly that an organisation produced this number of innovations, or that amount of time was spent on a certain task, is highly valuable to the management of any process. Unfortunately innovation is not a 'defined' subject and few if any quantitative measures, or metrics, are available.

**One Audit Versus Many**

Innovation is a vast discipline. To audit such a discipline one can not expect a single audit questionnaire containing approximately fifty questions, to master the task. To attempt this would result in unnecessarily complicating the questions, when trying to incorporate innovation's complex parts. Rather a path including a master audit followed by several in-depth, but specialised audits, may be followed. Such a master audit may identify the key areas of weakness in the organisation, which may then be investigated by more specialised audits afterwards. The proposed audit in this thesis may be regarded as a master audit, to be used in identifying the key strengths and weaknesses in the organisation. As such it does not focus on specifics, but rather the common foundations of innovation.

**Formal versus Unplanned Innovation**

The assumption of the audit in this thesis is that the innovation process in an organisation is formal and not left to happen at random. Two different viewpoints on innovation propose that innovation is intrinsically unmanageable and may be encouraged but not expected. On the other hand this thesis follows the viewpoint that innovation is manageable and may be improved through the formal structuring thereof. Rather, it is the 'creativity' part of innovation that may be classified as random. Although an argument may be made that even creativity may be formalised by systematically searching for new ideas and entering them into a storage system, for later application if not immediately valid. However, by ultimately giving a formal structure to the innovation process and including it into the organisation's strategy, it is brought to the fore and may be managed to the advantage of the organisation. This immediately opens the door for 'normal' employees to take a direct interest in innovation and follow the examples set by management and organisational strategy.

Innovation is a complex discipline but by exposing the necessary capabilities, methodologies and structures for improving it, more employees and organisations may feel comfortable to try their hand at it. Innovation has for too long been the subject of the 'weird or creative', and educating organisations to the advantages of a better structured process, should be of paramount importance to academics and industries with the necessary knowledge.

## 7.3 Conclusion

The time for innovation to become a major part of every organisation's business is nearing at an alarming speed. Although not every organisation in South Africa may be of that opinion, the seeds of such a discipline is germinating in traditionally high innovative countries such as the United States of America, Israel, and even some European countries. Developing methodologies for improving innovation is of utmost importance for the future survival of South African organisations, and with the recent trade agreements between South Africa and the European Union, it will increasingly surface as one of the best methods for creating competitive advantage and growth.

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# ADDENDUM



## Appendix A: Background Study

*Knowledge itself is power*

— Francis Bacon

No system can survive forever without adaptation and improvement. The second law of Thermodynamics states that chaos (entropy) is always on the increase, and so to survive the onslaught, we must adapt or die. Never has this been truer for business and technology than in present times.

Few people realise the extent to which the information age will change society including everything we see, hear and experience. The advent of complete communication (access to any information, any time, anywhere) could ultimately mean the unification of the human species into a Global Brain.[1] It will therefore become highly important for every human being to add value in his/her own domain, and not duplicate what others have done already. In reaching this goal, every person needs to think new and creatively, to find some place where others have yet to dwell. The information age will give birth to the proliferation of innovation as a highly successful business strategy.

## A.1 **Power Shift** (The future as seen by Toffler[2])

*Power grows out of the barrel of a gun*

— Mao Tse-tung

Throughout human development, power and the accumulation thereof, has driven people into countless battles and skirmishes. Power and the struggle to find it serves as a motivator to people typically involved in managing, leading an organisation or process.[3] These power players rely on their position and other means to enforce their will on other people.

However, power does not primarily flow from position in an organisation, but finds its roots much deeper. Violence and money are two of the most common sources of power. They can be used to reward, or even punish anyone for good or bad performances. These power sources when used as threats can even become more versatile than direct reward or punishment implementation. One will always see these sources of power in a power player, no matter where or how he/she uses that power. To understand where power originates within such a person, these sources will serve as beacons.

In traditionally non-innovative organisations, entrepreneurs battle against bureaucratic power structures ingrained in the organisation. This can often lead to entrepreneurs avoiding new developments and becoming 'zombies' in their work. When this happens, organisations fall into a pattern of reaction to competition, rather than proactive development. In such surroundings almost all-new ideas are scorned and killed before they have the slightest chance for success. It is therefore not surprising that entrepreneurs either leave such organisations or simply get lost in the woodwork.

For entrepreneurs, salvation might lie in Toffler's words.[2] In his book 'Power Shift', Toffler describes how knowledge and information will become, and is already, one of the base sources of power. Toffler states that three power sources exist: *violence*, *money* and *knowledge*, and they are the basis for the most potent power available. These power sources vary in strength as they vary in versatility. Violence is less powerful than money, which is less powerful than knowledge. By wielding one a certain amount of power is gained, but by combining all three the greatest advantage is possible.

The quality of power lies in its versatility. Violence for instance, is the least versatile type of power source and has therefore the lowest quality. Violence is only good for one thing, and that is punishment. Punishment and the threat of punishment can only serve to alienate and scare people into doing something, never building loyalty or trust. Although violence is one of the oldest forms of power, it is the least effective type.

A vast improvement on violence happened when the bartering system started between humans. If someone had an item someone else wanted, he/she had direct power without turning to violence. Today money plays a highly interesting role in our society. One advantage money has over violence, is the ability to reward as well as punish in the course of wielding the power source. Another advantage is the threat of withholding money, as is the case with employees fearing for their jobs. In essence they do not fear for losing their jobs but rather fear losing the income. The 'boss' therefore has direct power over his/her employees by wielding the sceptre namely money.

With the development of personal computers and access to the Internet complete information freedom is fast becoming a reality. Many organisations and their directors are slow to realise the impact this may have on them. In Toffler's book the most versatile and potent source of power is identified as information. And it is this information that will be responsible for the turnaround in conventional business of the twentieth century.

In the old 'smoke stack' economy where managers were tough and employees did what they were told, the persons in power positions sacredly guarded information. This information about markets, technology, competitors and other factors is now slowly becoming available to employees and outside competitors. And they are suddenly demanding answers. For example:

> *Today no longer is a doctor the revered person they used to be a few years back, for patients can read about any disease or symptoms on the internet, or watch television educational programmes. This enables them to sometimes know even more about a specific disease, than their local physician. The information gathered by the patient therefore reduces the power of the physician and can have negative effects on his/her credibility. This may be one of the reasons for the increase in malpractice suits filed against doctors in the United States of America.*

In the same way every industry is being affected by the spread of information previously unobtainable.

The impact of a power shift, from money and violence towards knowledge and intelligence, can radically influence the way organisations operate, and even threaten their very existence. The power of knowledge enables absolutely any person to wield enormous power. For instance a patent or organisational specific competence can sometimes reside in a single person. This person therefore has enormous power for if he/she leaves the organisation the competence leaves as well.

Other pure information based power sprouts from such mundane surroundings as the local supermarket. Currently all consumer buying is monitored and fed into a computer on site, transforming this data into useful information for shop owners. Increasingly brand name product manufacturers have to ask supermarkets for information on consumer buying, to find trends and preferences in the market. The mere monitoring of shoppers thus becomes valuable information, capable of destroying or building new and old retail products.

A power shift does not only influence organisations, but the total way money and wealth is created. This new system of wealth creation is totally dependent on information and information flow. We can see this in the massive explosion of the World Wide Web and how this information flow is changing the way every human obtains information. Today it is not strange to rely on the Internet for up to date local and international news, rather than television or radio. And this information is increasingly becoming free of charge as organisations realise the power of informing their customers and suppliers of developments.

Twelve ways identified by Toffler how tomorrow's wealth may be created are:

1. The new accelerated system for wealth creation is increasingly dependent on the exchange of data, information and knowledge. It is 'super-symbolic'. No knowledge exchanged; no new wealth created.
2. The new system goes beyond mass production to flexible, customised or 'de-massified' production. Because of the new information technologies, it is able to turn out short runs of highly varied, even customised products at costs approaching those of mass production.
3. Conventional factors of production — land, labour, raw materials, and capital — become less important as they are substituted by symbolic knowledge.
4. Instead of coins or paper money, electronic information becomes the true medium of exchange. Capital becomes extremely fluid, so that huge pools of it can be assembled and dispersed overnight.
5. Goods and services are modularised and configured into systems, which require a multiplication and constant revision of standards. This leads to wars for control of the information on which standards are based.
6. Small (de-massified) work units, temporary or 'ad-hocratic' teams, increasingly complex business alliances and consortia replace slow-moving bureaucracies. Hierarchy is flattened or eliminated to speed up decision making. The bureaucratic organisation of knowledge is replaced by free-flow information systems.
7. The number and variety of organisational units multiply. The more such units, the more transactions among them, and therefore more information must be generated and communicated.
8. Workers become less and less interchangeable. Industrial workers in the past owned few of the tools of production. Today the most powerful wealth-amplifying tools are the symbols inside the workers' heads. Workers therefore own a critical, often irreplaceable, share of the 'means of production'.
9. The new hero is no longer a blue-collar worker, a financier or a manager, but the **innovator** (whether inside or outside a large organisation), who combines imaginative knowledge with action.
10. Wealth creation is increasingly recognised to be a circular process, with waste recycled into inputs for the next cycle of production. This method presupposes computerised monitoring and ever-deeper levels of scientific and environmental knowledge.
11. Producer and consumer, divorced by the industrial revolution, are reunited in the cycle of wealth creation, with the customer contributing not just money, but market and design information vital for the production process. Buyer and supplier share data, information and knowledge. Someday, customers may also push buttons that activate remote production processes. Consumer and producer fuse into a 'prosumer'.
12. The new wealth creation system is both local and global. Powerful micro-technologies make it possible to do locally what previously could be done economically only on a national scale. Simultaneously, many functions spill over.

The above ninth wealth creation statement is quite interesting and here Toffler states that current workers, managers, and 'bean-counters' will not be the creators of future wealth. It will be the innovators, capable of truly new products and innovation that will prosper in the future. This brings us to the question of innovation and the 'where' and 'how to' for the future.

What does a power shift have to do with innovation, one might ask? Yet the answer is apparent. Should the nature of national and international business change, innovation could become one of the cornerstones of such a change. When change happens, a lot of turbulence occurs forcing people to think new and make sure they are still on the right path. What better path to be on than innovation, which flourishes on change and discontinuity. Innovation can only occur through change, and therefore innovation will be the best vehicle to steer through the turmoil of Toffler's proposed 'Power Shift'.

As turmoil and turbulence increase throughout the world the old 'smokestack' organisations, which were isolated from small competitors by economies of scale, face the real possibility of dying. Information and new manufacturing procedures enable small start-up companies to challenge these large organisations in almost every aspect of business. The customers of the twenty-first century do no longer simply want a product, they want a unique custom-made product. The Apple Company for instance took the computer world by storm, and if the large IBM corporation did not change and follow Apple's example as fast as they did, they would not have been with us today. For IBM almost lost the war on personal computers, and only its large business customers and its fast reaction to Apple's onslaught, saved the company in the end.

This battle happened many years ago, yet today it is even more relevant, for large organisations seldom account small market entrants as serious threats. No longer is only domestic competition a threat, but the whole world. Not realising or accepting this may yet surprise many organisations in the future.

> *For this is the dawn of the Power shift era. We live at a moment when the entire structure of power that held the world together is now disintegrating. A radically different structure of power is taking form. And this is happening at every level of human society.*
>
> — Alvin Toffler

## A.2 Current Global Reasons why Innovation is Already Imperative (The Future as seen by Drucker[4])

Peter Drucker, a leading business consultant and economist, concludes in an article published in the Harvard Business Review[4] that not economical, technological, or even new breakthroughs will have the greatest effect on the world in the next millennium. In the article Drucker points out that 'his' future has already happened and we can do nothing about it. What he is referring to is the underpopulation of the 'First world countries', which includes the United States, Europe and the East.

The truth of the matter is that every first world country currently has a negative population growth rate. This means the collective age of the population in these countries is rising. This will require that people retire later or survive with fewer benefits in their retirement years.

In Europe, where this effect is already most pronounced, it is an enormous burden on younger people. To support the society they live in these younger people are forced to choose between living in relative comfort by reducing the amount of children per couple or carrying the burden and raising more than one child. The obvious choice of living in more comfort with fewer children results in severely reduced childbirth, which in turn undermines the total population in an escalating downward spiral. More and more people are staying single, preferring to live in luxury without any dependants.

The worst part of this reality is that the first world countries can do nothing to solve the situation. Even if young parents started having children at an enormous rate, these children would need at least 20 to 25 years to mature, before being able to contribute significantly to the economy. However, as yet there is no trace of a birth rate increase in any of the first world countries.

The underpopulation of the first world countries may be seen as a kind of salvation for many third world countries. One may argue that the overpopulated countries may supply the underpopulated with the necessary people, yet new high-technology processing and automated factories are making unskilled workers (which is the only people the overpopulated countries have) nearly obsolete. Development in robotics and virtual prototyping offer enormous efficiency and versatility, resulting in the replacement of repetitive labour and forcing workers to become more knowledge oriented. If the third world countries therefore hope to benefit from the people shortage in the first world countries, they will have to educate their workforce to similar education standards as the first world countries. This, however, has yet to be done on a large scale, for without education, third world countries will not be able to supply the first world countries with skilled workers, and no benefit will be realised.

With the third world countries out of contention, there remains only one alternative. Every person, young or old, will have to earn his or her own keep by working more effectively and more efficiently. No more will one be able to ride along with the wave of creative growth in large organisations, for nowhere in the world will information have to be duplicated as it was in the past. Entry into the magnificent twenty-first century will mean connectivity between all science and research institutions, enabling them to work together like never before. The possibility may arise where several research or science institutions could work together on world development issues, each being responsible for a specific part in reaching a common goal. This opportunity plays the central part in the ever-increasing dynamics of technological advancement in all fields of research. There is for instance currently a move towards a complete world unification of genome research institutions to increase the speed of mapping the human genome.

In this regard innovation will become a key factor in harnessing the new research findings and discoveries, enabling corporations and employees to better their own living environments by increasing productivity, efficiency and effectivity. For today with diminishing world resources, technology is becoming the only mechanism able to sustain an older world population and help younger people to survive and support them.

## A.3 Managing the Post Entrepreneurial Organisation (Kanter[5])

How should large organisations enter and survive the future? In the words of Kanter: '...they should learn to dance', for no one is safe any more, neither large nor small organisations. In the informational rich environment, choices are limitless and to keep customers, the business will have to do 'more with less' and continuously satisfy. Therefore in the 'Corporate Olympics' businesses become players, and in order to win or at least survive, knowledge of the games and competitors are imperative. Yet knowledge alone is not enough and to win, organisations need to be pro-active, do more creative manoeuvring, be more flexible, react faster and form closer partnerships with customers and employees as were typical in the previous corporate bureaucracy.

It is the great bureaucracy of organisations that is preventing them from proactive innovation, as well as reacting fast enough to unforeseen scenarios. The mad rush to improve performance and pursue excellence has multiplied the demands placed on managers and organisations. And to comply with these, managers often feel a sense of hopelessness at the impossibility and incompatibility of business with changes in the technological and market environments.

In the nineties most major companies have started a formal program addressing innovation issues. Most have excellent plans, a total quality plan or even an innovation and entrepreneurial plan. In 1986 Moss Kanter's team already found that over 90% of large companies had spent, on average of 2.2 years on a corporate campaign of this sort. These campaigns should therefore be deeply ingrained in organisations by now and contribute significantly to current business competitiveness and success.

The corporate balancing act between continuous downsizing yet growing and doing more with less, is becoming the task of every manager and strategist. In the ever shrinking global environment, no company may be certain that a new unexpected competitor, leaner and meaner will not arrive to capture valuable market share and even company employees. Thus the balance between new ideas and continuous business and accomplishing more with less will force business, currently and in the future, to tune and retune practices and strategies.

### A.3.1 Doing More with Less

**Restructuring** — How to improve and grow through restructuring are concerns of every manager, especially those proposing take-overs and joint ventures today. Yet the possible mismatch that might occur could prove more debilitating than most managers would expect. Restructuring therefore becomes fraught with danger, keeping managers busy with seemingly trivial problems, yet preventing them from doing their job. Threats held by restructuring are diverse and mostly they happen unexpectedly and seemingly without reason. For instance:

> The *state of uncertainty* while restructuring can reduce employee commitment and goal setting by undermining their belief in what they are doing and what they will be doing in the future. No person is immune to changes in their environment and when the future looks uncertain, few are willing to engage new challenges or even complete current ones.

