



Innovation models and the front-end of product innovation



Hillet van Zyl

US student number: 13333771

Thesis presented in partial fulfilment of the requirements for the degree of Masters
of Science in Industrial Engineering at the University of Stellenbosch.

Study leaders: Prof. Niek du Preez

Corne Schutte

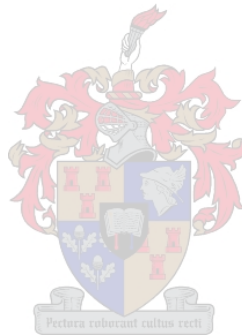
December 2006

Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety, or in part, been submitted at any university for a degree.

Signature: _____

Date: _____



Abstract

This thesis explores the innovation survival issue. As role players in an increasingly global marketplace, businesses acknowledge that regular and constant innovation is the key to remaining competitive. In other words, in order to be successful, businesses are compelled to operate and produce products that will satisfy the changing market requirements and exploit new technology opportunities. The study also investigates the difficulties and risks associated with innovation activities.

Secondly, with the goal of addressing the identified problems and risks, a study is made of formal innovation models. The different innovation models are then compared with each other and plotted on a general Innovation Landscape. The populated Innovation Landscape thus serves as a positioning guide to innovators, so that they can select the best-suited innovation model for a specific industry and project.

A case study is then undertaken to test the level of applicability and the possible support that formal innovation models can offer to a real industrial problem. The case study focuses on the front-end of innovation and the formal innovation model studied was the W-Model. The W-Model is also critically evaluated, based on the results of the case study, in order to propose improvements so that it can better support future industry innovation applications.

Opsomming

Hierdie tesis ondersoek die innovasie oorlewings kwessie. As rolspelers in 'n toenemende globale mark herken besighede dat gereelde en voortdurende innovasie die sleutel is om kompetend te bly. Met ander woorde, om 'n suksesvolle bestaan te voer word besighede gedwing om te funksioneer en produkte te lewer wat die aanhoudende veranderde mark behoeftes bevredig en nuwe tegnologie geleentheid benut. Die navorsings studie ondersoek ook die probleme en risiko's wat met innovasie aktiwiteite gepaard gaan.

Volgende, met die doel om die geïdentifiseerde probleme en risiko's aan te spreek, word formele innovasie modelle bestudeer. Die verskillende innovasie modelle word met mekaar vergelyk en geplot op 'n algemene Innovasie Landskap. Die gepopuleerde Innovasie Landskap dien as posisionerings riglyn vir innoveerders om sodoene die mees geskikte model vir 'n spesifieke industrie en projek te kies.

'n Gevallestudie is onderneem om die toepaslikheid en ondersteunende rol van formele innovasie modelle op werklike industrie probleme te bepaal. Die gevallestudie fokus op die aanvangs area van produk innovasie en die formele innovasie model wat bestudeer word is die W-Model. Die W-Model word ook, na aanleiding van die resultate van die gevallestudie, krities geëvalueer om sodoene verbeteringe aan te beveel om te voorsien dat die W-Model toekomstige industrie produk innovasie toepassings selfs beter sal ondersteun.

Acknowledgements

The author thanks everybody who contributed time, assistance and expertise towards the realization of this project. A special thanks to Collotype Paarl Labels, and specifically Mr Andrew Holt, for consenting to the case study and supplying the author with the necessary information and insight. Finally, many thanks go to Prof. Niek du Preez and Corne Schutte for their tremendous guidance.



Glossary

- **ARIS** *Architektur fur Informations Systeme* (Architecture for Information Systems)
- **BCG** The Boston Consulting Group
- **C4ISR** Command, control, communications, computers, intelligence, surveillance and reconnaissance
- **CIM** Computer-integrated manufacturing
- **CIMOSA** CIM open systems architecture
- **D&D** Design and development
- **DoDAF** Department of Defence architecture framework
- **FDI** Foreign direct investment
- **Fraunhofer IPT** Fraunhofer Institute for Production Technology
- **GDP** Gross domestic product
- **GEM** GRAI evolution methodology
- **GIM** GRAI integrated methodology
- **GMO** Genetically modified organism
- **GRAI** *Grappe resultants et activités interliées* (graphs with results and activities interrelated)

- **IPR** Intellectual property rights
- **ITC** Innovation-to-cash
- **LAP** Laboratory for Automation and Production
- **MIT** Massachusetts Institute of Technology
- **OECD** Organisation for Economic Cooperation and Development
- **PERA** Purdue enterprise reference architecture
- **QFD** Quality function deployment
- **R&D** Research and development
- **ROI** Return on investment
- **TOC** Theory of Constraints
- **UML** Unified Modelling Language
- **Wosa** Wine of South Africa



List of Illustrations

Figure 1.1 Thesis structure _____	5
Figure 2.1 Two-dimensional characteristics of products _____	8
Figure 2.2 The third dimension of innovation _____	9
Figure 2.3 The innovation funnel _____	13
Figure 2.4 Thesis structure: Chapters 2 and 3 _____	16
Figure 3.1 Thesis structure: Chapters 3 and Chapters 4 & 5 _____	22
Figure 4.1 Internal and external influences on innovation _____	25
Figure 4.2 Abernathy-Utterback product and process innovation model _____	30
Figure 4.3 Innovation levels _____	32
Figure 4.4 Disruptive innovation model _____	34
Figure 4.5 Innovation life cycle _____	36
Figure 4.6 Linear model of innovation _____	39
Figure 5.1 A continuous process improvement system for product development _____	41
Figure 5.2 Map no. 1: Map of the world drawn in 1363 by Randulf Higden _____	43
Figure 5.3 Map no. 2: Map of the world drawn in 1520 _____	43
Figure 5.4 Map no. 3: Map of the world drawn in 1544 by Batista Angese _____	44
Figure 5.5 Map no. 4: Map of the world drawn in Robinson projection _____	44
Figure 5.6 Map no. 5: The Earth as seen by the Apollo 17 astronauts in 1972 _____	45
Figure 5.7 Thesis structure: From Chapters 4 & 5 to Chapter 6 _____	46
Figure 6.1 The development of enterprise architecture frameworks _____	50
Figure 6.2 The Innovation Landscape: Enterprise architectures _____	51
Figure 6.3 The CIMOSA reference architecture _____	52
Figure 6.4 The CIMOSA life cycle phases _____	53
Figure 6.5 GIM structured approach _____	55
Figure 6.6 Enterprise master planning _____	57
Figure 6.7 The ARIS architecture _____	59
Figure 6.8 ARIS life cycle phase concept _____	59
Figure 6.9 The Zachman framework methodology _____	61
Figure 6.10 The DoD architecture framework _____	63
Figure 6.11 The Innovation Landscape: Product innovation architectures _____	64

Figure 6.12 The Schmidt-Tiedemann's Concomitance model _____	65
Figure 6.13 Twiss's Activity Stage model _____	67
Figure 6.14 The Department Stage model _____	68
Figure 6.15 The W-Model _____	69
Figure 6.16 French's model _____	71
Figure 6.17 Archer's product innovation model _____	73
Figure 6.18 March's model of the design process _____	74
Figure 6.19 Suireg's model _____	76
Figure 6.20 Ullman's design process _____	78
Figure 6.21 Utterback's three-stage model for innovation _____	80
Figure 6.22 The Chiesa key elements of innovation _____	82
Figure 6.23 The Improved Chiesa framework _____	83
Figure 6.24 The Systems Engineering model _____	85
Figure 6.25 The full Innovation Landscape _____	87
Figure 6.26 Thesis structure: From Chapter 6 to Chapters 7 & 8 _____	88
Figure 7.1 Evolution of the industry innovation capability from 1980 – 2005 _____	92
Figure 8.1 Wine Find™ advertorial _____	97
Figure 8.2 The focus area of the case study within the bigger Innovation Landscape ____	101
Figure 8.3 Matching Collotype's seven steps to the phases of the W-Model _____	102
Figure 8.4 Comparison of the degree of the relation between the informal and formal innovation processes _____	103
Figure 8.5 The closed loop image of the strategically related phases of the W-Model __	106
Figure 8.6 The linear representation of the operational related phases of the W-Model _	106
Figure 8.7 Thesis structure: From Chapter 8 to Chapter 9 _____	107
Figure 9.1 The proposed Operational Related Innovation Roadmap _____	109
Figure 9.2 Thesis structure: From Chapter 9 to Chapter 10 _____	112

List of Tables

Table 1.1 Innovation management practices _____	4
Table 2.1 Seven sources of innovation _____	10
Table 2.2 Success and failure as a function of the quality of the working relationship between marketing and R&D _____	15
Table 4.1 Sectoral systems of innovation: manufacturing vs. services “system traits” ____	27
Table 4.2 Different dimensions of innovation _____	29
Table 6.1 Mapping between life cycle phases and activities _____	49
Table 6.2 The life cycle coverage of the CIMOSA model _____	54
Table 6.3 The life cycle coverage of the GRAI-GIM model _____	56
Table 6.4 The life cycle coverage of the PERA model _____	58
Table 6.5 The life cycle coverage of the ARIS model _____	60
Table 6.6 The life cycle coverage of the Zachman framework _____	61
Table 6.7 The life cycle coverage of the DoDAF innovation model _____	63
Table 6.8 The life cycle coverage of the Schmidt-Tiedemann’s Concomitance model ____	66
Table 6.9 The life cycle coverage of Twiss’s Activity Stage model _____	67
Table 6.10 The life cycle coverage of Saren’s model _____	68
Table 6.11 The life cycle coverage of the W-Model _____	70
Table 6.12 The life cycle coverage of French’s model _____	72
Table 6.13 The life cycle coverage of Archer’s model _____	73
Table 6.14 The life cycle coverage of March’s model _____	75
Table 6.15 The life cycle coverage of Suireg’s innovation model _____	77
Table 6.16 The life cycle coverage of Ullman’s model _____	79
Table 6.17 The life cycle coverage of Utterback’s model _____	81
Table 6.18 The life cycle coverage of the Improved Chiesa framework _____	83
Table 6.19 The life cycle coverage of the Systems Engineering innovation approach ____	86
Table 9.1 The relationship between the Operationally Related Innovation Roadmap and the W-Model information composition _____	110

Table of Contents

Declaration	ii
Abstract	iii
Opsomming	iv
Acknowledgements	v
Glossary	vi
List of Illustrations	viii
List of Tables	x
Table of Contents	xi
Chapter 1	1
Background Information	1
1.1 Introduction	1
1.2 Innovation and the market situation today	1
Chapter 2	7
Understanding the Role of Innovation and the Need for Recurrent Innovation	7
2.1 Introduction	7
2.2 Where does innovation come from?	7
Innovation drivers	10
2.3 Why is innovation needed?	11
2.4 What are the pitfalls?	12
2.5 The risks of innovation	13
2.6 Can innovation be made easier?	14
2.7 Will a structured framework help?	15
Chapter 3	17
Research Problem Definition	17
3.1 Introduction	17
3.2 Survival scenario	17
3.3 Research focus	19
Chapter 4	23
Defining Innovation and Understanding the Different Types and Scopes of Innovation	23
4.1 Introduction	23
4.2 Defining innovation	24
4.3 Types of innovation applications	26
Product innovation	26

Service innovation _____	27
Process innovation _____	28
Product vs. process innovation _____	28
The dynamics of product and process innovation _____	30
4.4 Levels of innovation _____	31
Radical innovation vs. incremental innovation _____	32
4.5 The impact of innovation _____	35
The importance of innovation cycle time _____	35
4.6 The innovation challenge _____	37
An innovation model for the real world _____	38
Chapter 5 _____	40
Innovation As a Process _____	40
5.1 Introduction _____	40
5.2 The innovation process _____	40
5.3 Mapping the innovation process _____	42
Chapter 6 _____	47
The Innovation Landscape _____	47
6.1 Introduction _____	47
6.2 The landscape _____	47
The Innovation Landscape _____	47
Life cycles and architectures _____	48
6.3 Enterprise architectures _____	50
6.3.1 CIMOSA _____	52
6.3.2 GRAI-GIM _____	54
6.3.3 PERA _____	56
6.3.4 ARIS _____	58
6.3.5 The Zachman framework _____	60
6.3.6 The DoD architecture framework _____	62
6.4 Product innovation architectures _____	64
6.4.1 Schmidt-Tiedemann's Concomitance model _____	65
6.4.2 Twiss's Activity Stage model _____	66
6.4.3 Saren's Department Stage model _____	68
6.4.4 The W-Model _____	69
6.4.5 French's model _____	71
6.4.6 Archer's model _____	72
6.4.7 March's model _____	74
6.4.8 Suireg's model of the design process _____	75
6.4.9 Ullman's model of the development process _____	77
6.5 General models of innovation _____	79
6.5.1 Utterback's three-stage model _____	79
6.5.2 The Improved Chiesa framework _____	81
6.5.3 The Systems Engineering approach to the design process _____	84
6.6 The whole Innovation Landscape _____	86
Chapter 7 _____	89
Innovation in Practice: The Wine Industry _____	89
7.1 Introduction _____	89
7.2 The wine industry market situation _____	89

The future of the South African wine industry	90
Innovation in the wine industry	91
7.3 Collotype Labels and innovation in the wine industry	94
Chapter 8	96
A Product Innovation Case Study	96
8.1 Introduction	96
8.2 The product: Collotype Labels' Wine Find™	96
8.3 The process: An informal approach	98
8.4 Mapping the informal approach against the W-Model	100
Why the W-Model?	100
Mapping the innovation approaches	101
8.5 Gap analysis: theory vs. practice	105
Chapter 9	108
The Proposed Solution and Conclusions	108
9.1 The proposed solution	108
9.2 Conclusions	111
Chapter 10	113
Thesis Summary	113
Reference List	xiv
Bibliography	xviii
Appendix A:	xxiv
A detailed W-Model representation	xxiv



Chapter 1

Background Information

1.1 Introduction

“Business has only two basic functions – marketing and innovation.”

- Peter Drucker, 1959

This statement was made many years ago, but it appears that companies are only now starting to realize the full impact of innovation on the sustained success of an organisation. Or maybe companies are only now being forced to concentrate on innovation in order to survive in the current very competitive global market. Irrespective of the main trigger for the global innovation awareness, the reality is that, more than ever before, recurrent innovation has become a necessity for any business that wants to survive and grow.

What is the actual situation in the marketplace? Does everyone realize the importance of innovation and, if so, what are they doing about it? It is necessary to answer these questions in order to gain insight into the present “innovation-needs” that companies are experiencing.

1.2 Innovation and the market situation today

In the fast-changing business environment of global competitiveness, extremely fast technology developments, and demanding customer requirements, companies are forced to be innovative in order to survive. But is this easier said than done?

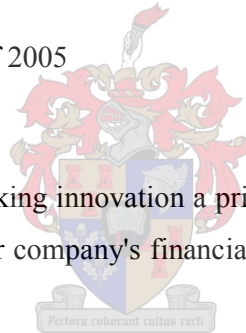
In a recent study by PricewaterhouseCoopers, CEOs from two-thirds of America's fastest-growing private companies report that innovation is an organisation-wide priority, and almost all say it has had a significant, positive impact on their business (SmartPros Editorial Staff 2005).

Also, in this study sixty-eight percent of fast-growth CEOs state their company has made innovation an organisation-wide priority. Among these businesses, the extent of innovation is extensive, including:

Corporate strategy	85%
New product/service development	78%
Corporate value	73%
Employee training	64%
Human resources (hiring, performance reviews, compensation)	54%
Public relations, advertising, communications	43%
Recognition or award programmes	41%
E-commerce/ Web site	34%

Source: SmartPros Editorial Staff 2005

Eighty-four percent of CEOs making innovation a priority, report that it has changed the way they do business or affected their company's financial performance in a number of important areas, as listed below:



Revenues	88%
Earnings/profit margins	79%
Efficiency of own organisation	78%
Number of customers	76%
Customer service	69%
Delivery of products/services	65%
Change in business processes	64%
Change in employee skill sets required	64%
Prioritising investments	44%
Change in suppliers/supply chain	22%
Market capitalization	12%

Source: SmartPros Editorial Staff 2005

"Emphasis on innovation has brought positive benefits to an impressive array of financial, marketing, and operational areas," noted Jay Mattie, PricewaterhouseCoopers' U.S. Private Company Services Assurance Services Leader (SmartPros Editorial Staff 2005). It was concluded from the results of this study by PricewaterhouseCoopers' researchers that, while most companies realize the importance of being innovative, they still struggle to be successful at it.

Another leading name in the financial service industry also conducted a research study on innovation, focusing not only on the necessity, but also the difficulty, of innovation. A short summary of this study of the "Innovation Paradox" is as follows (Mastering the Innovation Paradox 2004):

- It is based on research from 650 leading manufacturers worldwide.
- Manufacturers cite launching new products and services as the No. 1 driver of growth.
- They expect new product revenue to increase to 35% of sales by 2006, from 21% in 1998.
- By 2010, products representing more than 70 percent of current sales will be obsolete due to changing customer demands and competitor offerings.
- Despite their knowledge of these facts, these manufacturers view supporting product innovation as one of the least important priorities in their companies.
- Most manufacturers have not developed reliable systems for bringing new products and services to market.
- 50% to 70% of all new product introductions fail.
- Failures to successfully launch new products are due to:
 - Insufficient information on customer needs;
 - Insufficient supplier capabilities;
 - A reluctance to allocate additional spending on R&D; and
 - Uncoordinated approaches to innovation across product-, customer- and supply chain operations.

The conclusions of the two foregoing studies thus indicate that innovation plays a key role in the current and future accomplishments of a company. If this is the case, why are so few successful at creating new winning products, processes and services?

Further results of the innovation studies by Deloitte and PricewaterhouseCoopers explain, to some extent, the lack of successful innovations: companies do not support innovation activities sufficiently; and being innovative is clearly challenging and risky.

Although innovation is also not a new term, the need for innovation has become more critical and the essence of innovation also has, and still is, changing to become more diverse, complex, and integrated.. Additional perspectives on the changing nature of innovation are presented in Table 1.1.

Table 1.1 Innovation management practices

FROM → → → → → → → TO	
Invention	Innovation
Linear innovation models	Dynamic innovation models
Standard products	Customized products integrated with service
Build to forecast demand	“Sense and respond” to demand
Sequential technology transfer	Simultaneous co-creating
Engineering and incrementalism	Creativity and disruptive innovation
Managing production workers	Creating/motivating knowledge workers
Closed innovation – do it yourself	Open innovation – multiple innovation sources
Independent	Interdependent
Hierarchical organisations	Distributed, networked, adaptive and virtualised organisations
Optimising vertical processes	Optimising horizontal processes / outsourcing
Input driven performance metrics	Outcome driven performance metrics
Quantitative innovation metrics	Qualitative innovation metrics
Single discipline	Multiple discipline
Basic research orientation	Application orientation
Centralized and product centric	Closer to customer
Product functions	Value to customer
Local R&D teams	Globalized 24x7 and linked into regionally specialized clusters
Market valuation based on historical performance and tangible assets	Market valuation based on knowledge assets and expected future performance

Source: (Measuring innovation for national prosperity 2004)

The following chapters will, therefore, look at innovation, firstly by identifying what innovation involves and what the different types of innovations are. Then the identified “innovation problem” will be investigated, as well as ways and means to address the identified problem and thereby better support innovation. The structure of this thesis is illustrated in Figure 1.1 below.

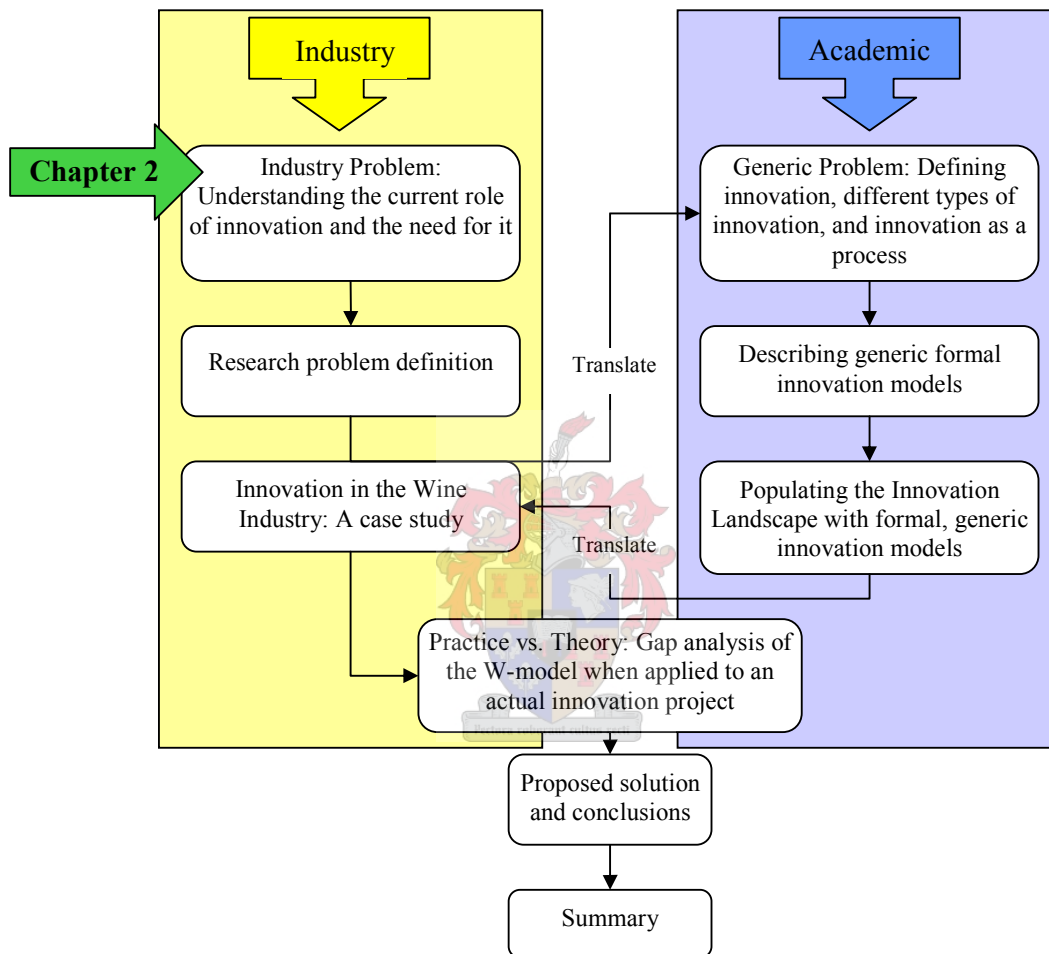


Figure 1.1 Thesis structure

As depicted by Figure 1.1 the first focus area will be the investigation of the current market and the impact of innovation, set out in Chapter 2. Following the outcome of the discussion of the real-life situation in Chapter 2, the research problem is then identified in Chapter 3. With the aim to solve the documented problem, aspects of the real life situation are then researched, explored and defined in Chapter 4 and Chapter 5.

Having identified the research problem and established a common understanding of the subject matter, the study continues in Chapter 6, exploring various possible solutions, namely generic innovation methodologies. At the end of Chapter 6, the identified methodologies are then compared and placed within a general Innovation Landscape.

When placing these innovation models in the context of the focus area of this study, the researcher used applicable available information and added value to it in order to solve the problem at hand. Next, in Chapter 7 and the first part of Chapter 8 the best suitable academic solution is tested and applied to a real-life problem that resembles the identified theoretical research problem. The problem, the applied solution and the procedures followed are then discussed in detail.

In order to evaluate the applicability and success of the academic solution, a gap analysis is performed (Chapter 8.5). The results of this analysis not only indicate the extent to which the research problem is addressed, but also identify the shortcomings of the academic solution when applied to an actual problem. In Chapter 8.6 the outcomes of the gap analysis are considered in order to find the optimal solution to the research problem, thus combining the academic research results with actual industry requirements. Finally, the conclusions of the case study are documented in Chapter 9.



As indicated by the last step in Figure 1.1, the essence of this thesis, from identifying the research problem to finding and evaluating a solution, is summarized in Chapter 10.

Chapter 2

Understanding the Role of Innovation and the Need for Recurrent Innovation

2.1 Introduction

In every business environment, changes occur, and company leaders know they can't win a new game using an old script.

A dramatic change in the approach to innovation is now required if a company wishes to sustain its competitive advantage. Sustaining a competitive advantage requires moving beyond efficiency and quality towards creating new markets, increasing value to customers and innovating continuously on a global basis.

2.2 Where does innovation come from?

In this changing world, product life cycles are shortening dramatically as companies try to beat competitors at every possible angle. Innovation is not a new concept, but rather the issue at hand is that the nature of the current highly competitive and global marketplace has driven the need for innovation to where it is now a vital part of any business. Innovation has come to equate survival and companies need to continuously initiate novel new ways of beating the competition.

Therefore, the key is to understand the core of innovation, the drivers and the pitfalls, in order to manage innovation within a business as any other main business function rather than an occasional occurrence. Twenty-five years ago, Rothberg (1981) stated that a product has two key dimensions: namely, technology and markets (see Figure 2.1). Technology involves knowledge, which enables the product to be produced economically. Markets include to whom and how the product will be sold, thus enabling profitable distribution. Therefore, in order to be successful at innovating, it is crucial to accurately match market characteristics with available technology.

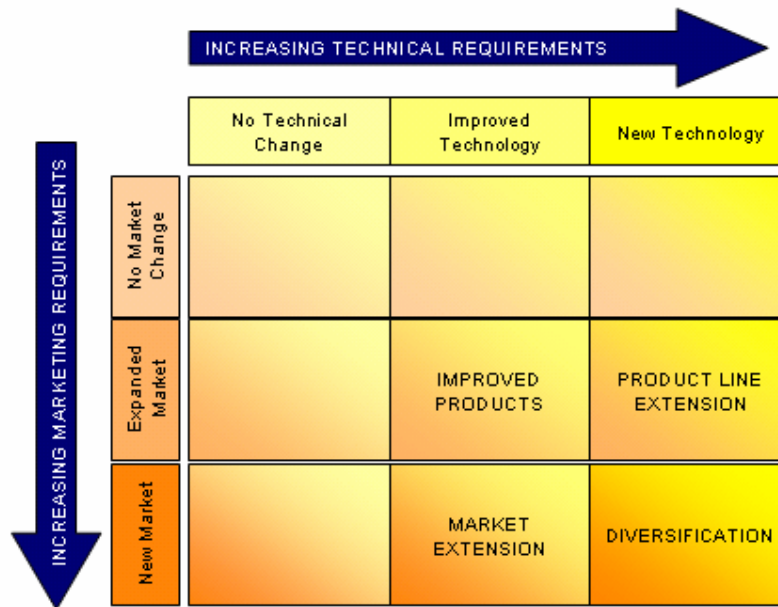


Figure 2.1 Two-dimensional characteristics of products

Source: Rothberg 1981, p.178

The target customer of a future product will determine the market requirements and the technical requirements, thus positioning a product in one of the four areas in Figure 2.1. With the commencement of an innovation project, it is essential to carefully investigate and plan both innovation dimensions. According to Rothberg (1981), the questions that arise in the early stages of any innovation drive should focus on the implicated market, technology, and the combinations of market and technology. The three key questions to ask are:

1. Which customers and what specific needs will the prospective innovation address?
2. What are the benefits associated with the alternative technology sets applicable to an innovation project?
3. How do the technology alternatives satisfy the customer needs and what benefits are contained with each market and technology combination?

Booz et al. (Rothberg 1981, p.178) also identify a third dimension, namely, evolution. This evolution dimension (see Figure 2.2) may also be regarded as the scope (or stages) of an innovation with a specific market requirement and technological requirement.

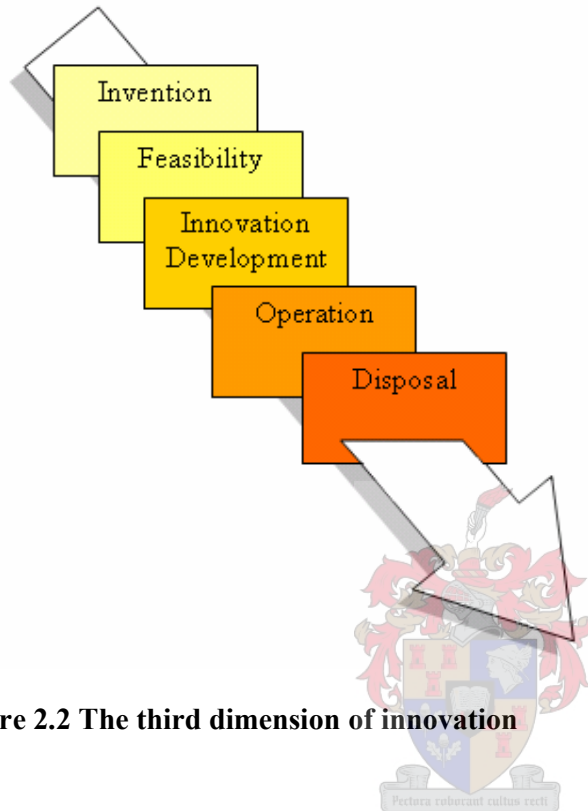


Figure 2.2 The third dimension of innovation

Although innovations are broadly either born out of a market-pull or a technology-push situation, Drucker (Drucker 1985) divides the origin of an innovation into seven further specific causes:

Table 2.1 Seven sources of innovation

Sources	Description
The Unexpected	Unexpected successes (e.g. products selling in an unanticipated way) Unexpected failures (e.g. products or services that “should” succeed but fail miserably) Unexpected outside events (such as the explosion in book-buying in the US)
Incongruities	A discrepancy between what “is” and what “ought” to be: <ul style="list-style-type: none"> • Incongruities with the economic realities of the industry • Incongruities between the reality of the industry and the assumptions about it • Incongruities between the efforts of an industry and the values and expectations of its customers • Incongruities within a process
Process Needs	A clearly understood need for which a process solution does not yet exist
Changes in the Industry or Market Structure	Shifts in the relationships and dynamics between players in an industry or market (often brought on by rapid growth, technology convergence, or rapid changes in practice)
Demographics	Changes in population (size, age, employment, educational status, income, and ethnicity)
Changes in Perception, Mood and Meaning	Changes in how people think about problems or issues (for example, the obsession with health and fitness)
New Knowledge	Advances in scientific and technical knowledge and know-how

Source: (Drucker 1985)

All of the seven areas described in Table 2.1 are sources that, depending on the specific case, create opportunities for both market-pull and technology-push innovation activities.