Other threats may include:

> The *cost of confusion*: New letter heads are not yet ready, telephone extensions are unknown, and everything has seemingly disappeared into different filing or storage places.
>
> *Loss of energy*: Any change consumes emotional energy and by changing such a big part of a person's life as his/her work, it can sap much needed energy for other tasks.

*Breakdown of initiative*: If the future is uncertain and managers are restructuring, employees have the tendency to sit and wait to hear what will happen next.

*This is the way it is*: Restructuring makes the order of management explicitly clear to employees and upcoming managers alike. The power associated with the ability to restructure and change people's lives puts a heavy strain on the relationship between the management and the workforce. Suddenly the status quo where managers and employees worked together changes radically, and so bonds and working relationships are broken, emphasising power and seniority.

Restructuring, in short, increases the likelihood of unilateral managerial actions, which is exercised on everything all at once and further disempowers the rest of the people. Thus the need all the more exist for clear leadership that can reinforce employees' perceptions of value and belonging.

**Synergies** — The old saying goes: 'Build a better mousetrap and the world will beat a path to your door'. Yet to build a better mousetrap in a typical bureaucratic organisation, may change the process a bit. Here is how Moss Kanter envisions such a process might turn out:

*You are very excited about your mousetrap and eager to get it to the consumers. But first, the mousetrap department manager, her boss and her boss's boss insist upon thorough reviews, each one asking for some changes before taking it to the others and then the whole thing goes to the vice-president of Mouse, Mole, and Skunk Traps Division (MMSTD). The price is marked up way over costs to cover the costs for the company volleyball court, executive dining rooms, middle management training on how to conduct downward and upward reviews, newspaper subscriptions and lounge chairs for the internal press clipping group, and other overhead charges.*

*At last the better mousetrap brand is ready to go to market, so an elaborate research project is begun in three rodent-rich cities in three different countries. Unbeknownst to you, the Chemicals and Pesticide Division (CPD) has already collected extensive data for the launching of its new Mouse Repellent, which is being sold through exactly the same channels (You learn this from reading the accident report filed by one of your MMSTD truck drivers who almost ran over one of CPD's truck drivers). Furthermore Animal Services, the company's innovative new lease-a-pet acquisition, has completed a psychological profile of the mouse-averse for its Kittycat product line, which points out the desirable features for mouse traps, a profile they are careful not to show you.*

*Meanwhile costs have mounted, there has been no way to build on what the other divisions have done, and Better Mousetrap gets to the market later and at a higher price than the offering of a spiffy new mousetrap speciality start-up. Wall Street which had once praised your parent corporation, 'Unrelated holdings, Inc.', for its smart move towards synergy by acquiring three companies with a common interest in rodent control, reacts unfavourable to the news. The stock drops precipitously. Raiders see the break-up value of UHI is higher than its current stock price; after all, three mouse-oriented divisions are gaining nothing by being together anyway, and 'corporate' requirements are a drag on their performance.*

> *Then your boss calls you in for a heart-to-heart. 'Sad news, better mousetrap builder,' he says. 'The company has to cut its loses to avoid take-over, and since your product isn't doing well, we're letting you go."*

Post-entrepreneurial organisations are taking steps to combat this bureaucracy and focus on synergies as a central part of their strategies. They start by clearing clutter out of the way through getting rid of extraneous activities, and making sure every area contributes something to the others. This improves the total value added by different areas, together with emphasis on the 'whole' contributing more than the separate parts.

Although this sounds straightforward, it is revolutionising corporate strategy.

In reducing bureaucracy and becoming 'leaner and meaner', organisations face the question of how to innovate and transform old products into new exciting ones. And the current direction of large corporations is to 'stick to their knitting', yet develop new products on the side for possible inclusion in mainstream business.

### A.3.2 Cutting Paths for Innovation

Moss Kanter describes the trend we find in several organisations of splitting new innovations and ventures from the main business. She coins the term 'newstreams' which refers to the opposite of *mainstream* business.

This 'newstream business' sits apart from the mainstream with its own resources and management, capable of driving new ideas and projects. For example in the Kodak organisation there exists a division called 'Kodak New Technologies'. When an employee gets a good idea, and wants to develop it further, the employee contacts the New Technologies division for support. The division then assists the developer in researching and developing the idea into a fully-fledged product, including possible market penetration. It is required that the person with the idea is continuously part of the new venture, since that person feels responsible and is responsible for successes or failures. In this regard the New Technologies division acts as an incubator for new innovations, with special emphasis on innovation that is different from the typical mainstream efficiency improvements. If the venture becomes successful and the product is launched in the market, it will most probably be reincorporated into the mainstream business becoming a fully-fledged company product. In this way Kodak can stay ahead of competitors through radical and incremental innovation.

Kanter describes the advantages of splitting the mainstream and 'newstream' activities, because they differ so much in *uncertainty*, *intensity* and *autonomy*. For a new venture to work properly the environment needs to be different from mainstream's systems and formality. Entrepreneurs need to be free to experiment and react quickly to influences, which they would not be able to do in a mainstream environment. It sometimes becomes so crucial that any interference by mainstream management could offset many months of hard work and quick timing. Yet, 'newstream' management still needs to exist and account for resources received and goals accomplished. The 'newstream' environment, however, needs its own management people with open minds and a readiness to accept uncertainty, risk, defeats and great victories.

This exciting field of development can offer entrepreneurs an increasingly vibrant environment when attached to large organisations. By creating a separate, yet highly innovative cluster of 'newstreams', organisations may, where otherwise unsuccessful, draw entrepreneurs capable of doing masterfully innovative new things. Such a program could prove to be one of the best rescue plans for large bureaucratic organisations. That is if they are able to integrate these ventures successfully into the mainstream.

Kanter has many years of experience in the field of management and innovation as illustrated in the clear manner she writes about innovation. The mainstream and 'newstream' development paths may work excellent in some organisations, yet organisation are so different in their application of innovation that much adaptation to the mainstream and 'newstream' methods will have to be done. Integration between the 'newstream' and mainstream cultures may be a problem as well. However, Burgelman and Maidique may propose a solution in the next section on challenges to the innovation manager

## A.4 Challenges to the Innovation Manager (Burgelman and Maidique[6])

There are two major innovation challenges for the established firm today. Identified by Burgelman, firms should distinguish between *induced* strategic planning (action) and *autonomous* strategic planning (action). Every firm faces these two paths when strategizing.

> *Induced strategic action* takes place as result of the firm's vision, mission and external environment. This strategy therefore reflects top-management's beliefs and understanding about the basis for the firm's past and current successes.[6] This includes their core competencies and product market domain wherein they compete successfully. While in small firms this strategy and action are usually closely linked this is not the case in large organisations. They typically require the creation of structural context to secure the link between strategy and action.
>
> *Autonomous strategic action* does not form part of current corporate strategy, yet opens up new areas and niches for creativity. Successful autonomous initiatives lead to an amendment of the firm's strategy through the process of strategic context determination. It specifically involves the middle-level managers in their formulating of a broader strategy for the initiatives of internal entrepreneurs. They also act as organisational champions to convince management to support these initiatives. The autonomous action is guided by the strategic recognition capacity of senior and top managers, rather than by strategic planning.

## A.5 Innovation Opportunities in the Induced Process

Innovations associated with the induced process are typically incremental or architectural.[7] They emerge in part from the firm's R&D (research and development) investments, and its formal new product development process. Incremental or architectural innovations are not necessarily small innovations yet they build on previous products and experience. When the Boeing Company for instance develops a new airframe for its next-generation aircraft the innovation is incremental, for it is well understood and builds on the previous model. It is, however, an extensive innovation.

As products reach the mature stage in their lifecycle the development process shifts from the 'fluid' stage to the 'specific' phase. This places more emphasis on incremental process innovation than on product innovation.[8] In the short term, however, managing incremental and architectural innovation is the most significant challenge to established firms. To meet this challenge firms must develop strong product and process development procedures.

## A.6 Innovation Opportunities in the Autonomous Process

Typically, innovations associated with the autonomous process are technological or modular.[9] These opportunities emerge unexpectedly from an array of stimuli including corporate research, individual creativity and social discussions. These ideas are mostly radical and not necessarily large, at least at the beginning. For instance an individual engineer invented electronic fuel injection (EFI) at the Bendix Corporation. Now however, EFI is a $100 million-plus segment of the automotive industry. Similarly Steve Jobs and Steve Wozniak developed the personal computer in a garage and total computer sales are currently well into the hundred billion dollar per year scale.

Allowing the autonomous strategic process to happen is important for large organisations. To ensure future growth new radical and modular developments need to happen, since the growth potential of the mainstream diminishes as its product's lifecycle nears the end. Thus sooner or later firms must find and exploit new growth opportunities and this can only happen by encouraging diversification and radical innovation. Understandably organisations are sensitive to these kinds of innovations since they are risky and often fail. It is therefore not surprising to find many authors arguing that firms should maintain the 'common thread' or 'stick to their knitting'. This may be good advice for firms who have not yet exploited all the possibilities for further growth in their mainstream business, but does not hold true for those who have. Such statements overlook the fundamental growth problem of stretching a single concept to the limit. To meet the innovation challenge associated with the autonomous process, firms must develop a capability to manage internal entrepreneurship.

### A.6.1 The Balancing Act

These two concepts in the management of innovation and its strategic development, force the top-level manager to find a balance between induced and autonomous innovation, since each of the separate strategies is crucial to the immediate and long-term survival of the organisation. This is, however, difficult in part because the two innovation challenges require different management approaches, and there is a strong tendency for firms to address the challenges sequentially rather than simultaneously.[6]

### A.6.2 Managing Corporate Entrepreneurship

If not repressed, technology-based innovation often emerges spontaneously.[6] With firms continuously bringing in new talent, they encourage new ideas and methods to form, in as yet, uninfluenced employees. Ideally these new talents are responsible for new technological innovations, yet a receptive and structured environment often plays the key role in deciding a new venture's outcome. Here are some examples illustrating the value of young entrepreneurs:

*In 1966 calculators were largely mechanised. A young man working for one of the calculator companies took a model of an electronic calculator to the Hewlett-Packard firm. His own firm was not interested in it, because they did not have the electronic capability. In spite of unfavourable market research forecasts, William Hewlett personally championed the project.*[10]

*In 1980, Sam H. Eletr, a manager in Hewlett-Packard's laboratories, tried to persuade the company's new product development division to get into biotechnology. 'I was laughed out of the room', he said. But venture capitalists didn't laugh. They persuaded Mr. Eletr to quit Hewlett-Packard and staked him $ 5.2 million to start a new company. Its product: gene machines, which make DNA, the basic material for the genetic code — and the essential raw material in the burgeoning business of genetic engineering. Now, three years later, Hewlett-Packard has formed a joint venture with Gentech Inc. to develop tools for biotechnology. A new product it is currently considering; 'gene machines'.*[11]

How should corporate managers deal with autonomous strategic initiatives? Clearly, not every new initiative can or should be supported. Yet it seems reasonable to ask if the managers in the above examples made a decision on the strategic implications of the initiative or simply on the basis that 'we don't have that kind of capability'. Such almost rash decisions can influence the future of the firm drastically if for instance a close competitor launched the proposed new initiative. Therefore the firm must allow the entrepreneur to develop the idea to a presentable product, even as far as a prototype. This is because the autonomous strategic initiative explores the boundaries of the organisation's competencies and markets, and forms a crucial part of the strategic development process in established firms.

### A.6.3 New Venture Divisions

In response to new technologies developed in corporate research or initiatives in the autonomous process, top managers have tried to create separate new venture divisions (NVD). The idea was that internal entrepreneurs should be allowed to pursue ventures, unencumbered by the constraints of mainstream business management. Then having reached critical mass, such new ventures would be reintegrated within the mainstreams, or become a division on its own. This opportunity of becoming a manager of a major new business would be a strong incentive for corporate entrepreneurs.

However, the validity of these management procedures have been discounted by experts such as Fast,[12] and Burgelman, who documented serious problems associated with the NVD design. It may therefore not be so easy to increase innovation by simply creating new venture divisions. Reasons and a possible solution are discussed in the following paragraphs.

### A.6.4 NVD-operating Division Interface Problems

Product-market domain and synergy interference between new venture development units and current divisions, can lead to serious problems for both parties. The product market domain of new ventures is meant to be outside the divisional domain, yet many times conflicts between the division's and the corporation's interests arise. For instance: A current division of the firm might want to absorb a successful new venture into its mainstream of business, yet the venture may feel its purposes best served staying apart. Other conflicts may arise when the sales force of the new venture starts contacting current division clients and thus steals market share from the division.

Except for the potential clashes between strategy and market potential, frictions between administrative and management staff may also occur. This may result in the new venture being sabotaged by disgruntled employees in the mother firm not chosen to be part of the new venture. The new venture workers may act as if they are better than the mother firm's workers, making it extremely difficult to reintegrate the two, should the need ever arise.

### A.6.5 NVD-corporate Management Interference Problems

One key problem facing a new venture is the possibility of an unclear corporate strategy on diversification. In addition corporate management often has no idea of the rate of strategic change the firm can sustain. Finally top-management may become concerned with the effect new ventures may have on the firms corporate image. For instance if an inferior product is sold to a client by one of the new ventures, the customer may assume that the whole firm's product range has decreased in quality, resulting in massive depreciation of corporate image. With this being the case and top-managers often not knowing what to expect, they adopt a vacillating stance towards new ventures. Since venture managers are aware of this, it puts enormous pressure on them to grow the business as fast as possible, sometimes even at all costs.

The friction between new venture and mother firm, often has its source in venture managers cutting corners on quality and standards. Also, the lack of measurement and reward tailored for the new venture environment serve as motivation for dysfunctional actions. For example if the size of a business is the major criterion for managerial compensation, it should not be surprising to see managers of new ventures growing their ventures disproportionately large, to secure this bonus. Further more venture managers are likely to resist attempts on the part of corporate managers to institutionalise their venture, as long as they feel that the corporate ways and means are impeding their struggle for success in the market, as well as in the internal corporate environment.

### A.6.6 A framework for Assessing Internal Entrepreneurial Initiatives

If then, the new venture option is not the best, what can corporate management do to deal with autonomous strategic initiatives? Clearly dumping innovation initiatives into new ventures divisions every time, is not elegant, nor does it get the job of effective new development done efficiently. There simply has to be a better option in dealing with new initiatives. The first thing to understand is that each new initiative is different and that different ideas need different managerial and strategic inputs. The next step is to develop an analytical framework that can be used to assess entrepreneurial initiatives, and can lead to tentative conclusions about the type of organisational design best suited for the new venture. This in turn helps with the relationship between the new venture and the corporation. A proposed framework focuses on two key dimensions of strategic decision-making concerning internal entrepreneurial proposals: The expected importance for corporate development and the degree capabilities are related to the core capabilities of the corporation.

***Assessing the Strategic Importance of Initiatives***

Assessing strategic importance involves considering the implications of an entrepreneurial initiative on the firms market position. It is important to note that not only the positive side (if the new venture is successful in launching the product) should be concerned but also the negative one (what if the competition launched such a product before the new venture could).

Although top-management may not often be well equipped to make decisions of strategic importance of entrepreneurial initiatives, they can turn to middle level managers. These managers often have a greater knowledge of the specific technology and based on their own substantive assessment, can offer valuable information to top-management as champion to new initiatives. Examples of critical issues to address in these substantive interactions are:

- How well does the initiative maintain the firm's capacity to move into areas where major current or potential competitors may move to?
- How does this help the firm determine where not to go?
- How does this help the firm create new defendable niches?
- How does it help mobilise the organisation?
- To what extent does it put the firm at risk?
- When should the firm get out of the venture if it does not seem to work?
- What is missing in the analysis?

Strategic assessment of proposals may result in them being characterised as *very* or *not at all* important. In several cases the outcome may be unclear and then lead to assessments like 'this may be important in the future' or 'important for the time being'. The key to such analysis is the finding of substantive grounds to base one's assessments on, especially if they have to serve as reference for future assessments.

***Assessing Operational Relatedness of Initiatives***

Core competencies are the key factors making an organisation what it is. To find the relations between a new initiative and these core competencies are necessary and useful. Synergies between initiatives and firm core competencies can not only enhance the success possibilities of the venture, but the firm's competencies as well.

In order to make the required assessment of operational relatedness, corporate management again needs to consult with middle management that champion entrepreneurial projects. Some critical issues to be addressed are:

- What key capabilities are required to make this project successful?
- Where, how and when will the firm get it if it does not have it yet, and at what cost?
- Who else may be able to do this, perhaps better?
- How will these new capabiliti affect the capacities currently employed in the firm's mainstrean. . usiness?
- What other areas may possibly require successful innovative efforts, if the firm moves forward with this project?
- What is missing in the analysis?