Now that the sources of potential innovation exploitation have been discussed, attention will be given to the factors that drive the creation of these innovation opportunities.

Innovation drivers

The “innovation necessity” is driven by a number of broad changes in the business environment. Shifting trends are accelerating change, thus causing a state of continuous

unsteadiness in the market. According to Cleveland (2005), the following trends create the need for the utilization of innovation skills:

- *Knowledge economy*. Higher levels of education and rapid advances in knowledge creation and transfer, globally and at all levels of society and the economy, result in an increased “knowledge content”, that accounts for a larger percentage of the gross domestic product (GDP).
- *Connectivity*. Higher levels of connectivity in the economy, largely due to information technology advances, create:
 - More rapid diffusion of knowledge and ideas
 - More discriminating customers, who change their requirements more rapidly.
- *Flexibility*. New business designs and communications systems create an ability to rapidly form novel combinations of all the elements of the value chain – people; capital; hard assets; and knowledge.
- *Globalisation*. The spreading of market economies creates both new opportunities to sell innovation and more competition, requiring higher levels of innovation to succeed.

Thus, successful innovation stems from the accurate combination of consumer requirements with technological capabilities. Innovation is a worldwide priority brought along by changes in the market and economy and the fast speed of technological advances. Many of these changing factors encourage an environment suitable for ideas to be realized as innovations.

2.3 Why is innovation needed?

As shown in the results of the respective innovation research studies by Deloitte and PricewaterhouseCoopers (Chapter 1.2), customer demands are changing and competitor offerings are improving at such a rapid pace that more 70% of current sales will be outdated in five years time. Therefore, the key to a company’s survival and growth rests in a continuous flow of new and improved products.

Many competitors have the same leading technology and high-class processes, which force them to compete on the grounds of the best product rather than the lowest price. Although price-cutting will always be an objective of any company, nowadays it is no longer a

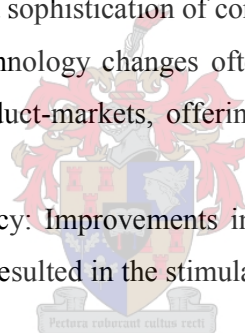
guaranteed differentiator. If a company does not produce the right product at the right time, the price of the product does not really matter at all.

2.4 What are the pitfalls?

The discovery of ideas for new products, the improvement of existing products, and the converting of these ideas into products that are feasible and commercially acceptable is a complex process. In today's market situation, any organisation, whether it is a bank, retail store, or manufacturing firm, is confronted with the same challenges.

These challenges are environmental forces that affect product innovation. The main forces are identified by Rothberg (1981, p.4-7) as:

- Consumer and competitor behaviour: The increasing instability of consumer preferences and the growing intensity and sophistication of competition.
- Changes in technology: Technology changes often lead radical changes in the size and character of established product-markets, offering a broad range of product benefits to customers.
- Changes in government policy: Improvements in safety standards and infrastructure by government regulation have resulted in the stimulation of new products and processes.



The environmental factors mentioned above force businesses to press forward with new and improved products, services and processes or risk the loss of markets to present competition or being overtaken by potential competitors. When engaging in innovation activities, companies are sometimes compelled to take important decisions under uncertain conditions and therefore again risk failure, due to technical or commercial reasons.

There is powerful evidence that once a company's core business has matured, the pursuit of new platforms for growth entails daunting risk. Roughly one company in ten is able to sustain the kind of growth that translates into an above-average increase in shareholder returns for more than a few years (Christensen 1997).

According to a study that combined data from previous studies on innovation success rates, it takes about 3000 raw ideas to produce one truly new and commercially successful product.

The innovation process may be represented by a funnel, with many ideas going in on the one side and very few making it out on the other side as successful products (Stevens & Burley 1997).

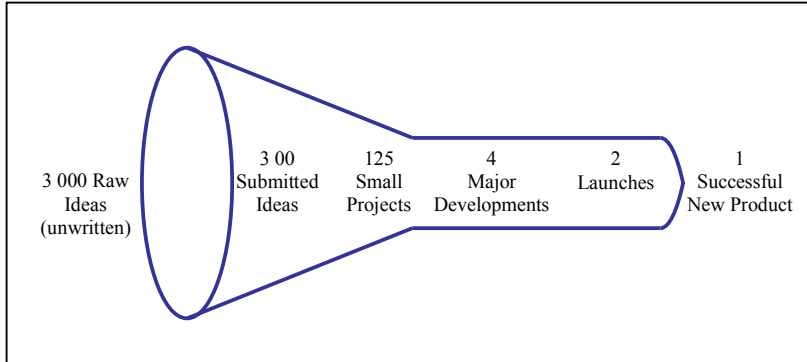
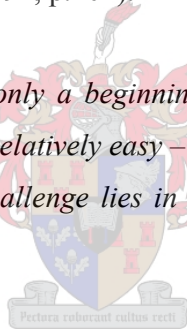


Figure 2.3 The innovation funnel

According to Henry and Walker (1991, p.102):

Creativity on its own is only a beginning. Human beings are relentlessly creative. Having ideas is relatively easy – having good ideas is slightly more difficult – but the real challenge lies in carrying ideas through into some practical result.



The problem is, therefore, not the lack of ideas, but rather mastering the complex pursuit of choosing the correct ideas and successfully growing these ideas into products, i.e. innovations.

2.5 The risks of innovation

One of the most significant challenges facing corporate executives is adaptability, which entails changing their organisations to fit tomorrow's dynamic market environment. Schon (Rothberg 1981, p.36) states that innovation is destructive to a company's stable state and that risk is involved, but that it is possible to keep the risks of innovation within boundaries - by processes of justification, decision, and optimisation. Innovation also involves many uncertainties, as a company is confronted with a situation in which the need for action is clear, but where it is by no means clear what to do. But a company cannot respond to innovation in

an exclusively negative way, because it is also accepted that change is essential to corporate growth. This innovation paradox thus makes companies very vulnerable when they are faced with the essential task of innovation.

With the constant pressure to innovate in a hurry, companies may find themselves beyond their depths, losing control and rushing into the development of new products without clear plans. While trying to beat competitors and put innovations on the market as soon as possible, these companies often leave out the crucial phases of developing strategies and processes for new product development. Such companies will often find themselves choosing projects that are not aligned with the company's capabilities or available resources and will, consequently, suffer lengthy development periods and high failure rates. Schilling (2005, p.4) agrees:

While innovation is popularly depicted as a freewheeling process that is unconstrained by rules and plans, study after study has revealed that successful innovators have clearly defined innovation strategies and management processes.

2.6 Can innovation be made easier?

According to Jay Mattie (SmartPros Editorial Staff 2005), PricewaterhouseCoopers' U.S. Private Company Services Assurance Services Leader, "The deep footprint of innovation in corporate strategy suggests that further impact can be expected elsewhere in the company".

Johnson and Jones (Rothberg 1981, p.188) also stress the fact that the development of new products must be the responsibility of top management. Of course top management cannot carry out the whole innovation project themselves, and their key responsibility therefore lies in the strategic decision-making and the organising of the innovation process.

A structure allows the organising of old and new data to facilitate a quicker and surer outcome (more confidence in methods as this grows out of lessons learned previously). Therefore, uncertainty accompanying innovation may be reduced using a structured model, as this not only guides innovators, but also facilitates their learning from their experience and capturing knowledge.

Innovation activities usually involve various people from various backgrounds and with different expertise. A structured approach makes it easier to align several people with the same goal and creates mutual understanding and common language. Additionally, performing innovation tasks within a structure assists participants in keeping track of project progress, assigning tasks and also integrating different efforts.

2.7 Will a structured framework help?

According to Rothberg (1981, p.8): "...there is a great deal of wasted time and effort in new product development. What are required are good strategic planning, proper management controls, and healthy organisational attitudes." Therefore, improving a company's innovation success rate requires a well-crafted strategy; aligning projects with a company's resources, objectives, and core competencies.

Enterprises are undergoing a transformation from a mass-production era, where the principal source of value was physical labour, to a new era of innovation-mediated production, where the principal component of value creation, productivity and economic growth is knowledge and intellectual capabilities. Survival in this new era requires enterprises to harness the knowledge and intelligence of all members of the organisation.

Because innovation implies matching customer needs with technology, it is worth looking at one key study on the impacts of functional disconnects between marketing and technology.

Souder (Campbell 2004) found a most remarkable dependence of success on organisational "harmony" between marketing and R&D. He classified 289 "new product development innovation projects" from 53 firms in terms of whether they reflected harmony, mild disharmony, and severe disharmony between these two functions. Table 2.2 shows success rates in terms of these categories.

Table 2.2 Success and failure as a function of the quality of the working relationship between marketing and R&D

Result	Success	Partial Success	Failure
Harmony (41%)	52%	35%	13%
Mild Disharmony (21%)	32%	45%	23%
Severe Disharmony (39%)	11%	21%	68%

Source: Campbell 2004, p.4

The impact is striking. The success rate in the case of harmonious working relationships is more than four times greater than the success rate of severe disharmonious working relationships. One might well ask what the impact of strong working relationships between all functional groups involved in product development would be. This data strongly suggests that a concerted approach to innovation has a much better chance of succeeding than functional groups that operate in isolation.

As depicted in Figure 2.4, the industry problem has been investigated and documented in Chapter 2. The next area of this research study (Chapter 3) will therefore focus on the formulation of the research problem according to the market situation studied.

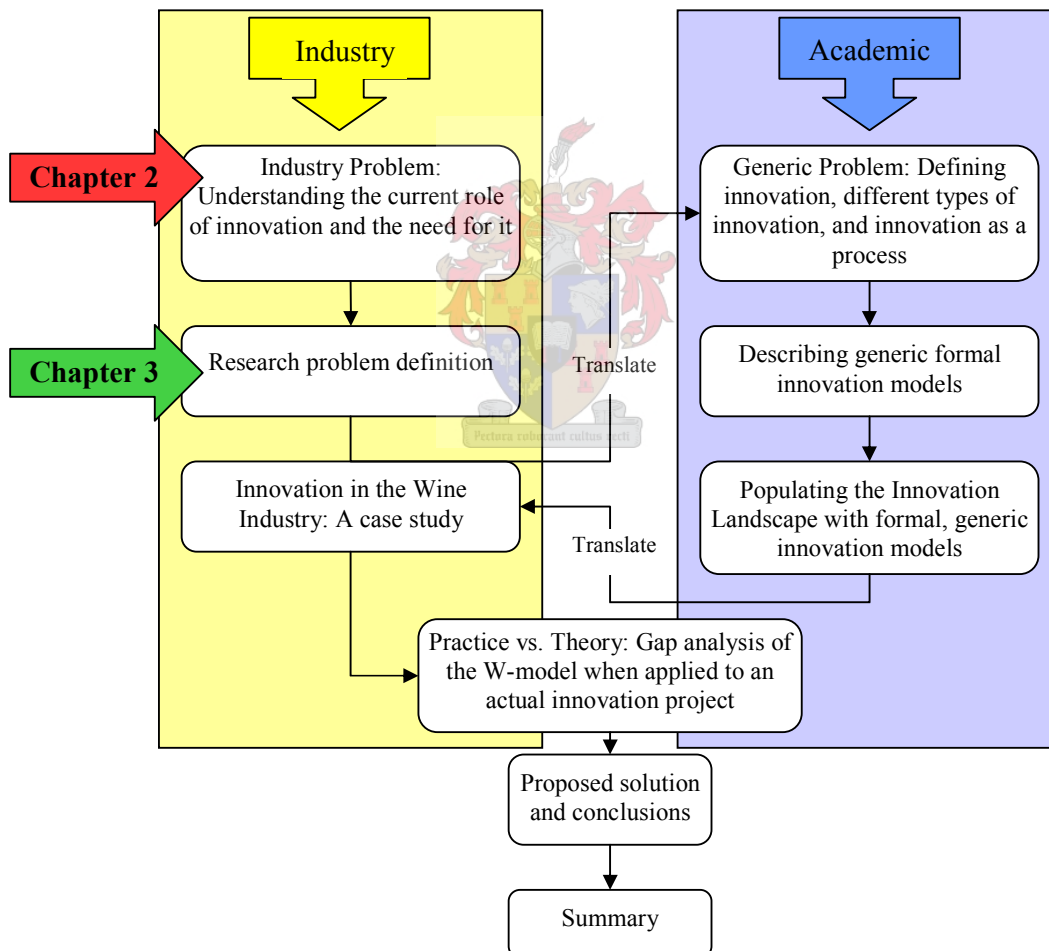


Figure 2.4 Thesis structure: Chapters 2 and 3

Chapter 3

Research Problem Definition

3.1 Introduction

In the previous two chapters innovation was identified as the present key to the success and survival of companies. Today, the market place is evolving and setting new demands at a rapid speed and does not tolerate clumsy companies that are struggling to move with the changing environment.

It is evident from the literature study and surveys that, although the importance of innovation is fully realised by most companies, the execution of the innovation process from an idea to a successful product at the market is complicated and difficult. Companies are investing a lot of money on innovation activities (and are willing to even invest more), but they do not feel that the results justify the investments.

This chapter looks at this innovation challenge closely and identifies the key research area and questions that will be investigated in the following chapters of this research study.

3.2 Survival scenario

Currently, the global marketplace is a cut-throat industry that gets more competitive daily as businesses strive to survive by staying abreast of changing customer needs and international trends. With every successful innovative product a company moves closer to this survival goal - as creating these products means beating your competition in satisfying some customer need or opening a new market.

Recently, The Boston Consulting Group (BCG) conducted its second annual global survey of senior executives on innovation and the innovation-to-cash (ITC) process. The ITC process covers the many interrelated activities involved in turning ideas into economic returns. A total

of 940 executives from all major industries and representing 68 countries participated in this Senior Management Survey (BCG Senior Management Survey 2005).

It is clear from the survey's results that the market today is characterized by extremely brief product life cycles, low barriers to entry, frequent disruptive innovations, and truly global competition. This all leads to creating an environment in which the ability to create and commercialise new products and services is essential, not only for success, but also for survival.

Successfully managing the innovation process appears to be far from easy. One of the most troubling findings of the Boston Consulting Group's survey is that a large number of companies continue to spend more and more on innovation, but this is generating neither satisfactory profit nor competitive advantage. Despite all the time and money companies spend on improving innovation, many executives across all industries say their organisations are still:

- Not as fast as they need to be;
 - Not successful as often as they need to be;
 - Too fragmented across too many different projects; and
 - Not well-aligned across the whole organisation (functions, geographies, etc.)
- (BCG Senior Management Survey 2005)

The executives who participated in the survey list the following distinct characteristics that they most admire about top innovators:

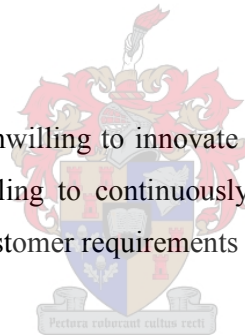
- Firstly is the characteristic "market insight", i.e. the ability to understand, and even shape, the desires of ones customers.
- A second characteristic that was mentioned by many executives is an ability to "institutionalise" innovation; that is, to create and maintain a corporate culture of innovation, a culture that leverages the best thinking from all employees.
- The last characteristic attributed to the most innovative companies is their ability to take an existing product or technology and improve on it or tailor it to satisfy a new customer need. Successful innovation doesn't necessarily mean breakthroughs - it can also mean creating something new from something old. The Apple iPod is a good

example: Compaq had already developed a personal music player featuring a small hard-disk drive, the PJB-100, in 1999, but customers did not seem very interested in such a product. When Apple launched a similar product in 2001, namely the iPod, it was an immediate hit in the market and it outperformed all competition (BCG Senior Management Survey 2005).

In the end, it is clear that the biggest challenge in innovation remains execution, not invention. Successful innovation is profitable innovation.

For most of the executives, the key issue is aligning the entire organisation, so that everyone agrees on the aspects concerning objectives, tactics, and commitment. Like any other business activity, the entire innovation process must be aligned with the strategic plan of the organisation so that it can also be systematically managed. Failing to do so essentially leaves the return on innovation to chance and, in most cases, that is leaving the future of the company to chance.

The conclusion is clear: those unwilling to innovate are following a losing strategy and will be overtaken by companies willing to continuously work at the improvement of existing offerings, satisfying changing customer requirements and creating new markets.



3.3 Research focus

Firstly, the meaning and reach of innovation, as implied in this project, will be defined. Also, the different types and applications of innovation will be investigated in order to gain a full understanding of what innovation entails and how it is applied. Innovation issues, such as the scope and types of innovation, the innovation life cycle, and drivers of innovation, will be discussed in detail. Innovation is currently a very popular topic and, due to so many different authors' viewpoints, an abundance of definitions have been coined. It is important, therefore, to first establish the boundaries of this study, before continuing with the problem investigation and solution.

Secondly, it is evident from the introductory chapters and the documented high failure rates of innovation products that companies struggle to manage innovation. The second research

question therefore concentrates on the characteristics of the innovation process and how it can function within an enterprise along with many other processes.

Thirdly, it is important to put the research of this project in context within the bigger Innovation Landscape. As stated earlier, the problem of innovation creation does not lie with the creation of ideas, but rather with growing ideas into winning innovation products. This study will thus focus on the area of idea-selection and concept-creation. In other words, it will include the process from the idea- or invention phase up to the start of the final product development phase.

Fourthly, the research focus will be on models, methodologies and frameworks that support innovation. The Innovation Landscape already contains various models that support different part of the innovation process, and from different viewpoints. The challenge does, therefore, not lie in the creation of another innovation model, but rather in the recording of the existing models in context. Understanding the existing models and where each one fits in the bigger picture will allow for easier alignment of ones own companies' innovation efforts.

When the populated Innovation Landscape is fully described, the next logical step will be to concentrate on one model that supports the innovation life cycle from the invention to the production phase, as this area is the focus for further investigation in this project. The focus area, therefore, entails the process of choosing the right idea and developing it up to the point of going into production. The lack of processes and systems to support repeated innovation represents a very important hurdle to overcome, since the front-end of innovation has often been viewed as a task for research and development, not an organisational initiative.

Even though one rarely complains about the lack of ideas, only very few successful ideas are launched into the market. Therefore, based on uncertain or missing information, wrong decisions are made in the very early stages, leading to high capital investment in the later stages in personnel and material for flawed ideas. It is essential for companies to recognize that merely generating ideas is not enough, and that there needs to be an organised business process that will move ideas through a filtering and evaluation framework in order to determine which ideas should be converted to new products and/or services.

The main problem identified in this study then focuses on this part of the innovation process, as most companies struggle to choose the right ideas that will deliver ‘star’ products. Many companies have procedures and responsible people in place for the product development process, but still do not manage to innovate. Innovation within each company is not only influenced by the market and technology but also by the enterprise itself.

Choosing innovation projects it is a complex process that involves the consideration of many aspects, such as, the enterprise’s strategy, core capabilities, the market demand, available technology, existing products, etc. Therefore, to support innovation and facilitate more successful innovation, it is essential to investigate the process of idea selection and growing the ideas into product concepts, in order to establish a model that will guarantee faster and more successful innovation.

In order to assess whether this particular innovation model satisfies the identified need for supporting and facilitating quicker and more successful innovation, a case study will be evaluated. This case study will aim, firstly, to measure the relevance of this theoretical model in practice; secondly, to identify shortcomings in the model with the purpose of improving the model; and, thirdly, to verify the impact of the model on a typical innovation project.

Once the industry situation has been studied and the industry problem is formulated, the next step (as indicated in Figure 3.1) is to map the identified problem onto the academic research area. The purpose, then, in Chapter 4, of mapping the industry problem against similar academic topics is to glean insights from previous studies that are relevant to the information captured about the current problem, with the goal of ultimately finding a suitable solution.

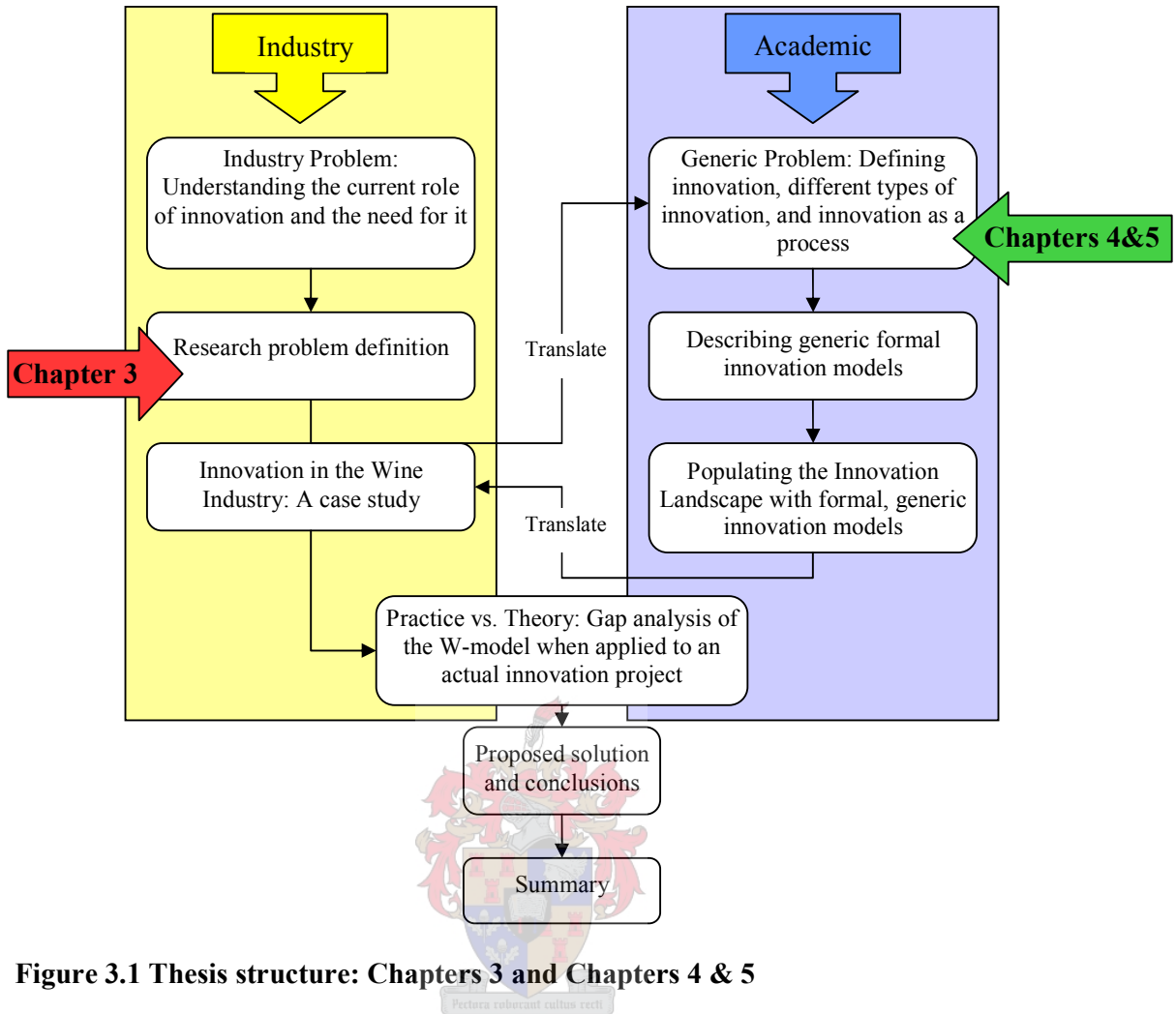


Figure 3.1 Thesis structure: Chapters 3 and Chapters 4 & 5

Chapter 4

Defining Innovation and Understanding the Different Types and Scopes of Innovation

4.1 Introduction

*Innovation is not just about technology development. Innovation had to be in the way we did our financing, the way we did our marketing and marketing relationships, the way we created strategic partnerships, the way we dealt with government. The innovative nature of doing business for us had to be pervasive in the company, and had to look at more than just technology development (Firoz Rasul, Chairman of a Canadian firm named Ballard Power Systems, in *The Practice of Innovation – Seven Canadian Firms in Profile* 2003).*

From the research studied and captured, it can be stated that innovation holds the key to economic growth and social prosperity. In other words, businesses achieve advantage through acts of innovation. However, a vital question deserves to be raised: "How do we perceive innovation?"

Is innovation merely making new products or processes? Is innovation confined to passing from invention to diffusion? Is innovation limited to performing R&D?

If you assume innovation is merely a synonym for new products, think again. What about strategy innovation, such as entering new markets with your existing products? What about supply chain innovations? What about value-adding service enhancements that allow real time responsiveness, make the customer's life easier, and otherwise take on the customer's problems in ways the competition is unable or unwilling to do? Such strategy innovations are a bold new frontier that many firms have never pursued (Tucker 2004).

Innovation has evolved into complex processes and is also not such a rare occurrence anymore. But what is innovation and how is it executed?

The following paragraphs look at defining “innovation”, different types of innovation, and other issues, such as, the dynamics of innovation.

4.2 Defining innovation

Over the last few years much has been written about innovation and many have tried to define “innovation” uniquely and precisely. But, the fact is that innovation is a complex process with various faces, and, therefore, many names are used to describe it. Some of these definitions are as follows:

“To innovate is to introduce something new” (New Oxford Dictionary 2002). Schumpeter, an economist who recognized the importance of innovation before most of his peers, classified innovation into five categories, namely (Frombach 2003, p.6):

- The introduction of a new product or a qualitative change in an existing product.
- The process innovation that is new to an industry.
- The opening of a new market.
- The development of new sources of supply for raw materials or other inputs.
- The changes in industrial organisations.

In a study of innovation it is important to distinguish between “invention” and “innovation”. The difference between an innovation and an invention is that the latter is a solution to a problem, often a technical one, whereas an innovation is the commercially successful use of such a solution (Henry & Walker 1991, p.103). Not every invention is an innovation. Invention is the first stage in the process of technological innovation. Innovations are relevant to practice and lead to improved company performance.

Campbell (2004) stresses this above-mentioned difference when he defines innovation strictly as the successful creation of new market value through the satisfaction of customer needs with new technology. Essentially, it isn’t innovation until it succeeds in the marketplace. The central challenge is the alignment of new customer needs with technology in the form of

market offerings. ‘Successful’ in this context implies financial returns that exceed investment guidelines based on revenue, share, and profit requirements.

The following extensive definition of innovation is given by Morton, combining all the preceding ideas:

Innovation is not just one simple act. It is not just a new understanding or the discovery of a new phenomenon, not just a flash of creative invention, not just the development of a new product or manufacturing process; nor is it simply the creation of new capital and markets. Rather innovation involves related creative activity in all these areas. It is a connected process in which many and sufficient creative acts, from research through service, are coupled together in an integrated way for a common goal (Salvendy 1992, p.1170).

Thus, to sum up all the above-mentioned definitions, it can be said with certainty that innovation is a multifaceted process that entails the development and commercialisation of products, services and processes. The process of innovation involves and affects a company as a whole, not just the R&D department. Within a company, innovation projects vary from one project to another, but they often influence each other. These innovation interactions that take place within an enterprise and with external influences are shown below:

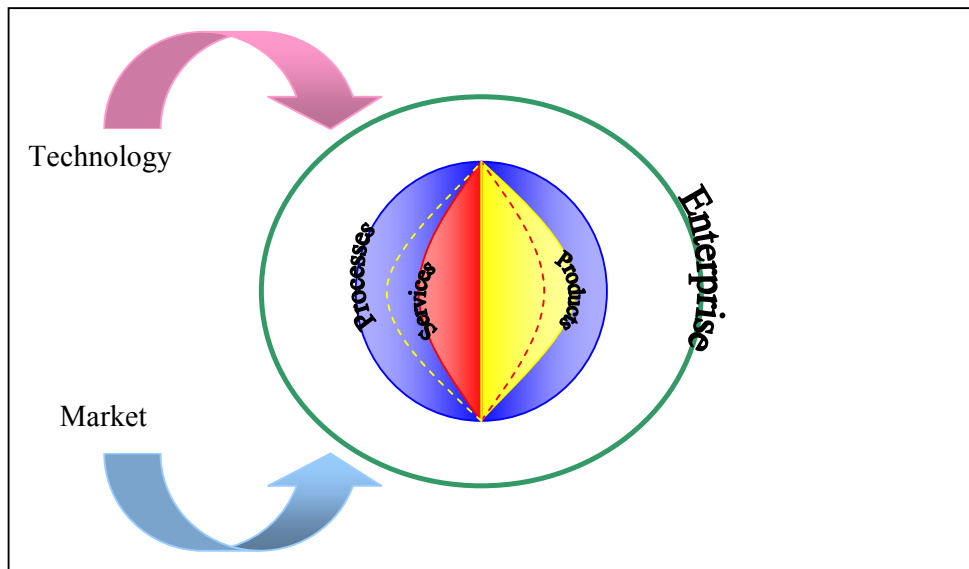


Figure 4.1 Internal and external influences on innovation

Figure 4.1 depicts that process, product and service innovation projects are not carried out in isolation, but that an innovation project usually involves other innovation projects and/or other types of innovation as well. These projects not only interact with one another, but they also interact and influence the enterprise within which these projects are executed. Therefore, just as external factors (such as market demands and technology changes) have an impact on an enterprise as a whole, they also have an indirect effect on individual innovation projects. From Figure 4.1 it is evident that a synthesis of valued offerings that align customer needs with technology possibilities lies at the heart of innovation.

Thus, innovation involves products, services and processes. It also ranges from completely new creations to improvements and to the reorganising and combination of existing and new components. Essentially, innovation adds value to an enterprise. In short, for the scope of this project, innovation is defined as: putting valuable ideas into action as new and successful products, services or business processes.

Now that a common understanding of innovation has been established, the different types and scope of innovation are explored in more detail in the following paragraphs.

4.3 Types of innovation applications

Product innovation

According to Rothberg, ‘product innovation’ can be defined in different ways, depending on whether the perspective adopted is that of the business or the market:

From a business perspective a product innovation can be said to represent change in, or an addition to, the physical entities that comprise its product line. From a market perspective, however, the term refers to a new or revised set of customer perceptions concerning a particular benefits cluster (Rothberg 1981, p.3).

Service innovation

Service innovation is obviously critical for companies that are in the service business. However, in many manufacturing environments, the services that surround the product are as important, or often more important, than the product itself.