Drawing up a competencies/capabilities framework for the organisation may help in evaluating operational relatedness, if it does not already exist in the organisation. In light of this the new initiative may be classified as very or not at all related to the corporate operation. Or in other cases the assessment could lead to a partly related outcome. In every case however, the assessment should be made in specific substantive terms.

### A.6.7 Design Alternatives for Corporate Entrepreneurship

After assessment of a new initiative for its strategic importance and operational relatedness, corporate management must choose an organisation design for structuring the relationship between the new business opportunity and the corporation. This involves various combinations of administrative and operational linkages.

**Organisational Designs for Corporate Entrepreneurship**

| Operational Relatedness ↑ | | | |
|---|---|---|---|
| Unrelated | Special Business Units | Independent Business Units | Complete spin-off |
| Partly Related | New Product Department | New Venture Division | Contracting |
| Strongly Related | Direct Integration | Micro New Venture Department | Nurturing and Contracting |
| | Very important | Uncertain | Not Important |

**Strategic importance** →

*Table A.1 Organisational Designs for Corporate Entrepreneurship, Source: Burgelman*

***Determining Administrative Linkages***

Control and how much control should be applied by the corporation, is one of the crucial factors that needs to be determined, before a new initiative is started. If strategic importance of the new initiative is high strong bonds between the corporate and new business are in order. This in essence means that the new business will be folded into the corporation sooner rather than later and close co-operation becomes essential. Thus measurement and reward systems must reflect the corporations, ensuring complete compatibility between the two businesses.

However, when strategic importance is low, management should rather evaluate how best to spin off the new venture. In ambiguous situations where strategic importance is somewhat unclear, management should relax the structural context and allow new initiatives some leeway in its strategic management. Such undecided new business units require mechanisms, facilitating substantive interaction between middle and corporate management, and a measurement and reward system capable of dealing with as yet unclear performance dimensions.

***Determining Operational Linkages***

The advantages of initiatives with high operational relatedness are obvious. If there are many synergies between the corporation and the new venture, they reduce learning time and increase utilisation of current corporate capabilities. Corporate management should ensure that both new and existing capabilities and skills are employed well, through integration of work flows, adequate mutual adjustments between resource users through lateral relations at the operational level, and free-flows of information and know-how through regular contracts between the corporation and the new venture.

When low operational relatedness occurs, the new business unit may require complete detachment from the corporation, with as little intervention from it as possible. In the instance of unclear operational relatedness, loose coupling seems most appropriate. In these situations the workflow of new and existing businesses should essentially remain separate, and interaction should be through individual integrators rather than direct operational managers. The flow of information and know-how needs however to remain uninhibited.

### A.6.8 Choosing Design Alternatives

To facilitate the setting up of a new business unit, a matrix detailing the various combinations of administrative and operational linkages have been proposed by Burgelman.[13] The matrix comprises of the three assessment outcomes of each operational and strategic relation between the corporation and the new initiative, as discussed earlier.

The design alternatives are, however, not exhaustive and the scales for different dimensions used, remain rudimentary. The framework provides a conceptual underpinning for a number of practices adopted by established firms.

***Direct Integration***
This type of venture is nearest to the corporation in strategic and operational importance, and requires strong operational and administrative linkages. It means that this business unit will be directly integrated into the corporate mainstream.

***New Product Department***
With high strategic importance yet lower or ambiguous operational relatedness, this business unit requires a strong administrative, but medium to relaxed operational linkage. This may be achieved by creating a separate department around an entrepreneurial project, with the possibility of significant skill sharing.

***Special Business Units***
High strategic importance and low operational relatedness, may require the creation of a separate business unit. In such a case strong administrative linkages are needed, yet little or no skills transfer between corporate and business unit is possible.

***Micro Ventures Department***
Uncertain strategic importance and strong operational linkages are ideal for peripheral projects, which are likely to emerge in operating divisions on a rather continuous basis. Such projects require loose administrative linkages with venture managers able to develop a strategy within budget and time.

They should, however, not be otherwise limited by divisional or corporate level strategies.

***New Venture Division (NVD)***
With both operational and strategic importance low, the new venture is the most ambiguous business unit. The NVD may serve best as a nucleation function, and provide a fluid internal environment for projects. Its strategic importance however still has to be determined as the new business unfolds.

***Independent Business Units***
Uncertain strategic importance, yet strong operational linkages, make this arrangement appropriate. The corporation may want to keep strong ties with the new venture, possibly becoming a high quality supplier with little need for administration by the corporation. In such cases the firm may want to have a percentage of ownership of the venture and offer the rest to the start-up managers.

***Nurturing Plus Contracting***
When niche markets appear, which may be too small for large firms to enter, new entrepreneurial ventures may do the trick. When strategic importance is low, yet high operational relatedness exists, new entrepreneurial ventures are appropriate. Top management may want to help entrepreneurs set up their business and help with some operational skill, yet stay detached where administrative links apply.

***Contracting***
The possibilities and linkages between corporations and new contracting ventures may seem to diminish with lower operational and strategic relatedness. However, some scope for technical transfer and cross company learning may still exist.

***Complete Spin-off***
When strategic and operational importance both seem to be low, a complete spin off seems most appropriate. A careful assessment of both dimensions, by the entrepreneur and the corporate management, would probably result in a well-founded decision.

### A.6.9 Implementing Design Alternatives

To implement designs for corporate entrepreneurship effectively, organisations first have to understand three major issues and possible problems.

1. Corporate management should view the assessment framework as a tool to clarify their community of interests and interdependencies and to structure a non-zero sum game.
2. Corporate management should establish measurement and reward systems, capable of accommodating the incentive requirements of different designs.[14]
3. As the development process unfolds, new information may modify the strategic or operational importance of the venture, requiring renegotiations of previous designs.

Corporate management should treat entrepreneurs as 'strategists' and perhaps even encourage them to think as such. This will be necessary to ensure both parties feeling they have achieved their individual interests to the greatest extent.

## Appendix B: Realising Innovation, a Systems Approach

Factors in the systems engineering field influencing the realisation of an invention may be categorised in the following manner. They directly influence the timing and success of innovation and therefore form a crucial part in the life cycle of an innovation.[15]

### B.1 Conceptual System Design[15]

The requirement for the success of any system or product is acceptance and demand in the market. System requirements form a key part in identifying exactly what the product needs to accomplish, and deliver to the client. In the conceptual design phase emphasis falls on defining of system requirements such as market need, project feasibility, system operational requirements and finally system maintenance concepts.

The conceptual system design phase, in essence try to define the complete scope of the product and the tasks associated with realising it in the market.

### B.2 Preliminary System Design[15]

The technical baseline as defined by the previous stage, forms the starting point of preliminary systems design.

System functional analysis is one of the essential aspects of a new system, for it highlights design requirements in a hierarchical way. As a systematic approach to system design, functional analysis constitutes the process of translating system operational and support requirements into specific design requirements. As such it is intended to facilitate design, development and definition in a logical manner.

Allocation of requirements relates to the assigning of resources to proposed new systems. Systems can be broken down into their different categories and components, each of which needs to be allocated certain resources. It is therefore necessary to first establish requirements at the systems level, and then allocate requirements to the depth necessary to provide guidance in the design process.

In any design or new innovation, many trade-offs and optimisations are made. Parameters of primary importance at the systems level include cost effectiveness, system effectiveness, logistics effectiveness, life-cycle costs effectiveness, operational availability, and performance. These parameters should relate directly to the problem statement. The objective of course is to arrive at a decision where the selected approach is clearly the best among the alternatives evaluated, with the associated risk and uncertainty minimised.

With the allocation of requirements and definition of optimised direction, a synthesis of elements is required. System synthesis can be achieved when sufficient trade-offs and preliminary design have been accomplished to confirm and assure the completeness of system performance, and design requirements allocated for detail design.

In conclusion a system design review concludes preliminary system design. At each major stage of the design process, an evaluative function is accomplished to ensure that the design is correct at that point, prior to proceeding to the next stage.

## B.3 Detail Design and Development[15]

The detail design process comprises the description, preparation, definition development and testing of all aspects of the system. A high degree of documentation and specification is needed to ensure all aspects are designed and developed appropriately, as well as tested thoroughly.

**Detail design requirements**
Detail design requirements need to comply with all previously specified documentation in the conceptual and preliminary design phases. Some other key areas in the detail design phase include:

> *Design for functional capability or performance (functional design)* — the characteristic of design that deals with the technical performance of the system. This includes size, weight, volume, shape, accuracy, capacity, flow rate, speed of performances, power output, and all of the technical and physical characteristics a system should exhibit to accomplish its planned mission.
>
> *Design for reliability* — the characteristic of design and installation concerned with the successful operation of the system, throughout its planned mission. A common way of measuring this is the MTBF (mean time between failure) method.
>
> *Design for maintainability* — the characteristic of system design and installation that is concerned with the ease, economy, safety, and accuracy in the performance of maintenance functions. The objectives include minimising maintenance times, maximise supportability characteristics, as well as logistic support resources required for the maintenance.
>
> *Design for manability* — the characteristic of system design that is directed toward the optimum human-machine interface. Human factors that need to be considered are operational and aesthetic features as well as personnel skill, level for operation, training requirements, and minimising potential personal error rates.
>
> *Design for producibility* — the characteristic of system design that allows for the effective and efficient production of one or a multiple quantity of items of a given configuration. The objective is to minimise resource requirements during the production or construction process.
>
> *Design for supportability* — the characteristic of systems design, directed towards ensuring that the system can ultimately be supported effectively and efficiently, throughout its planned life cycle. An objective is to consider both the internal aspects of equipment design, as well as the logistics needed for support.
>
> *Design for economic feasibility* — the characteristic of system design and installation, which is directed toward maximising the benefits and cost effectiveness of the overall system configuration. An objective is to base design considerations on life-cycle cost, and not just on system acquisition cost or purchase prices.

*Design for social acceptability* — the characteristic of system design directed towards ensuring that the system can become an acceptable part of the social system. An objective is to seek minimum pollutability, ease of disposability, minimum safety risk, high transportability, and many others.

The above-mentioned considerations are but some of the areas of importance in the field of detail design. Ultimately the satisfaction of the client regarding cost, quality and performance is the key in successful detail design.

**Technical performance measures**
Technical performance measures refer to design-related factors expressed quantitatively, which can be applied in the evaluation of a system or one of its components.

Cost-effectiveness relates to the measure of a system in terms of mission fulfilment and total life cycle cost. It can be expressed in various terms, depending on the parameters one wishes to evaluate. As such, true cost effectiveness is impossible to evaluate, since many factors influence the operation and support of a system, which cannot be realistically quantified. Some common figures of merit (FOM) used are:

$$\text{FOM} = \frac{\text{System benefits}}{\text{Lifecycle cost}}$$

$$\text{FOM} = \frac{\text{System effectiveness}}{\text{Lifecycle cost}}$$

$$\text{FOM} = \frac{\text{Availability}}{\text{Lifecycle cost}}$$

$$\text{FOM} = \frac{\text{System capacity}}{\text{Lifecycle cost}}$$

$$\text{FOM} = \frac{\text{Supply effectiveness}}{\text{Lifecycle cost}}$$

By presenting these and other factors for alternative designs, a realistic comparison can be made. Given two or more alternatives based on these values, the best can be selected.

**Detail design activities**
Once the goals and objective for the detail design process have been established, a design team is appointed. Such a team needs to consist of all role-players as proposed by the concurrent engineering design approach.

**Establishing a design team**
Due to the nature of projects and innovation, every design team will consist of different people and disciplines. A typical design team may include a combination of:

*Engineering technical expertise* — electrical engineers, mechanical engineers, computer engineers, civil engineers, nuclear engineers, system engineers, reliability and maintainability engineers, logistics engineers, and/or others appropriate to the projects.

*Engineering technical support* — draftsmen, technical publication specialists, component-parts specialists, laboratory technicians, model-builders, computer programmers, test technicians, and the like.

*Non-technical support* — marketing, purchasing and procurement, contracts, budgeting and accounting, legal, industrial relations, and many more.

Proper integration and good motivation are crucial to the success of the design team. An organisational goal, project organisations, functions and tasks and associated management of project resources, need to be properly managed and controlled.

**Evolution of detail design**
The design process is iterative and can be better illustrated with a flow diagram. The process starts at the system specification level, and progresses to an output that can be produced in single or multiple quantities. Checks and balances in the form of reviews at each stage ensure conformity to specifications, with the added feedback loop for corrective action [Figure B.1].

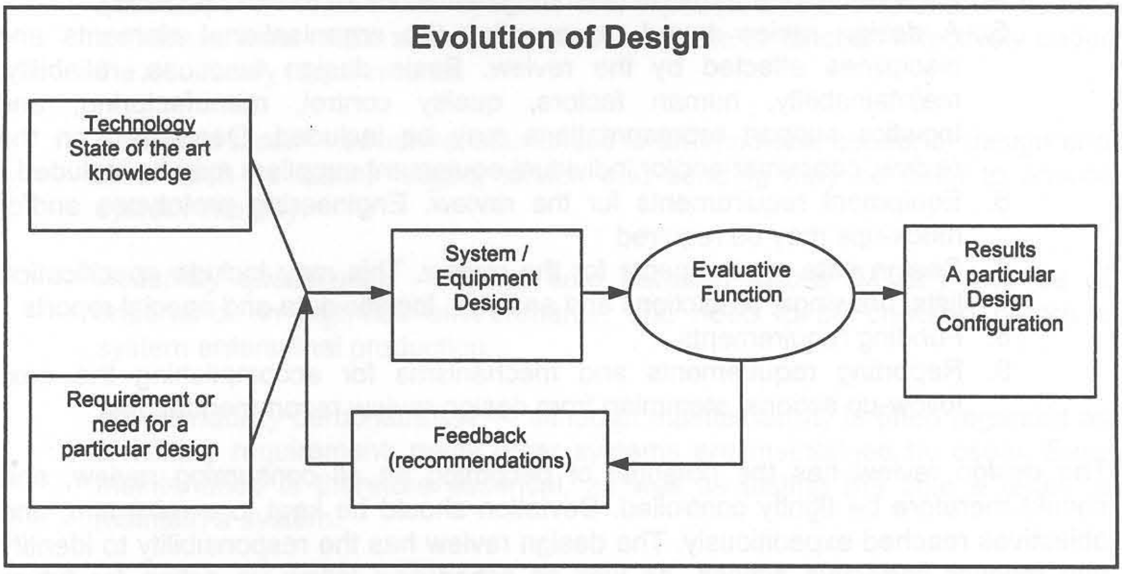



*Figure B.1: Evolution of Design adapted from Blanchard and Fabrycky*[15]

As detail design progresses, actual definition is accomplished through documentation, in the form of specifications and plans, procedures, drawings, material and part lists, reports and analyses, computer programs, and so on. Design documentation is absolutely critical, since people other than the design engineer should be able to check and understand the reasons behind every design output.

Traditionally design documentation consists of a combination of the following:

*Design drawings* — assembly drawings, logic diagrams, installation drawings, schematics, and so on.

*Material and part lists* — part lists, material lists, long-lead item lists, bulk-item lists, provisioning lists, and so on.

*Analysis and reports* — trade-off study reports supporting design decisions, reliability and maintainability analysis and predictions, human factor analysis, safety reports, logistic support analysis, configuration identification reports, computer documentation, installation and assembly procedures, and so on.

Design review checklists are commonly used in design reviews to indicate compliance to requirements. When all items on such a basic design checklist are completed, a formal design review is conducted, where final checks and requirements need to be met. The formal design review utilises product specifications, developed earlier to finalise the design process.

**Formal design review**
The success of a formal design review is dependent on the depth of planning, organisation, and data preparation prior to the review itself. Co-ordination is required regarding the following aspects:

1. Items to be reviewed
2. A selected date for the review
3. The location or facility where the review is to be held
4. An agenda for the review (including definitions of basic objectives)
5. A design review board representing the organisational elements and disciplines affected by the review. Basic design functions, reliability, maintainability, human factors, quality control, manufacturing, and logistics support representations may be included. Depending on the review, consumer and/or individual equipment suppliers may be included.
6. Equipment requirements for the review. Engineering prototypes and/or mock-ups may be required
7. Design data requirements for the review. This may include specification lists, drawings, predictions and analysis, logistic data and special reports
8. Funding requirements
9. Reporting requirements and mechanisms for accomplishing the next follow-up actions, stemming from design review recommendations

The design review has the potential of becoming an all consuming review, and should therefore be tightly controlled. Deviation should be kept to a minimum, and objectives reached expeditiously. The design review has the responsibility to identify and monitor corrective actions, as well as scheduling follow up action for future reviews.