Schilling (2005, p.37) states that: “Product innovations are embodied in the outputs of an organisation – its goods or services.” Different industries have different types of outputs and, although the output of a service-providing company may not be a concrete, tangible object, it still is the output. For example, in the banking industry there are many different types of bank accounts that different banking institutions offer customers. These accounts are the products that banks offer clients, each with different characteristics, benefits, and supporting services.

Although some services and manufactured goods can both be classified as products, it is important to acknowledge their differences in innovation traits. Thus, the two types of end results both satisfy some customer needs, but their make-up is not precisely the same.

Table 4.1 Sectoral systems of innovation: manufacturing vs. services “system traits”

	System trait	Status/Significance	Manufacturing	Services
1	Intellectual property rights (IPR)	Current, strong	Strong; patents	Weak; copyright
2	Technology orientation	Historical, declining	Technology “push” science; technology-led	Technology “pull”; consumer/client led
3	Research/innovation generation and supply	Declining significance; manufacturing and services converging	“In-house”	Mainly sourced externally
4	Technology/labour productivity	Current, but declining significantly	High impact	Low impact (until 1980’s?)
5	Innovation cycle times	Declining, weak	Short	Long
6	Product characteristics	Declining significance; medium	Tangible, easy to store	Intangible, difficult to store
7	International “servicing”	Current; medium	Exports, then foreign direct investment (FDI)	Foreign direct investment (FDI), then exports
8	Spatial scale of system or reach	Declining significance; services catching up on internationalisation	National, then global	Regional, then national, then global

Source: (Howells et al. 2000. p. 218)

For the scope of this project, product innovation comprises both actual physical products and services.

Process innovation

Innovation activities that are aimed at changing the way an organisation conducts its business are called process innovation. For example, process innovation can be innovation projects regarding the techniques of producing or marketing goods, or services. Process innovations are often orientated toward improving the effectiveness or efficiency of production (Schilling 2005, p.37). However, process innovation does not just include manufacturing processes, but rather the end-to-end processes (or the value chain) of building, selling, distributing, servicing, and supporting products.

Innovation in business processes that is not visible to the customer is often a source of significant market differentiation. Wal-Mart, for instance, relies primarily on its sophisticated logistics and communications systems to maintain its lower prices.

Product vs. process innovation

In order to better explain product and process innovations, it is useful to make a distinction between process innovation and product innovation.

Dell Computers' success is an example of process innovation. Dell combined new technology in selling, configuring, building, and distributing personal computers to what is, in effect, a micro-segment the PC market, and let customers get exactly what they wanted while operating at a lower cost structure than their competitors. Wal-Mart Stores' integration of sales and customer information with a highly responsive supply chain enabling a very high inventory turns ratio is a second example of innovation across the entities of the value chain. What customers want is in the store at low prices (Campbell 2004).

Product innovation, in contrast, focuses on innovation in the product itself. A classic example of product innovation is the Apple Macintosh. Based on the technology inventions from Xerox PARC, Apple innovated by aligning the graphical user interface technology with customer needs for an easy-to-use interface at the right range of price points.

Although the product/process innovation distinction is useful, it should not be viewed as a dichotomy. Some innovations cut across product and process. The fly-by-wire technology introduced by Airbus was product technology, in that it introduced a new kind of control technology into the product, but much of its benefit to the customer was realized in support areas, such as requiring less pilot training to fly new aeroplanes or to convert from one type to the other, because of control consistency across the aircraft types. The xerographic example is a second example of the interaction and, indeed, the compound effect, of joint product and process innovation. The product innovation inherent in the xerographic process was complemented by the value chain innovation of marketing relatively expensive xerographic machines by selling on a cost-per-copy basis. The penetration rate would have been far lower without this value chain innovation.

Process and product innovation can be seen as different views of innovation, as they satisfy different types of opportunities. These differences are summarised in Table 4.2 below.

Table 4.2 Different dimensions of innovation

Category	Opportunity for Innovation	Examples of Successful Innovations
Products and Services	<ul style="list-style-type: none"> •Design •Features •Technology •Quality •Price 	<ul style="list-style-type: none"> •Adjustable pedals •Electro-chromic mirrors •Telematics •Tire pressure monitors •Fold-flat seats
Processes: Manufacturing and Business	<ul style="list-style-type: none"> •Equipment •Technology •Management practices •Business design 	<ul style="list-style-type: none"> •Hydro-forming •Laser welding •Digital prototyping •Lean manufacturing •Customer relationship management •Strategic alliances •Corporate development •Value chain realignment

Source: The Right Place Inc.

New product innovations and process innovations often occur in tandem.

- Firstly, new processes may enable the production of new products. For example, the development of new metallurgical techniques enabled the development of multi-gear bicycles.

- Secondly, new products may enable the development of new processes. For example, the development of advanced workstations has enabled firms to implement computer-aided-manufacturing processes that increase the speed and efficiency of production. Though product innovations are often more visible than process innovations, both are extremely important to an organisation's ability to compete (Schilling 2005, p.37).

The dynamics of product and process innovation

Although this study focuses on the increasing necessity of innovation activities for growth and survival of contemporary companies, on the academic side, the effect of innovation has been studied for some time. In a series of articles published from the mid- to late-1970s, William Abernathy and James M. Utterback laid out a model describing the dynamics of innovation. This model hypothesizes that the rate of major innovation for both products and processes follows a general pattern over time.

As Figure 4.2 below indicates, the rate of product innovation in an industry or product class is highest during its formative years. During this period, called the 'fluid phase,' considerable experimentation with product design and operational characteristics takes place. As shown in Figure 4.2, this phase is characterized by high product innovation, with much less attention given to the processes by which products are made (Utterback 1994).

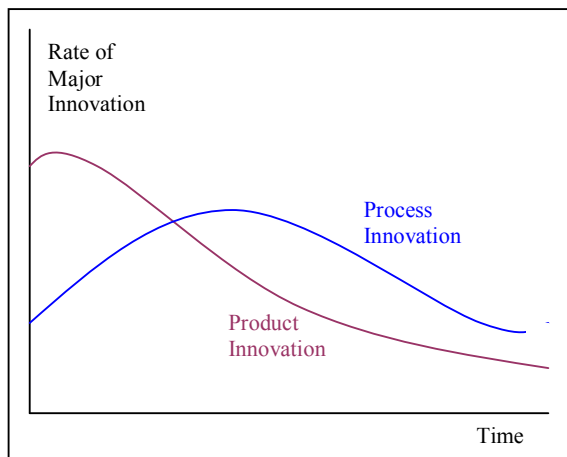


Figure 4.2 Abernathy-Utterback product and process innovation model

Source: Rothberg 1981, p.429

According to the model, the 'fluid phase' typically gives way to a 'transitional phase' in which the rate of product innovation decreases while the rate of process innovations increases. By this stage, a product would already have been accepted by industry and consumers as satisfying the market's needs best. Once the evolution of the product itself has stabilised, improvement efforts shift to focus on the way that the product is produced.

Finally, the 'transitional phase' is followed by the 'specific phase', in which the rate of major innovation for both product and process is low. Only incremental innovation tweaks take place, with the aim of cutting costs further or improving capacity of the established products and processes.

Not all industries or products pass through these phases, but through evaluation over the years since it was formulated, the model has proved to represent a realistic view of the characteristics of the phases of innovation and competitive advantage that lie within the pace of innovations.

4.4 Levels of innovation

In addition to being differentiated by what aspect of the business they affect, innovations can be differentiated by the breadth of their scope. Innovations can range everywhere from a significant improvement in a business process, to a radical redesign of the company's entire business model. Figure 4.3 illustrates that as the scope of the innovation increases, the level of complexity and risk associated with it also increases.

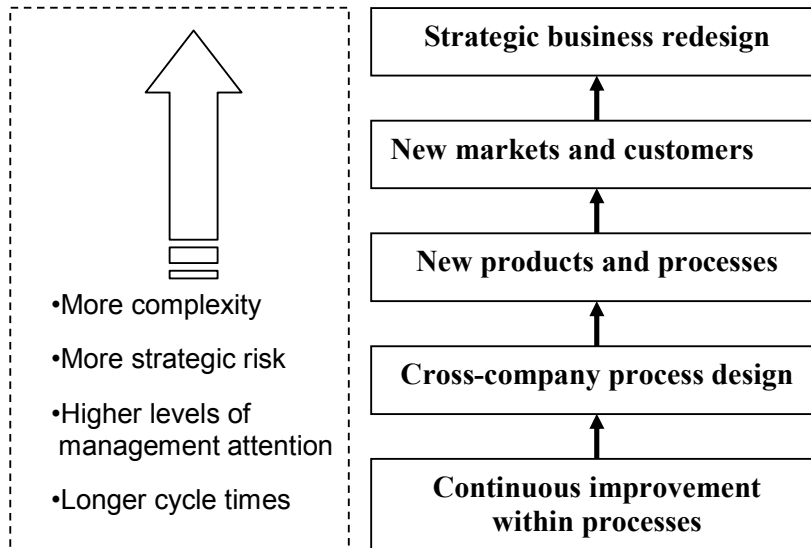


Figure 4.3 Innovation levels

Source: The Right Place Inc.

Innovation can be classified into three groups:

- Firstly, there is the complex system, such as moon missions, that may take many years and a great amount of money to accomplish.
- The second group of innovation represents the major, radical breakthrough in technology that turns out to change the whole character of an industry, for example, the xerography.
- Thirdly, there is the ‘nuts and bolts’ innovation that includes overcoming short-term concerns like those of product improvement, cost-cutting, quality control, expanding the product line, and so forth. This third group of innovation is absolutely essential for the average company’s survival and consists of problems that the company can cope with quite naturally with their own technical competence.

This thesis mostly involves the third group of innovation – the expected, frequent kind of change, without which no business can sustain competitiveness.

Radical innovation vs. incremental innovation

The literature distinguishes between two types of innovation scope, namely radical innovation and incremental innovation. A number of definitions have been formulated to explain these two types, but most hinge on the degree to which an innovation represents a departure from existing practises.

Schilling defined it as follows:

Radical Innovation is an innovation which is very new and different from prior solutions; and Incremental Innovation is an innovation that makes a relatively minor change from (or adjustment to) existing practices (Schilling 2005, p.38).

For example, a radical innovation would be the introduction of wireless telecommunication products, as this involves new technologies that require new manufacturing and service processes. An incremental innovation might be changing the configuration of a cell phone from one that has an exposed keyboard to one that has a flip cover, or offering a new service plan that enables more free weekend-minutes.

The distinction made above is the most fundamental distinction concerning innovation. Christensen's (1997, p.34).view on these two types of innovations is given below:

*A **sustaining innovation** targets demanding high-end customers with better performance than what was previously available. Some sustaining innovations are the incremental year-by-year improvements that all good companies grind out. Other sustaining innovations are breakthrough, leapfrog-beyond-the-competition products. It does not matter how technologically difficult the innovation is, however: The established competitors almost always win the battles of sustaining technology. Because this strategy entails making a better product that they can sell for higher profit margins to their best customers, the established competitors have powerful motivations to fight sustaining battles. And they have resources to win.*

***Disruptive innovations**, in contrast, don't attempt to bring better products to established customers in existing markets. Rather, they disrupt and redefine that trajectory by introducing products and services that are not as good as currently available products. But disruptive technologies offer other benefits – typically, they are simple, more convenient, and less expensive products that appeal to new or less-demanding customers.*

Christensen described his Disruptive Innovation Model in his worldwide bestseller, *The Innovator's Dilemma*. This model, which is depicted in Figure 4.4, identifies three critical elements of disruption.

For all products or markets there is a rate of improvement that customers can utilize or absorb. There's a distribution of customers around this median - a range indicated by the distribution curve on the right. Therefore, in reality, the most demanding customers will never be satisfied with the best available product and the least demanding customers will always be over-satisfied.

Secondly, in every market there's a distinctly different pace of technological progress that companies provide as they introduce new and improved products. This rate of improvement mostly exceeds the needs of customers in any given tier of the market. Therefore, a company's future products will probably exceed its current target market.

The third critical element of the model is the distinction between sustaining and disruptive innovation and the different target markets, as discussed in the preceding paragraphs.

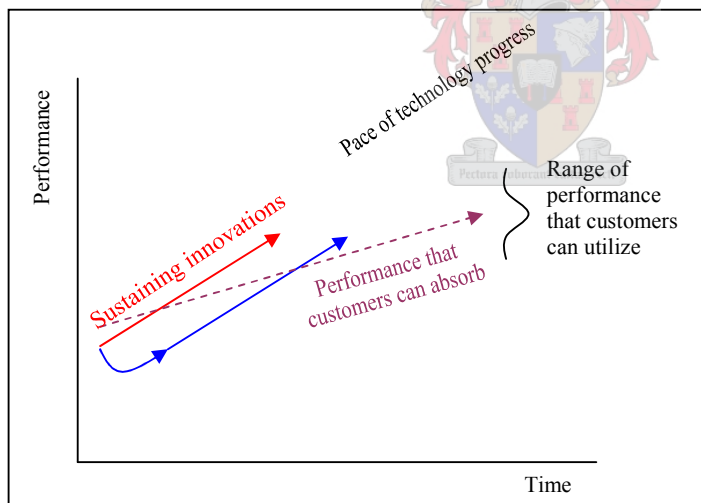


Figure 4.4 Disruptive innovation model

Source: (Christensen 1997)

The improvement cycle begins once a disruptive innovation enters the market, because the pace of technological progress exceeds customers' abilities to use it. Technology that satisfied the low-end customer will eventually improve to satisfy the needs of the more demanding, mainstream customer. According to Christensen's model, current leaders of the industry

almost always triumph in battles of sustaining innovation, but most successful disruptions are launched by companies entering a market.

4.5 The impact of innovation

The introduction of a new product helps enterprises gain a greater market percentage and income, while process innovation usually results in cutting costs for firms. Advances in information technology, such as computer-aided design and computer-aided manufacturing, have helped speed up the pace of innovation through speeding up the processes of new products design and production. Flexible manufacturing technologies have played a large role in the economically viable reduction of production runs, thereby also reducing the importance of economy of scale. Through the development of these technologies, companies were able to customize products according to different customer needs and differentiate their products from competitors. For example, Sony produces more than 75 models of its Walkman portable stereo that has different features, such as, size, colour, music format, etc. (Schilling 2005, p.1).

The importance of innovation cycle time

It is accepted knowledge that the primary aim of most business is to make money. In order to achieve this goal, there are two basic objectives in business: to satisfy customers and to make a return on investment. According to Patterson, the one factor that has the most impact on both these objectives (satisfying customers and ROI) is the time it takes to develop and introduce a new product, measured from the time the opportunity occurs (Patterson 1993, p.3).

The following Figure 4.5 of the innovation life cycle represents the impact of the foregoing paragraph.

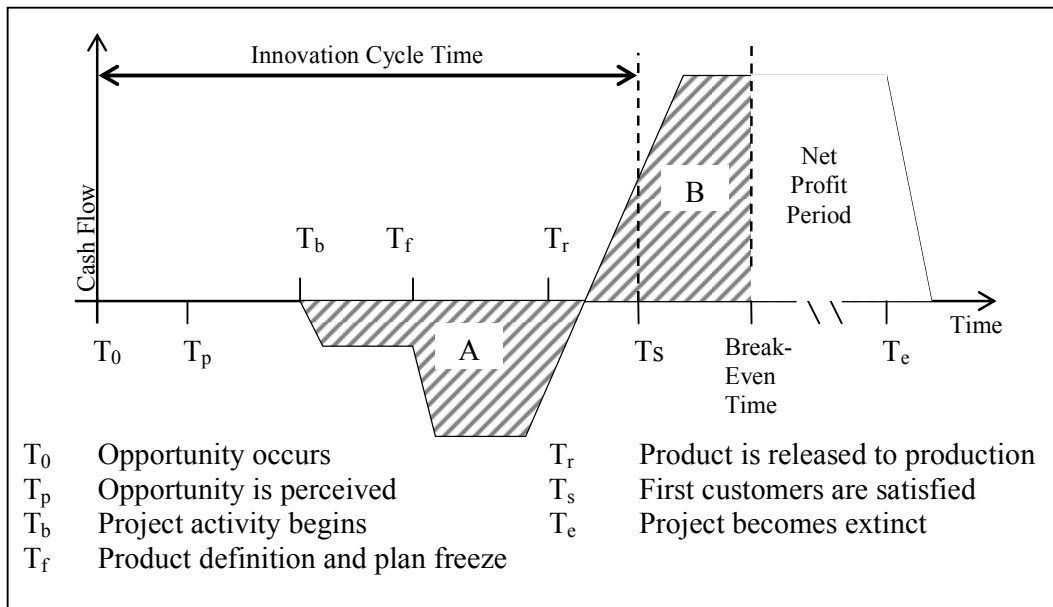


Figure 4.5 Innovation life cycle

Source: (Patterson 1993, p.4)

Time T_0 indicates a point in time when an opportunity for a new product arises. This happens when a new technology demonstrates the ability to satisfy a market need. Matching new customer needs with fresh technology triggers new product possibilities. Patterson labels the phase from point T_0 till when the first customer is satisfied as the “Product Innovation Cycle”.

It sometimes happens that a company anticipates a market opportunity and starts with the development of an innovation before T_0 . This allows a company to immediately launch a product when the anticipated customer need or awaited technology emerges, thereby taking advantage of the situation.

The opportunity for companies to potentially make money exists from the time T_0 . Those products that best satisfy the customers’ needs or the products that are first launched into the market will have an advantage over their competitors’ products. If a product is launched into the market after some competitors have launched theirs, a market share has been lost. Therefore, according to Patterson (1993, p. 4), “the success of a company is a steadily decreasing function of time: the later a company introduces an innovation, the lower the impact of it and thus the lower the possibilities of business success.”

After an innovation has been launched into a market, it is important for a company to sustain improvement and innovation activities in order to stay ahead of competitors and continue being a successful business. It is not enough to deliver a once-off winning solution to a demand, because customer requirements change and technology develops almost by the minute. Many Asian consumer electronics manufacturers proved this by following pioneers with a ‘me-too-but-better’ strategy, and, in so doing, build successful businesses.

There are more advantages to frequently pushing new products to the market than the obvious ones of survival discussed above. Patterson (1993, p.10-13) identified these advantages as:

- *Higher sampling rate:* The more often a company puts new products on the market the more feedback they will get from the customers and they will have more samples to analyse in order to create more new products that better satisfy the customers’ needs.
- *Better product definition stability:* The shorter the development time is the better are the chances that the end product will satisfy the intended definition.
- *Leadership reputation:* If a company frequently puts leading edge products on the market that company’s name will become equivalent with innovative products and customers will gain confidence in that brand.
- *Increased organisational learning:* The more often a company goes through the motions of developing and producing an innovative product, the easier it will become for the company, allowing them to create more successful new products more often and/or with less effort.

The fact is that companies have to innovate in order to survive and there will always be a new market to exploit, a new way of creating a product faster or cheaper, and another customer requirement to be met, but the trick is to match the correct market requirement with the appropriate technology that suits a specific business at a particular time.

4.6 The innovation challenge

How does a company figure out whether it is worth making some novel, specialized product?

How does a prospective customer decide whether this product is worth buying?

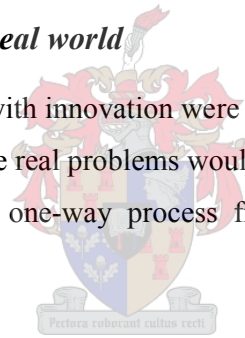
The product is not worth making unless it's worth buying; therefore, the two questions above are related. However, it is hard to predict what the demand for a product will be before that product is actually tested in the market. Therefore, back in 1986, Eric von Hippel, a professor at MIT's Sloan School of Management, offered a way of thinking about innovation in the guise of a formula: $b = (v \times r) - c - d$ (Sterling 2005).

The b represents the customer's benefit, which ultimately determines demand. The company would calculate b this way: How much of its business (dollar volume, or v) would the innovation apply to? How much would this new technology increase the profit margin (rate of profit, r) of that business? What's the change cost (c) of switching? And what's the loss in 'old benefits' (d) when the company abandons its current way of doing things?

If a company can manage the change and survive without lost benefits, the equation will have a positive result, but mastering this constitutes a great innovation challenge for any company.

An innovation model for the real world

If equating the process of R&D with innovation were true, understanding innovation would be far simpler than it truly is, and the real problems would be far simpler and less interesting than they truly are. It is not just a one-way process from R&D to the market that delivers innovations.



In contrast, the creation of new technologies often does not begin with the discovery of something new, but rather with using existing knowledge to design something in order to meet a recognized need. The process of innovation moves back and forth between market needs, design, development, applied research, and at times, basic research. Consequently, any model of a real-world innovation system cannot limit itself to R&D as the whole innovation (Mahdjoubi 1997).

Innovation is, therefore, a dynamic process with various inputs at different stages, leading to the design, development, creation and marketing of tangible, as well as intangible products. Figure 4.6 depicts innovation activities not as a one-way process, but rather as a continuous, evolving process in which innovation moves between the various stages, such as design, research, production, and the market.

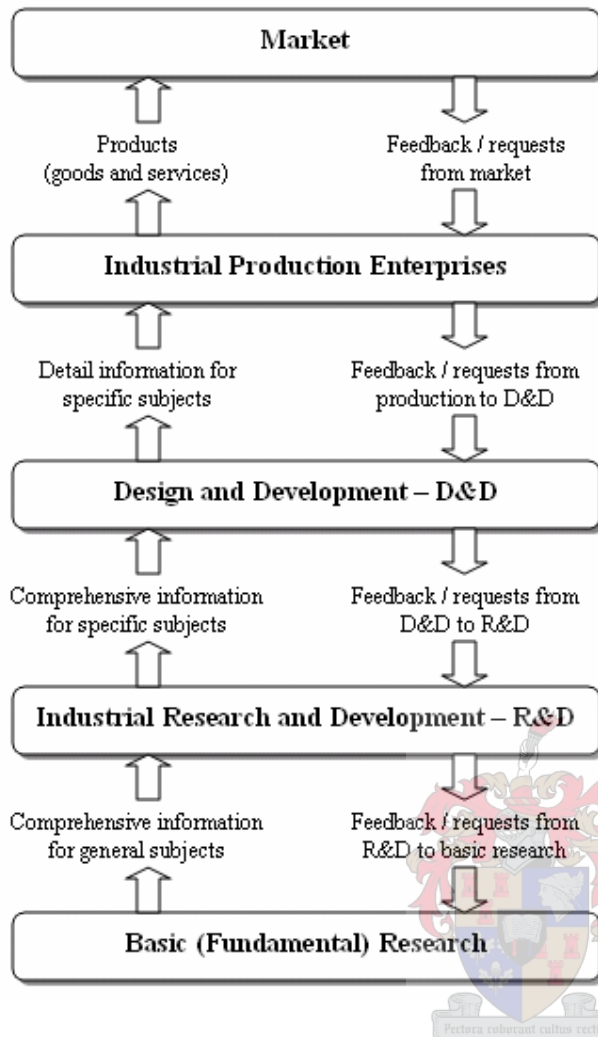


Figure 4.6 Linear model of innovation

Source: (Mahdjoubi 1997)

The Oslo Manual, another document of the Organisation for Economic Cooperation and Development (OECD) for collecting and interpreting technological innovation data, emphasizes that R&D data does not accurately and fully represent the innovative activity in firms. Also, it admits that innovators are still a long way from understanding all of the factors which shape the rate, direction and effects of innovation and technological change, at enterprise, industry, regional or country level (Frombach 2003). Nevertheless, models of innovation may be useful for exploring and supporting the innovation process more fully.

Chapter 5

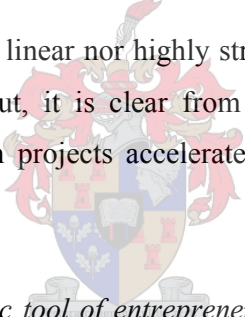
Innovation As a Process

5.1 Introduction

In order for today's enterprises to be flexible and meet the present challenges, they need to have a process that supports innovation within the enterprise; just like the other processes supporting the various other enterprise functions.

Innovation should be an enterprise-wide matter, associated with a process and methodology that facilitates the development of new processes and products.

The innovation process is neither linear nor highly structured, particularly in the early stages of discovery and exploration. But, it is clear from literature that structured management approaches applied to innovation projects accelerate product development. Drucker (1985, p.20) supports this, stating:



Innovation is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service. It is capable of being presented as a discipline, capable of being learned, capable of being practiced.

5.2 The innovation process

The goal of innovation activities must be to create and maintain a rate of advancement greater than that of the competition. It is therefore important to recognize innovation as a process, and not as magic, luck or pure invention.

Patterson confirms this when stating:

Translating a market opportunity into a new product requires perhaps 15 percent invention. The remaining 85 percent of the work involves previously learned processes that often are undocumented and undisciplined (Patterson 1993, p.16).

It is thus accepted that innovation entails more process than invention, and it can also be said that innovation activities and task outcomes can be anticipated, controlled and supported.

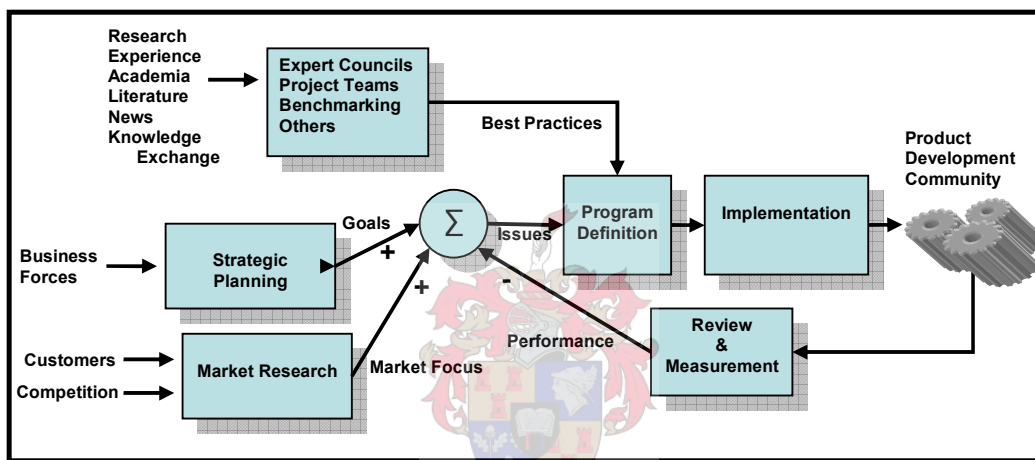


Figure 5.1 A continuous process improvement system for product development

Source: (Patterson 1993, p.16)

Figure 5.1 was formulated by Patterson to address (in theory) the elements that should be in place within an organisation in order to accomplish the goal of more competitive innovation.

The drivers of the system are the forces entering on the lower left: the competitors' capabilities, customer needs and how they are changing, and the company's business needs. These variables are compared with the current performance of the product development activity to determine the competitive issues.

Issues are identified by analysing the differences between these market forces and the product development community's performance, as determined by the review and measurement feedback process.

Before a company can begin to define how to deal with the issues, it needs to bring the element of ‘best practices’ to bear on the issues. With ‘best practices’ and ‘the issue’ as inputs, innovation programmes can then be identified.

Quoting J.A Telfer, former CEO of Maple Leaf Mills Ltd.: “A company must ‘innovate or die’. The process of innovation is fundamental to a healthy and viable organisation. Those who do not innovate ultimately fail.” (Biemans 1992, p.2)

5.3 Mapping the innovation process

The development of an innovation can be compared to taking a journey into unknown terrain. As the route is unfamiliar it is very difficult to navigate from where one is to the place where one needs to be. A map would thus be of great help in such a situation, as it would orientate one and indicate what needs to be done in order to move from the start to the finish. Also, in the case where more than one person needs to reach the same destination, a map would ensure that all the parties involved understand the planned route and the exact end point.

According to Darius Mahdjoubi:

Our perception and understanding of the process of innovation depends largely on the paradigms and models that we implement. In understanding the process of innovation, models may have the same role as that of maps and atlases in determining our perception of the world. Map-making has always been a useful analogy to help us understand the interconnectedness of human life, and mapping is an active metaphor to study the process of innovation (Mahdjoubi 1997, p.5).

Maps play different valuable roles, such as assessing one’s position; depicting where you started and where you are going; facilitating measurement, by providing a scale of valuation; and illustrating people’s perception of their environment.

Maps have changed dramatically over time. Maps also vary in the level of abstraction and scope. One could possibly compare the mapping of innovation to this process: Map No. 5

represents the real-life situation and one might start with a basic representation, such as map No.1, in order to describe the real-life process. Detail is added as needed in order to describe the specific process more accurately, but an innovation atlas - similar to map No. 5 – is obviously unattainable.

In Figure 5.2, the World is depicted flat and this map is primarily a representation of some territories in the Old World. There is no scale in this map, and therefore no measurements can be based on it (Mahdjoubi 1997).

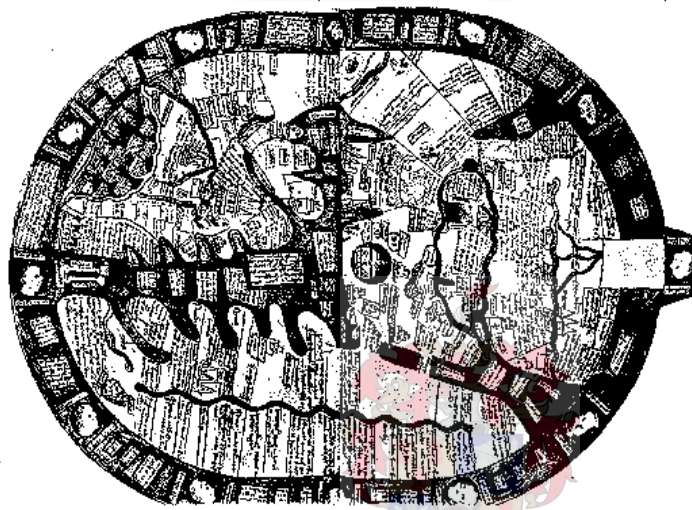


Figure 5.2 Map no. 1: Map of the world drawn in 1363 by Randulf Higden

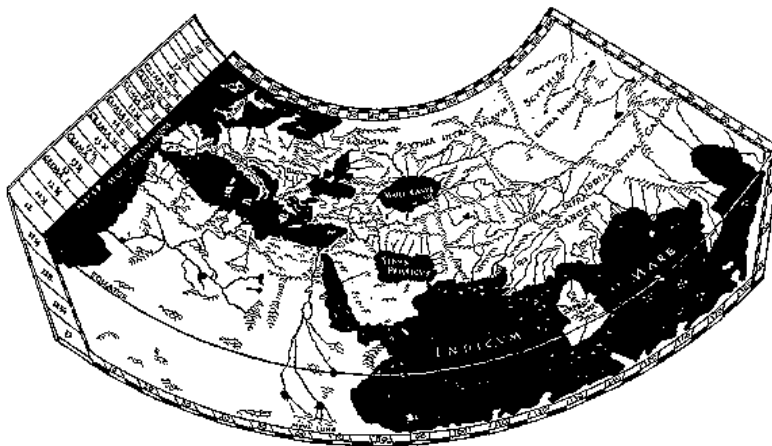


Figure 5.3 Map no. 2: Map of the world drawn in 1520

The map in Figure 5.3 is based on the writings of the Greek geographer, Polemy, who lived around 150 AD. Polemy was the first to use a system of regularly spaced coordinates on maps to be used as a type of scale (Mahdjoubi 1997).