## B.4 System Test and Evaluation[15]

Systems, no matter how well designed, need to be examined and judged. Elements such as quality of performance, degree of effectiveness, condition and a measure of worth, should be evaluated. The purpose of testing is to determine the true characteristics of the system and ensure that they fulfil their intended requirements.

Different testing procedures exist and this section will shortly define some of the most relevant areas.

**Categories of test and evaluation**
The specific needs for test and evaluation are initially defined during the conceptual design, when requirements for the overall system are established. Methods must be established for evaluation, to ensure the relevant system meets the initially defined needs. The test procedures are often an ongoing process, consisting of four different types of tests.

**Type 1 testing**
During the early phases of detail design, this form of continuous testing is often employed to validate solutions to problems, as well as certain performance and physical design criteria.

These tests are not formal demonstrations, but serve to validate design decisions made by the engineer. It is often at this early stage where test results may be directly incorporated into the design, on a minimum-cost basis.

**Type 2 testing**
Formal tests are necessary to justify and accomplish the latter part of the detail design phase. Prototypes and pre-production units are mostly used. Test procedures may include a variety of tailored processes such as.

*Performance tests* — specific characteristics of the system is tested and verified with design criteria.

*Environmental tests* — all systems are exposed to the elements of nature, and these tests make sure the systems are able to function effectively under the necessary requirements.

*Structural tests* — structural soundness is an important aspect of design and tests such as strain, fatigue, torsion and bending may be used to ensure system integrity.

*Reliability qualification* — mean time between failure (MTBF) may be of importance in high-risk environments, and need to be checked before a system enters final production.

*Maintainability demonstration* — although maintainability is often regarded as a military requirement, many other systems are maintained by users. Easy maintenance is therefore essential, as well as testing the time it takes to maintain a system.

*Support equipment compatibility tests* — tests to make sure the support systems can and will function together.

*Personnel test and evaluation* — interaction between humans and machinery may be of importance, and if so, tests to verify this are required.

*Technical data verification* — verification of operational and maintenance procedures are accomplished

*Software verification* — making sure the operational and maintenance software meet the necessary requirements.

These test procedures serve to qualify the system or product for production and are concluded before the first run.

**Type 3 testing**
Field tests are often required by the client, especially if a complex system is being manufactured or sold. This is often the first time when all systems and logistic support are operational together. In essence total system performance and operational readiness may be determined.

**Type 4 testing**
To improve new product design and find possible places for improvement, formal tests are sometimes conducted after the product is already in operation. The test usually takes place at the site of operation, and measures total system performance.

*Corrective action* — may be necessary in response to system/equipment deficiency, or to improve system performance, effectiveness, and or logistic support. If corrective action is to be accomplished, the necessary planning and implementation steps are prerequisites to ensure complete compatibility of all elements of the system throughout the change process.

*Test performance and reporting* —are there to identify and report failures and non-compliance to design requirements. Data storage for historic and operational analysis forms an important part of this process. When a test failure occurs, changes have to be made to the system, and these need to be documented. By following a strict data sub-system with criteria for success and failure, the test process is accurately and consistently documented for future reference.

This concludes the discussion on systems engineering and the realisation of innovation.

**Appendix C: Audit Questionnaire**

## Beta testing

# Measuring Individual and Organisational Innovation Practices and Potential

Please enter your current:

**Employment Position**

________________________

**Division**

________________________

**Organisation**

________________________

Score (don't fill in)

| | | | | |
|---|---|---|---|---|
| External | | | | |
| Organisation | | | | |
| Individual | | | | |

**Instituut vir Tegnologiese Innovasie**
**Institute for Technological Innovation**

## Fostering Technological Innovation. An Audit.

The following questionnaire was compiled for the purpose of beta testing a newly developed innovation audit as theme for a master's thesis in the management of technology. As such the questionnaire covers many different aspects of the innovation process, touching on things such as culture, creativity, flexibility, management style, and many others. Innovation is a diverse process and no one single best avenue for success exists. It is often a coming together of many different disciplines, all effectively partaking in the innovation process, which has the greatest influence. This means that the management of innovation per sé will become increasingly important as globalisation and competitiveness increase.

Innovation consists of many linear and non-linear processes, yet ultimately it has a beginning and an implementation or end. To represent every aspect of this process as well as possible, a model was constructed and can be seen in Figure C.2. The innovation/product cycle can be seen in the centre of the model, as represented by the three spheres. Each of these represents a distinct stage in the innovation cycle, by displaying the core process employed at that stage. Although the spheres are illustrated as separate entities, in practice they almost always overlap.

Like most business concepts, innovation does not consist of a singular process from beginning to end. It needs a very special environment or milieu to flourish. 3M proud themselves on the fact that they are one of the most innovative firms in the world. Through many interviews with senior as well as junior employees, their environment has been identified as one of the keys to their success.

In the model presented here, the innovation cycle (three spheres in the centre), is enclosed by a hoop, representing the three fields in the innovation milieu. We can see individual, organisational and external environment as the three fields, as well as divide them into many different aspects, influencing the innovation process individually.

> For example: in keeping with 3M one of the aspects they employ to improve the generation of new ideas and creativity is a unique management process. Most employees are able to work on their own projects for some time every day. However the amount of freedom and responsibility every employee carries is quite striking. Each employee is regarded as an individual and restricted as little as possible by bureaucracy, giving rise to new-found freedom and a highly improved sense of creativity.

This example illustrates the importance of the organisational structure, the individual level of innovation as well as the profound influence each and every employee can have on the innovation process. To target another field in the innovation milieu, the external environment (see model) may be considered. Here aspects such as technology, market, social or economic factors play key roles and organisations need to realise their importance throughout the innovation process. The aspects in the external environment field are crucial in ensuring good contact between the innovation process and the real world outside the organisation.

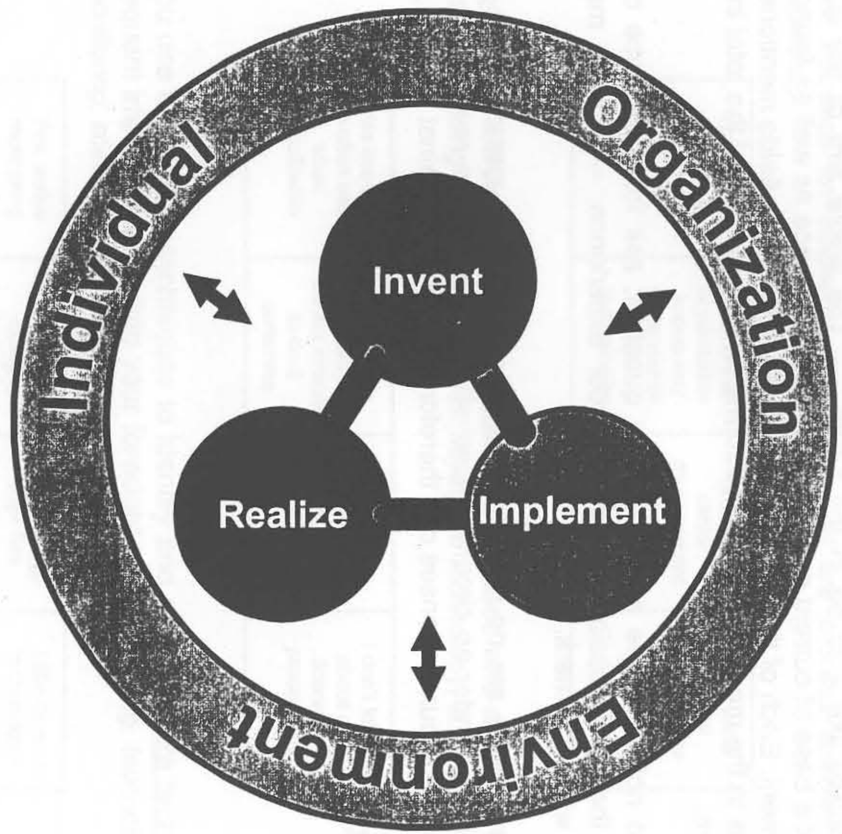
The complexity of human needs, expectations and cognition can, however, increase the influencing aspects on the innovation cycle to infinity. Just as some chaos theory meteorologists believe the flap of a butterfly's wing may cause a hurricane, so may

## Technological Innovation Model

**Invention**
- Contact with Technology/Market
- Creative Idea generation/ Need recognition
- Find solutions to ideas — Random R&D, technology buy/license
- Development of solutions to demonstrateable format
- License inventions out or develop further.

**Realisation**
- Program initialisation
- Filter, prioritise, choose
- Resource
- Plan, specify
- Technology acquisition
- Design and develop to maturity
- Test
- Pre-production

**Implementation**
- Full scale production
- Market development/ customer development
- Innovation commercialisation/ diffusion
- After sales support




**Individual**
- Leadership
- Team working
- Networking/ communication
- Key individuals
- Individual development
- Creativity
- Human learning
- Different intelligences

**Organisation**
- Structure
- Vision
- Strategy
- Resources

**Environment**
- Market/ customer
- Technology
- Industry/ competitor
- Suppliers
- Political
- Social
- Economical

*Figure C.2: Innovation Model, Proposed in Chapter 3* any minute occurrence influence the innovation process. To make sense out of such a situation would prove preposterous, and therefore this questionnaire aims at condensing the influencing aspects into high impact questions, able to detect problem areas, as well as possible recommendations toward improving them and shortening the total number of questions considerably.

For more information on the nature and goals of the questionnaire, see the end of this document.

## <u>The questions</u>

- The following questions are based on the innovation milieu and should be answered in an honest as well as clear manner.

- Please answer the questions as you currently perceive your organisation and not as you would like it to be in the future. — The whole aim of the audit is to construct a base of current practices for future reference as well as foundation for improvement. Each of the sections correlates to the three fields mentioned above as well as in the model and therefore forms an intricate part of the total innovation procedure.

- If you do not know the answer to any question, ask for assistance or simply indicate the best possible likeness to your experience. — Please mark such answers with a "?" mark.

- Remember: there are no right or wrong answers in this questionnaire and it is totally private. Under no circumstances will any answers be revealed to superior personnel and your responses can therefore not be held against you.

## <u>Please start now.</u>

## INTERACTION WITH THE EXTERNAL ENVIRONMENT

### Technology

1. Is dynamics of technological change a priority for strategic and general management, in deciding what new innovations to pursue, and where the company is heading?

| | | | |
|---|---|---|---|
| Yes, always | Often | Sometimes | Almost never/ not yet |

2. Is there an ingrained knowledge throughout the organisation of key technologies and how they contribute towards strategy and core competencies? *(Key technologies are those which the organisation's bottom-line depends on, with the greatest influence on efficiency, capabilities and are process oriented, or improve development.)*

| | | | |
|---|---|---|---|
| Yes, almost everyone | Most of the organisation knows and understands our technologies | Probably only senior management knows this | I don't know our key technologies or how they contribute |

3. Is licensing of technology, in and out, actively pursued and are the criteria clearly stipulated? (*selling patents, licensing in (buying) of technology, licensing out (selling) of technology*)

| | | | |
|---|---|---|---|
| Yes licensing is often used when applicable | Licensing is used only if we are unable to do it ourselves | Licensing almost never used + criteria unclear | I don't know about our licensing procedures |

4. Do you use exploratory techniques to identify and predict future technologies for subsequent implementation into your foresight program? *(e.g. technology scanning and monitoring, scenario analysis and Delphi)*

| | | | |
|---|---|---|---|
| Yes, active monitoring and scenario planning are done in conjunction with the organisational strategy | Changes are being implemented from technology scan with some positive improvements visible | A technology scan has been done yet nothing changed | Little or no technology scanning is done |

5. Do your broad organisational technology trajectories (as outlined in the strategy for future development) foster innovation?

| | | | |
|---|---|---|---|
| Strong scientific R&D components + long term technology development | Some scientific and unique research yet most emphasis on scale | Future technologies focus on cost cutting and reengineering | I don't know about our future technology needs |

## Market and Customer

1. Is there an intimate knowledge of the market/customer and its needs, preferences or demands with every person involved in new projects/innovations? *(Each function, from R&D, to design, to manufacturing, to after sales service, knows the needs and preferences of customers and how this product will satisfy them? "These guys really thought before designing this!" "This is a well designed product!" "This is beautiful and so useful, it's just what I needed".)*

| | | | |
|---|---|---|---|
| Yes, there is an intimate knowledge built through personal contact and observation of product use | A strong knowledge of market needs exists, yet products sometimes miss expected markets or initial user needs | Customer needs difficult to translate to actual work done in organisation | Market not yet well identified, yet information from marketing agency used extensively |

2. How strongly does the market/customer influence the characteristics, introduction price, operating procedures and final outcome of the project? *(Does the customer have a say in the features of the product, its safety, its reliability and its "looks". Does a feedback system exist for customer comment on current products?)*

| | | | |
|---|---|---|---|
| Customers part of development team, as well use of screening with customer groups | Customer needs and preferences used throughout development, yet little direct contact between project team and customer | Customer input used, yet often irrelevant since customer doesn't know what he/she wants | Market needs used as identified by marketing department |

3. Are criteria for market/customer development clear? *(Is the market developed before launching a new product; is advertising or similar development techniques used effectively.)*

| | | | |
|---|---|---|---|
| Strong market development with design and R&D giving input to marketing | Some market development done by advertising and personal contact with customers | Little market development done, just product advertising | Little or no market development is done |

4. Is the development capability of lead users (consumers that usually buy the first of almost everything) fully exploited? *(These consumers can give valuable critique on the product when in final development stage, since they usually have a good technical knowledge. E.g. Netscape launching a beta browser version and asking the lead users to find any bugs.)*

| | | | |
|---|---|---|---|
| Yes, lead users are identified and used extensively | Some preference made between customer test groups with emphasis on technical and non-technical people | Customer test groups are identified at random | No lead users are identified |

5. Do you use exploratory techniques to identify and predict future market trends in line with the strategic foresight of the organisation? *(e.g. market positioning and trend analysis, scenario analysis and Delphi)*

| | | | |
|---|---|---|---|
| Yes, active monitoring and scenario planning are done in conjunction with the organisational strategy | Correlation between strategy and market analysis with some benefits starting to occur | Market analysis is done, yet it is not linked to strategy | Little or no future market analysis done |

## Industry

1. Do you encourage suppliers to develop their systems and products to deliver a higher quality and overall better product to you? *(Strong relationships between you and suppliers can improve delivery, quality, price, and add to the total value chain)*

| | | | |
|---|---|---|---|
| Yes, direct contact and deliberation on new products with emphasis on best supplier possibilities | Lots of encourage-ment as well as pressure | Some encourage-ment | Little or no contact with suppliers on such issues |

2. Are your motives for collaborating with other companies in the industry made explicit, and related to subsequent outcomes? *(Do industry work groups exist to develop certain basic needs for the industry. — e.g. Japan's industries stand united against the world, yet compete fiercely on national level.)*

| | | | |
|---|---|---|---|
| Yes, direct contact and collaboration with clear motives and outcomes | Lots of collaboration | Some collaboration | Poor relations with competitors and other role players |

3. Is benchmarking used in your industry on a national and international scale? *(how does your organisation compare with the best in the world)*

| | | | |
|---|---|---|---|
| Yes, regular benchmarking used nationally and internationally | Regular benchmarking used | Some benchmarking used | Poor relations with competitors and no benchmarking used |

4. Compared to your competitors, does a strategy exist that will result in your ultimate leadership in the industry (niche), through development and innovation? *(secrecy, accumulated tacit knowledge, product complexity, complementary assets, learning curve, standards, patents, lead times and product support )*

| | | | |
|---|---|---|---|
| Yes, our strategy takes competitors into account and will try to lead to leadership | Some competitor trends included in strategy | Knowledge of competitors, yet their development not included in strategy | The competitions strategies are not known, neither is our own future development |

5. Do you learn from the competition, and is competitive intelligence used? *(R&D and reverse engineering, licensing, hiring, information collection)*

| | | | |
|---|---|---|---|
| Yes, good intelligence of competitors available and is used as learning tools | Regular intelligence and learning activities are undertaken | Some competitor intelligence available | No or little knowledge of competitors |

## Political, Economical and Social

1. Do you specify and communicate your education and training needs to local and leading providers? (*Universities, Technicons, or NGOs*)

| | | | |
|---|---|---|---|
| Yes, continuous contact with short courses and research programmes | Regular contact yet little input or direction given | Some contact no input | None or little contact with such institutions |

2. Are all parties influential to new projects or innovation, captured by your information network? (*national and international "gurus" in the political, environmental ("green"), economical, social and government arena*)

| | | | |
|---|---|---|---|
| Yes, continuous contact with strong benefits | Regular contact and some benefit derived | Some contact little benefit | None or little contact with such parties |