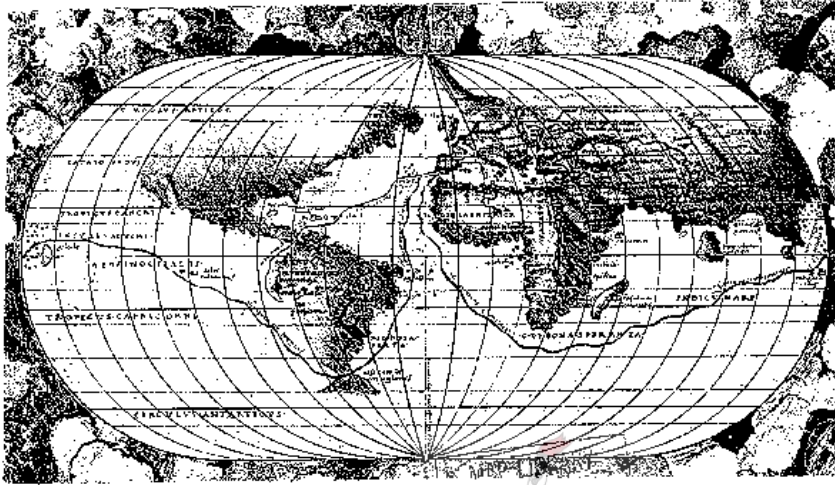


Figure 5.4 Map no. 3: Map of the world drawn in 1544 by Batista Angese

The voyage of Magellan, the first to circumnavigate the globe, is marked out in Figure 5.4. This map, depicting Earth as a sphere rather than a flat object, is based on presentation of a systematic scale to make measuring possible (Mahdjoubi 1997).

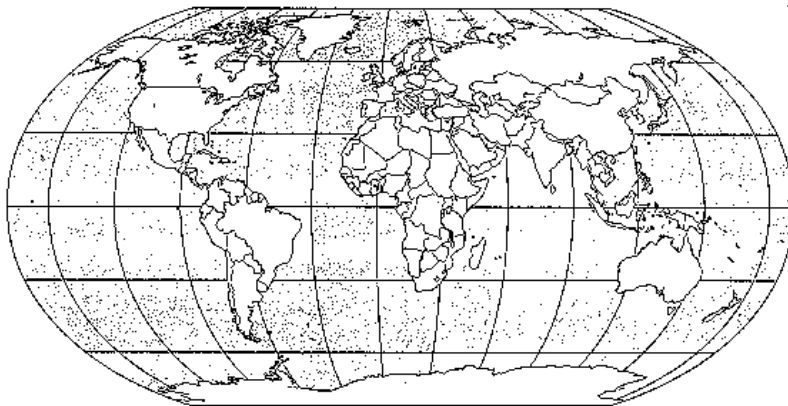


Figure 5.5 Map no. 4: Map of the world drawn in Robinson projection

Figure 5.5 depicts what we commonly consider as ‘a map of the world’. Although this map may include a scale, which makes the comparison of different regions possible, its measurement for navigation purposes is still inaccurate (Mahdjoubi 1997).

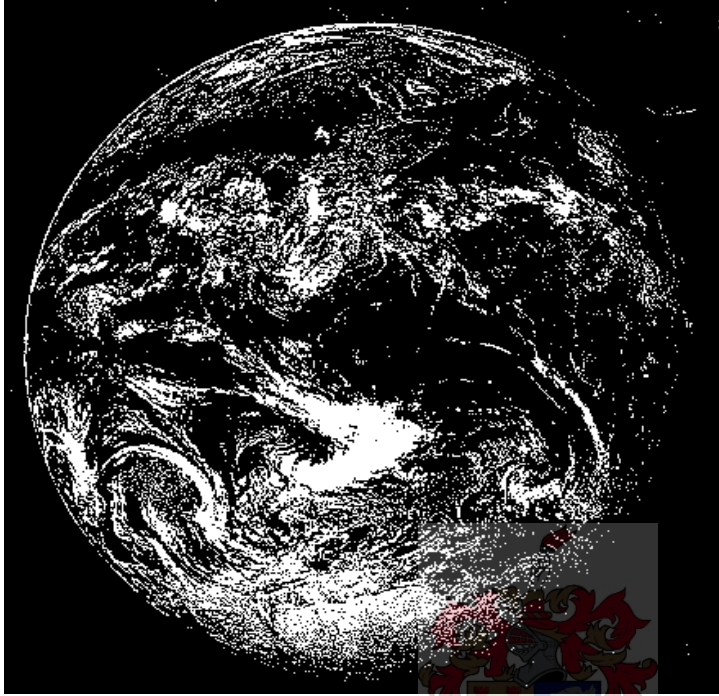


Figure 5.6 Map no. 5: The Earth as seen by the Apollo 17 astronauts in 1972

Figure 5.6 is an exact representation of the earth and, with advanced technology, a satellite image like this can be used to pinpoint precise coordinates of a location, and distances can be accurately calculated.

As different aspects and views of innovation are studied by various disciplines, it becomes necessary to properly map innovation in order to provide a unified view of the relationships between the different environments. In addition to creating a better overall understanding of innovation, the mapping of innovation also assists in identifying the impact of innovation.

In the past, enterprises have had to make many business- and market opportunities and needed to apply initiatives - like innovation - in order to stay competitive and survive. Sustainable innovation requires the awareness of the importance of current innovation, executive vision and commitment, together with the implementation of an innovation process.

The next chapter, Chapter 6, focuses on existing formal innovation models and methodologies, as indicated in the thesis structure image in Figure 5.7. The differences and similarities of these models will be discussed in order to gain a better understanding of the different innovation situations and environments to which the various models can be applied. As industries, companies and products all have individual characteristics and processes, it is essential to choose the correct model that would best support each company's innovation activities. In order to compare these models an Innovation Landscape was populated with the models studied in Chapter 6.6.

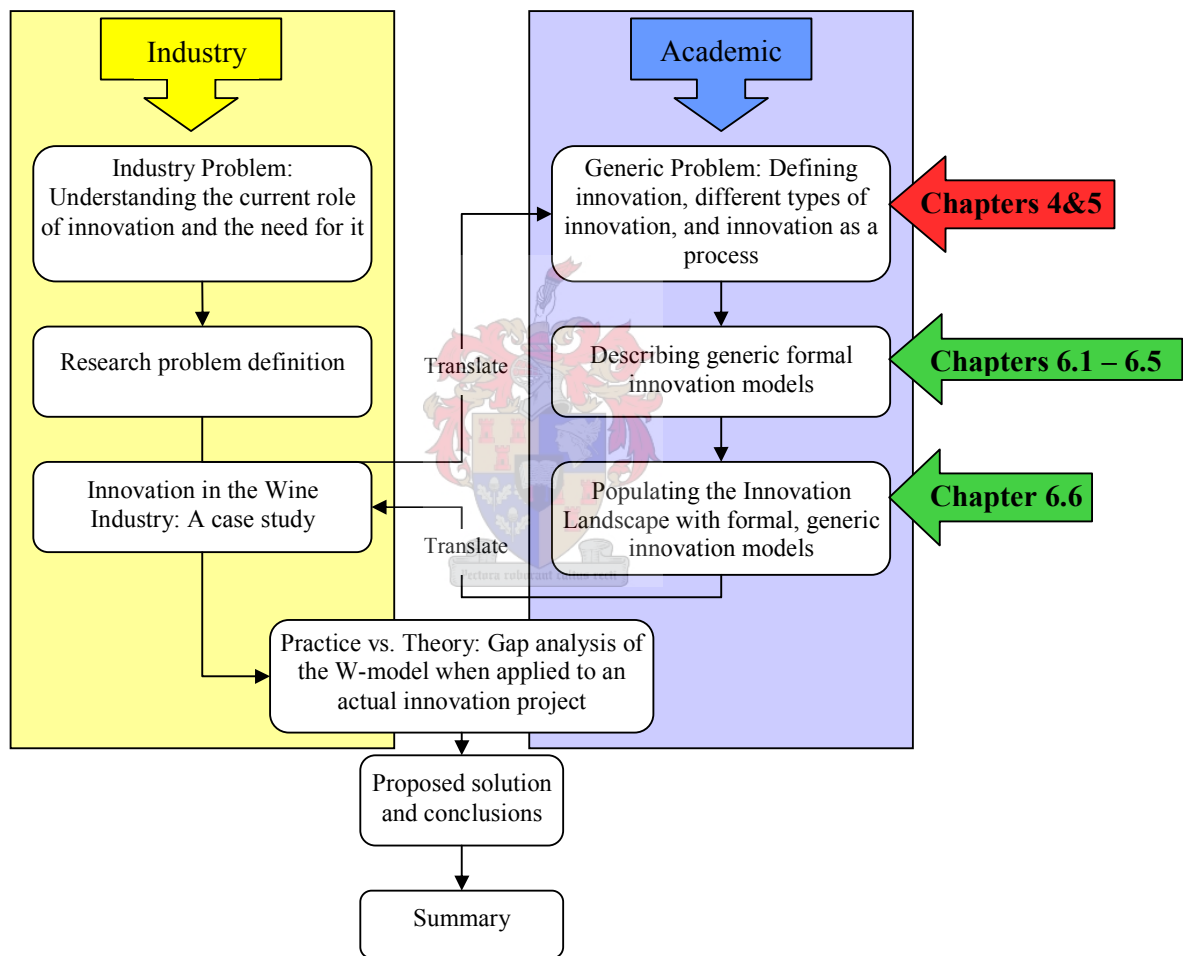


Figure 5.7 Thesis structure: From Chapters 4 & 5 to Chapter 6

Chapter 6

The Innovation Landscape

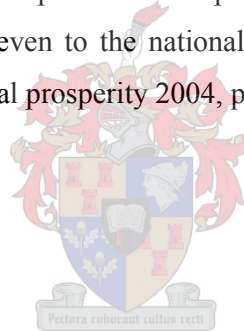
6.1 Introduction

Innovation frameworks establish the important relationships between innovation inputs, strategy, operations, market needs and final outputs. The function of a framework is to guide the processes of collecting and analysing data in order to determine the abovementioned relationships and results sought.

An innovation framework can be constructed at a number of levels of abstraction and detail: from an individual project and to a particular company (specific framework), to the industry sector (partial framework), and even to the national and global levels (generic framework) (Measuring innovation for national prosperity 2004, p.12).

6.2 The landscape

The Innovation Landscape



In order to compare the different innovation frameworks a common standard is needed and the Innovation Landscape was therefore created. The Innovation Landscape represents an innovation project's life cycle from the idea phase to the disposal phase. The full life cycle consists of five phases, namely:

1. Invention – The generating of ideas.
2. Feasibility – The specification, design, functional analysis and the concepts.
3. Innovation (Implementation) – The detailed design and manifestation of the concepts.
4. Operation – The production and related maintenance activities.
5. Disposal – The termination of the system.

These five phases of the Innovation Landscape are closely related to the formats of life cycle phases used by researchers such as Campbell (2004) and Williams et al. (1998) to compare innovation models in the literature.

Different enterprise-, product- and general innovation models are discussed in the following sections: 6.3, 6.4 and 6.4, and these models are then all placed within the Innovation Landscape (see section 6.6) according to the scope and purpose of the specific model.

In order to compare all the innovation models that will be discussed in this chapter, a life cycle coverage table is constructed for each innovation model. This life cycle coverage table indicates which phases of the Innovation Landscape are covered by the specific formal innovation model and also to what extent. A specific table for each model is shown after the discussion of the related model.

Life cycles and architectures

Like everything in this world, every innovation project also has a beginning, a purpose, and an end. As indicated by the five phases of the Innovation Landscape, every entity goes through the same series of phases in its progress from its invention to its disposal. These life cycle phases describe the progression of an innovation project from beginning to end, but may also be used to describe the necessary steps in the development of a future project.

The following table (Table 6.1) illustrates William et al.'s version (1998, p.20) of the steps or activities associated with each life cycle step.



Table 6.1 Mapping between life cycle phases and activities

	“What” Activities	“How” Activities	“Do” Activities
Plan and Build Phase (e.g. before sell/buy title transfer)	<ul style="list-style-type: none"> • Develop goals • Define strategy • Define the product needs 	<ul style="list-style-type: none"> • Develop requirements • Define the concept • Design the product • Plan to produce the product • Plan to support the product 	<ul style="list-style-type: none"> • Procure the parts • Produce the product • Test the product • Ship the product
Use and Operate Phase (e.g. after the sell/buy title transfer)	<ul style="list-style-type: none"> • Define the support needs • Define the use 	<ul style="list-style-type: none"> • Define use requirements • Define support requirements 	<ul style="list-style-type: none"> • Use the product • Support the product
Dispose and Recycle Phase (e.g. after the product is no longer useful)	<ul style="list-style-type: none"> • Define the recycle/dispose needs 	<ul style="list-style-type: none"> • Define the recycle/dispose requirements 	<ul style="list-style-type: none"> • Recycle the product • Dispose the product

A model representing the structure of a physical or conceptual entity is called Architecture. According to T.J. Williams et al. (1998, p.15), the architectures that deal with manufacturing or enterprise entities may be divided into the following two types:

- Type 1 - The structural arrangement (design) of a physical system, such as the computer control system part of an overall enterprise integration system.
- Type 2 - The structural arrangement (organisation) of the development and implementation of a project or programme, such as a manufacturing or enterprise integration or other enterprise development program.

A Type 1 Architecture is a model of an entity at a point in time and, therefore, not a life cycle representation of the entity.

The life cycle approach is the basis for most Enterprise Integration Architectures (Type 2) being proposed today. This is due the fact that a life cycle representation may provide an

excellent model of the application methodology, containing a full set of steps and tools for an enterprise engineering or related project.

6.3 Enterprise architectures

One of the most important characteristics of today's enterprises is that they operate in a rapidly changing environment and can no longer plan long-term strategies or make long-term arrangements. Therefore, enterprises themselves need to evolve, so that change and adaptation becomes a natural dynamic function of the business, rather than something occasionally forced upon the enterprise. It is necessary to organise all the knowledge required for identifying the need for change and carrying out that change successfully within enterprises. In the discipline of enterprise engineering, architectures have been produced for the organising of all this enterprise integration knowledge. These architectures then guide the enterprise integration programmes. As shown in the following figure, many different architectures have been developed through previous research:

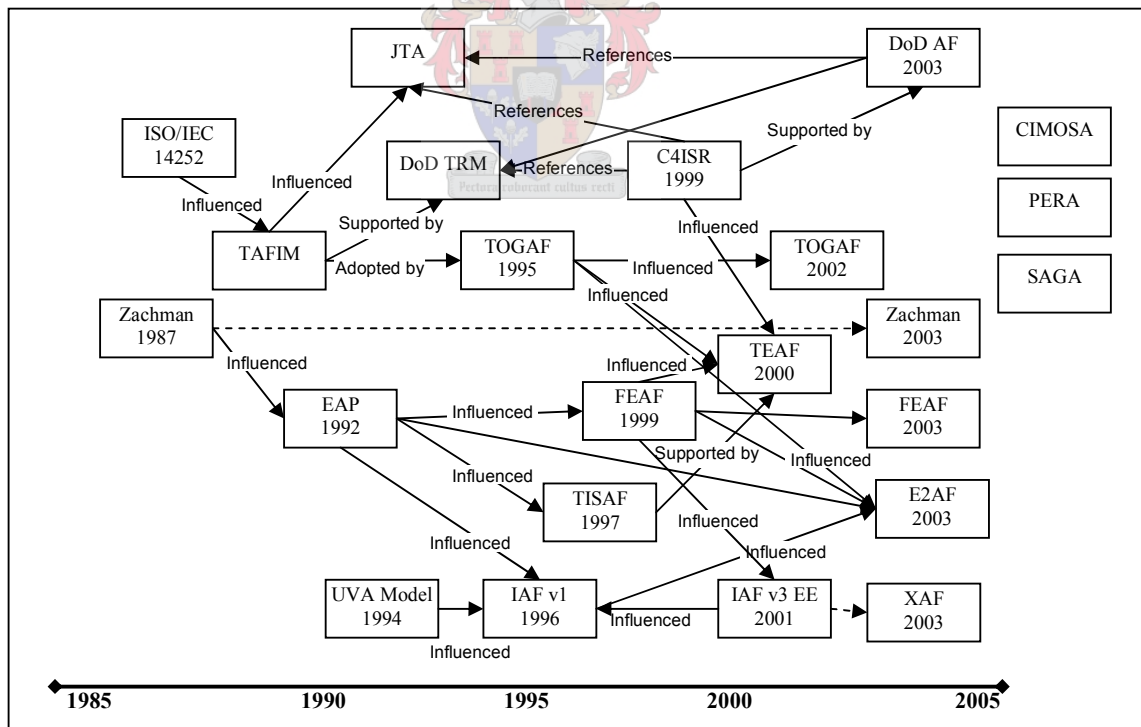


Figure 6.1 The development of enterprise architecture frameworks

Source: (Schekkerman 2004)

Some of the most popular Enterprise Architectures are:

- ARIS – *Architektur fur Informations Systeme* (Architecture for information systems)
- PERA – Purdue enterprise reference architecture
- CIMOSA – CIM open systems architecture
- GRAI/GIM – *Graphe resultants et activités interliées* (graphs with results and activities interrelated)/GRAI integrated methodology
- Zachman – The Zachman (2003) life cycle aspect
- C4ISR – Command, control, communications, computers, intelligence, surveillance and reconnaissance

The following paragraphs briefly discuss these different enterprise architectures, by referring to the purpose and life cycle phases of each of these architectures. Bernus et al. defines the function of “methodologies” thus: “...to guide the user through the enterprise architecture (including modelling) process.” (Bernus et al. 2003, p. 141)

According to the Handbook of Enterprise Architecture, a life cycle phase is: “a set of possible processes or activities which may be performed (once or several times) in the enterprise during its existence, i.e. throughout its life history.” (Bernus et al. 2003, p.69)

According to the scope that the life cycle phases of each architecture cover, and in order to better understand and to compare the applications of the various architectures, the architectures are mapped on the bigger Innovation Landscape in the next figure.

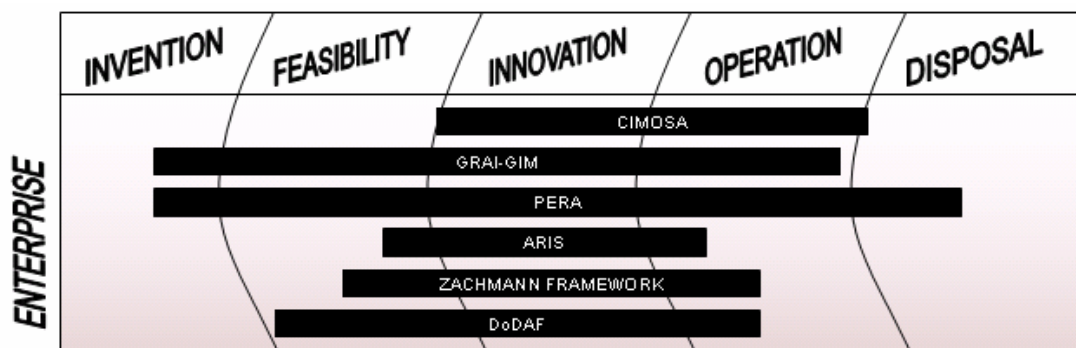


Figure 6.2 The Innovation Landscape: Enterprise architectures

The next few paragraphs discuss each of the six abovementioned Enterprise Architectures in more detail.

6.3.1 CIMOSA

The ESPRIT Consortium AMICE worked on the definition and specification of a CIM architecture for enterprise integration during the period of 1985–1996 (Nazzal 2004). The completed model, the CIM Open System Architecture (CIMOSA) model, is a process-planning tool that provides a framework, and is also based on the life cycle concept of systems. It was originally created for the manufacturing environment.

CIMOSA consists of:

- Enterprise modelling framework (reference architecture)
- Enterprise modelling language
- Integrating infrastructure

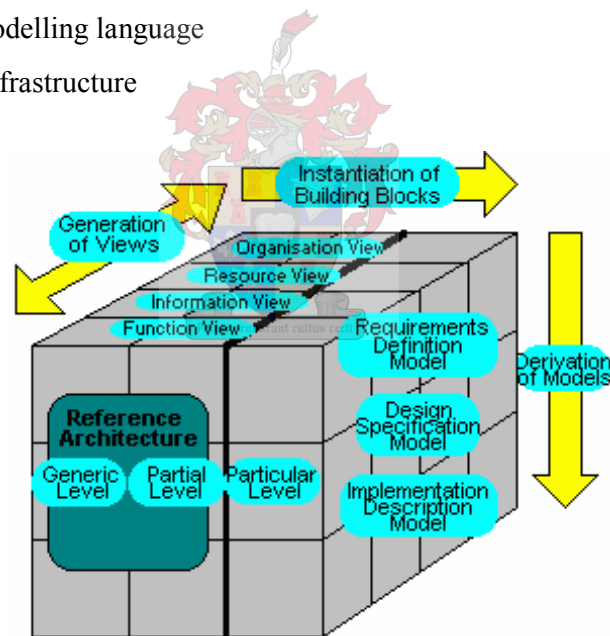


Figure 6.3 The CIMOSA Reference Architecture

Source: (Nazzal 2004)

As can be seen in Figure 6.3, CIMOSA defines three levels of generality, from purely generic to the highly particular: a generic level; a partial level; and a particular level.

The CIMOSA life cycle phases guide the user through the three modelling levels: from the (1) Requirements Definition; through the (2) Design Specification; and finally to the (3) Implementation Description. This architecture includes an additional Model Maintenance task. This is a repeatable process, and may be triggered, for example, by change request events originated by customers, new technology, change in constraints, etc. Although the CIMOSA methodology does exclusively define the life cycle phases, it does not prescribe an order, thus allowing for top-down, bottom-up or iterative approaches.

On each of these levels the enterprise is analysed from different “Modelling Views”. After the modelling process is finished, the CIMOSA model of an enterprise can be released (Integration Process) for execution in the information systems environment.

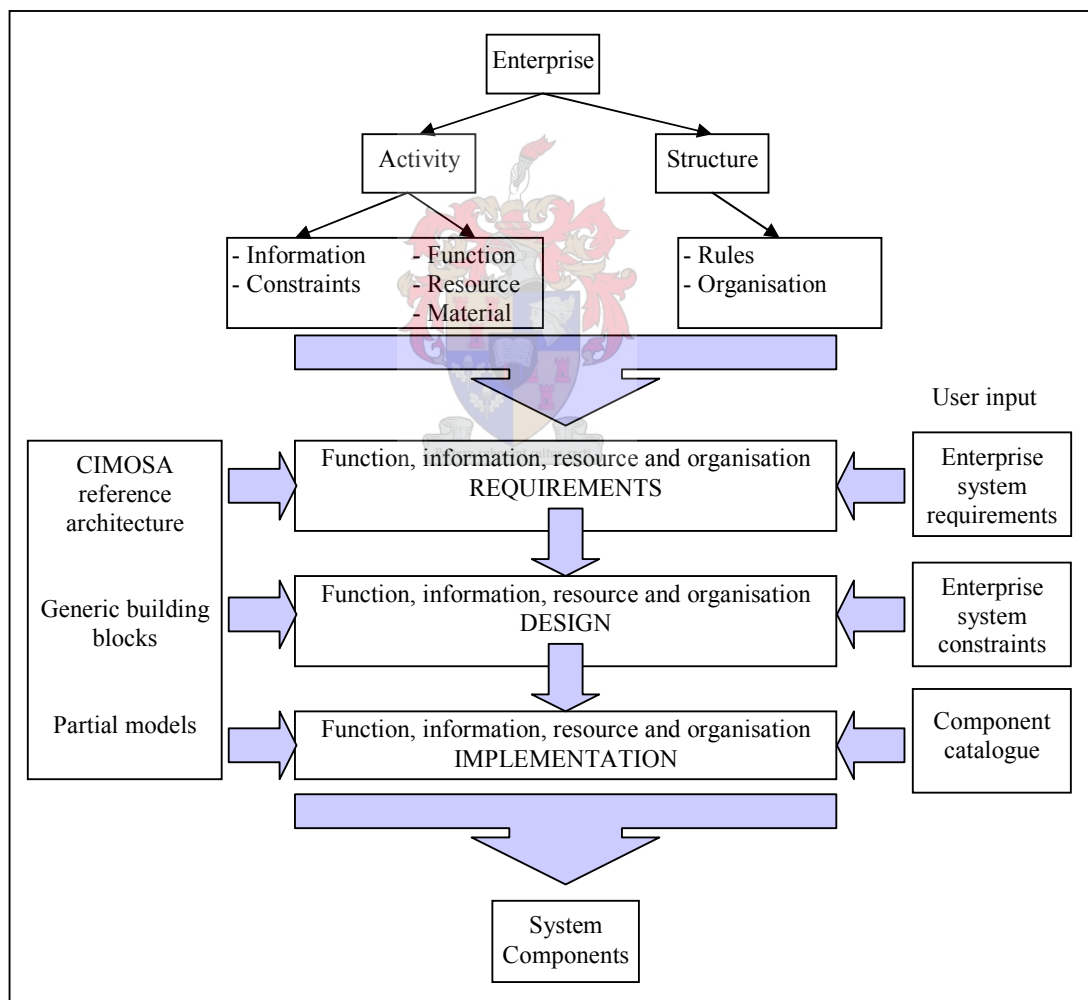


Figure 6.4 The CIMOSA life cycle phases

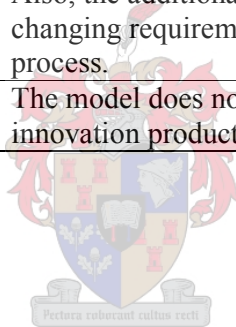
Source: www.pera.net

CIMOSA assumes that the need for change has already been identified and also that the decision has been taken to react to this need in a specific way. Therefore, CIMOSA centres round the gathering of the user requirements and the preliminary and detailed design life cycle phases, as shown in the life cycle coverage table in Table 6.2.

Table 6.2 The life cycle coverage of the CIMOSA model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	No	The need for change and requirements are already identified.
2. Feasibility	No	Feasibility studies are not executed as the response strategy, the to-be state, has been decided.
3. Innovation	Yes	With the requirements as inputs, an architecture model is created in the design phase.
4. Operation	Yes	The final detailed model is released for execution and implementation in the information systems environment. Also, the additional maintenance model is triggered by changing requirements and is, therefore, a repeatable process.
5. Disposal	No	The model does not give attention to the termination of an innovation product or process.

6.3.2 GRAI-GIM



In 1977, the GRAI method was published for the first time. The GRAI Integrated Methodology (GIM) was developed by the Laboratory for Automation and Production (LAP) at the University of Bordeaux (France) and has taken its current form since 1988.

The GRAI-GIM methodology includes:

1. The GRAI conceptual reference model.
2. The GRAI-GIM modelling framework.
3. The GRAI-GIM structural modelling method.

GRAI-GIM is a modelling methodology intended for general description, but focuses on details in manufacturing control system. The life cycle of the GRAI-GIM methodology has five phases: (1) Analysis, (2) Design, (3) Technical Design, (4) Development, and (5) Operation. Similar to the PERA architecture, GRAI-GIM includes specific life cycle diagrams.

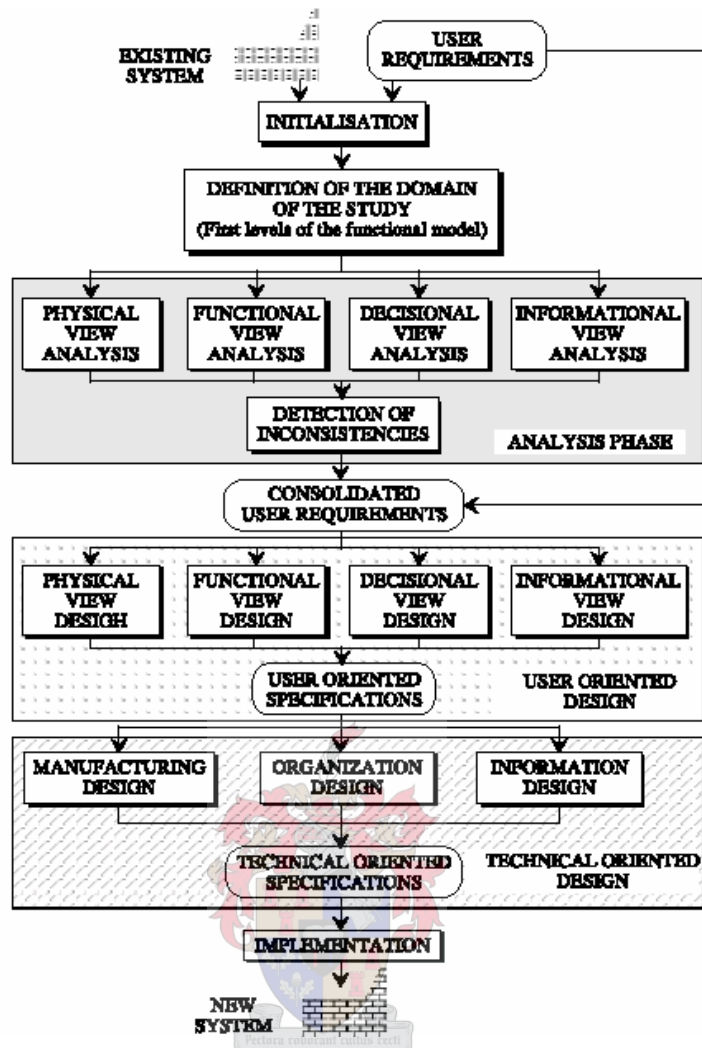


Figure 6.5 GIM structured approach

Source: (Nazzal 2004)

The GRAI Evolution Methodology (GEM) is used to model the continuous development of enterprises. It uses so-called NEXT-STEP phases in order to move from AS-IS states to the SHOULD-BE states. Each NEXT-STEP state that is reached becomes the current AS-IS state (Bernus et al. 2003, p.143).