3. Do your links with government provide early warning of relevant regulation, promotion and mechanisms that would have a positive or negative impact on your organisation?

| | | | |
|---|---|---|---|
| Yes, many links with strong benefits | Many links with some benefit derived | Some links exist | Little or no such links |

4. Are potential advantages, that may derive from the national environment, effectively used and implemented? *(Tax breaks, special development areas, science base, input prices, workforce skills, market demand, support industries, and other.)*

| | | | |
|---|---|---|---|
| Yes, all available advantages are employed | Many advantages used | Some advantages used | Don't know of any |

5. Is action being taken to benefit from foreign systems of innovation? (*Foreign investment, joint ventures and alliances, trade agreements, suppliers and customers, licensing, reverse engineering, public research*)

| | | | |
|---|---|---|---|
| Yes, all available advantages are employed | Many advantages used | Some advantages used | Don't know of any |

## ORGANISATIONAL

### Strategic

1. Does an active foresight programme exist, looking five to ten years into the future, complementing the strategy in reaching the future of your organisation?

| Yes, foresight and strategy, shape our future focus | A foresight study has been done | Some future planning is done | Don't know of any |
|---|---|---|---|
| | | | |

2. Are new generation products and technologies planned and developed in accordance with your foresight and strategy formulation? *(number of new generations of products planned in advance)*

| Yes | Most new projects are strategic and in accordance with the foresight | Some projects are strategic | No or I don't know |
|---|---|---|---|
| | | | |

3. Does the overall foresight and business strategy, link with innovation and innovation management throughout the organisation? *(Are clear goals for innovation set, and is innovation seen as a method for gaining a competitive edge over competitors.)*

| Yes, mostly | In certain cases | Marginally | No or I don't know if it does |
|---|---|---|---|
| | | | |

4. Is the correct structure for a particular innovation determined, be it tiger teams, multi-disciplinary teams, functional participation, or matrix based, with strong leadership and early involvement by future members of the chosen structure.

| Yes, best possible team structure chosen with early participation of all functions that are present in the team throughout the innovation lifecycle | Task team as well as good concurrent engineering practices | Some flexibility with better involvement of innovation parties | Only one formal structure with functional participation as project reaches each stage in the lifecycle |
|---|---|---|---|
| | | | |

5. Do you clearly identify potential new company technological competencies — corporate visions, technical judgements, product-technology matrices, incremental trial, error and learning?

| Yes, all available advantages are employed | Many advantages used | Some advantages used | Don't know of any |
|---|---|---|---|
| | | | |

## Implementation

1. Is your organisation able to extract the ultimate amount of advantage from available resources, and previous experiences? *(Learning (project review) and realising new possibilities for current resources, can significantly reduce a organisation's overhead costs i.e. Japan)*

| Yes | Mostly | Sometimes | Not really |
|---|---|---|---|

2. Do new innovations/ventures have a balanced repertoire of Product Development, Production, and Distribution? *(If compared to a three-legged chair, if any one is not present, consequences can be disastrous.)*

| Yes | Mostly | Sometimes | Not really |
|---|---|---|---|

3. Is there a measure of elapsed time from the first funding of a new development/innovation, and the time it has been recovered through market sales? *(Time for ROI)*

| Yes, clear metrics and measurements for new developments are in place | Mostly | Sometimes, yet generally little track is kept | Not really |
|---|---|---|---|

4. Is there early involvement (while still planning) and concurrent working by as many functions as possible, within the new product development system?

| Yes | Mostly | Sometimes | Not really |
|---|---|---|---|

5. Are there formal procedures for reviewing new product development progress against a series of stage 'gates' throughout the innovation lifecycle?

| Yes | Mostly | Sometimes | Not really |
|---|---|---|---|

## Fostering Environment

1. Do career structures and skill improvement courses, include learning about creativity, core competencies, technology and innovation and how to implement them practically in each employee's working environment?

| Yes, almost all employees learn of these concepts | Most management people | For some employees | Not that I know of |
|---|---|---|---|
| | | | |

2. Are key individuals identified, advertised, recognised and supported by management, to make the necessary information and experience available to entrepreneurial employees, in your organisation?

| Yes, we have an active key peoples network | Mostly | To a certain degree | Not that I know of |
|---|---|---|---|
| | | | |

3. Is your organisation capable of actively learning, as well as learning faster than competitors, from each new product innovation, even if the innovation was unsuccessful?

| Yes | Mostly | Sometimes | Not really |
|---|---|---|---|
| | | | |

4. If a new product fails, is there a feeling of total dismay and hopelessness concluded in shutdown of the project, or does quick learning occur from the experience, followed by renewed vigour for succeeding and making the project work better? *(Few first innovations are immediate success stories. New product market expectations are always difficult to judge, and the only way is by actually launching a product and learning from the reaction.)*

| Yes always | Mostly | Sometimes | Not really |
|---|---|---|---|
| | | | |

5. Does management or leadership expect innovation and creativity, and strives to create a truly friendly environment for new ideas and expectations to be discussed and pursued?

| Yes, management leads the way through excitement and example | Innovation expected, rewarded and fostered but not by all | Innovation expected but little done to create the environment | Not really |
|---|---|---|---|
| | | | |

6. Does a flexible incentive scheme exist, with rewards that have real influence on employee innovativeness? *(Base pay with bonus opportunities doubling or even tripling the base salary)*

| Yes, a good formal and informal incentive schemes exist | A formal innovation scheme exists | Year-end bonus scheme exists | Not really |
|---|---|---|---|
| | | | |

## INDIVIDUAL

### Personality and Feelings

1. If you win the lottery tomorrow with a total prize of $10 million, would you?

| | | | |
|---|---|---|---|
| Invest the money and continue working | Take a long vacation but stay on in your current position | Resign after completing immediate tasks and responsibilities | Immediately resign and do whatever you like |

2. Do you feel compelled to be as creative as possible when solving problems, or starting with a new project? (*Do rules and regulations exist limiting your creativity or inhibiting controversiality.*)

| | | | |
|---|---|---|---|
| Yes | Mostly | Sometimes | Almost never |

3. Do you as an individual experience the strategic goals of your organisation (as set by the foresight and strategy of your organisation) as motivational?

| | | | |
|---|---|---|---|
| Yes | Mostly | Sometimes | Not really |

4. When pursuing or suggesting an innovative avenue, do you at any stage feel threatened (promotion wise, to be showing disrespect, being ridiculed, feel foolish, seem to be naïve, fear of failure, not wanting to stand out, being branded as different, or losing social standing) by management or colleagues?

| | | | |
|---|---|---|---|
| Yes, I often feel threatened in some way | Many times especially in the company of superiors | Sometimes | Not really, the culture is very open and most things go down well |

5. Do you as an individual feel like you are making a significant contribution to your organisation's strategic and foresight goals, or do you feel like a cog in a huge machine?

| | | | |
|---|---|---|---|
| Yes, I often feel significant | In many projects I have felt significant | I sometimes feel significant | Not really |

## Knowledge, Intelligence, Experience and Background

1. When starting a new project, are you and your colleagues made aware of the common goal for the project, as well as the significance to the organisational strategy? (common goal = total project goal = successful market penetration = reaching planned strategic future)

| | | | |
|---|---|---|---|
| Yes, always | Mostly, depending who is involved | Sometimes, yet depending on who is involved | Seldom or not really |

2. Are you creative in new projects or do your years of experience inhibit crazy ideas, - possibly childish or ridiculous? (Do you use creative techniques in your own work and in group situations?)

| | | | |
|---|---|---|---|
| Yes, I always try | Mostly, if time allows | Sometimes, depending on the project | Seldom, I just try to finish the project on time in 'spec' |

3. Do you often study inside and outside your field to improve your knowledge base, enabling you to adopt different approaches, when solving problems? (Self motivation to grow and learn)

| | | | |
|---|---|---|---|
| Yes, I try to broaden my knowledge on many aspects | Mostly if time allows | Sometimes | Not really |

4. Are you aware of the key people (champions, gatekeepers, entrepreneurs, mentors) in your organisation to contact if a new idea occurs to you, even if it is completely outside your department's field of expertise?

| | | | |
|---|---|---|---|
| Yes, I know all the key people and how to get in contact with them | I am aware of most key people | I am aware of some key people in my department | Not really |

5. Do your family and home environment support you in entrepreneurial efforts you make at the office, even if it may result in a negative outcome?

| | | | |
|---|---|---|---|
| Yes, my family is part of my work and is prepared to adjust as I am for them | Mostly | As long as the changes does not impact to severely | Work and home does not mix |

## Social Environment

1. Do you have a <u>relationship</u> of communication and understanding with at least one person in each of the functional departments of your organisation?

| | | | |
|---|---|---|---|
| Yes, I have a relationship in each of the functions and it always broadens my perspective when discussing new projects with them | I know most relevant people in the different functions | Some relationships, yet they are not specifically in certain departments | Not really, I am not that social |

2. Does a spirit of <u>innovation and dedication</u> prevail throughout your organisation, recognising and celebrating employees brave enough to propose new innovations or whom are creative and resourceful in their daily tasks?

| | | | |
|---|---|---|---|
| Yes | Mostly | To a certain degree | Not really |

3. Is it possible that everybody in your organisation <u>essentially thinks in the same way</u> (is the workforce predominantly engineers/ economists/ lawyers/ doctors) or are diverse thinking really present? *(Do most employees follow and agree with the leader or manager and form a sort of herd around a single person, without giving their opinion, or sometimes not even having an opinion of their own?)*

| | | | |
|---|---|---|---|
| Yes, it is quite possible | It is mostly possible | To a certain degree, yet we are quite diverse | No, we are an extremely diverse group of employees, ranging from many different countries, as well as occupations |

4. Are there any <u>mavericks or 'weirdoes'</u> in your organisation, and are they sort of accepted in the social structure of your organisation. *(They are often catalysts for different thinking and breaking the herd mentality )*

| | | | |
|---|---|---|---|
| Yes, mavericks are purposefully hired and made to feel welcome, as any other employees | Some mavericks are hired, yet they seldom fit in | Most new employees are hired to fit in, yet the few who slip through, are accommodated | Not really, no weirdoes |

5. Is there a person or persons in your organisation that tells and embodies powerful and purposeful <u>stories</u>, with the aim of imbedding in the identity of the organisation's past legends, faiths, myths, and stories relating to innovative activities and highly successful past and future activities?

| | | | |
|---|---|---|---|
| Yes, we have many storytellers | Some do exist, yet their value are not recognised by management | Few active story tellers, but stories in the form of rumors do occur | Not really |

**Please answer the following**

Does the audit, to your experience, cover every aspect crucial to the innovation process?

________________________________________

________________________________________

If not, please list any fields you think are important, but not represented in the questionnaire.

1 ______________________________________

2 ______________________________________

3 ______________________________________

4 ______________________________________

5 ______________________________________

6 ______________________________________

7 ______________________________________

8 ______________________________________

## Appendix D: Innovation Models

This appendix contains examples of Innovation Models as proposed by Twiss,[16] Utterback,[17] Tidd *et al*,[18] Marquis,[19] Katz,[20] Thamhain[21] and Wheelwright[22]

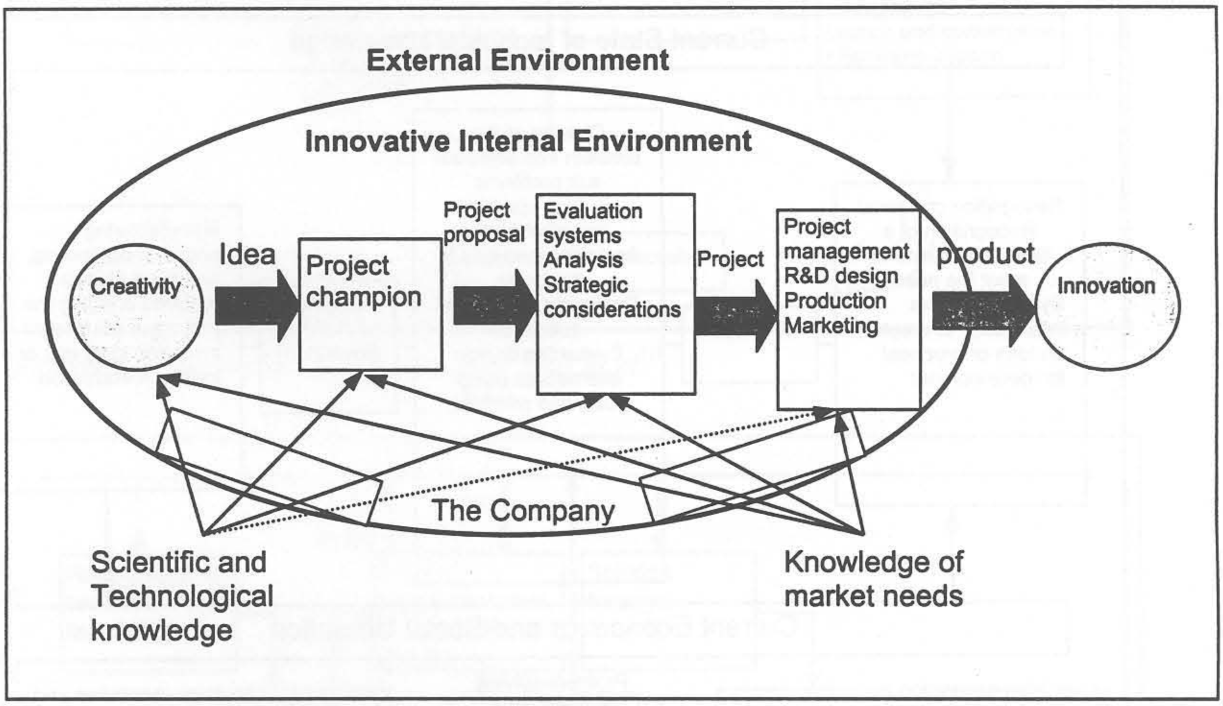



*Figure D.1: Innovation Model, Source: Twiss[16]*

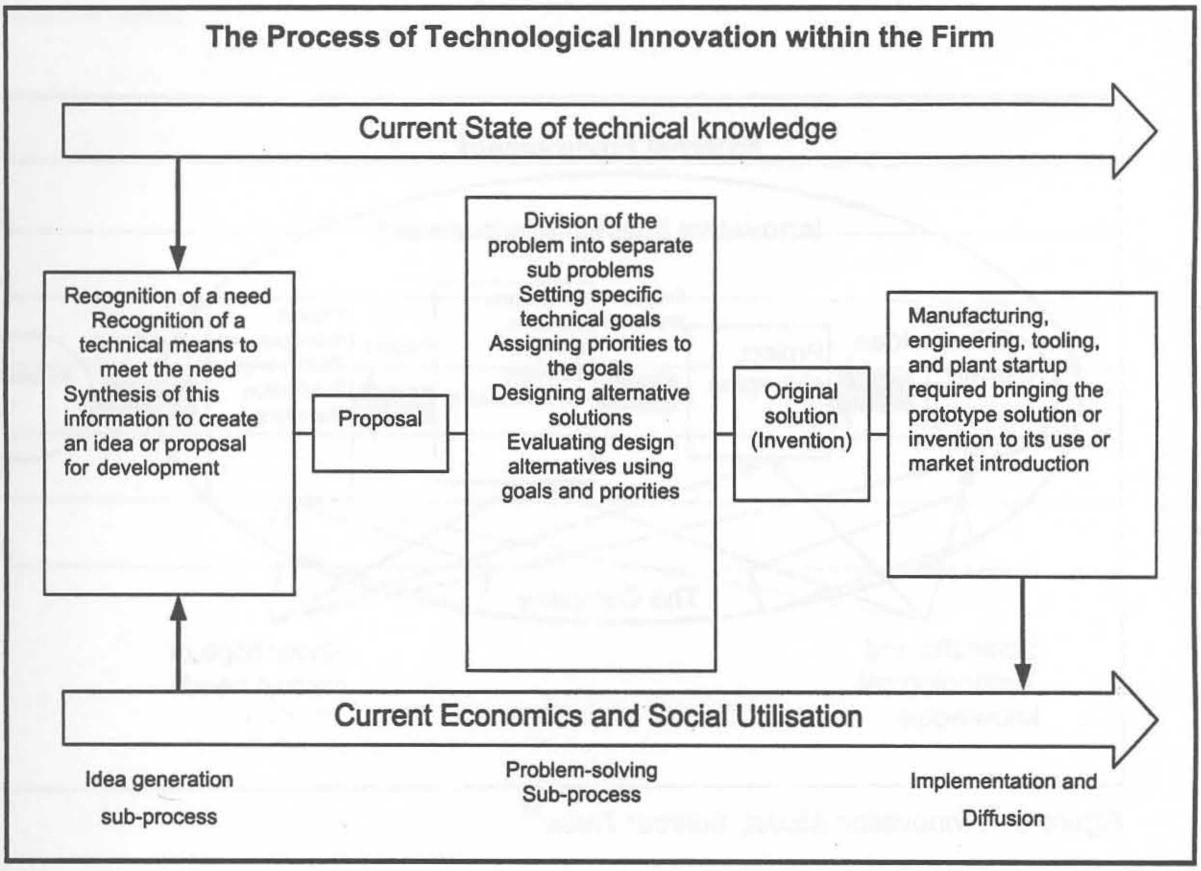



*Figure D.2: The Process of Technological Innovation within the Firm, Source: Utterback*[17]