As indicated in the following Table 6.3, the GRAI-GIM Structured Approach essentially supports the tasks involved in the user- and system requirements definition and preliminary design phases.

Table 6.3 The life cycle coverage of the GRAI-GIM model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Some	The need for change and requirements are already identified.
2. Feasibility	Yes	Detailed analyses from different views are included.
3. Innovation	Yes	The development of the user-orientated and technical-orientated designs enjoys much attention.
4. Operation	Yes	The operational issues are included in the implementation phase and, as this approach is used for the continuous development of the enterprise, the maintenance activities are also covered.
5. Disposal	No	The model does not give attention to the termination of an innovation product or process.

6.3.3 PERA

The Purdue Enterprise Reference Architecture (PERA) was developed at Purdue University. It was originally built for the field of computer-integrated manufacturing and other engineering applications.

Although initially only intended as a graphical guide to accompany the methodology, the PERA diagram also acts as reference architecture as it specifies each life cycle phase and the associated tasks. The PERA methodology, the Purdue Guide for Master Planning, supports this architecture. The Master Plan life cycle phases are shown graphically in Figure 6.6.

Much attention is given to defining the human role, while the main focus is on preparing the Master Plan. The Master Plan is the result of the Preliminary Design Phase.

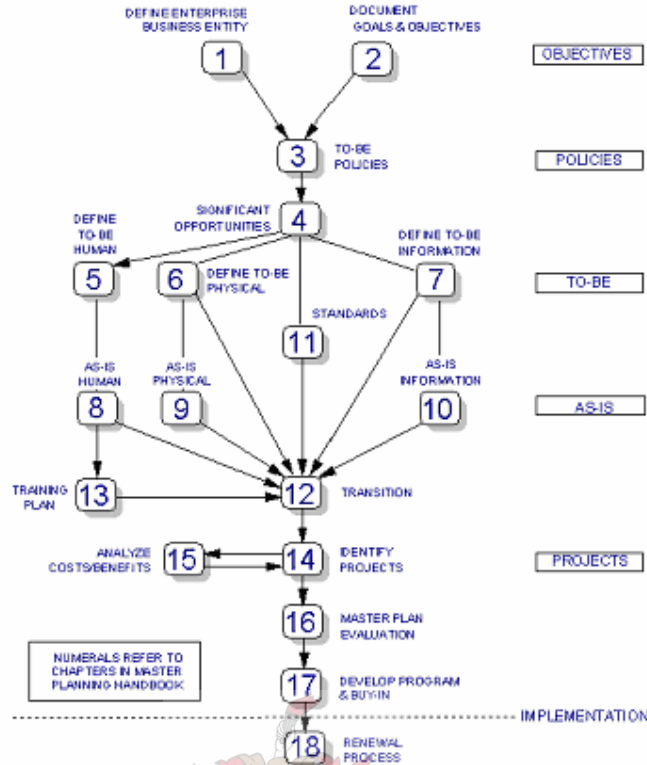


Figure 6.6 Enterprise master planning

Source: www.pera.net

According to the Handbook of Enterprise Architectures (Bernus et al. 2003, p.142), the Master Planning has several advantages:

- The cost of production of the Master Plan is small relative to the cost of detailed design and implementation;
- A Master Plan does not have to be implemented in one stage. Depending on the available capabilities, a Master Plan may form the basis of a strategic enterprise integration programme, implemented over a few years;
- The Master Plan defines sub-architectures of the entity in question, such as human-organisational architecture, the production and services delivery architecture, and the management information, communication and control system. These systems may be implemented by separate (and possibly parallel) projects, thus decreasing complexity. These separate projects would use domain specific methodologies.

The PERA model is a very comprehensive architecture and it covers almost all the phases of the enterprise life cycle, but - as can be seen in Table 6.4 - although it supports maintenance and renewal, attention is not given to the retirement of an innovation project.

Table 6.4 The life cycle coverage of the PERA model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Some	Opportunities are identified and from there to-be information is generated.
2. Feasibility	Yes	The transitions possibilities from as-is to to-be are investigated and cost benefit analyses are also performed.
3. Innovation	Yes	Innovation projects are defined and developed.
4. Operation	Yes	The PERA supports the implementation of the innovation project and an intended renewal process.
5. Disposal	No	The model does not give attention to the termination of an innovation product or process.

6.3.4 ARIS

Architecture for Information Systems (ARIS) is a framework concept, developed by Prof. August-Wilhelm Scheer, to describe companies and application software, while concentrating on the business processes. The focus of this framework is not on the execution of the business process, but on the analysis and definition phase during the design of managerial information systems.

The ARIS architecture contains four main architecture views, namely: Organisation View; Function View; Data View; and Control View.

The *Data View* describes what information is important, e.g. supplier, product, or material calculation information.

The *Function View* identifies which functions will be performed, e.g. production plan creation or order processing.

The *Organisation View* describes the organisational units involved, e.g. purchasing, sales, and accounts units.

The *Control View* depicts the relationship between data, functions and organisational units.

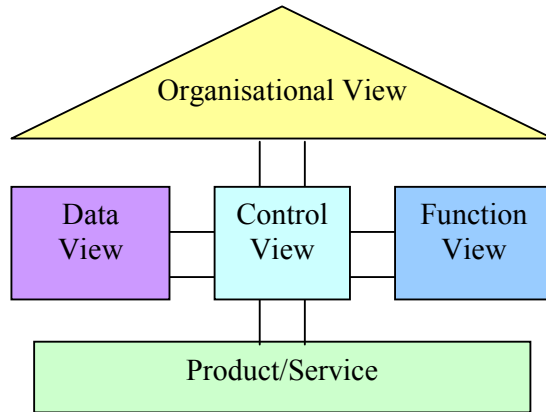


Figure 6.7 The ARIS architecture

Source: ARIS Framework Concept 2005

The modelling methodology covers entities identified within the ARIS views and some entities may be common to multiple views.

ARIS defines the concept of life cycle 'levels' or 'phases' explicitly, quite similar to those of CIMOSA. The ARIS life cycle phases are depicted in Figure 6.8 below.

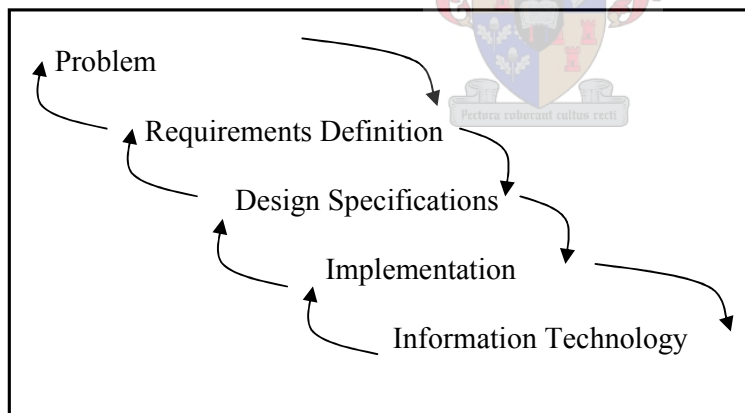


Figure 6.8 ARIS life cycle phase concept

The ARIS framework is widely applicable to large-scale industrial and business enterprises of all types, including discrete and process manufacturing, service industries, government and military. It is evident from Table 6.5 that the ARIS model mainly concentrates and supports the development (or innovation phase) of the enterprise innovation.

Table 6.5 The life cycle coverage of the ARIS model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	No	The need for change and requirements are already identified.
2. Feasibility	Some	Design specifications are generated.
3. Innovation	Yes	With the requirements as inputs design specifications are created in the design phase.
4. Operation	Some	This approach focuses on the design of managerial information systems and not on the execution, but in order to create this system, some attention is given to the planning of the implementation process.
5. Disposal	No	The model does not give attention to the termination of an innovation product or process.

6.3.5 The Zachman framework

Pinnacle Business Group (and its predecessor companies) invested over 15 years in developing the Zachman framework. The function of this model is three-fold and consists of a robust methodology, including tool support for doing the architecture planning (Row 1); business process engineering (Row 2); and application development (Rows 3, 4 and 5), as shown in Figure 6.9.

The Zachman framework aims to be generic and does, therefore, not prescribe any specific implementation- or modelling methodology. However, the Zachman enterprise architecture identifies two main phases of enterprise modelling:

1. Model the existing enterprise so as to improve existing operational processes; and
2. Change the enterprise using a generalisation of the models developed.



Figure 6.9 The Zachman framework methodology

Source: www.zifa.com

The Zachman framework is essentially a planning tool, and also has a history in the manufacturing environment. The Zachman framework takes a somewhat different approach towards life cycle, presenting life cycle phases as perspectives of various stakeholders involved in the enterprise engineering effort.

Table 6.6 The life cycle coverage of the Zachman framework

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	No	The need for change and requirements are already identified.
2. Feasibility	Some	The feasibility of concepts is evaluated through the execution of the planning and business re-engineering functions.
3. Innovation	Yes	Much attention is given to detail development and the modelling of the necessary improvements of existing operational processes.
4. Operation	Some	This model is mainly a planning tool, but operational issues are given attention to as the planned change of the enterprise is modelled.
5. Disposal	No	The model does not give attention to the termination of an innovation product or process.

The Zachman framework methodology mainly focuses on the development of the enterprise innovation, while some consideration is given to feasibility analyses and to operational planning – see Table 6.6.

6.3.6 The DoD architecture framework

The purpose of the DoDAF, formerly called the Command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) architecture framework, is to improve capabilities by enabling the synthesis of the Commands, Services, and Agencies, and enabling the efficient engineering of warrior systems. This framework provides the rules, guidance, and product descriptions for developing and presenting architecture descriptions that serve as a common ground for understanding, comparing, and integrating architectures.

Although the DoDAF does not include a dedicated life cycle concept, it does distinguish between the operational, systems, and technical views (see Figure 6.10).

The *operational architecture view* is a description of the tasks and activities, operational elements, and information flows required to accomplish or support an operation.

The *systems architecture view* is a description, including graphics of systems and interconnections, and may describe the internal construction and operations of particular systems within the architecture.

The *technical architecture view* is a set of rules that govern the arrangement, interaction, and interdependence of system parts or elements, in order to satisfy a specified set of requirements.

According to the handbook of Enterprise Architectures (Bernus et al. 2003, p.148), the guidance provided by DoDAF can be summarized in 6 steps:

1. Determine the intended use of the architecture
2. Determine scope of the architecture
3. Determine characteristics to be captured
4. Determine views/products to be built
5. Build the requisite products
6. Use architecture for intended purpose

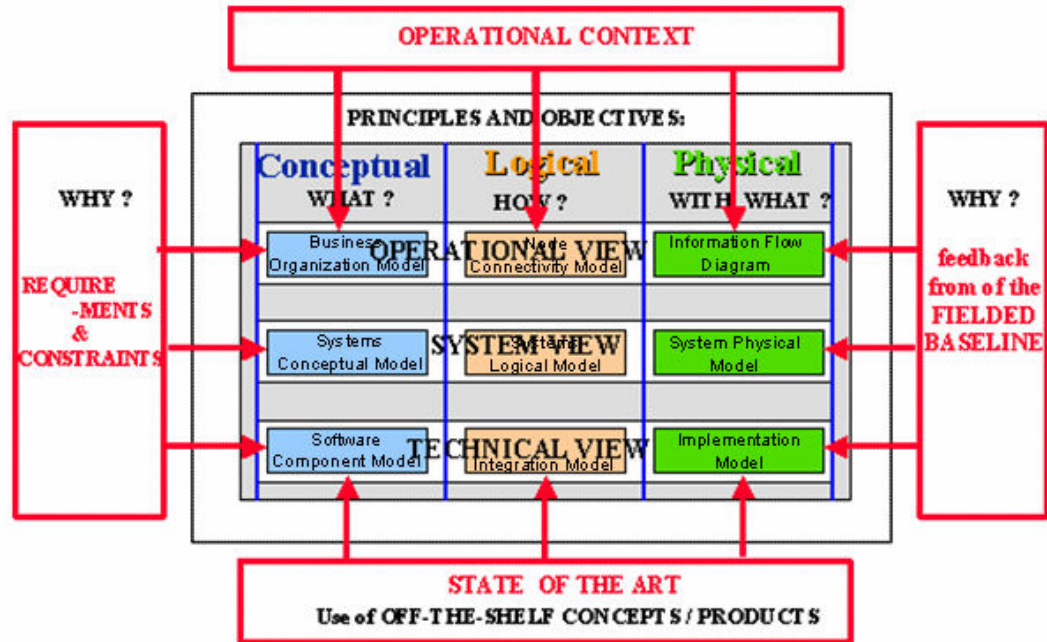


Figure 6.10 The DoD architecture framework

Source: (Schekkerman 2004)

The current trend is to document software architectures within the DoDAF framework by applying the standard unified modelling language (UML) notations. In the DoDAF methodology no attention is given to the aspect of the design of human tasks.

Table 6.7 The life cycle coverage of the DoDAF innovation model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	No	The need for change is already identified, but the conceptual views are modelled.
2. Feasibility	Yes	The operational-, systems- and architecture views provide constraints against which the characteristics and the scope of the conceptual products are measured in order to form logical models.
3. Innovation	Yes	According to the determined detail of the logical model, the required products are built.
4. Operation	Some	An implementation model is constructed to plan for the operational phase.
5. Disposal	No	The model does not give attention to the termination of an innovation product or process.

Although it has a history in defence, this framework is now an accepted positioning framework, used widely. As indicated in Table 6.7 above, this tool mainly supports the feasibility investigation and development life cycle phases.

6.4 Product innovation architectures

Most models that can be applied to product innovation are actually product development models. Therefore, a great many models have been created to support the development of products in numerous industries, with varying life cycle times, and at different levels of detail. It is evident from Figure 6.11 that most of the existing product innovation architectures focus on the areas of “feasibility” and “innovation” within the Innovation Landscape and that few models support the fuzzy front-end of the innovation cycle.

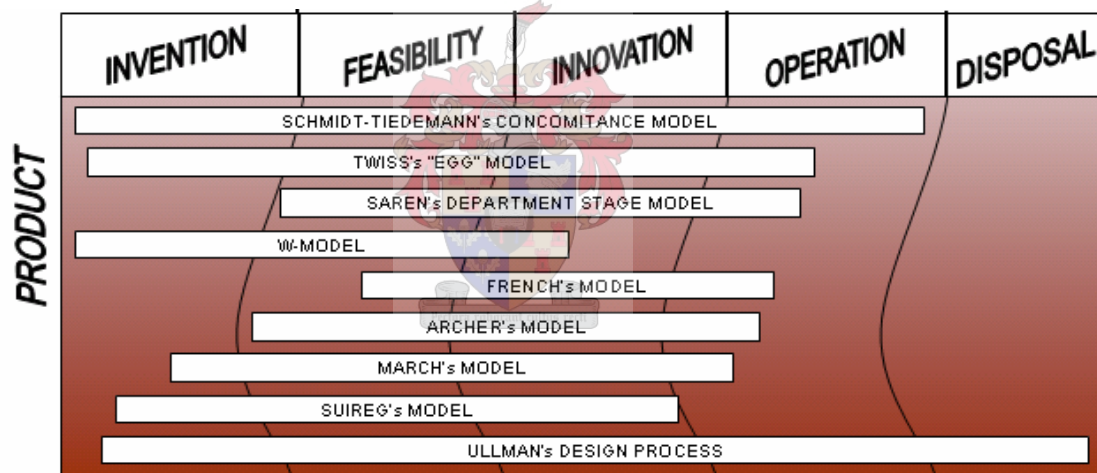


Figure 6.11 The Innovation Landscape: Product innovation architectures

The following paragraphs look at these product innovation models in more detail, focusing on the scope and applications of each model. The similarities and differences between the architectures different approaches for supporting product innovation are also explored.

6.4.1 Schmidt-Tiedemann's Concomitance model

Schmidt-Tiedemann, a practitioner in the management of the process of innovation, created this for use in the managerial planning process of an innovation project.

The Schmidt-Tiedemann's model divides the innovation activities into three functional areas, namely: (1) The research function; (2) the technical function; and (3) the commercial function. This so-called concomitance model derives its name from the fact that the three functions interact with one another throughout the life of the innovation process. The three functions are also treated as simultaneous activities.

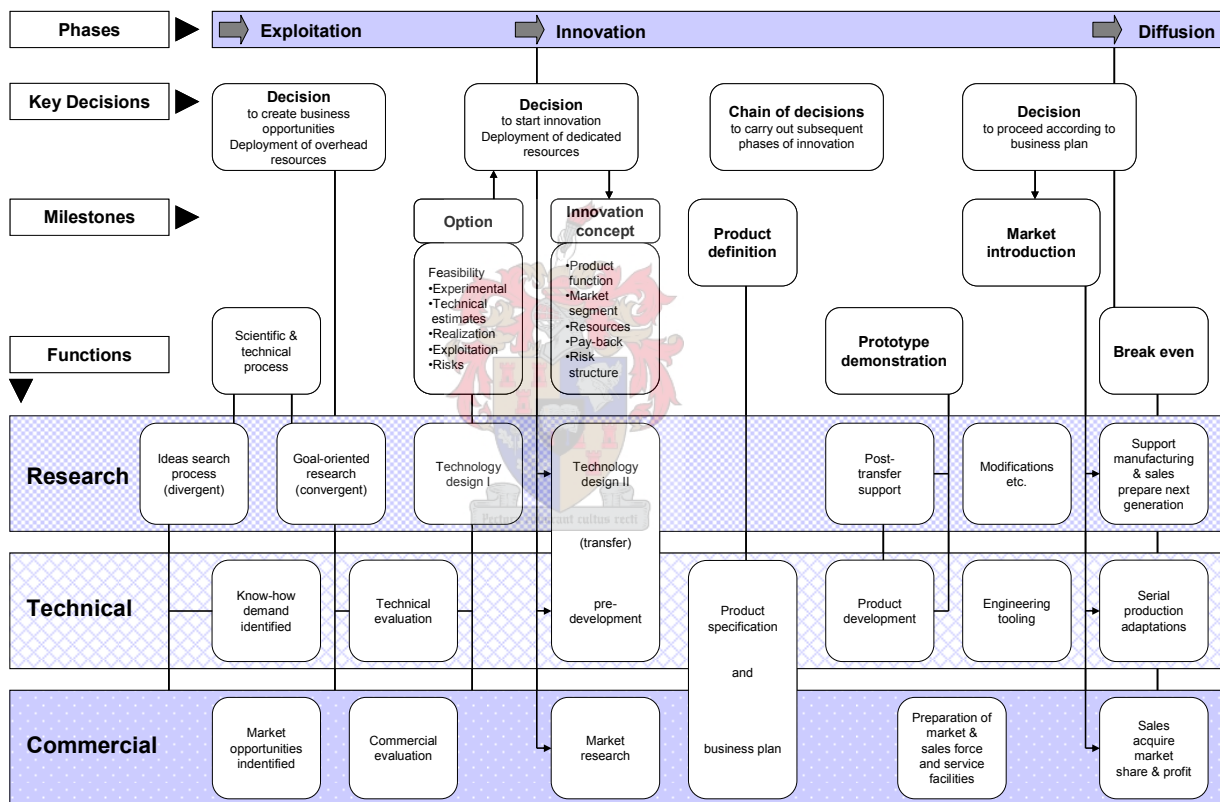


Figure 6.12 The Schmidt-Tiedemann's Concomitance model

Source: (Forrest 1991, 9.446)

As depicted in Figure 6.12, this model represents the innovation processes with three phases: exploitation, innovation, and diffusion, each with its own clearly identified key decisions, milestones, and feedback loops.

One of the important aspects of this model is its recognition of milestones, which are business-oriented rather than organisation-dependent parameters. Also, the model has important decision points where the process can be terminated if necessary. Throughout, the model feedback loops are present and link the research, technical and commercial functions (Forrest 1991, p.445).

As shown in Table 6.8, this model's level of detail and scope is extensive, but it does not take the influences of external environments (suppliers, customers etc.) into account. As the Schmidt-Tiedemann's concomitance model was created as a managerial innovation tool, it is a useful model for showing the processes and decisions carried out during the innovation process.

Table 6.8 The life cycle coverage of the Schmidt-Tiedemann's Concomitance model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Yes	Within the exploitation phase, ideas research is performed and opportunities are identified.
2. Feasibility	Yes	Technical and commercial evaluations are performed in the exploitation phase before the innovation phase commences.
3. Innovation	Yes	Ideas are grown into concepts and the chosen product is defined during the innovation phase, while involving the commercial, research and technical functions.
4. Operation	Yes	The product development, market introduction and serial manufacturing tasks are supported in this approach during the diffusion phase.
5. Disposal	No	The model does not give attention to the termination of an innovation product.

6.4.2 Twiss's Activity Stage model

Twiss developed a model, which includes alternative pathways and decision points, by evaluating several studies. It is clear from Figure 6.13 that there is an interaction between the internal and external environments. Knowledge is gained from the external environments and fed to the internal innovation process.

Twiss's activity stage model is not a highly detailed model and thus allows the user more flexibility. However, it also requires users to be more experienced when applying this model to an innovation project.

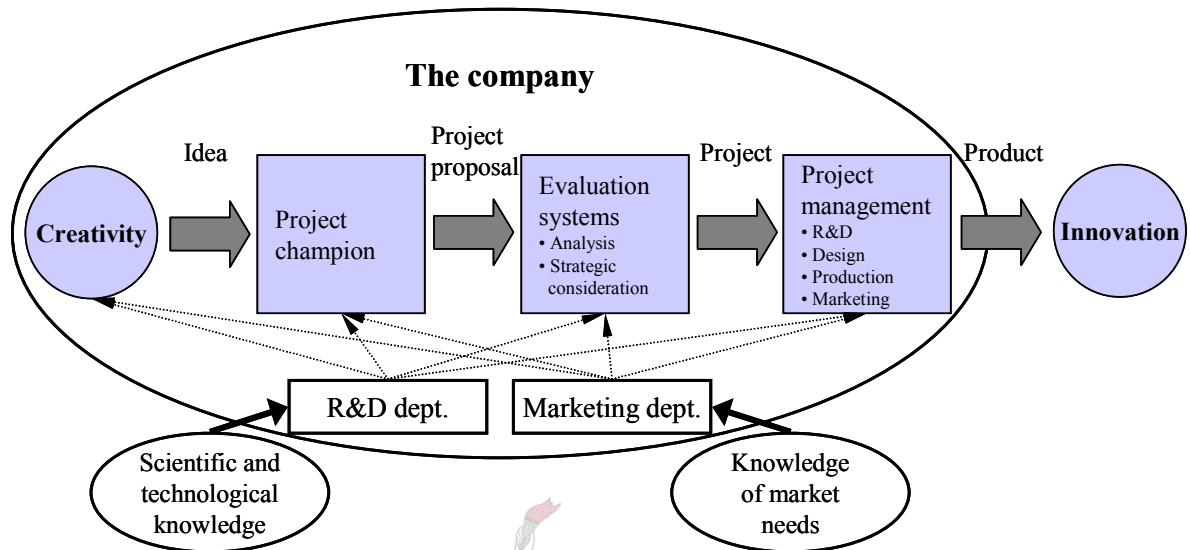


Figure 6.13 Twiss's Activity Stage model

Source: (Forrest 1991, p. 442)

This innovation model only fully supports the life cycle phases from invention to innovation, while giving some support to the operation phase (see Table 6.8).

Table 6.9 The life cycle coverage of Twiss's Activity Stage model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Yes	With technological and market knowledge as inputs, ideas are generated during the first phase of Twiss's model, namely the creativity phase.
2. Feasibility	Yes	The ideas are evaluated through various analyses, while taking strategic planning in consideration.
3. Innovation	Yes	The design and development of the selected idea is carried out as part of the project management phase.
4. Operation	Some	The project management phase also includes the production and marketing activities, but maintenance activities are not included.
5. Disposal	No	The model does not give attention to the termination of an innovation product.

6.4.3 Saren's Department Stage model

Another approach to modelling the innovation process is to describe the process in terms of the departments that are involved at each successive phase. Saren's model describes such a linear departmental stage model, and is also called a pipeline model.

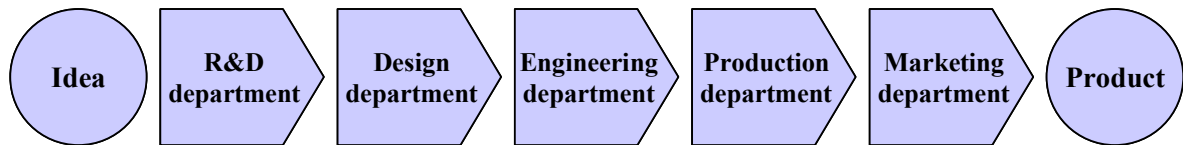


Figure 6.14 The Department Stage model

Source: (Forrest 1991, p.441)

This model portrays the various departments functioning in isolation, which is not a realistic situation. In practice, the activities are much more complex as departments continuously interact and many activities take place simultaneously. Also, Saren's department stage model is only a descriptive representation of the innovation activities, mainly focusing on the feasibility and innovation life cycle phases (see Table 6.10), and is not a tool for properly managing the innovation process.

Table 6.10 The life cycle coverage of Saren's model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	No	This approach is triggered by an idea, i.e. Saren's model assumes that the innovation idea is already defined.
2. Feasibility	Yes	For the purpose of analyses, research and testing, a research and development department are included in this approach.
3. Innovation	Yes	The development of the innovation idea is performed by the design and engineering departments.
4. Operation	Some	Saren's model includes production and marketing departments, but no separate maintenance department.
5. Disposal	No	The model does not give attention to the termination of an innovation product.

6.4.4 The W-Model

The W-Model was developed by the Fraunhofer IPT for technical product innovations. This model describes the process of product innovation in the following seven steps (see Figure 6.15):

1. Defining objectives;
2. Analysing future;
3. Generating ideas;
4. Valuing ideas;
5. Detailing ideas;
6. Valuing concepts; and
7. Transfer.

The seven different phases of the W-Model are divided into sub-steps (see Appendix A). In order to guide the user and enhance the effectiveness of this model, tools and techniques are associated with these sub-steps, with the goal of ensuring the systematic development of the necessary information. This required information that is generated at each sub-step throughout the progression of the project is vital in order to make the correct (informed) decisions, to move from one phase to the next, and ultimately to the final innovation product concept.

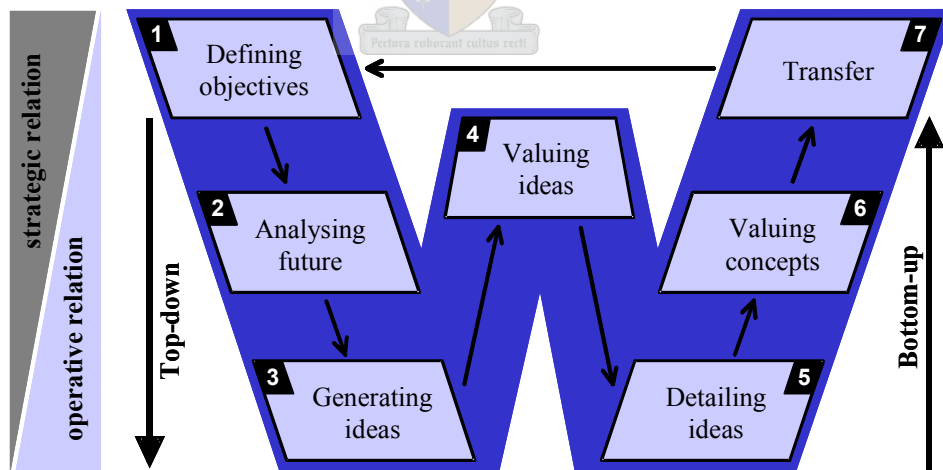


Figure 6.15 The W-Model

Source: (Baessler et al. 2002)

It can be seen from Figure 6.15 that the W-Model takes both the strategic issues and operational issues into consideration throughout the innovation process, thus ensuring that the innovation projects are aligned with the strategic goals and that they fall within the operational capabilities range.

The W-Model provides very good guidance for managing innovation in practice, because it guides the user through different phases, from invention to some degree of innovation (see Table 6.11). It also provides the innovator with activities associated with the mentioned phases and the necessary “toolkit”.

Table 6.11 The life cycle coverage of the W-Model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Yes	The activities of this life cycle phase are covered by the W-Model’s steps: 1. defining objectives; 2. analysing future; and 3. generating ideas.
2. Feasibility	Yes	Ideas are evaluated and tested for feasibility during step 4, namely valuing ideas. After detailing the second-generation ideas, the concepts are further analysed and evaluated in step 6, valuing concepts.
3. Innovation	Some	Some innovation activities are performed during the detailing of second-generation ideas, but the output of the W-Model is an Innovation Roadmap, which plots innovation projects on a timeline. The further development of each innovation project needs to be performed per innovation concept and according to the suggested timeline.
4. Operation	No	Although production capabilities and marketing aspects are analysed and captured during the execution of the W-Model steps, this approach does not support the production and maintenance phase, but provides some valuable guidelines for operational planning.
5. Disposal	No	The model does not give attention to the termination of an innovation product.

6.4.5 French's model

French described product innovation also in a linear model, but with feedback loops and in more detail than Saren's department stage model. As shown in Figure 6.16, this innovation architecture focuses on the design process of a product.

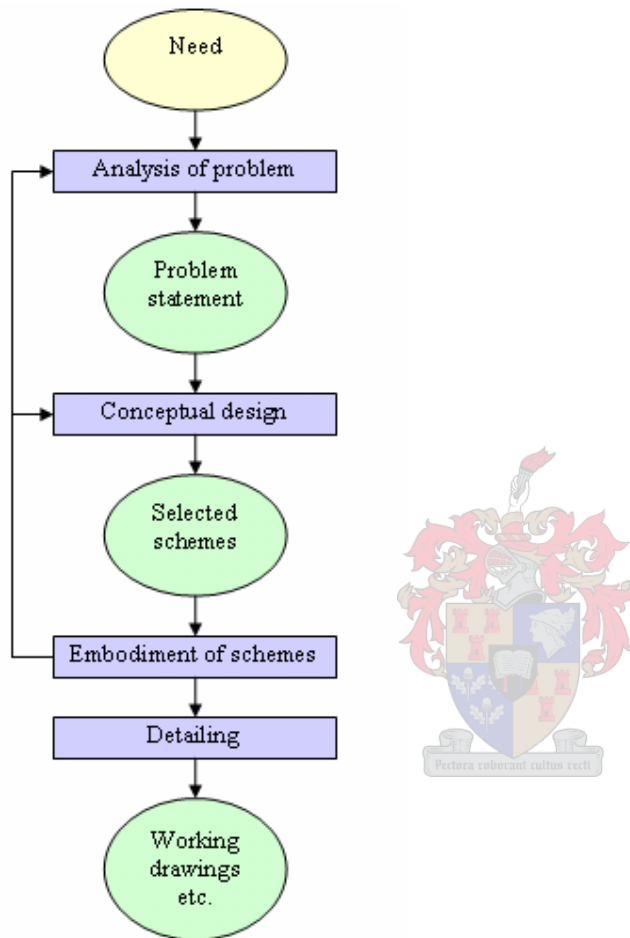


Figure 6.16 French's model

Source: (Cross 1994)

According to French's model, the product innovation process is triggered by an identified need. French's model consists of the following four functional phases:

1. Analysis of problem
2. Conceptual design
3. Embodiment of schemes
4. Detailing

This model depicts the functional phases and the required outputs of each stage. In Figure 6.16 the functional phases are indicated in blue and the required outputs are indicated in green. French's model therefore bears a close resemblance to the stage-gate concept, as a user cannot proceed from one stage to the next before the decision gate is satisfied (which, in this case, is a desired output).

As explained in Table 6.12 below, French's model supports product innovation during the feasibility, innovation, and operation phases – focusing on the innovation phase.

Table 6.12 The life cycle coverage of French's model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	No	It is assumed that the need has already been identified.
2. Feasibility	Some	Not much attention is given to feasibility studies, as the need and way forward are inputs for this approach. Some valuation takes place in selecting feasible conceptual designs.
3. Innovation	Yes	This approach mainly focuses on this area, and it is covered in two phases: the conceptual design phase and the detailing phase.
4. Operation	Some	Although French's approach does not support the full operation life cycle phase, the output of this model is detailed designs for production purposes.
5. Disposal	No	The model does not give attention to the termination of an innovation product.

6.4.6 Archer's model

Archer's model of the product design process, shown in Figure 6.17, consists of the following three broad phases:

1. Analytical phase;
2. Creative phase; and
3. Executive phase.

Each of these phases is further divided into activities, namely: Programming, Data collection, Analysis, Synthesis, Development, and Communication.

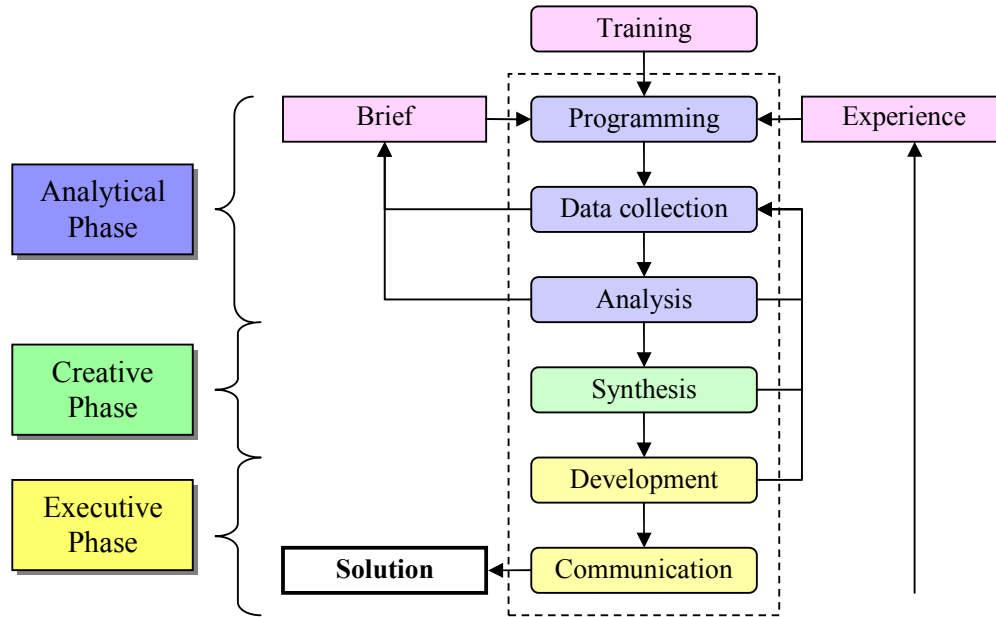


Figure 6.17 Archer's product innovation model

Source: (Cross 1994)

Archer's model includes various feedback loops that represent a much more real interpretation of the actual iterative nature of the design process than does French's model. As shown in Table 6.13, Archer's model primarily supports the feasibility and innovation life cycle phases, while it also acknowledges the role external factors, such as training, in the success of the final product.

Table 6.13 The life cycle coverage of Archer's model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	No	Attention is not given to idea-generation activities.
2. Feasibility	Yes	In the analytical phase, much attention is given to analyses and viability studies, taking external factors into consideration.
3. Innovation	Yes	In the creative phase the innovation product is designed using the outputs of the analytical phase as inputs.
4. Operation	Some	The development of the innovation product is supported and information from this process is fed back to earlier phases for continuous improvement. No attention is given to support further production actions.
5. Disposal	No	The model does not give attention to the termination of an innovation product.

6.4.7 March's model

The product innovation model of March is based on the following concepts:

- *abductive reasoning*: suggests that something may be;
- *deduction*: proves that something must be; and
- *induction*: that something actually is.

The Wikipedia (www.wikipedia.org) defines *abductive reasoning* as follows: "...the process of reasoning to the best explanations, i.e. it is the process that starts from a set of facts and derives their most likely explanations". Also, according to the Wikipedia (www.wikipedia.org) the difference between abduction and deduction is: "deduction is the process of deriving the consequences of what is known, whereas abduction works in reverse to deduction, in other words, abduction is the process of explaining what is known".

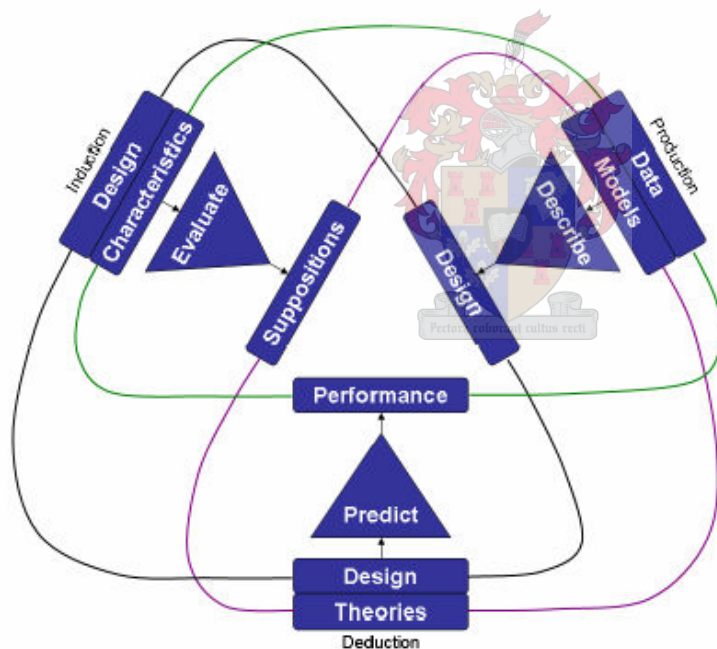


Figure 6.18 March's model of the design process

Source: (Cross 1994)

As reported by Cross (1994), during the synthesis activities in the design process, the designer uses abductive reasoning to create a design proposal. This proposal is then analysed using deductive reasoning to determine the performance characteristics of the design. The inductive

evaluation of the characteristics then leads to further refinements of the design, and the cycle is repeated. Figure 6.18 clearly illustrates the iterative nature of the design process.

This different approach to product innovation aims to support the feasibility and innovation life cycle phases fully, while also giving some attention to the invention and operation phases (see Table 6.14).

Table 6.14 The life cycle coverage of March's model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Some	Ideas are generated (using abductive reasoning) from available information, or a problem or need identified, and a design proposal is created.
2. Feasibility	Yes	Using deductive reasoning, the design proposal is evaluated and analysed.
3. Innovation	Yes	The outputs from the feasibility study are used to further define and develop the design proposal.
4. Operation	Some	The process does not support operational activities but it includes inductive reasoning analyses that are fed back into the process, creating a recurring process of product improvement.
5. Disposal	No	The model does not give attention to the termination of an innovation product.



6.4.8 Suireg's model of the design process

Suireg states that although the design process, “is not expected to have a rigid set of rules for a heuristic process, there are general guidelines which constitute the basic structure of the design activity” (Suireg 1981).

Figure 6.19 presents the structure of the design process as set out by Suireg. This is a very simple description of the product innovation process and mainly focuses on the design of the product.

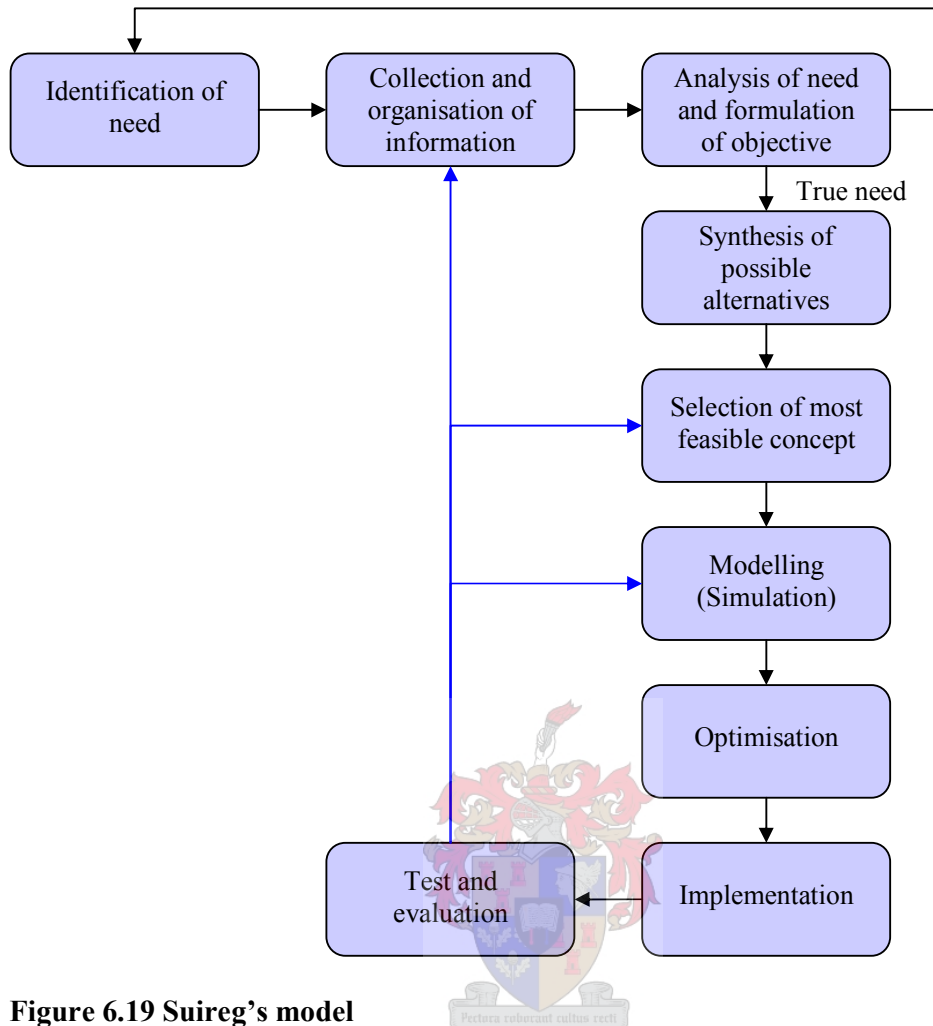


Figure 6.19 Suireg's model

Source: (Suireg 1981)

Suireg's model does not consider any external factors or the possibility of activities taking place simultaneously. However, if the results of the test and evaluation phase are not satisfactory, feedback loops (indicated in blue in Figure 6.19) allow the necessary information to be fed back into the process, thereby initiating multiple design iterations.

As described Table 6.15, Suireg's model assists product innovation from the beginning feasibility phase until the end of the development phase.

Table 6.15 The life cycle coverage of Suireg's innovation model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Yes	Possible ideas are generated from the identified true need.
2. Feasibility	Yes	The potential ideas are evaluated and the most feasible concept is chosen.
3. Innovation	Yes	The chosen concept is modelled and optimised and refined accordingly. The innovation product is then developed, and results from this implementation are repeatedly fed back into the design process, with the aim of creating the best final product to release to the production phase.
4. Operation	No	The process does not support operational activities.
5. Disposal	No	The model does not give attention to the termination of an innovation product.

6.4.9 Ullman's model of the development process

Ullman describes the engineering product development process as consisting of five phases, (see Figure 6.20):

1. In the first phase, the project team is assembled and the project is planned.
2. The second phase entails the generation of a product specification
3. The third phase is a typical conceptual design phase.
4. Ullman calls the fourth phase "product development" and it incorporates the embodiment and detail design stages of the other models.
5. The fifth and final phase concentrates on product support, in production, at the vendors and the customer.

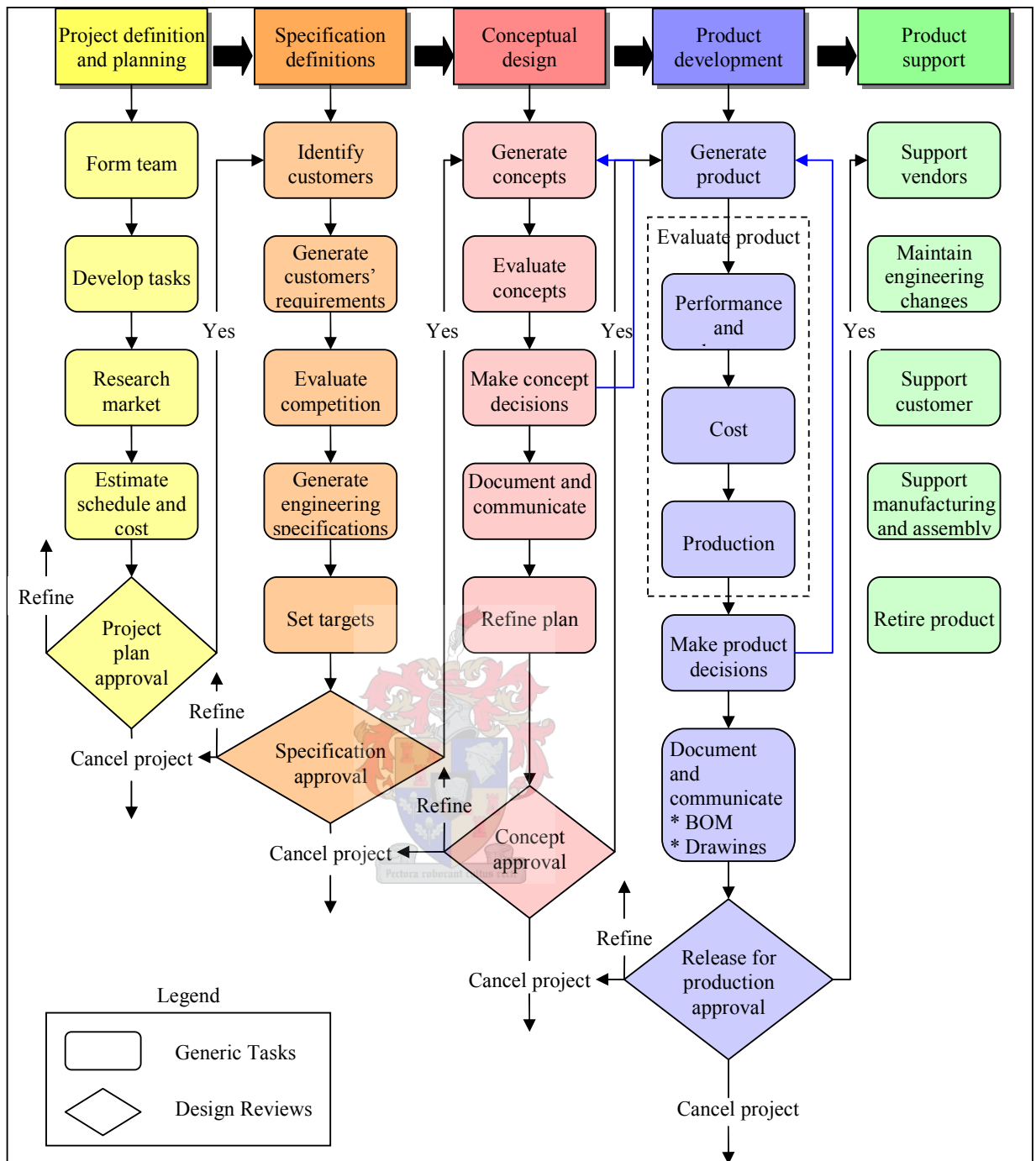


Figure 6.20 Ullman's design process

Source: (Ullman 2003)

Ullman's design process encompasses all activities from the project-planning phase to the actual product production phase and final retirement phase - in much detail (see Table 6.16 below). The scope of this model is therefore much greater than that of the preceding models.

Table 6.16 The life cycle coverage of Ullman's model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Yes	After the project plan and specifications are created and approved, the idea generation process takes place.
2. Feasibility	Yes	The concepts are evaluated and the decisions on the different concepts are documented.
3. Innovation	Yes	The concept evaluation documentation is the input for the further design and development of chosen concepts. The innovation products are developed, created and accompanying production drawings are also created.
4. Operation	Yes	The product production, maintenance and engineering changes are all supported by Ullman's design process.
5. Disposal	Yes	In this approach the final product support step is the support of the retirement of the product.

6.5 General models of innovation

The preceding two sub-sections (6.3 and 6.4) dealt with models for enterprise innovations and product innovations, respectively. The models discussed focus on a specific area in the bigger Innovation Landscape. They were created to fit a certain application and satisfy a recognized need. This section now moves on to look at three models that have a high level approach to innovation. These are general innovation models and they need to be adapted in order to accurately suit the type of project to which they are applied. These models may therefore be applied to enterprise and product innovation projects.

6.5.1 Utterback's three-stage model

Utterback describes the innovation process as a simple three-stage process. The three stages are: (1) Generation of an idea; (2) Problem solving or development; and (3) Implementation and diffusion.

Although Utterback treats innovation as a sequential-linear activity, attention is given to the activities involved within each of the three stages. This model also interacts with external environments.

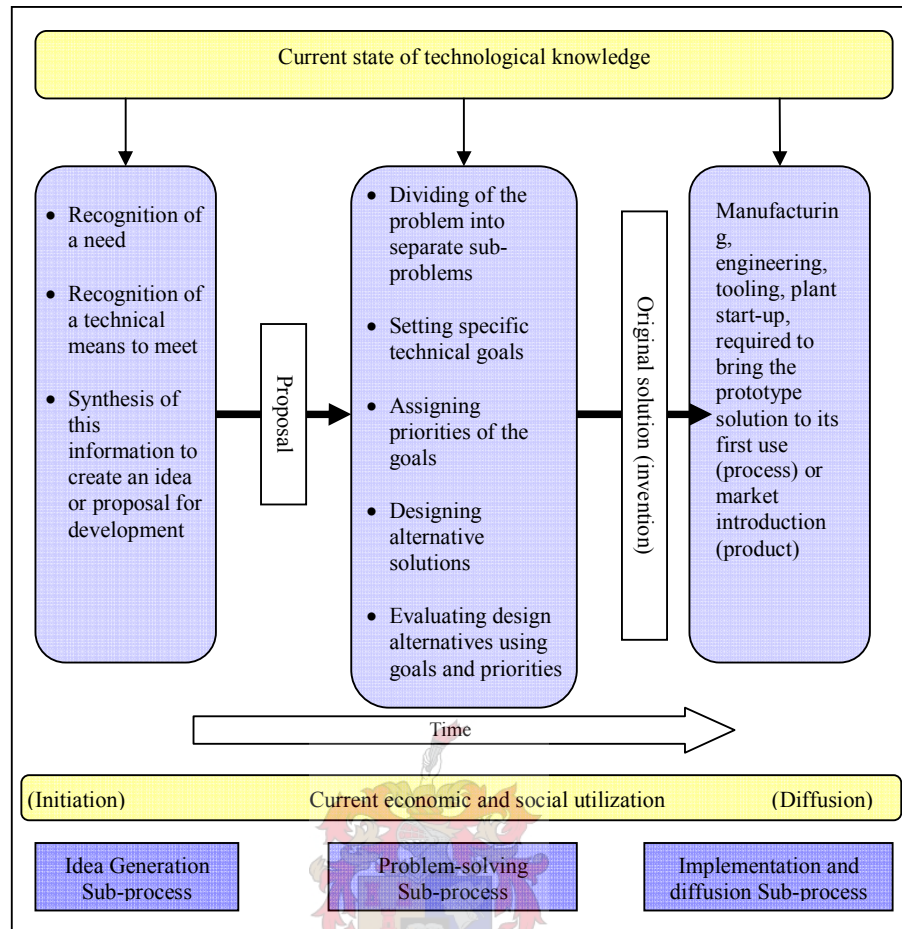


Figure 6.21 Utterback's three-stage model for innovation

Source: (Forrest 1991, p. 440)

Utterback's model is a basic model, which provides the building blocks for later models and is useful for providing an initial understanding of the innovation life cycle. As indicated in Table 6.17, Utterback's innovation model concentrates on the first three life cycle phases of the Innovation Landscape, namely: invention; feasibility; and innovation.

The next step, taken by other researchers, extends the model by adding the time- and the cost dimensions.

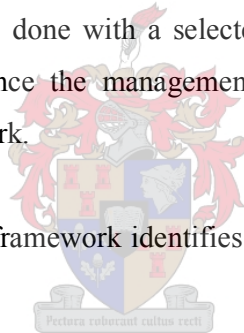
Table 6.17 The life cycle coverage of Utterback's model

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Yes	Ideas are generated and innovation alternatives are proposed.
2. Feasibility	Yes	The alternative concepts are evaluated against identified goals and priorities, and a final solution is chosen.
3. Innovation	Yes	The chosen concept is developed along with production plans and designs.
4. Operation	Some	This approach supports the operational process only until all the necessary processes are implemented, and the first product is produced and introduced to the market.
5. Disposal	No	Utterback's innovation model does not include the support of the retirement of the product.

6.5.2 The Improved Chiesa framework

The Chiesa model was created in order to develop a management framework for innovation, utilising the inputs of interviews done with a selected group of managers. The aim was to cover all the points that influence the management of innovation and capture it in one framework – the Chiesa framework.

As depicted in Figure 6.22, this framework identifies the three key elements of innovation as (Verhaeghe & Kifr 2002, p.411):



1. Inputs of innovation
2. The core process of innovation
3. Outputs of innovation.

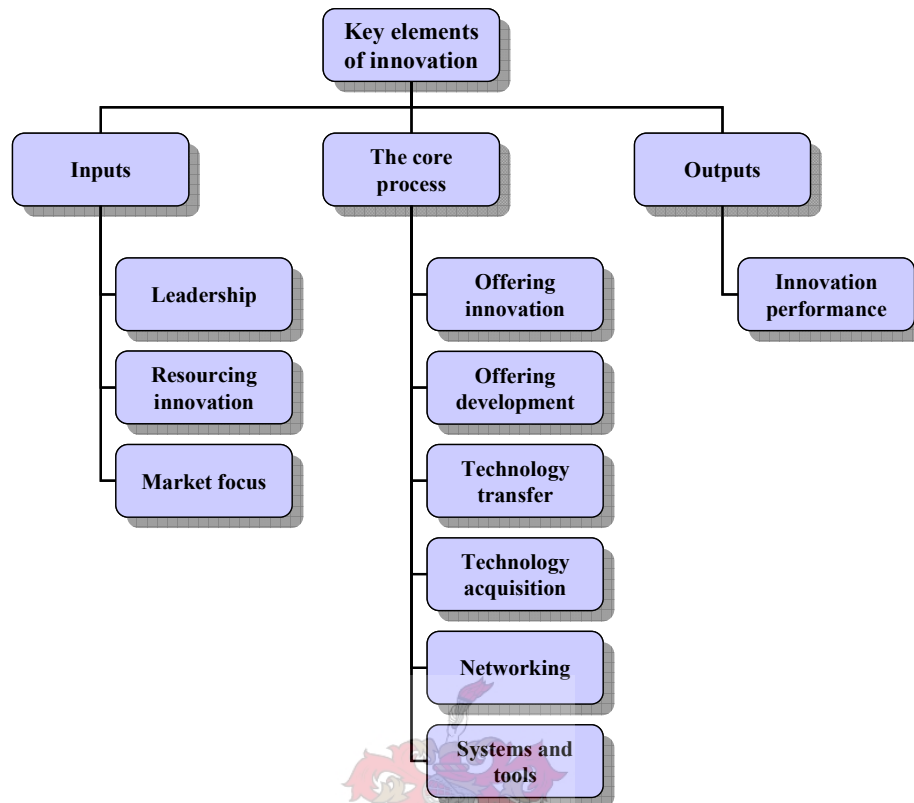


Figure 6.22 The Chiesa key elements of innovation

Source: (Verhaeghe & Kifr 2002, p.411)

Based on an audit of the initial Chiesa framework, new key elements were identified as drivers of innovation in the research organisation to improve the Chiesa model. The improved Chiesa model is shown in Figure 6.23 below. The three elements of the framework were subdivided into ten sub-elements. The input sub-elements are: leadership, resourcing innovation, and market focus. The core process of innovation is divided into the five topics of idea generation, technology acquisition, offering development, networking, and technology transfer. The outputs of innovation contain the innovation performance indicators.

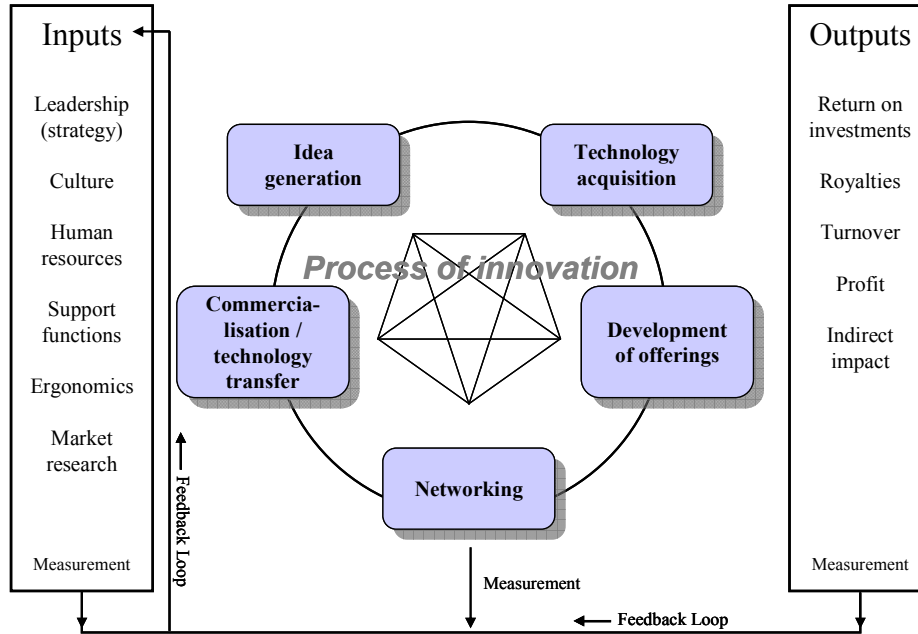


Figure 6.23 The Improved Chiesa framework

Source: (Verhaeghe & Kifr 2002, p.411)

The improved Chiesa framework for innovation is useful for the holistic management of innovation from the invention life cycle phase to some part of the operation phase (see Table 6.18). The model indicates that all the elements are interconnected and it also presents guidance as to which elements should be measured. However, although it does not depict the innovation life cycle phases, it remains an excellent basis for the building of more specific models.

Table 6.18 The life cycle coverage of the Improved Chiesa framework

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Yes	Idea generation is the first task in the Chiesa framework, generated by utilizing the external input elements.
2. Feasibility	Yes	The innovation ideas are measured against the capabilities, possibilities and accessibilities of the required technology.
3. Innovation	Yes	The feasible innovation offerings are developed.
4. Operation	Some	This approach supports the operational process only until the transfer of technology of the developed innovation offerings.
5. Disposal	No	The Chiesa framework does not cover the retirement of the innovation offering life cycle phase.

6.5.3 The Systems Engineering approach to the design process

In his book, Blanchard quotes the definition of systems engineering as follows:

An interdisciplinary approach encompassing the entire technical effort to evolve and verify an integrated and life cycle balanced set of system, people, product, and process solutions that satisfy customer needs.

System engineering encompasses:

- 1. the technical efforts related to development, manufacturing, verification, deployment, operations, support, disposal of, and user training for, system products and processes;*
- 2. the definition and management of the system configuration;*
- 3. the translation of the system definition into work breakdown structures; and*
- 4. the development of information for management decision making.*

(Blanchard & Frabrycky 2006, p.18)



The simple representation of the systems engineering model for the development process is shown in Figure 6.24 below.