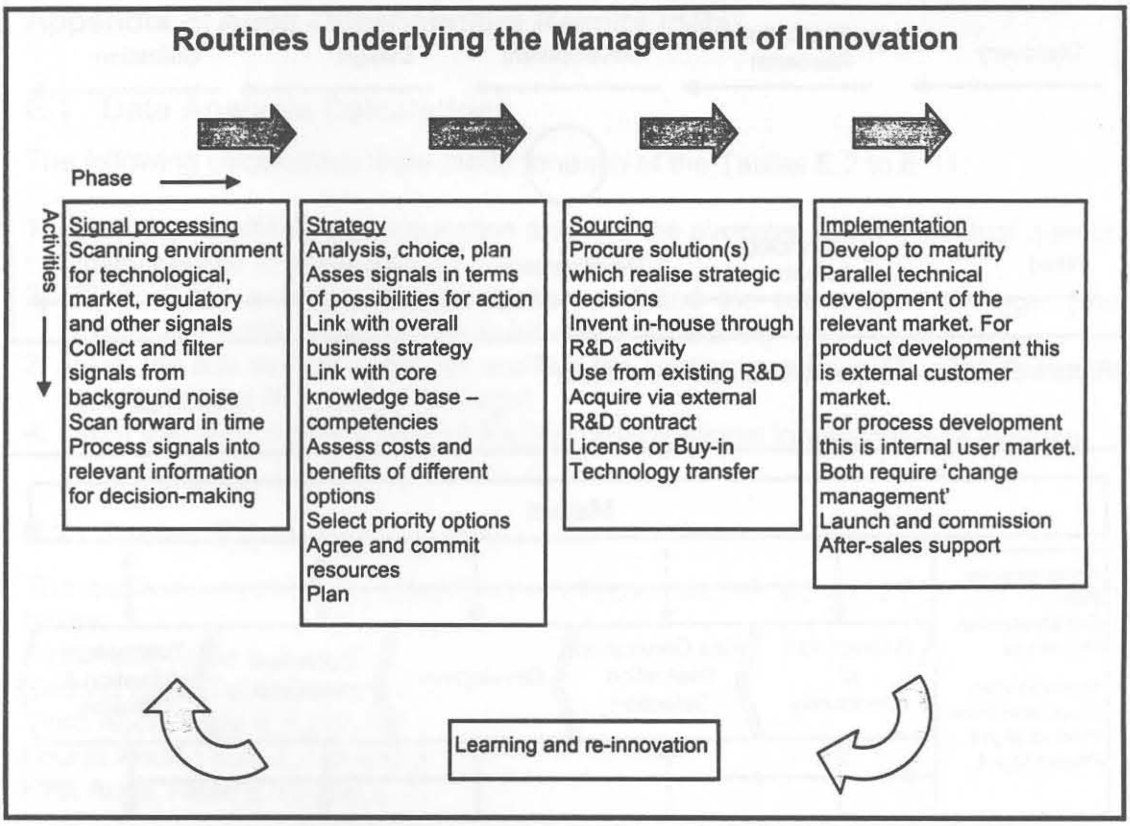



*Figure D.3: Innovation Model, Source: Tidd et al*[18]

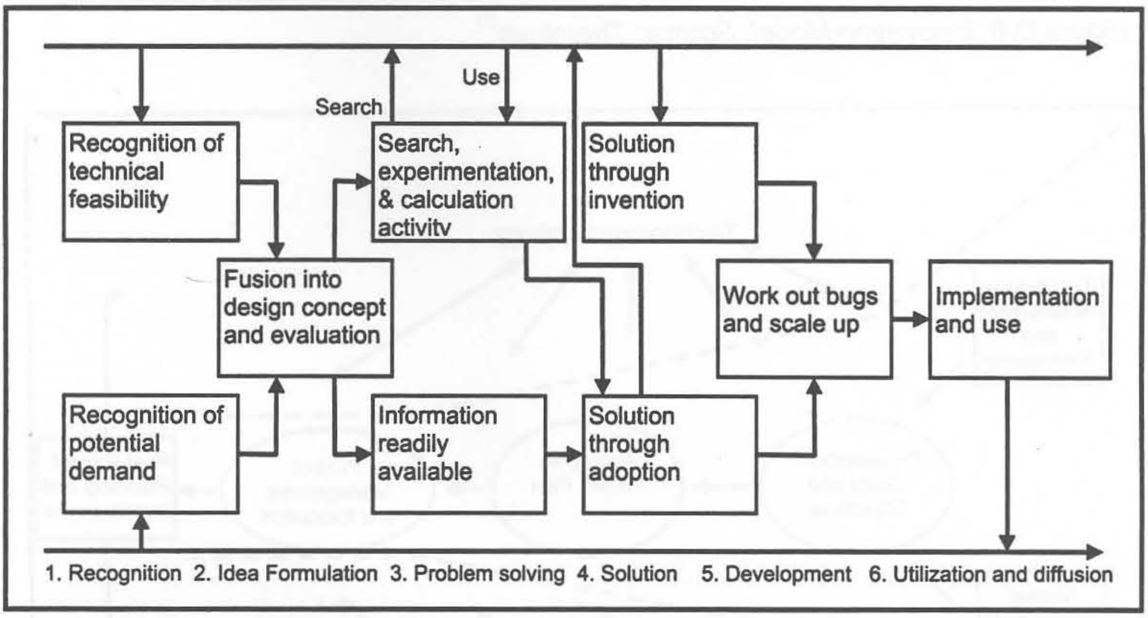



*Figure D.4: Innovation Model, Source: Marquis*[19]

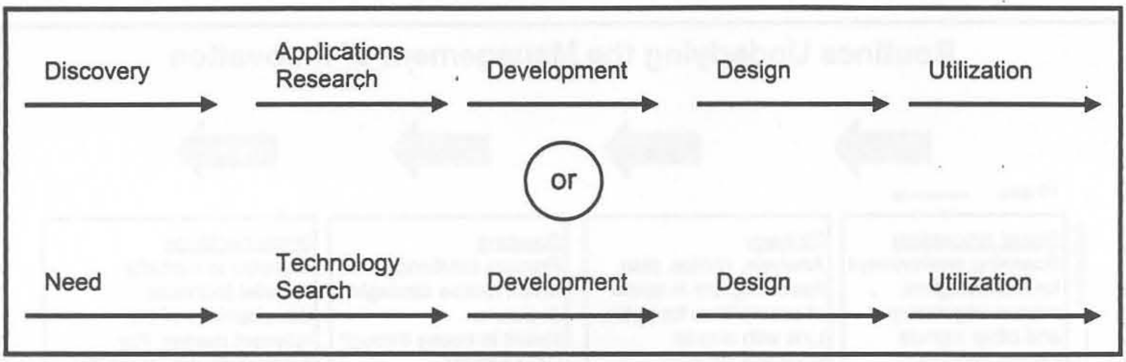



*Figure D.5: Innovation Model, Source: Katz*[20]

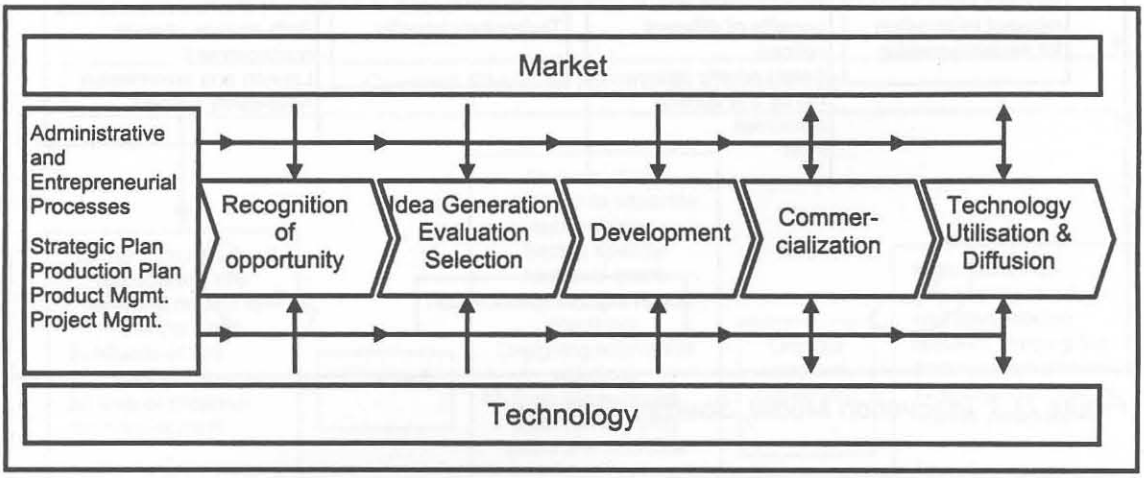



*Figure D.6: Innovation Model, Source: Thamhain*[21]

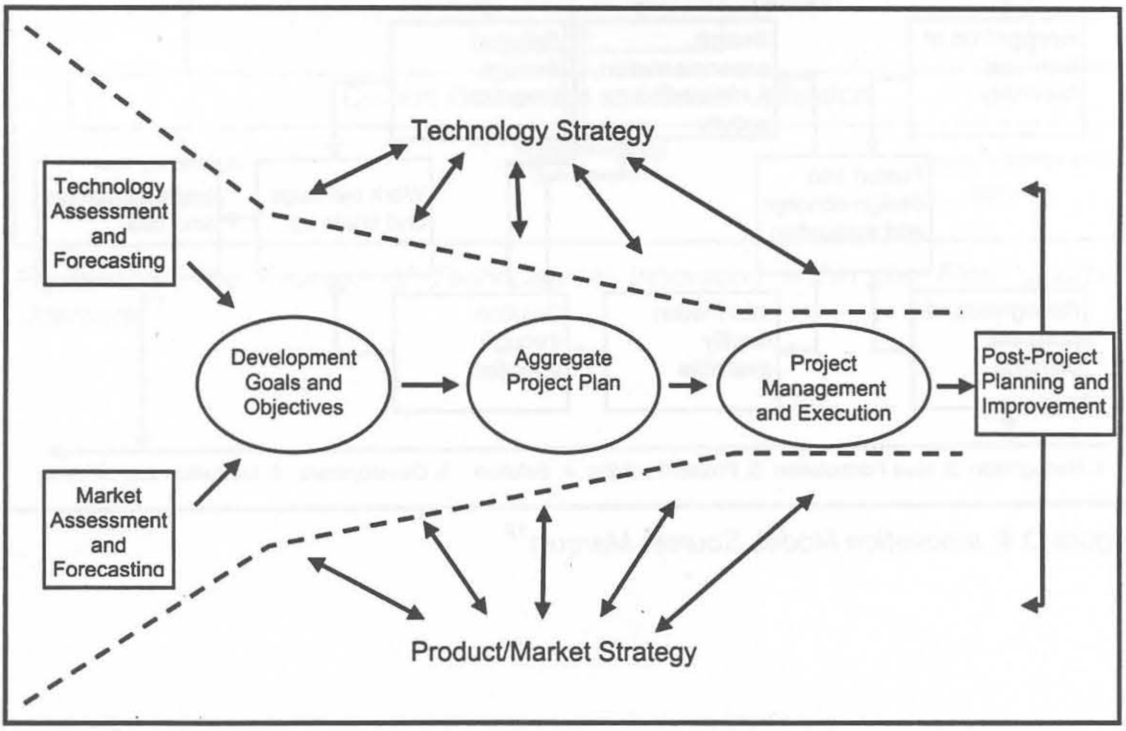



*Figure D.7: Project Funnel, Source: Wheelwright and Clark*[22]

# Appendix E: Audit Questionnaire Results (data)

## E.1 Data Analysis Calculations

The following calculations were made for each of the Tables E.2 to E 11:

1. Sum the results for each question and find the average. [Sum individual question rows, answer in average column]
2. Sum all the averages by sub-section and find the sub-section average. [Sum average column, answer in sectional average column]
3. Sum the sub section averages and find the section averages. [Sum sub-sectional averages and find section average]
4. Sum the section averages and find the organisational innovativeness average.

## E.2 Tables E.2 to E.11

The audited organisations described in chapter six are illustrated by the following tables:
First Audit Table E.2 and E.3
Second Audit Table E.4 and E.5
Third Audit Table E.6 and E.7
Fourth Audit Table E.8 and E.9
Fifth Audit Table E.10 and E.11

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Production | Marketing | R&D Project Management | Strategy / Technology | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|
| Electronics Org. | Environment | Technology | Dynamics of Technological Change | 2.85 | 3 | 3 | 4 | 3 | 3.25 |
| Electronics Org. | | | Key Technologies | | 3 | 3 | 3 | 4 | 3.25 |
| Electronics Org. | | | Licensing | | 1 | 4 | 3 | 3 | 2.75 |
| Electronics Org. | | | Future technologies monitor/scan | | 3 | 2 | 2 | 4 | 2.75 |
| Electronics Org. | | | Technology trajectories | | 1 | 2 | 2 | 4 | 2.25 |
| Electronics Org. | | Market and Customer | Knowledge of Market/customer | 2.65 | 1 | 1 | 3 | 3 | 2.00 |
| Electronics Org. | | | Market/customer influence | | 2 | 4 | 3 | 4 | 3.25 |
| Electronics Org. | | | Market/customer development | | 1 | 3 | 3 | 3 | 2.50 |
| Electronics Org. | | | Lead Users | | 1 | 2 | 3 | 4 | 2.50 |
| Electronics Org. | | | Future Market Trends | | | | | 3 | 3.00 |
| Electronics Org. | | Industry | Supplier development | 2.85 | | | | 4 | 4.00 |
| Electronics Org. | | | Collaboration | | 3 | 2 | 3 | 1 | 2.25 |
| Electronics Org. | | | Benchmarking | | | | | 2 | 2.00 |
| Electronics Org. | | | Ultimate Leadership | | 2 | 3 | 2 | 3 | 2.50 |
| Electronics Org. | | | Learn from competition | | 4 | 3 | 3 | 4 | 3.50 |
| Electronics Org. | | P.E.S. | Education and training needs | 2.40 | 3 | 2 | 1 | 3 | 2.25 |
| Electronics Org. | | | Relevant parties captured (national/international) | | 3 | 3 | 3 | 3 | 3.00 |
| Electronics Org. | | | Government Links | | 3 | 3 | 3 | 2 | 2.75 |
| Electronics Org. | | | Advantages from national environment | | 1 | 2 | 1 | 2 | 1.50 |
| Electronics Org. | | | Benefit from foreign systems of innovation | | 2 | 3 | 2 | 3 | 2.50 |
| Electronics Org. | Organizational | Strategic | Active foresight program | 2.75 | | | | 3 | 3.00 |
| Electronics Org. | | | New generation products in accordance with strategy | | | | | 3 | 3.00 |
| Electronics Org. | | | Foresight and business strategy link with innovation | | 2 | 1 | 2 | 2 | 1.75 |
| Electronics Org. | | | Correct project management structure for each innovation | | 4 | 4 | 3 | 3 | 3.50 |
| Electronics Org. | | | Identify new technological competencies | | 2 | 3 | 2 | 3 | 2.50 |

*Table E.2 Electronics Organisation, First Audit*

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Production | Marketing | R&D Project Management | Strategy / Technology | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|
| Electronics Org. | | Implement | Maximum Advantage from available resources and experience | 3.40 | | | | 4 | 4.00 |
| Electronics Org. | | | Balanced repertoire, Invent Realise, Implement | | | | | 3 | 3.00 |
| Electronics Org. | | | Elapsed time for ROI measurement | | | | | 4 | 4.00 |
| Electronics Org. | | | Early involvement by all | | 3 | 3 | 3 | 4 | 3.25 |
| Electronics Org. | | | Formal review procedures | | 1 | 3 | 3 | 4 | 2.75 |
| Electronics Org. | | Fostering environment | Skill improvement | 2.75 | 2 | 1 | 1 | 3 | 1.75 |
| Electronics Org. | | | Key individuals advertised and supported by management | | 3 | 2 | 4 | 4 | 3.25 |
| Electronics Org. | | | Active organisational Learning | | 2 | 3 | 3 | 4 | 3.00 |
| Electronics Org. | | | Failure followed by vigour or hopelessness | | | | | 4 | 4.00 |
| Electronics Org. | | | Management expect innovation | | 4 | 4 | 3 | 3 | 3.50 |
| Electronics Org. | | | Flexible & motivational incentive scheme | | 1 | 1 | 1 | 1 | 1.00 |
| Electronics Org. | Individual | Personality and Feelings | Lottery | 1.75 | | | | 1 | 1.00 |
| Electronics Org. | | | Creative as possible | | 1 | 3 | 3 | 1 | 2.00 |
| Electronics Org. | | | Strategic goals motivational | | | | | 1 | 1.00 |
| Electronics Org. | | | Threatened | | 2 | 1 | 3 | 2 | 2.00 |
| Electronics Org. | | | Are you Making a significant contribution | | 2 | 3 | 3 | 3 | 2.75 |
| Electronics Org. | | Knowledge experience and background | Common goal of project | 2.85 | 3 | 2 | 4 | 4 | 3.25 |
| Electronics Org. | | | Experience inhibiting Creativity | | | | | 2 | 2.00 |
| Electronics Org. | | | Study inside and outside | | 3 | 4 | 2 | 4 | 3.25 |
| Electronics Org. | | | Awareness of Key people | | 3 | 2 | 2 | 4 | 2.75 |
| Electronics Org. | | | Home environment support | | | | | 3 | 3.00 |
| Electronics Org. | | Social environment | Functional relationships in each department | 3.10 | | | | 3 | 3.00 |
| Electronics Org. | | | Spirit of innovation & Dedication | | 3 | 2 | 2 | 3 | 2.50 |
| Electronics Org. | | | Thinking the same way | | | | | 2 | 2.00 |
| Electronics Org. | | | Mavericks & weirdo's | | | | | 4 | 4.00 |
| Electronics Org. | | | Stories | | | | | 4 | 4.00 |

*Table E.3: Electronics Organisation, First Audit*

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Director/Businss man | Div Mangr Aircft sys | Senr Design eng. | Project Manager | System Engineer | System Engineer | System Engineer | System Engineer | System Engineer | System Engineer | System Engineer | Engineer | Software design engineer | Design Draftsman | Technologyst | Technician | Hardware Technician | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electronics/software Org. | Environment | Technology | Dynamics of Technological Change | 2.43 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 4 | 2 | 2.53 |
| Electronics/software Org. | | | Key Technologies | | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 2.47 |
| Electronics/software Org. | | | Licensing | | 4 | 1 | 2 | 1 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | | 2 | 4 | 3 | 4 | 2 | 2.50 |
| Electronics/software Org. | | | Future technologies monitor/scan | | 1 | 2 | 2 | 3 | 3 | 1 | 2 | 2 | 1 | 3 | 3 | | 3 | 3 | 1 | 4 | 1 | 2.19 |
| Electronics/software Org. | | | Technology trajectories | | 3 | 3 | 1 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | | 2 | 4 | 3 | 3 | 4 | 2.44 |
| Electronics/software Org. | | Market and Customer | Knowledge of Market/customer | 2.85 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 2 | 3 | 3 | 3 | 3 | 4 | 2.88 |
| Electronics/software Org. | | | Market/customer influence | | 2 | 4 | 1 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | | 4 | 4 | 3 | 4 | 3 | 3.31 |
| Electronics/software Org. | | | Market/customer development | | 3 | | 2 | 2 | 4 | 4 | 3 | 3 | 1 | 3 | 3 | | 2 | | 1 | 3 | 4 | 2.71 |
| Electronics/software Org. | | | Lead Users | | 1 | 4 | 3 | 3 | 4 | 4 | 1 | 3 | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | 1 | 3.00 |
| Electronics/software Org. | | | Future Market Trends | | 3 | 1 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 1 | 3 | 3 | 2 | 4 | 1 | 2.35 |
| Electronics/software Org. | | Industry | Supplier development | 2.42 | 2 | 3 | 3 | 4 | 3 | 4 | 2 | 2 | 1 | 3 | 3 | | 3 | 4 | 3 | 3 | 4 | 2.94 |
| Electronics/software Org. | | | Collaboration | | 2 | 4 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 4 | 2 | 2 | 1 | 2.06 |
| Electronics/software Org. | | | Benchmarking | | 2 | 2 | 2 | 4 | 4 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 4 | 1 | 4 | 2 | 2.53 |
| Electronics/software Org. | | | Ultimate Leadership | | 4 | 4 | 2 | 1 | 2 | 1 | 3 | 2 | 3 | 4 | 2 | | 2 | 4 | 2 | 3 | 1 | 2.50 |
| Electronics/software Org. | | | Learn from competition | | 2 | 4 | 1 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 4 | 2 | 2.06 |
| Electronics/software Org. | | P.E.S. | Education and training needs | 2.23 | 2 | 2 | 1 | 1 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2.41 |
| Electronics/software Org. | | | Relevant parties captured (national/international) | | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 1 | 2 | 4 | | 2 | 3 | 1 | 3 | 2 | 2.38 |
| Electronics/software Org. | | | Government Links | | 2 | 3 | 3 | | 2 | 3 | 2 | 2 | 1 | 3 | 4 | 2 | 2 | 2 | 1 | 1 | 1 | 2.13 |
| Electronics/software Org. | | | Advantages from national environment | | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 2 | 1.71 |
| Electronics/software Org. | | | Benefit from foreign systems of innovation | | 3 | 4 | 4 | 2 | 1 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 2.53 |
| Electronics/software Org. | Organizational | Strategic | Active foresight program | 2.04 | 3 | 1 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 3 | 4 | 2 | 2 | 3 | 2 | 3 | 1 | 2.06 |
| Electronics/software Org. | | | New generation products in accordance with strategy | | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 1 | 2.00 |
| Electronics/software Org. | | | Foresight and business strategy link with innovation | | 4 | 2 | 3 | 2 | 1 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 2.41 |
| Electronics/software Org. | | | Correct project management structure for each innovation | | 4 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 2 | 4 | 1.94 |
| Electronics/software Org. | | | Identify new technological competencies | | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 1.76 |

*Table E.4: Electronics and Software Organisation, Second Audit*

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Director/Busins man | Div Mangr Aircft sys | Senr Design eng. | Project Manager | System Engineer | System Engineer | System Engineer | System Engineer | System Engineer | System Engineer | System Engineer | Engineer | Software design engineer | Design Draftsman | Technologyst | Technician | Hardware Technician | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electronics/software Org. | | Implement | Maximum Advantage from available resources and experience | 2.51 | 3 | | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 4 | 1 | 2 | 3 | 2.19 |
| Electronics/software Org. | | | Balanced repertoire, Invent Realise, Implement | | 3 | | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 1 | 3 | 2 | 3 | 1 | 2.38 |
| Electronics/software Org. | | | Elapsed time for ROI measurement | | 4 | | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | | 3 | 3 | 2 | 3 | 4 | 2.67 |
| Electronics/software Org. | | | Early involvement by all | | 4 | | 1 | 2 | 3 | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 1 | 3 | 2 | 2 | 3 | 2.31 |
| Electronics/software Org. | | | Formal review procedures | | 3 | | 2 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 2 | 2 | 3 | 1 | 2 | 4 | 3.00 |
| Electronics/software Org. | | Fostering environment | Skill improvement | 1.89 | 2 | | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 1.63 |
| Electronics/software Org. | | | Key individuals advertised and supported by management | | 4 | | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 1 | 4 | 2.00 |
| Electronics/software Org. | | | Active organisational Learning | | 2 | | 3 | | 2 | 3 | 1 | 2 | 1 | 2 | 2 | 2 | 3 | 4 | 2 | 3 | 4 | 2.40 |
| Electronics/software Org. | | | Failure followed by vigour or hopelessness | | 2 | | 2 | 3 | 1 | 3 | 2 | 2 | 1 | 2 | 3 | | 2 | 1 | 2 | 2 | 4 | 2.13 |
| Electronics/software Org. | | | Management expect innovation | | 2 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 3 | 2 | 3 | 2 | 2.00 |
| Electronics/software Org. | | | Flexible & motivational incentive scheme | | 1 | | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1.19 |
| Electronics/software Org. | Individual | Personality and Feelings | Lottery | 2.41 | 3 | 2 | 4 | 4 | 4 | 3 | 2 | 4 | 1 | 2 | 4 | 2 | 4 | 4 | 1 | 4 | 4 | 3.06 |
| Electronics/software Org. | | | Creative as possible | | 4 | 2 | 2 | 3 | 4 | 4 | 2 | 2 | 2 | 3 | 4 | 1 | 2 | 1 | 4 | 2 | 4 | 2.71 |
| Electronics/software Org. | | | Strategic goals motivational | | 3 | 2 | 2 | 3 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 1 | 2 | 1.94 |
| Electronics/software Org. | | | Threatened | | 1 | 3 | 1 | 2 | 2 | 1 | 2 | 4 | 2 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 1 | 1.94 |
| Electronics/software Org. | | | Are you Making a significant contribution | | 3 | 3 | 4 | 3 | 1 | 4 | 2 | 1 | 1 | 2 | 4 | 1 | 4 | 2 | 2 | 2 | 2 | 2.41 |
| Electronics/software Org. | | Knowledge experience and background | Common goal of project | 2.86 | 3 | 2 | 3 | 2 | 4 | 3 | 2 | 2 | 2 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 2.53 |
| Electronics/software Org. | | | Experience inhibiting Creativity | | 1 | 2 | 3 | 4 | 2 | 4 | 3 | 4 | 3 | 3 | 4 | 2 | 2 | 3 | 2 | 3 | 3 | 2.82 |
| Electronics/software Org. | | | Study inside and outside | | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 2 | 4 | 4 | 2 | 3 | 2 | 4 | 2 | 3.00 |
| Electronics/software Org. | | | Awareness of Key people | | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 1 | 1 | 3 | 4 | 2 | 4 | 3 | 2 | 3 | 2 | 3.00 |
| Electronics/software Org. | | | Home environment support | | 4 | 4 | 3 | 4 | 3 | 4 | 3 | 1 | 1 | 3 | 4 | 1 | 4 | 4 | 1 | 3 | 3 | 2.94 |
| Electronics/software Org. | | Social environment | Functional relationships in each department | 2.02 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 1 | 3 | 2 | 4 | 3 | 3 | 3 | 2 | 3 | 3 | 2.88 |
| Electronics/software Org. | | | Spirit of innovation & Dedication | | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1.82 |
| Electronics/software Org. | | | Thinking the same way | | 4 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 1.24 |
| Electronics/software Org. | | | Mavericks & weirdo's | | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 4 | 1.94 |
| Electronics/software Org. | | | Stories | | 3 | 4 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 3 | 2 | 1 | 2 | 2 | 3 | 3 | 2.24 |

*Table E.5: Electronics and Software Organisation, Second Audit*

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Managing Director | Bus. Dev.mnt Mangr | Operations Manager | Softw. Dev.mnt Mnger | Support Manager | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|---|
| Software Org. | Environment | Technology | Dynamics of Technological Change | 3.30 | 3 | 3 | 4 | 3 | 3 | 3.20 |
| Software Org. | | | Key Technologies | | 4 | 3 | 4 | 3 | 3 | 3.40 |
| Software Org. | | | Licensing | | 4 | 4 | 3 | 4 | 4 | 3.80 |
| Software Org. | | | Future technologies monitor/scan | | 4 | 3 | 3 | 2 | 3 | 3.00 |
| Software Org. | | | Technology trajectories | | 3 | 2.5 | 4 | 3 | 3 | 3.10 |
| Software Org. | | Market and Customer | Knowledge of Market/customer | 2.92 | 4 | 4 | 2 | 4 | 3 | 3.40 |
| Software Org. | | | Market/customer influence | | 4 | 3 | 2 | 4 | 3 | 3.20 |
| Software Org. | | | Market/customer development | | 3 | 3 | 3 | 1 | 3 | 2.60 |
| Software Org. | | | Lead Users | | 4 | 4 | 1 | 4 | 1 | 2.80 |
| Software Org. | | | Future Market Trends | | 3 | 2 | 3 | 2 | 3 | 2.60 |
| Software Org. | | Industry | Supplier development | 2.64 | 4 | 4 | 4 | 3 | 4 | 3.80 |
| Software Org. | | | Collaboration | | 3 | 2 | 1 | 1 | 1 | 1.60 |
| Software Org. | | | Benchmarking | | 3 | 2 | 2 | 3 | 2 | 2.40 |
| Software Org. | | | Ultimate Leadership | | 4 | 4 | 2 | 2 | 3 | 3.00 |
| Software Org. | | | Learn from competition | | 3 | 2 | 2 | 3 | 2 | 2.40 |
| Software Org. | | P.E.S. | Education and training needs | 2.12 | 2 | 1 | 2 | 1 | 1 | 1.40 |
| Software Org. | | | Relevant parties captured (national/international) | | 4 | 3 | 3 | 2 | 1 | 2.60 |
| Software Org. | | | Government Links | | 2 | 2 | 1 | 2 | 2 | 1.80 |
| Software Org. | | | Advantages from national environment | | 2 | 2 | 2 | 2 | 2 | 2.00 |
| Software Org. | | | Benefit from foreign systems of innovation | | 4 | 2 | 2 | 4 | 2 | 2.80 |
| Software Org. | Organizational | Strategic | Active foresight program | 2.64 | 4 | 4 | 2 | 2 | 2 | 2.80 |
| Software Org. | | | New generation products in accordance with strategy | | 3 | 3 | 3 | 3 | 1 | 2.60 |
| Software Org. | | | Foresight and business strategy link with innovation | | 3 | 3 | 4 | 4 | 3 | 3.40 |
| Software Org. | | | Correct project management structure for each innovation | | 2 | 2 | 3 | 2 | 2 | 2.20 |
| Software Org. | | | Identify new technological competencies | | 2 | 2 | 3 | 3 | 1 | 2.20 |

*Table E.6: Software Organisation, Third Audit*

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Managing Director | Bus. Dev.mnt Mangr | Operations Manager | Softw. Dev.mnt Mnger | Support Manager | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|---|
| Software Org. | | Implement | Maximum Advantage from available resources and experience | 0.00 | | | | | | 0.00 |
| Software Org. | | | Balanced repertoire, Invent Realise, Implement | | | | | | | 0.00 |
| Software Org. | | | Elapsed time for ROI measurement | | | | | | | 0.00 |
| Software Org. | | | Early involvement by all | | | | | | | 0.00 |
| Software Org. | | | Formal review procedures | | | | | | | 0.00 |
| Software Org. | | Fostering environment | Skill improvement | 3.10 | 2 | 4 | 4 | 2 | 1 | 2.60 |
| Software Org. | | | Key individuals advertised and supported by management | | 3 | 2 | 4 | 3 | 2 | 2.80 |
| Software Org. | | | Active organisational Learning | | 3 | 4 | 4 | 4 | 2 | 3.40 |
| Software Org. | | | Failure followed by vigour or hopelessness | | 3 | 3 | 3 | 3 | 2 | 2.80 |
| Software Org. | | | Management expect innovation | | 4 | 3 | 4 | 4 | 4 | 3.80 |
| Software Org. | | | Flexible & motivational incentive scheme | | 3 | 4 | 4 | 4 | 1 | 3.20 |
| Software Org. | Individual | Personality and Feelings | Lottery | 3.48 | 4 | 4 | 4 | 3 | 2 | 3.40 |
| Software Org. | | | Creative as possible | | 4 | 4 | 4 | 4 | 4 | 4.00 |
| Software Org. | | | Strategic goals motivational | | 4 | 3 | 3 | 4 | 3 | 3.40 |
| Software Org. | | | Threatened | | 2 | 1 | 1 | 1 | 1 | 2.80 |
| Software Org. | | | Are you Making a significant contribution | | 3 | 4 | 4 | 4 | 4 | 3.80 |
| Software Org. | | Knowledge experience and background | Common goal of project | 3.44 | 3 | 3 | 3 | 4 | 3 | 3.20 |
| Software Org. | | | Experience inhibiting Creativity | | 3 | 4 | 4 | 3 | 3 | 3.40 |
| Software Org. | | | Study inside and outside | | 3 | 4 | 4 | 4 | 2 | 3.40 |
| Software Org. | | | Awareness of Key people | | 4 | 3 | 4 | 4 | 3 | 3.60 |
| Software Org. | | | Home environment support | | 3 | 4 | 3 | 4 | 4 | 3.60 |
| Software Org. | | Social environment | Functional relationships in each department | 2.88 | 3 | 4 | 4 | 4 | 3 | 3.60 |
| Software Org. | | | Spirit of innovation & Dedication | | 3 | 4 | 4 | 4 | 2 | 3.40 |
| Software Org. | | | Thinking the same way | | 3 | 1 | 3 | 4 | 4 | 1.00 |
| Software Org. | | | Mavericks & weirdo's | | 2 | 2 | 4 | 4 | 2 | 2.80 |
| Software Org. | | | Stories | | 4 | 4 | 4 | 3 | 3 | 3.60 |