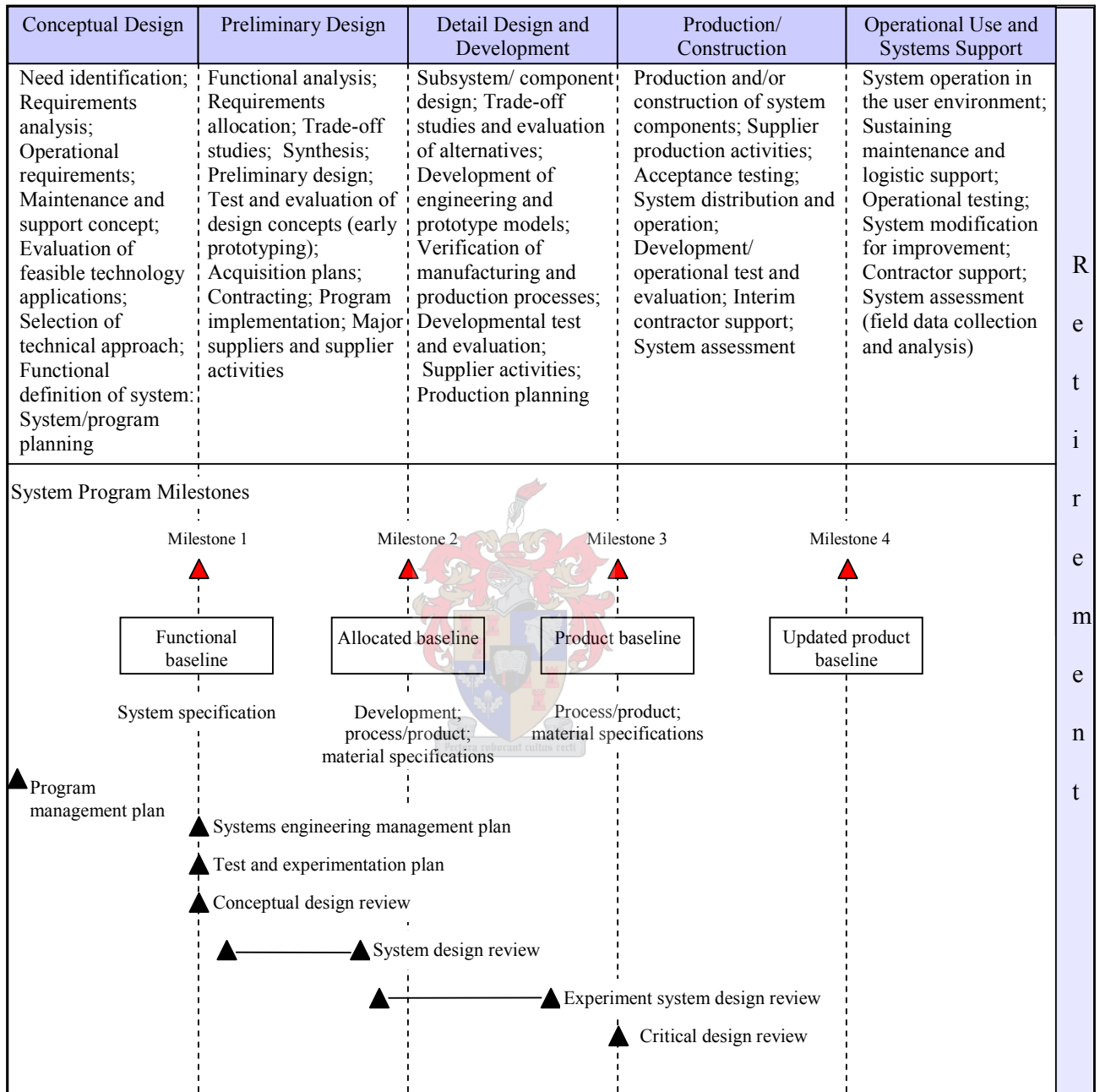


Figure 6.24 The Systems Engineering model

Source: (Blanchard & Frabrycky 2006, p. 31)

With the introduction of more and more complex products, such as automobiles, large ships for commercial and warfare purposes, commercial and military aeroplanes, to name a few, it

was realised that complex systems are more than the sum of their parts, i.e. local optimisation of the components and sub-systems does not provide optimised system.

Table 6.19 The life cycle coverage of the Systems Engineering innovation approach

Innovation life cycle phases	Life cycle coverage	Comment
1. Invention	Yes	Ideas are generated during the first phase of the Systems Engineering approach, i.e. the conceptual design phase.
2. Feasibility	Yes	Feasibility studies are performed after the preliminary design phase.
3. Innovation	Yes	The design and development of the innovation concept are covered in great detail in the Systems Engineering approach.
4. Operation	Yes	During the production construction phase, planning is carried out for the operational phase. The operational use and system support phase support the actual production and maintenance activities.
5. Disposal	Some	While the retirement of the innovation is indicated right at the end of the Systems Engineering life cycle, no detail or support are provided for the processes and activities involved with this phase.

The Systems Engineering approach is a highly detailed and structured approach and, as described in Table 6.19, involves all the processes from the problem formulation phase right up to the maintenance phase. Applying the complete model to a project may be too much detail for small smaller scale innovation project applications. Therefore, this model is best suited for very complex systems.

6.6 The whole Innovation Landscape

So far, many innovation models that vary in scope, application, function, and detail have been discussed in this Chapter. Now that a better understanding of each has been established, it is important to put these models into perspective. Many models have been created to fit a specific problem and it is therefore important to select the best-suited existing innovation model when applying it to a project. The full Innovation Landscape, see Figure 6.25, provides a bigger picture of the different areas focussed on by the various models focus.

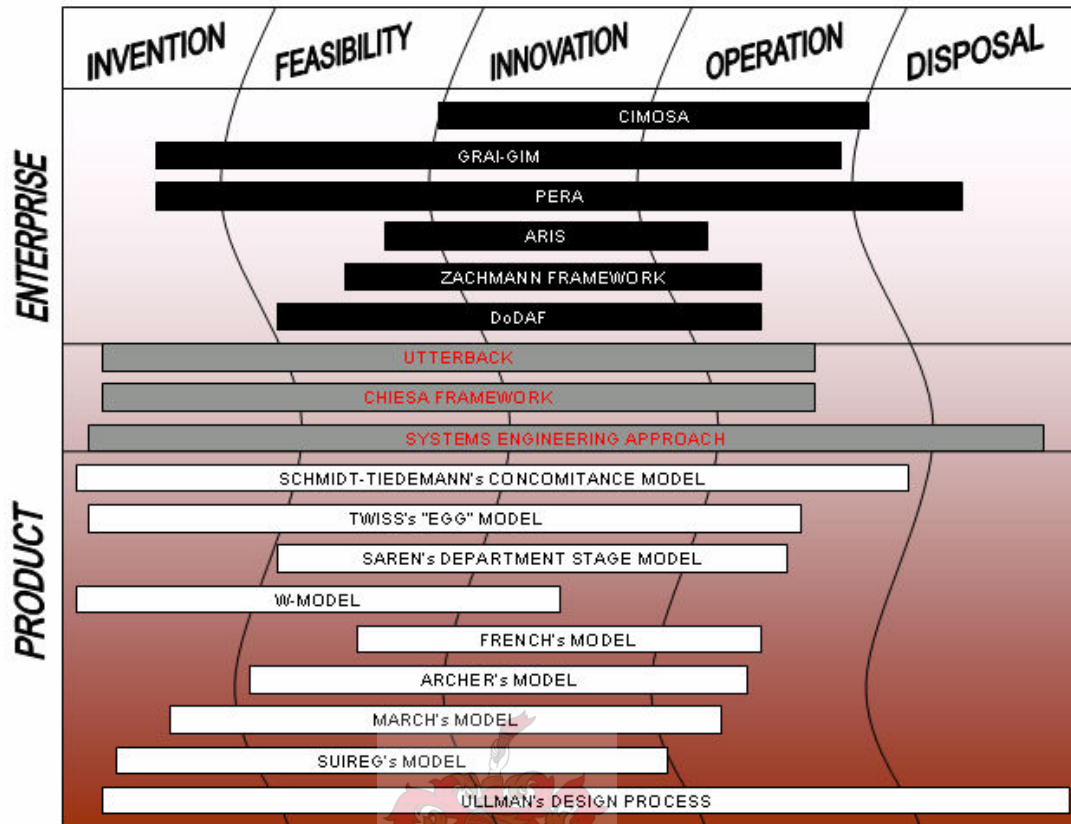


Figure 6.25 The full Innovation Landscape

The black blocks contain enterprise innovation models and the white blocks contain product innovation models. The grey blocks represent the innovation models that can be applied to both enterprise- and product innovation projects.

Figure 6.25 provides a user with information on the various models and also the innovation life cycle, so that innovation models can be compared and a user can then select the correct model to support his/her innovation project.

These models are all generic models and, in order to successfully support innovation, need to be tailored for each industry and more specifically for each company.

Now that the academic aspect of the identified industry problem has been studied and an academic solution has been formulated, this solution is applied to an industry example in Chapter 7 and the first half of Chapter 8.

As shown in Figure 6.26, the focus of this study now shifts from the academic arena to the arena of industry in order to critically evaluate the suggested academic solution. The next step in the thesis structure, Chapter 8.5, attempts to combine the academic and industry arenas by conducting a gap analysis of the academic solution applied to an industry problem.

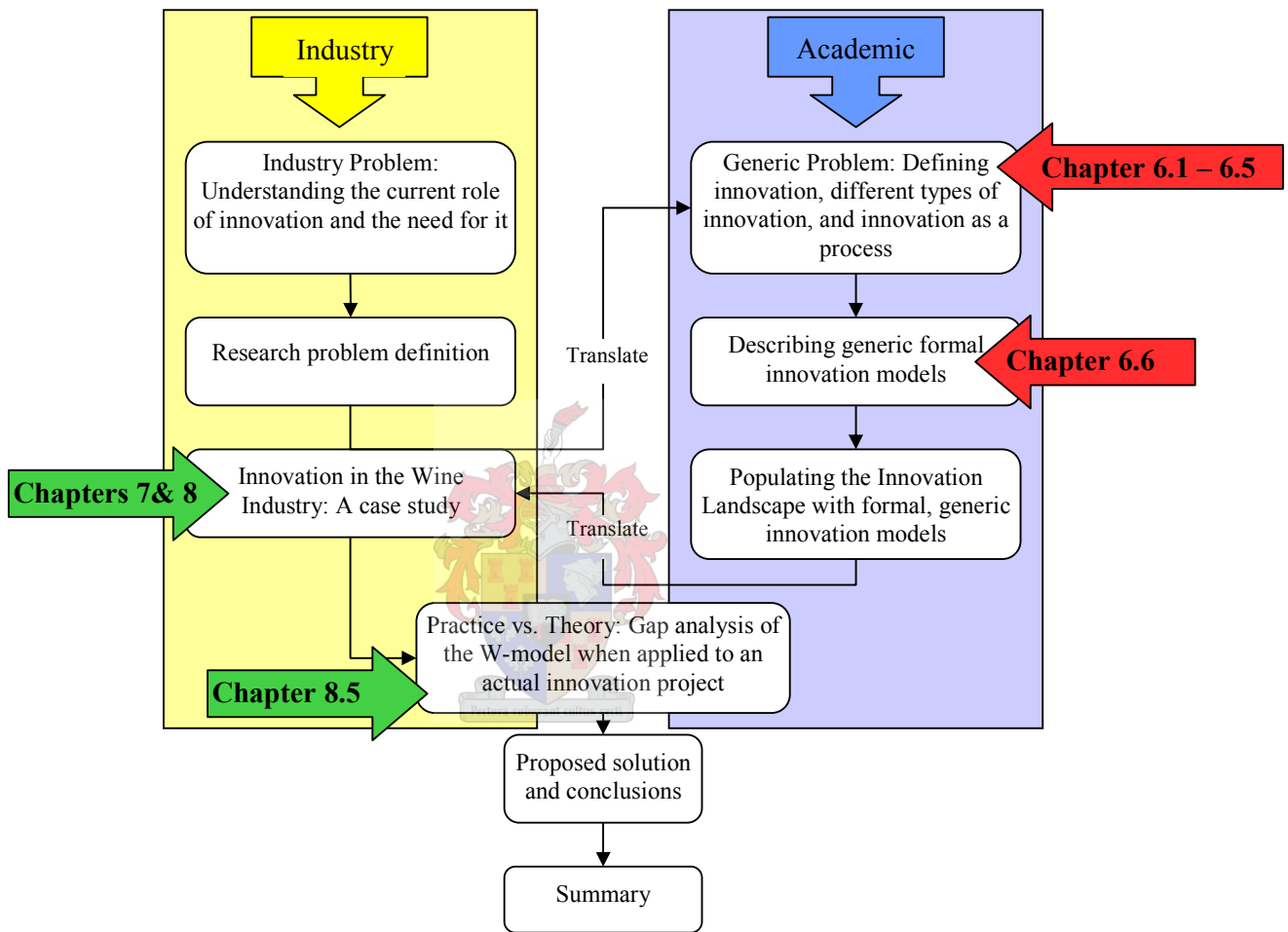


Figure 6.26 Thesis structure: From Chapter 6 to Chapters 7 & 8

Chapter 7

Innovation in Practice: The Wine Industry

7.1 Introduction

In the South African winelands, innovation is reshaping tradition and making its mark on the wine world. This reshaping was triggered when South Africa re-entered the international markets in the early 1990s, and has been accelerated by recent customer demands for New World wines.

In order to survive in the highly competitive national and international markets, role-players from right across the value chain - the marketers, distributors and representative bodies to the winemakers, growers, labourers and research institutions - are all spending time and money on creating “innovation-driven” and “market-directed” products and processes (Wood & Kaplan 2004).



7.2 The wine industry market situation

Looking at the current situation of the South African wine industry

Tregurtha (2004, p.2) sketches a concise picture of the South African wine market and its position in the international market:

South Africa is the world's tenth largest wine producer, accounting for 2.5% of global production. In 2003, the turnover of the industry was estimated at R10 675 million, of which more than one third was generated by export sales. In addition to this, the wine industry indirectly generated another R 4 198 million via tourism receipts. With respect to employment, the South African wine industry directly provides 108 000 jobs; 44 000 in primary agriculture, 21 000 in processing and 43 000 in the services sector

(wholesale, retail and transport). In 2003, State revenue from the industry via excise duties and VAT was R2 000 million". With respect to destination, South Africa's wine exports are heavily concentrated in the European Union, with the United Kingdom absorbing 44% of exports, followed by the Netherlands (18%) and Germany (8%).

In 2004 Deloitte & Touché launched a benchmarking survey of the South African wine industry as this industry was identified to have great room for improvement concerning worldwide competitiveness and high profitability. According to Deloitte:

"The South African wine industry is particularly complex, dealing not only with direct factors such as weather, disease, cost of importation of materials, seed and technology and quality control, but also with specifically South African requirements, such as transformation and BEE, globalization, AIDS and the introduction of global accounting standards, all in an increasingly competitive environment" (Global benchmarking survey launched in the South African wine industry 2004).

Although South African is still only a small role-player in the international scene, it has come far since 1994. There has been a significant shift away from quantity production, towards quality production. Emphasis is now also placed on targeting selected global niche markets with customer-specific products.

The future of the South African wine industry

In 2002 the SA Wine & Brandy Co (SAWB) was formed to drive the Vision 2020 strategy, a strategic plan for South Africa's wine industry that clearly outlines the development objectives. Planking (2003) states that:

"The strategy marks a decided shift away from the highly regulated, production-driven market of pre-1994 to a strongly market-focused one intent on ensuring that the local industry is globally competitive by 2020."

Customers' preference is increasingly shifting from traditional old world wines towards commercial new world wines. South Africa is trying to not just follow this trend, dominated

by the Californians and Australians, but to rather create a new niche market that lies between the old world wines and the easy-drinking new world wines.

As approximately 50 000 wine labels are produced annually worldwide, marketing and distribution are crucial in promoting that niche (Planting 2003). Wine-of-South Africa (Wosa) is an organisation dedicated to the promotion of SA wines abroad. Also, international exposure has had a remarkable influence on technical innovation in South Africa.

Innovation in the wine industry

Innovations in the wine industry include not only aspects of production, but also the increasingly important aspects of marketing and branding. Accordingly, Wood et al. (2004) state: “This is particularly important in view of the historical weakness of South African wine marketing by comparison with leading New World producers”.

Wine is an industry where radical innovation, either in terms of process or in terms of product, is limited. The key to success lies in understanding precisely what the intended consumer requires and aligning all innovation activities, whether it is production, distribution or marketing, to satisfy these requirements, and also staying on top of changing customer requirements. Innovation projects should therefore be aligned with customer needs and include all aspects of the operation. The ability to establish a close link between market and all the other stages would allow the producer to adopt a multi-dimensional view of innovation activity, one that includes viticulture, wine making, through to marketing, sales and distribution. Figure 7.1 describes some of the global impacts of innovations in the South African wine industry over the last 25 years.

The more successful established wineries have greater resources available for innovation and more capacity to utilise external consultants, particularly in defining product strategy. Consulting expertise was considered essential for providing the necessary confidence in their innovation investment.

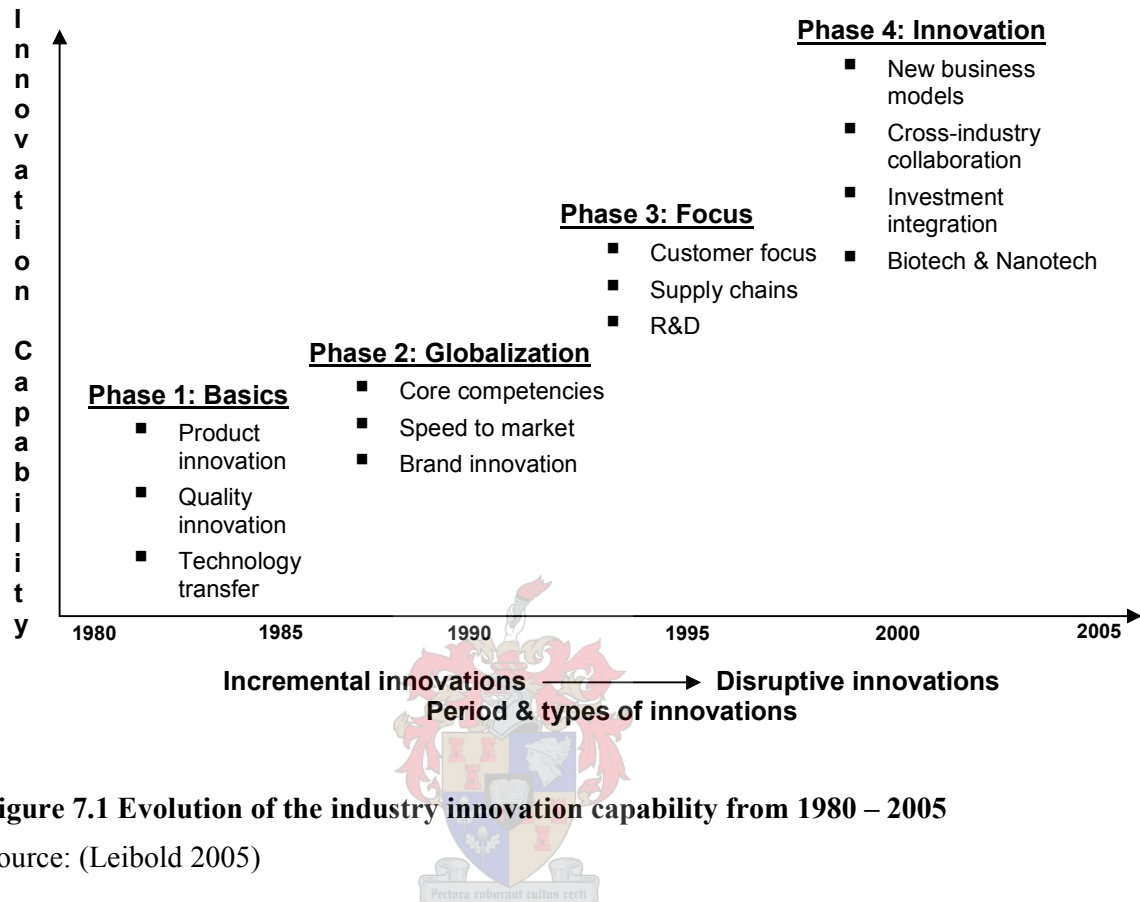


Figure 7.1 Evolution of the industry innovation capability from 1980 – 2005

Source: (Leibold 2005)

The new producers tend to be highly innovative, seeking creative solutions in the areas of both production and marketing. However, the new producers also face the problems of limited capital resources and brand weakness (Wood & Kaplan 2004). Michael van Wyk, Audit Partner at Deloitte in Cape Town, agrees by stating:

This problem is also exacerbated by the number of new local wineries coming into the market. It is especially these new wineries which will be facing an uphill battle over the next few years, competing with well established brands, while carrying the burden of heavy financing costs” (Challenges facing the wine industry 2005).

In pursuing leading-edge innovation the South African wine industry is now becoming a global, pro-active player.

Two examples of recent innovations in the South African wine industry are:

1. Self-adhesive labels, driving innovation from the market backwards into the industry value chain, for improved margins and profitability. According to Prof. Marius Leibold of the Stellenbosch University, the introduction of self-adhesive labelling has had an immense impact on the South African wine industry as this innovation holds great advantages when compared to the earlier glue-applied labelling.
2. GMO-biotechnology driving innovative rapid-response global “me-too-but-better” strategies (with GMO wine products and services), for competitive advantage.

From the preceding paragraphs, which give a brief overview of the current wine market, it is apparent that (as in almost any other industry) the South African wine industry is highly competitive and that it will not tolerate competitors who are reluctant to move with changing times and customer requests. The wine industry might not dominate the economy, but it does play an important role in the South African economy regarding employment, tourism and the GDP. The GDP/capital ratio of the wine industry is 46 percent, and this brings the “capital productivity” of the industry in line with the average for the economy as a whole, as the GDP/capital ratio for the total economy equals 47 percent (Tregurtha 2004, p.5).

Although the wine industry might traditionally not be seen as an industry that needs recurring innovations or as a front-runner of innovation activities, local and international role-players are now forced to innovate in order to survive. Throughout the value chain companies are trying to improve and re-invent their processes and products in order to beat the competition.

Innovations regarding wine labelling and the impact on the wine industry are discussed in more detail later, together with a case study that focuses on a specific wine labelling innovation. The purpose of this case study is to investigate the innovation process that was followed, and then to compare it with an established innovation model (in this case the W-Model) in order to determine the influence and role of an established innovation model in a real-life setting.

7.3 Collotype Labels and innovation in the wine industry

Paarl Labels was founded in 1999 and started out as a small self-adhesive wine-label printer. However, the demand for self-adhesive labels in the wine industry was underestimated and Paarl Labels soon became very successful.

As Paarl Labels' customer base grew, the company needed to grow their product range accordingly. Thus, in 2004, Paarl Labels became affiliated to the internationally acclaimed wine label specialists, Collotype Labels, and has been operating as a joint venture under the flag Collotype Paarl Labels ever since.

Collotype Labels is an Australian-based firm that opened their doors in 1903 as a small print shop. Today, this print shop has grown into the world's largest and most-awarded premium label printer, with locations in the finest wine-producing regions around the world.

Collotype Labels is dedicated to innovation and supplying their customers with leading-edge products. Collotype Labels have a comprehensive collection of successful innovations ranging from products with promotional-, cost-saving-, and security benefits. Some of these innovations are listed below:

- Collo Secure and DNA Smart Mark – Technology is built into the labels that protect brands by preventing forgery.
- Wine Find – A removable reminder labels that is incorporated into the back label.
- Sim Foil – A new foil-effect printing technique.
- Web Runner - Continuous self-adhesive web running labels that necessitate no roll changes.

Collotype Paarl Labels have had a big impact on innovations in the South African wine industry thus far. When looking at a collection of Prof Leibold's of the recent innovations in the South African wine labelling industry, Collotype Labels' contribution is remarkable (Leibold 2005). These include:

- Continuous self-adhesive web running;
- Digital printing systems;
- New papers, film, foil, etc. and printing techniques;

- Removable labels (tear-offs for re-order/reminder);
- Temperature indicator labels (thermal inks);
- Anti-counterfeiting labels (DNA and brand protection); and
- Radio frequency identification technology.

It is evident that innovation is part of Collotype Paarl Labels' culture and that the company not only recognizes the importance of innovations, but that it also exploits innovation opportunities to their own advantage.

The next chapter will discuss one of Collotype Labels' innovation projects, examining the innovation approach followed and comparing it with a suitable formal innovation model.



Chapter 8

A Product Innovation Case Study

8.1 Introduction

From the foregoing chapter it is clear that Collotype Paarl Labels is beating competition by staying innovative. Consequently, Collotype Paarl Labels supply products to customers in the wine industry that allows the wine producers to create more innovative end-products as well. In other words, many of Collotype Paarl Labels' innovations are not only innovations that affect the labelling industry alone, but also the whole wine industry.

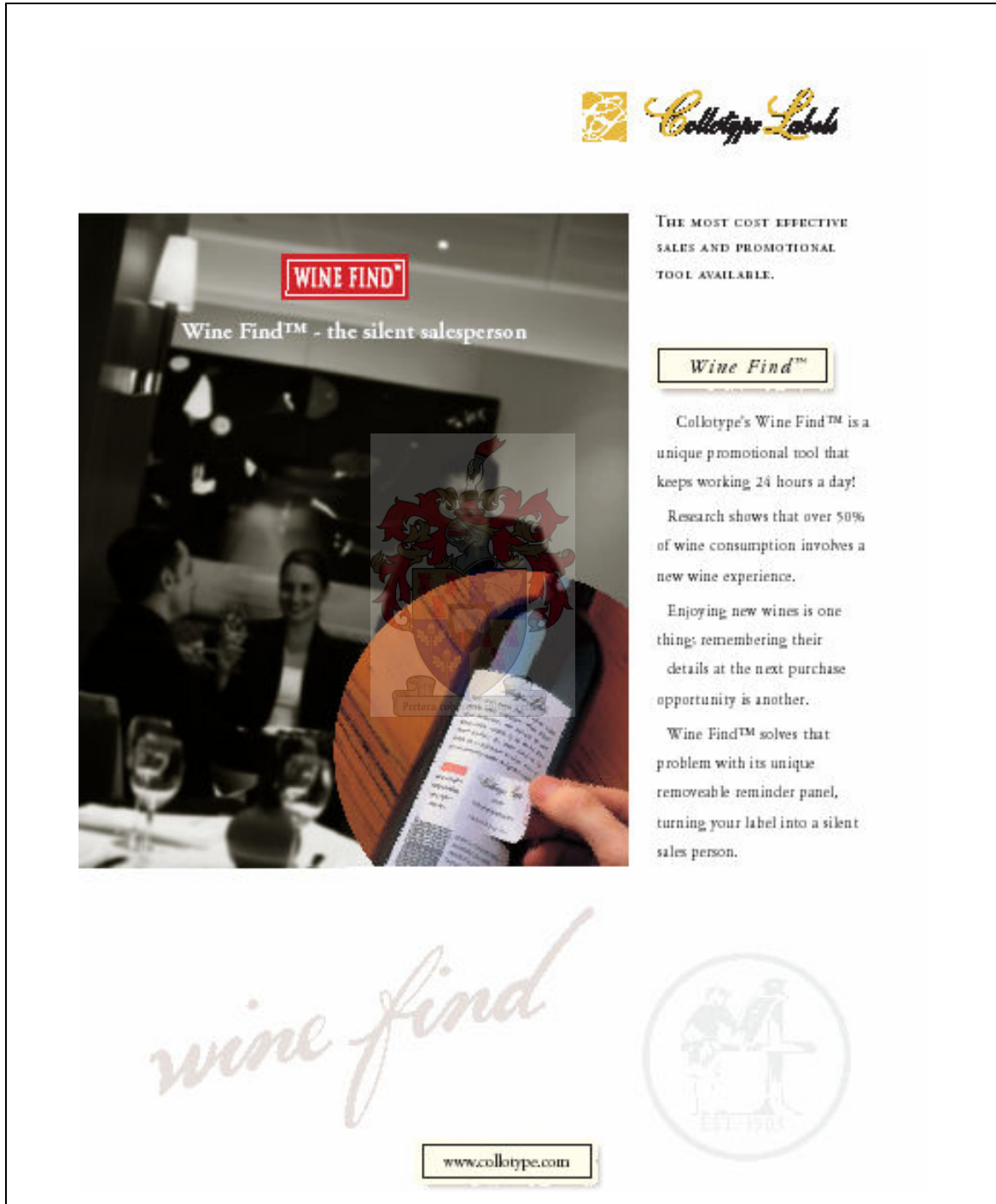
Chapter Eight now focuses on a recent innovation of Collotype Paarl Labels. First, the product is discussed. Then, the process that was followed in its innovation - from recognizing a market opportunity up to the final product concept - is explored. This is followed by the assessment of the applicability and possible impact of a previously discussed theoretical innovation model on this innovation project.

Finally, the goal of this case study is to determine how closely the theoretical innovation process and the real life innovation process are related, and how a formalized model would better support quicker and more successful innovation. A gap analysis is also executed with the aim of enhancing the specific formalized model used in the case study, so that it becomes even more useful.


8.2 The product: Collotype Labels' Wine Find™

Collotype's Wine Find™ is a peel-off label on the back wine bottle label. It forms part of the back label, but can easily be removed as it is perforated and the small peel-off label does not have an adhesive reverse side.

The peel-off label contains information about the specific wine, the winery and how it can be obtained. The information usually includes the wine cultivars, the harvest year, the winery's name and address, and its contact and sales details.







THE MOST COST EFFECTIVE
SALES AND PROMOTIONAL
TOOL AVAILABLE.

Wine Find™

ColloTYPE's Wine Find™ is a unique promotional tool that keeps working 24 hours a day!

Research shows that over 50% of wine consumption involves a new wine experience.

Enjoying new wines is one thing; remembering their details at the next purchase opportunity is another.

Wine Find™ solves that problem with its unique removable reminder panel, turning your label into a silent sales person.

wine find

www.colloTYPE.com



Figure 8.1 Wine Find™ advertorial

Collotype created the Wine Find™ for marketing and promotional purposes. As the sales information is stuck to the wine bottle, the Wine Find™ transforms a wine bottle label from a purely informative instrument into a sales tool as well. Figure 8.1 contains an example of the Wine Find™.

Now that the product has been discussed, the innovation process that led to the Wine Find™ will be investigated.

8.3 The process: An informal approach

Collotype Labels' R&D department is situated in Australia. Therefore, most of the innovation activities of the Wine Find™ project took place there. The Collotype Paarl Labels factory only became part of the innovation cycle after the commercialisation and innovation transfer of the Wine Find™ innovation took place.

The innovation life cycle time from commencement to the commercialisation of the Wine Find™ was approximately nine months.

The innovation process followed by the development team was an informal and responsive approach, stemming from the combined previous experiences of the team members.

The innovation process can be divided into seven main steps and contains feedback loops for continuous improvements and refinements. The seven steps are as follow:

1. *Identify the market opportunity*

A request came from a customer to have a removable reminder of the wine details.