*Table E.7: Software Organisation, Third Audit*

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Dr Delport | Dr Taylor | Luisa Busso Assistant | Prof Ubbink | Prof Anderson | Prof Medlen | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Medical Org. | Environment | Technology | Dynamics of Technological Change | 3.13 | 4 | 3 | 3 | 3 | 3 | 3 | 3.17 |
| Medical Org. | | | Key Technologies | | 3 | 2 | 3 | 3 | 2 | 2 | 2.50 |
| Medical Org. | | | Licensing | | 2 | 4 | 4 | 3 | 3 | 4 | 3.33 |
| Medical Org. | | | Future technologies monitor/scan | | 4 | 2 | 4 | 4 | 4 | 3 | 3.50 |
| Medical Org. | | | Technology trajectories | | 3 | 4 | 4 | 3 | 3 | 2 | 3.17 |
| Medical Org. | | Market and Customer | Knowledge of Market/customer | 2.65 | 3 | 2 | 3 | 3 | 3 | 2 | 2.67 |
| Medical Org. | | | Market/customer influence | | 3 | | 3 | 2 | 4 | 3 | 3.00 |
| Medical Org. | | | Market/customer development | | 4 | 4 | | 1 | 3 | 1 | 2.60 |
| Medical Org. | | | Lead Users | | 4 | 3 | 3 | 1 | 4 | 1 | 2.67 |
| Medical Org. | | | Future Market Trends | | 3 | 2 | 4 | 1 | 3 | 1 | 2.33 |
| Medical Org. | | Industry | Supplier development | 3.07 | 4 | 3 | 4 | 2 | 3 | 3 | 3.17 |
| Medical Org. | | | Collaboration | | 4 | 3 | 4 | 3 | 2 | 2 | 3.00 |
| Medical Org. | | | Benchmarking | | 3 | 4 | 4 | 2 | 3 | 2 | 3.00 |
| Medical Org. | | | Ultimate Leadership | | 4 | | 4 | 3 | 4 | 2 | 3.40 |
| Medical Org. | | | Learn from competition | | 4 | 3 | | 4 | 2 | 1 | 2.80 |
| Medical Org. | | P.E.S. | Education and training needs | 3.09 | 2 | | 4 | 4 | 4 | 4 | 3.60 |
| Medical Org. | | | Relevant parties captured (national/international) | | 3 | 3 | 4 | 3 | 3 | 4 | 3.33 |
| Medical Org. | | | Government Links | | 3 | 2 | 4 | 4 | 3 | 2 | 3.00 |
| Medical Org. | | | Advantages from national environment | | 3 | 1 | 4 | 3 | 3 | 2 | 2.67 |
| Medical Org. | | | Benefit from foreign systems of innovation | | 3 | 4 | 3 | 2 | 3 | 2 | 2.83 |
| Medical Org. | Organizational | Strategic | Active foresight program | 2.70 | 2 | 2 | 4 | 4 | 4 | 2 | 3.00 |
| Medical Org. | | | New generation products in accordance with strategy | | 2 | 4 | 3 | 3 | 4 | 2 | 3.00 |
| Medical Org. | | | Foresight and business strategy link with innovation | | 3 | 3 | 4 | 2 | 4 | 1 | 2.83 |
| Medical Org. | | | Correct project management structure for each innovation | | 3 | 1 | 4 | 2 | 2 | 1 | 2.17 |
| Medical Org. | | | Identify new technological competencies | | 2 | 2 | 4 | 2 | 3 | 2 | 2.50 |

*Table E.8: Medical Organisation, Fourth Audit*

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Dr Delport | Dr Taylor | Luisa Busso Assistant | Prof Ubbink | Prof Anderson | Prof Medlen | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Medical Org. | | Implement | Maximum Advantage from available resources and experience | 2.47 | 3 | 4 | 3 | 2 | 3 | 2 | 2.83 |
| Medical Org. | | | Balanced repertoire, Invent Realise, Implement | | 3 | 3 | 3 | 2 | 3 | 2 | 2.67 |
| Medical Org. | | | Elapsed time for ROI measurement | | 2 | 1 | | 1 | 3 | 3 | 2.00 |
| Medical Org. | | | Early involvement by all | | 2 | 2 | 3 | 2 | 3 | 1 | 2.17 |
| Medical Org. | | | Formal review procedures | | 2 | 3 | 4 | 1 | 4 | 2 | 2.67 |
| Medical Org. | | Fostering environment | Skill improvement | 2.49 | 2 | 2 | 4 | 4 | 2.5 | 2 | 2.75 |
| Medical Org. | | | Key individuals advertised and supported by management | | 3 | 2 | 4 | 3 | 3 | 3 | 3.00 |
| Medical Org. | | | Active organisational Learning | | 2 | 3 | 4 | 4 | 3 | 1 | 2.83 |
| Medical Org. | | | Failure followed by vigour or hopelessness | | 3 | 3 | 4 | 2 | 3 | 1 | 2.67 |
| Medical Org. | | | Management expect innovation | | 2 | 2 | 3 | 3 | 4 | 2 | 2.67 |
| Medical Org. | | | Flexible & motivational incentive scheme | | 1 | 1 | 1 | 1 | 1 | 1 | 1.00 |
| Medical Org. | Individual | Personality and Feelings | Lottery | 3.23 | 4 | 3 | 3 | 4 | 4 | 4 | 3.67 |
| Medical Org. | | | Creative as possible | | 4 | 3 | 4 | 4 | 4 | 4 | 3.83 |
| Medical Org. | | | Strategic goals motivational | | 3 | 1 | 4 | 3 | 4 | 1 | 2.67 |
| Medical Org. | | | Threatened | | 2 | 1 | 1 | 1 | 1 | 1 | 2.83 |
| Medical Org. | | | Are you Making a significant contribution | | 3 | 2 | 3 | 4 | 3 | 4 | 3.17 |
| Medical Org. | | Knowledge experience and background | Common goal of project | 3.13 | 3 | 2 | 3 | 3 | 3 | 2 | 2.67 |
| Medical Org. | | | Experience inhibiting Creativity | | 3 | 2 | 4 | 4 | 3 | 3 | 3.17 |
| Medical Org. | | | Study inside and outside | | 3 | 3 | 3 | 4 | 3 | 3 | 3.17 |
| Medical Org. | | | Awareness of Key people | | 3 | 3 | 4 | 3 | 3 | 4 | 3.33 |
| Medical Org. | | | Home environment support | | 3 | 1 | 4 | 4 | 4 | 4 | 3.33 |
| Medical Org. | | Social environment | Functional relationships in each department | 2.40 | 3 | 2 | 4 | 4 | 3 | 3 | 3.17 |
| Medical Org. | | | Spirit of innovation & Dedication | | 2 | 1 | 4 | 2 | 3 | 1 | 2.17 |
| Medical Org. | | | Thinking the same way | | 3 | 2 | 2 | 2 | 3 | 1 | 1.83 |
| Medical Org. | | | Mavericks & weirdo's | | 2 | 2 | 1 | 4 | 3 | 2 | 2.33 |
| Medical Org. | | | Stories | | 3 | 2 | 3 | 4 | 1 | 2 | 2.50 |

*Table E.9: Medical Organisation, Fourth Audit*

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Prod. Mngmnt/ Sales | Eng Manager | Production eng Mngr | Q.A. Technical Oficer | Project Manager /eng | Engineer Devlopment | Production engineer | Software test engineer | Systems Engineer | R&D Mech Design | Vendng Syst/Markting | Software Engineer | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electronics Org. | Environment | Technology | Dynamics of Technological Change | 2.68 | 3 | 4 | 3 | 3 | 1 | 3 | 2 | 3 | 2 | 3 | 3 | 4 | 2.83 |
| Electronics Org. | | | Key Technologies | | 4 | 3 | 4 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 2.83 |
| Electronics Org. | | | Licensing | | 4 | 3 | 2 | 1 | 2 | 3 | 2 | 1 | 3 | 4 | 4 | 1 | 2.50 |
| Electronics Org. | | | Future technologies monitor/scan | | 3 | 3 | 4 | 3 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 2.75 |
| Electronics Org. | | | Technology trajectories | | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 2.50 |
| Electronics Org. | | Market and Customer | Knowledge of Market/customer | 2.80 | 3 | 3 | 4 | 3 | 3 | 4 | 2 | 4 | 3 | 2 | 3 | 3 | 3.08 |
| Electronics Org. | | | Market/customer influence | | 3 | 3 | 3 | 4 | 2 | 3 | 2 | 3 | 1 | 3 | 3 | 3 | 2.75 |
| Electronics Org. | | | Market/customer development | | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3.08 |
| Electronics Org. | | | Lead Users | | 4 | 3 | 2 | 3 | 4 | 2 | 1 | 1 | 3 | 3 | 1 | 2 | 2.42 |
| Electronics Org. | | | Future Market Trends | | 4 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 1 | 3 | 3 | 3 | 2.67 |
| Electronics Org. | | Industry | Supplier development | 2.57 | 2 | 3 | 3 | 4 | 3 | 3 | 3 | 1 | 3 | 4 | 2 | 3 | 2.83 |
| Electronics Org. | | | Collaboration | | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 1.58 |
| Electronics Org. | | | Benchmarking | | 3 | 2 | 2 | 2 | 2 | 4 | 1 | 4 | 1 | 3 | 2 | 3 | 2.42 |
| Electronics Org. | | | Ultimate Leadership | | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 3 | 3 | 4 | 3 | 3.33 |
| Electronics Org. | | | Learn from competition | | 4 | 2 | 2 | 2 | 2 | 4 | 2 | 1 | 3 | 3 | 4 | 3 | 2.67 |
| Electronics Org. | | P.E.S. | Education and training needs | 2.08 | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 1.42 |
| Electronics Org. | | | Relevant parties captured (national/international) | | 4 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 1 | 3 | 2 | 2.08 |
| Electronics Org. | | | Government Links | | 3 | 4 | 4 | 2 | 2 | 4 | 2 | 2 | 1 | 2 | 2 | 2 | 2.50 |
| Electronics Org. | | | Advantages from national environment | | 3 | 2 | 3 | 2 | 3 | 4 | 1 | 1 | 3 | 1 | 3 | 3 | 2.42 |
| Electronics Org. | | | Benefit from foreign systems of innovation | | 3 | 2 | 2 | 1 | 2 | 3 | 2 | 1 | 2 | 1 | 3 | 2 | 2.00 |
| Electronics Org. | Organizational | Strategic | Active foresight program | 2.53 | 3 | 2.5 | 4 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 2.21 |
| Electronics Org. | | | New generation products in accordance with strategy | | 3 | 3 | 4 | 3 | 3 | 4 | 2 | 4 | 2 | 2 | 3 | 3 | 3.00 |
| Electronics Org. | | | Foresight and business strategy link with innovation | | 4 | 4 | 4 | 4 | 2 | 4 | 2 | 4 | 1 | 3 | 4 | 3 | 3.25 |
| Electronics Org. | | | Correct project management structure for each innovation | | 1 | 1 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 4 | 3 | 2 | 2.08 |
| Electronics Org. | | | Identify new technological competencies | | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 2 | 2 | | 3 | 3 | 2.09 |

*Table E.10: Electronics Organisation, Fifth Audit*

| Organisation | Questionnaire Sections | Questionnaire Sub-Sections | Abreviated Questions from Audit Questionnaire | SUB-SECTION AVERAGES | Prod. Mngmnt/ Sales | Eng Manager | Production eng Mngr | Q.A. Technical Oficer | Project Manager /eng | Engineer Devlopment | Production engineer | Software test engineer | Systems Engineer | R&D Mech Design | Vendng Syst/Markting | Software Engineer | QUESTION AVERAGES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electronics Org. | | Implement | Maximum Advantage from available resources and experience | 2.73 | 4 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 3 | 3 | 3 | 3.08 |
| Electronics Org. | | | Balanced repertoire, Invent Realise, Implement | | 3 | 3 | 4 | 4 | 2 | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 2.83 |
| Electronics Org. | | | Elapsed time for ROI measurement | | 4 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 3 | 2 | 3 | 2.00 |
| Electronics Org. | | | Early involvement by all | | 3 | 4 | 3 | 1 | 2 | 4 | 2 | 1 | 1 | 3 | 3 | 2 | 2.42 |
| Electronics Org. | | | Formal review procedures | | 4 | 4 | 4 | 2 | 3 | 4 | 3 | 4 | 2 | 2 | 4 | 4 | 3.33 |
| Electronics Org. | | Fostering environment | Skill improvement | 2.63 | 2 | 2 | 1 | 1 | 2 | 3 | 1 | 1 | 1 | 1 | 2 | 3 | 1.67 |
| Electronics Org. | | | Key individuals advertised and supported by management | | 1 | 4 | 3 | 2 | 2 | 4 | 2 | 4 | 1 | 2 | 2 | 3 | 2.50 |
| Electronics Org. | | | Active organisational Learning | | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 1 | 2 | 3 | 3 | 3.08 |
| Electronics Org. | | | Failure followed by vigour or hopelessness | | 3 | 4 | 4 | 4 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 4 | 2.83 |
| Electronics Org. | | | Management expect innovation | | 2 | 4 | 3 | 3 | 2 | 3 | 2 | 4 | 2 | 3 | 4 | 4 | 3.00 |
| Electronics Org. | | | Flexible & motivational incentive scheme | | 1 | 2.5 | 2 | 4 | 2 | 3 | 2 | 4 | 1 | 4 | 4 | 3 | 2.71 |
| Electronics Org. | Individual | Personality and Feelings | Lottery | 2.98 | 1 | 4 | 3 | 3 | 1 | 4 | 2 | 3 | 3 | 4 | 4 | 3 | 2.92 |
| Electronics Org. | | | Creative as possible | | 4 | 4 | 4 | 3 | 2 | 3 | 2 | 4 | 2 | 2 | 3 | 4 | 3.08 |
| Electronics Org. | | | Strategic goals motivational | | 4 | 4 | 3 | 4 | 2 | 4 | 1 | 4 | 2 | 1 | 3 | 3 | 2.92 |
| Electronics Org. | | | Threatened | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 2.75 |
| Electronics Org. | | | Are you Making a significant contribution | | 3 | 4 | 4 | 3 | 3 | 4 | 2 | 4 | 2 | 4 | 3 | 3 | 3.25 |
| Electronics Org. | | Knowledge experience and background | Common goal of project | 3.02 | 3 | 4 | 3 | 2 | 3 | 4 | 2 | 4 | 2 | 4 | 4 | 3 | 3.17 |
| Electronics Org. | | | Experience inhibiting Creativity | | 2 | 2 | 4 | 4 | 2 | 3 | 3 | 4 | 1 | 3 | 2 | 3 | 2.75 |
| Electronics Org. | | | Study inside and outside | | 4 | 3 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 2 | 3 | 2 | 2.83 |
| Electronics Org. | | | Awareness of Key people | | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 1 | 2 | 4 | 4 | 3.50 |
| Electronics Org. | | | Home environment support | | 2 | 4 | 3 | 4 | 3 | 4 | 1 | 1 | 2 | 4 | 3 | 3 | 2.83 |
| Electronics Org. | | Social environment | Functional relationships in each department | 2.58 | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 3 | 3 | 2 | 4 | 3 | 3.33 |
| Electronics Org. | | | Spirit of innovation & Dedication | | 4 | 4 | 4 | 4 | 3 | 3 | 2 | 4 | 1 | 2 | 4 | 2 | 3.08 |
| Electronics Org. | | | Thinking the same way | | 2 | 2 | 3 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 1.83 |
| Electronics Org. | | | Mavericks & weirdo's | | 2 | 4 | 3 | 1 | 2 | 4 | 2 | 2 | 2 | 1 | 4 | 2 | 2.42 |
| Electronics Org. | | | Stories | | 1 | 3 | 2 | 2 | 3 | 4 | 3 | 3 | 2 | 2 | 1 | 1 | 2.25 |

*Table E.11: Electronics Organisation, Fifth Audit*

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