2. *Brainstorming*

During the brainstorming sessions many packaging ideas within industries other than the wine industry were explored. Cost effectiveness was an important issue. The conclusion of the brainstorming was that a perforated/peel-off label was identified as the best concept.

3. *Agreement for exclusivity and commercialisation support with initial customer*

In order to start the development and experimentation of concepts, the initial customer was contacted to assist with the innovation activities. The initial customer carried the mutual costs of the trial and error processes and, in return, received six months' market exclusivity on the final product.

4. *Prototyping*

Prototype 1 – failed: adhesive issues

Prototype 2 – failed: shape issues

Prototype 3 – average: adhesive and shape issues were improved, perforation needed improvement

-
-
-
-
-
-

Continuous improvement/enhancement



Market research was carried out concurrently with prototyping activities



5. *Market research*

The development team determined that it was technically possible to produce the product concepts with existing equipment. The next logical step was to conduct market research in order to get closer to the customer, with the goal of matching the available technology with customer requirements/preferences.

A sample of 450 wine drinkers (people who drink at least one bottle of wine per week) was used for the market research survey. The two most significant results were as follows:

- 50% of the wines that the sample wine drinkers come in contact with are wines that they have not tasted before and are not familiar with.
- 75% of the times that wine drinkers come in contact with such “new” wines they can not remember what type and brand the wine was one day afterwards.

The market research also included the characterisation of the wine-drinking sample, according to the wine price categories and the requests of the different categories.

6. *Implementation of research feedback*

Feedback from the market contact resulted in improvements in the appearance, position and information of the peel-off label, and also other product- and service innovation ideas.

7. *Standardization of operational procedures*

Lastly, standard operational procedures were created. These include technical, design, and production manuals, accompanied by measurements and transfer-time framework details. Products are not released to the market if they do not measure up to the standards (such as, cost, quality, speed etc.) set out in the operating procedures.

This informal approach to the innovation Wine Find™ was an individual project, and although all innovations at Collotype Paarl Labels are developed using informal processes, they differ slightly according to the nature of the different projects.

8.4 Mapping the informal approach against the W-Model

Why the W-Model?

In Chapter Six various innovation models were discussed and mapped onto the bigger Innovation Landscape. It was also highlighted that different innovation models offer better or poorer support to different innovation projects, as each innovation model was developed for a certain industry, innovation area or project detail.

As the fuzzy front-end of innovation was identified as a problem area within innovation projects, this also thus the focus of the case study. As was determined and stated earlier in the foregoing chapters, there is no lack of ideas. Neither are companies unwilling to spend money on innovation projects, but companies do struggle, however, to choose the *best* innovation projects.

In order to create a true and thorough picture of the Innovation Landscape it was necessary to collect innovation models that support both product- and enterprise innovation, respectively. The focus of the case study is on innovation in the wine industry and, specifically, product innovation within the wine industry.

When looking at the populated Innovation Landscape, it is clear that the W-Model is the innovation model that fully supports this identified problem area. In Figure 8.2 the focus area of the case study is highlighted in blue and the W-Model is encircled in blue, showing its position relative to the whole Innovation Landscape.

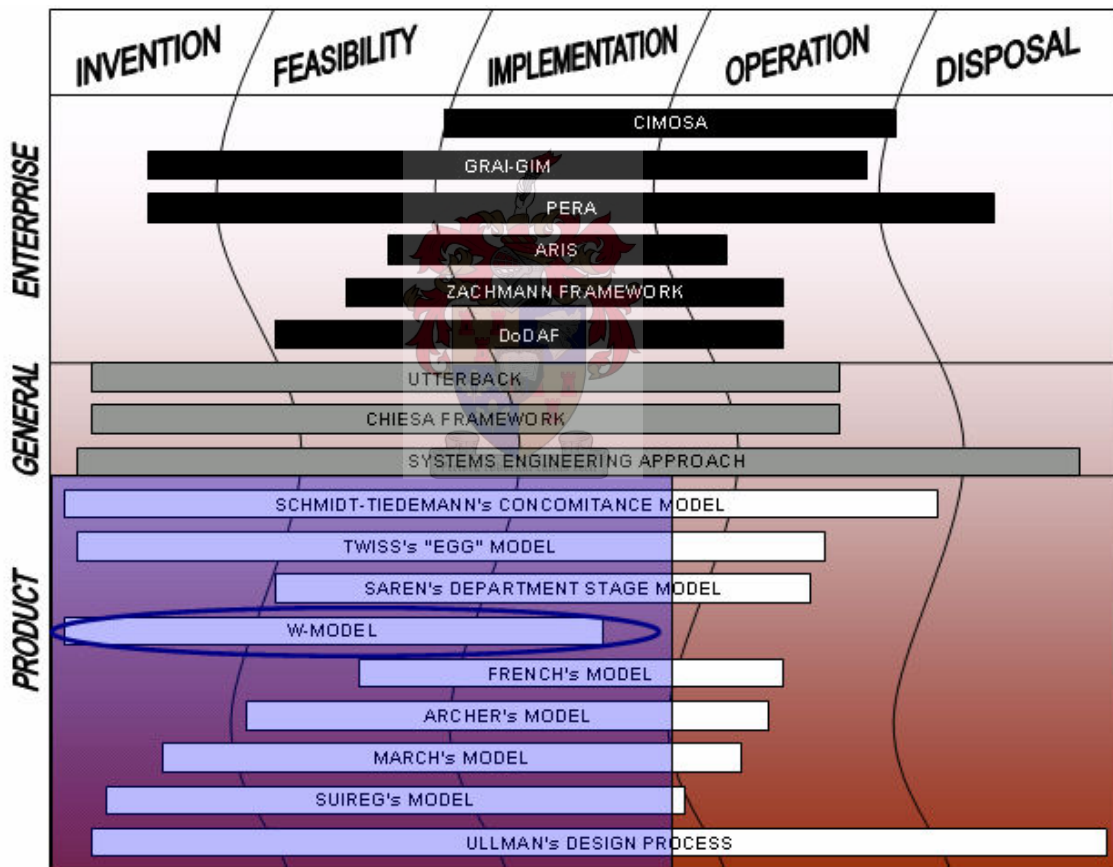


Figure 8.2 The focus area of the case study within the broader Innovation Landscape

Mapping the innovation approaches

For the case study application, the W-Model was chosen as the formal innovation model to apply to the development experience of the Wine Find™. The first step was to compare where

and to what extent the formal and informal approaches match. When putting the two different approaches to innovation next to one another, it is evident that, although companies might see theoretical models as too complicated and not in touch with reality, there are actually many areas in the two approaches that overlap. These are shown below in Figure 8.3, which illustrates which phases of the W-Model cover the same activities as the seven steps used by Collotype Labels.

The dotted lines indicate the steps of the informal model that are partially covered by the associated W-Model step. As can be seen from Figure 8.3, only the last steps of the two models are completely different and their function are also not contained in any other step of the opposing model.

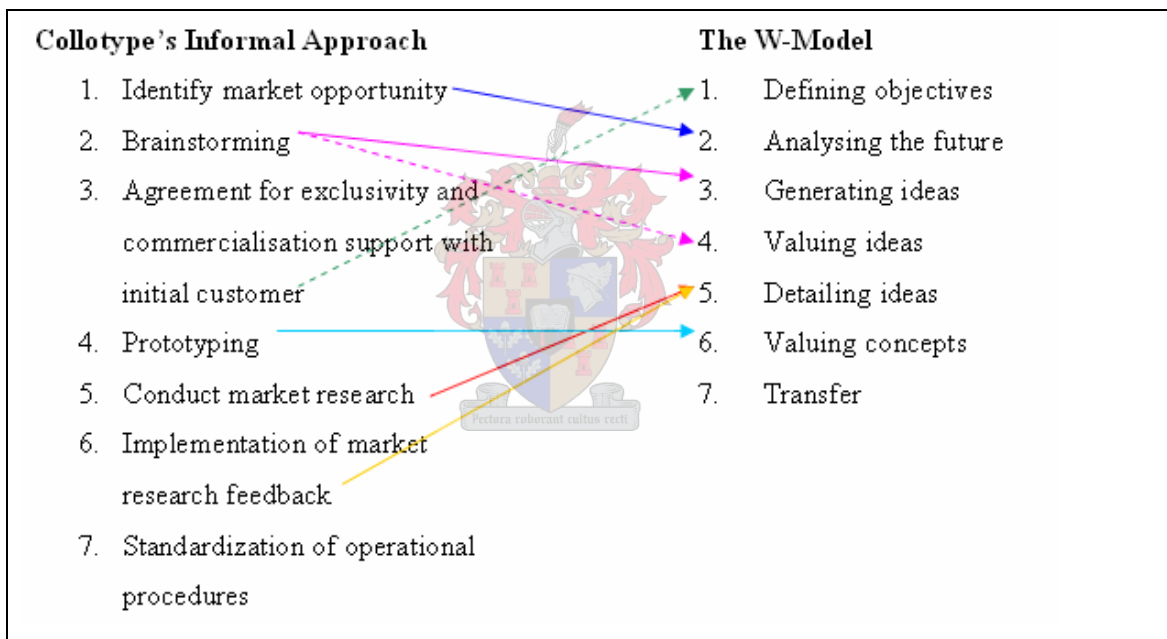


Figure 8.3 Matching Collotype's seven steps to the phases of the W-Model

The seventh step of Collotype's informal approach entails the planning and setting out of procedures, boundaries and measurements of the production of the innovation product, whereas the final step of the W-Model involves the classifying of the innovation concept into to-be-revised-, immediate-, and longer-term innovation project categories and the plotting of the projects on a timeline. In order to classify the innovation concepts and choose the correct innovation projects, information regarding the economical and technical feasibilities has to be investigated. In order for an innovator to be able to make strategic decisions on the timeline of

innovation projects, operational information must have already been generated, studied and captured in the preceding steps.

Following the line of reasoning in the above paragraph, it can be stated that the last step of Collotype's 7 steps is completely focused on the operational issues of the innovation project, contrasting with the final step of the W-Model, which relates to strategic relations.

Comparing these two approaches to innovation from another viewpoint, it is clear that the W-Model phases with a high operational relation have much more in common with the informal approach steps than those phases of a strategic nature. This comparison is depicted in Figure 8.4: where the yellow highlighting indicates areas of little similarity; the orange highlighting medium similarity; the red highlighting a great likeness between the two approaches; and the blue block indicates no similarities.

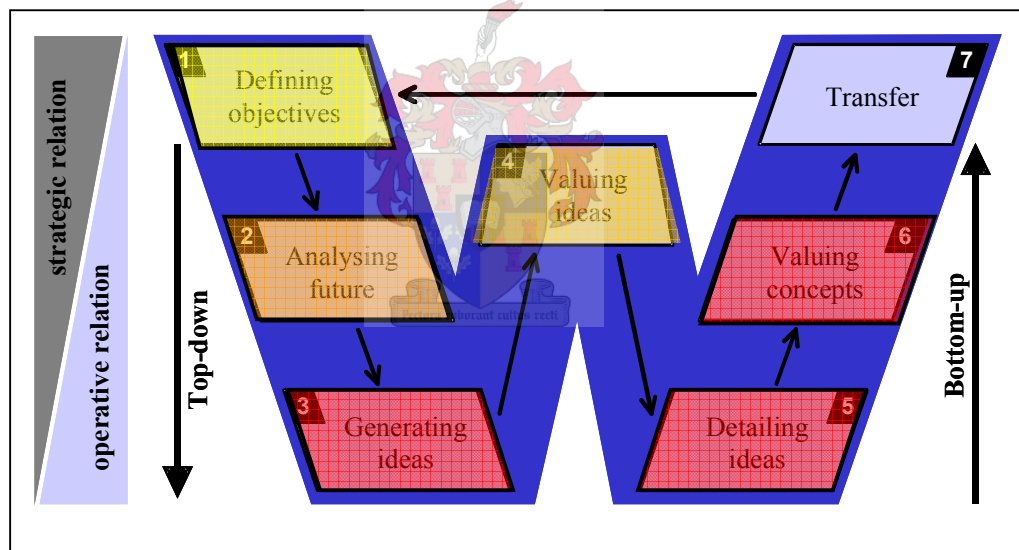


Figure 8.4 Comparison of the degree of the relation between the informal and formal innovation processes

Although the W-Model fully supports three phases of the informal Collotype approach, this does not imply that The W-Model does *not* support, or sufficiently support, the informal approach. Steps 1, 2 and 4 of the W-Model actually contain much more information acquisition activities and analyses than Collotype included in their similar steps. But, because the W-Model is a *formal* innovation model, and was specifically created for product

innovation, but has not been fine-tuned for this *exact* application, it includes more issues that *could have* an influence on the choice and development of a generic innovation product.

The informal approach is a much leaner approach than the W-Model as it is shaped for this specific application. However, because it was developed from prior experience, the risk exists that the innovator would not know what aspects were not properly considered until those features create problems. Should this happen, this informal innovation approach would then become more re-active in nature.

In the foregoing chapters, the advantages and positive impacts of formal innovation models on a company's innovation activities have already been discussed, and it is clear from the mapping of the two innovation approaches against each other, that the W-Model could indeed have been applied to the Wine Find™ innovation project. A closer look shows that, more specifically, if the W-Model had been used instead of an informal innovation process, it would have provided the development team with the following advantages:

- Extensive tools and techniques, e.g. creativity techniques; the portfolio analysis; the TRIZ method; the QDF method; the value benefit analysis etc., for the performing of each sub-step.
- Clear descriptions of the necessary inputs and outputs at each of the seven phases.
- A step-by-step procedure of choosing and developing the best innovation product, as the W-Model is a *pro-active* approach to product innovation, specifically designed to assist an innovator.
- Useful information would have been generated and captured, both for the current innovation project and for comparable future projects, when the innovator progressed through the seven phases of the W-Model.
- A common “language”, a unified goal and processes to obtain the goal would have been created, as the W-Model is a *formal* innovation guide when used by a group of people participating in an innovation project.
- It would have been clear how and where specific information was generated and captured, and what decisions were made. Using the W-Model would have resulted in improved knowledge sharing between team members.

The most important aim of the case study was to determine whether a formal innovation model (and more specifically the W-Model) could support actual innovation projects such as Collotype Paarl Label's Wine Find™ innovation. The foregoing discussion argued that the case study provides evidence to the effect that this is indeed the case, and that the W-Model could have supported the innovation activities of the development of Wine Find™ properly and with added benefits.

Now that the two approaches to innovation have been compared, a gap analysis will be performed.

8.5 Gap analysis: theory vs. practice

As mentioned above, the second object of the case study is to critically evaluate the W-Model, that is to answer this question: If the W-Model had been applied to the Wine Find™ innovation project, what shortcomings of the W-Model (if any) could be identified?

When comparing the phases of the W-Model to the stages of the informal approach, one obvious difference can be observed. The W-Model is more strategically focused than the informal approach (see Figure 8.3 and Figure 8.4). It should not be considered a disadvantage that a lot of emphasis is put on the strategic relation, but the shortcoming is rather that the W-Model does *not include the operational related output* that the informal approach does.

Strategically, the stages of the W-Model form a continuous circle that brings about recurring innovation activities on a strategic level. The final output of the W-Model is an Innovation Roadmap, which identifies future innovations and immediate innovations with a lot of potential for success, as well as innovations that should be investigated in more detail or at a later stage. The W-Model thus builds in strategic planning for immediate and future innovation projects and creates a further input for the W-Model (projects to be revised or investigated further). As illustrated in Figure 8.5, the W-Model fully supports the strategic component of the total innovation effort of a company both in the short- and long term.

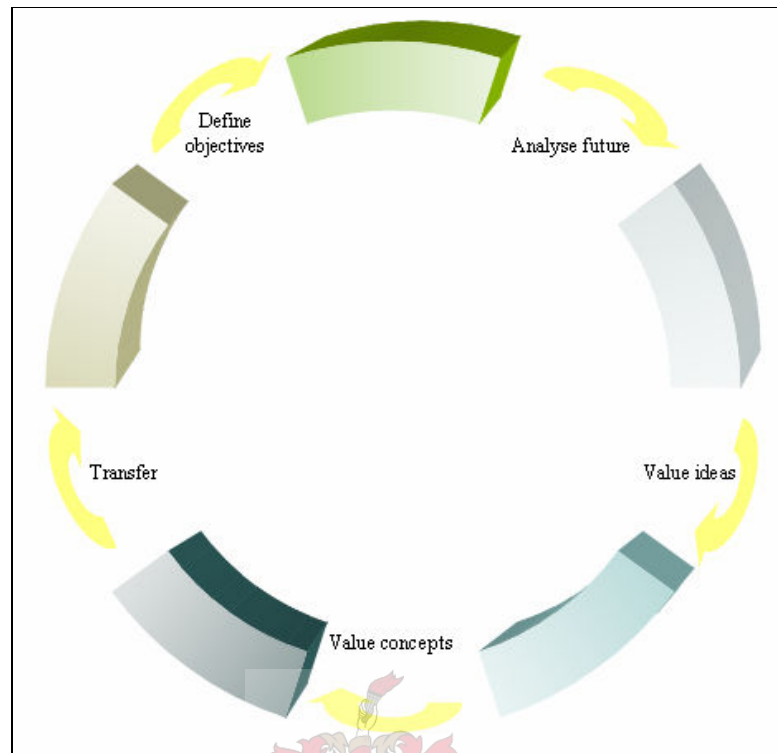


Figure 8.5 The closed loop image of the strategically related phases of the W-Model

In contrast, the stages of the W-Model with a relatively-high to high operational relation do not form a closed circle, but instead a linear figure, as can be seen in Figure 8.6. The first phase of the operationally related phases is also of strategic relation and therefore the linear representation below does have an input, but the results from the “Value concepts” step are not communicated to further innovation activities.

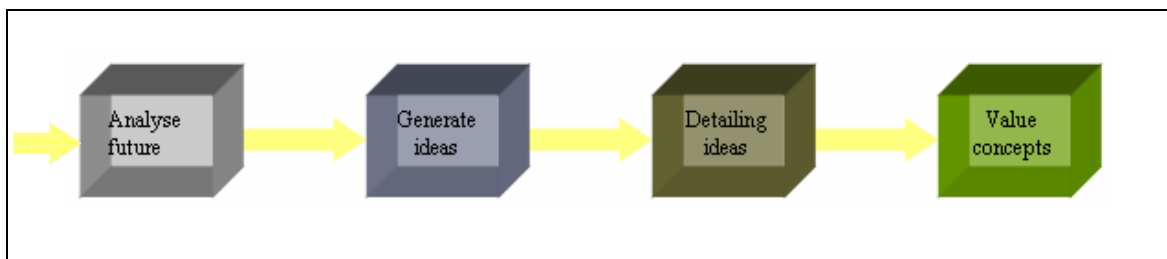


Figure 8.6 The linear representation of the operational related phases of the W-Model

Although many of the seven phases of the W-Model do include operational elements, the overall end-result is of a purely strategic relation (the Innovation Roadmap). Thus, the shortcoming of the W-Model that was identified when applied to the Collotype Labels case

study, is that the W-Model does not communicate operational detail to the next innovation life cycle phase, namely production.

As depicted in Figure 8.7, now that the gap analysis has been done and the shortcomings identified, a proposed solution will be discussed in Chapter 9, together with some conclusions.

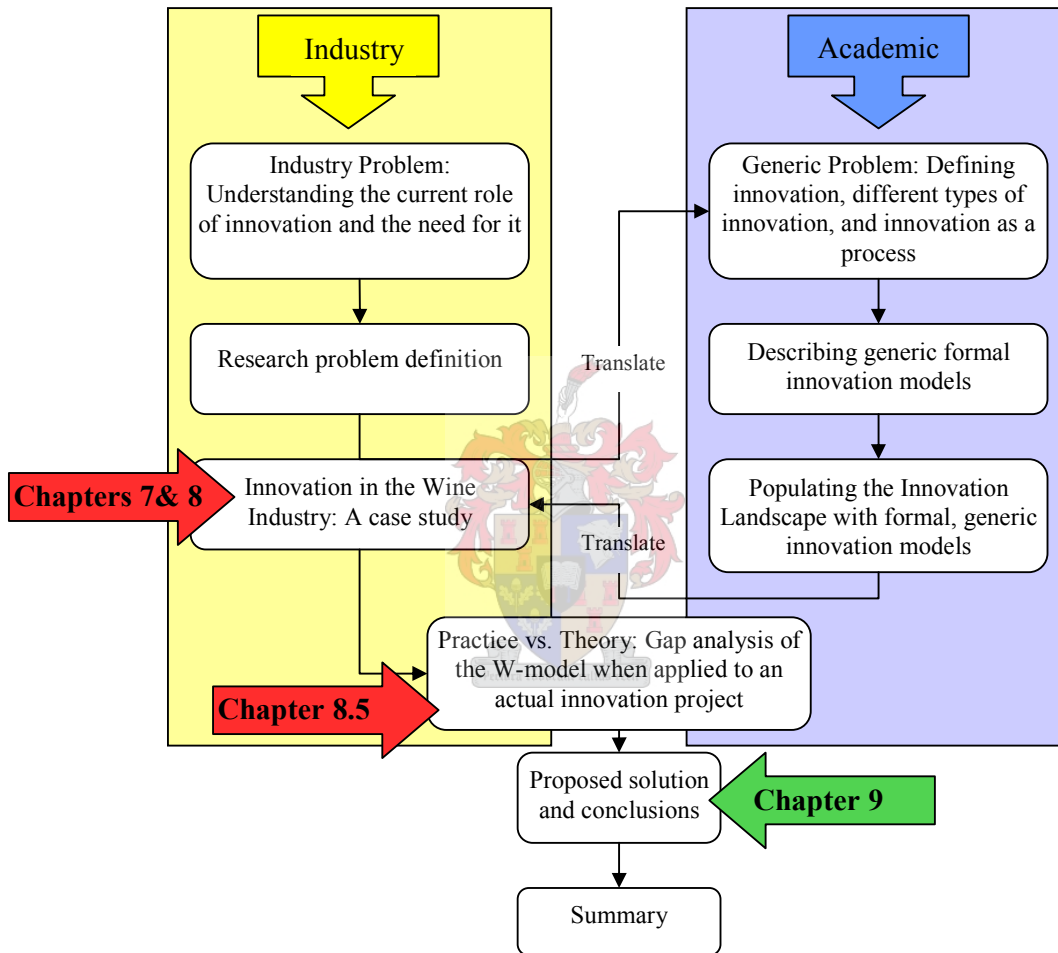


Figure 8.7 Thesis structure: From Chapter 8 to Chapter 9

Chapter 9

The Proposed Solution and Conclusions

9.1 The proposed solution

Now that a shortcoming of the W-Model has been identified when it is put into practice, a method of operational innovation transfer will be proposed, with the aim of overcoming this limitation of the W-Model.

The proposed solution is to create an operational innovation roadmap that would contain all the operational related information generated and collected during the execution of the seven W-Model steps. Much useful information would thus be created as users advance from one step to another, satisfying required input and outputs. It is suggested that the information for each innovation idea is captured in a “Product Idea Datasheet”.

The main function of recording such information is to provide the innovator with sufficient accurate information in order to make calculated decisions about the potential success of an innovation idea. The decisions thus made then allow the development team to create an Innovation Roadmap, plotting the potential innovation project on a strategic timeline. In doing this at this early stage, valuable operationally related information is being created and captured. However, this is not done in a form that can be shared and passed on to the operationally related business functions that will need to implement the operational requirements for the production of the chosen innovation projects.

The proposed solution is thus to transform the current static form containing valuable operationally related information into a roadmap where the information can be organised, contextualised, using a common language, and indicating the relationships and logical flow between the information elements. This would enhance the teamwork, collaborative efforts and transfer between the different departments and also between the various Collotype Labels locations internationally.

The new suggested roadmap structure that could replace the current product idea datasheet is set out in Figure 9.1 below. The sub-steps shown in Figure 9.1 represent the various pieces of information created during the progression of the W-Model, but captured in a unified, clear structure.

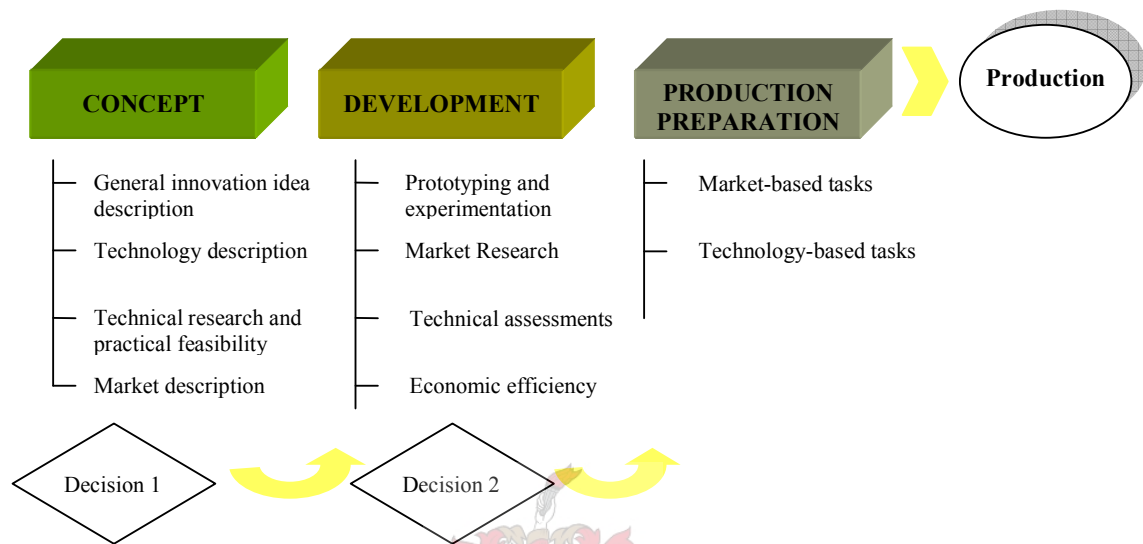


Figure 9.1 The proposed Operational Related Innovation Roadmap

This Operational Related Innovation Roadmap consists of three stages and two decision gates. Predefined sub-steps guide the innovators through the three phases, ensuring that all of the considerations required for a successful innovation are addressed at the appropriate point in the development. Decision gates are points in the Operational Related Innovation Roadmap where formal decisions must be made to continue, terminate, suspend, or reprocess the innovation project. The information supplied at each sub-step is measured against pre-defined success criteria of the decision gate.

The next table, Table 9.1, shows the correspondence between the information generated during the execution of the W-Model steps and the capturing of information in the newly proposed structure. From this it is evident that the information required for the Operationally Related Innovation Roadmap can indeed be acquired and analysed by an innovator using the W-Model, but that this would occur at different stages and not necessarily be an obvious output of a W-Model phase.

Table 9.1 The relationship between the Operationally Related Innovation Roadmap and the W-Model information composition

Operationally Related Innovation Roadmap sub-steps	W-Model sub-steps	W-Model tools and techniques
General innovation idea description	<ul style="list-style-type: none"> ○ Analysing future ○ Generating ideas 	<ul style="list-style-type: none"> ○ TRIZ method ○ Innovation potential matrix ○ Morphologic box
Technology description	<ul style="list-style-type: none"> ○ Valuing ideas ○ Detailing ideas 	<ul style="list-style-type: none"> ○ Portfolio analysis ○ TRIZ method ○ Primary and secondary market research ○ Criteria model
Technical research and practical feasibility	<ul style="list-style-type: none"> ○ Valuing ideas ○ Detailing ideas 	<ul style="list-style-type: none"> ○ QFD method ○ Primary and secondary market research ○ Pairwise comparison
Market description	<ul style="list-style-type: none"> ○ Valuing ideas ○ Detailing ideas 	<ul style="list-style-type: none"> ○ Portfolio analysis ○ TRIZ method ○ Primary and secondary market research ○ Criteria model
Prototyping and experimentation	<ul style="list-style-type: none"> ○ Detailing ideas ○ Valuing concepts 	<ul style="list-style-type: none"> ○ QFD method ○ Kano model ○ Selection algorithm
Market research	<ul style="list-style-type: none"> ○ Detailing ideas ○ Valuing concepts 	<ul style="list-style-type: none"> ○ Primary and secondary market research ○ Kano model
Technical assessment	<ul style="list-style-type: none"> ○ Valuing concepts 	<ul style="list-style-type: none"> ○ Value benefit analysis ○ Technology calendar
Economic efficiency	<ul style="list-style-type: none"> ○ Valuing concepts 	<ul style="list-style-type: none"> ○ Criteria model ○ Economic evaluation methods
Market-related tasks	<ul style="list-style-type: none"> ○ Detailing ideas ○ Valuing concepts 	<ul style="list-style-type: none"> ○ Conjoint analysis ○ Portfolio analysis
Technology-related tasks	<ul style="list-style-type: none"> ○ Valuing ideas ○ Detailing ideas ○ Valuing concepts 	<ul style="list-style-type: none"> ○ Technical capabilities analysis ○ QFD method ○ Technology calendar

Once an innovation idea has been classified and plotted on the W-Model Innovation Roadmap as an immediately successful innovation project, it needs to move forward from the innovation life cycle phase to the operation life cycle phase. The Operationally Related Innovation Roadmap then allows for the easy transfer and communication between the different parties involved. The deployment of the Operational Related Innovation Roadmap thus ensures the transfer of correct and up-to-date information, eliminates the need for reworking, and minimizes confusion between the various role players.

9.2 Conclusions

The Operational Related Innovation Roadmap is just an adaptation and different application of information that is already being generated during the execution of the seven W-Model steps. It does not, therefore, necessitate the creation of additional information and analyses, but rather structures the existing information in such a way that it guides the implementation of an innovation product. Value is thus added to the generated information through the use of this new approach of capturing the information in an easily accessible and useful format. This structure allows the team involved with the production of the final innovation ideas to easily understand the thinking behind the idea, the development of the concept, the assessment of the concept, and, most importantly, the details of the operational tasks for the production of the innovation product.

From the observations of this case study, it can be stated with confidence that the Operational Related Innovation Roadmap would create an environment that encourages innovation. The Operational Related Innovation Roadmap is a substantial enhancement to the W-Model as it successfully addresses the shortcoming identified in the case study. In consequence, it allows the W-Model to be applied rapidly and effectively to support product innovations.

As the thesis structure represented in Figure 9.2 indicates, the study is now complete and a summary follows in Chapter 10.

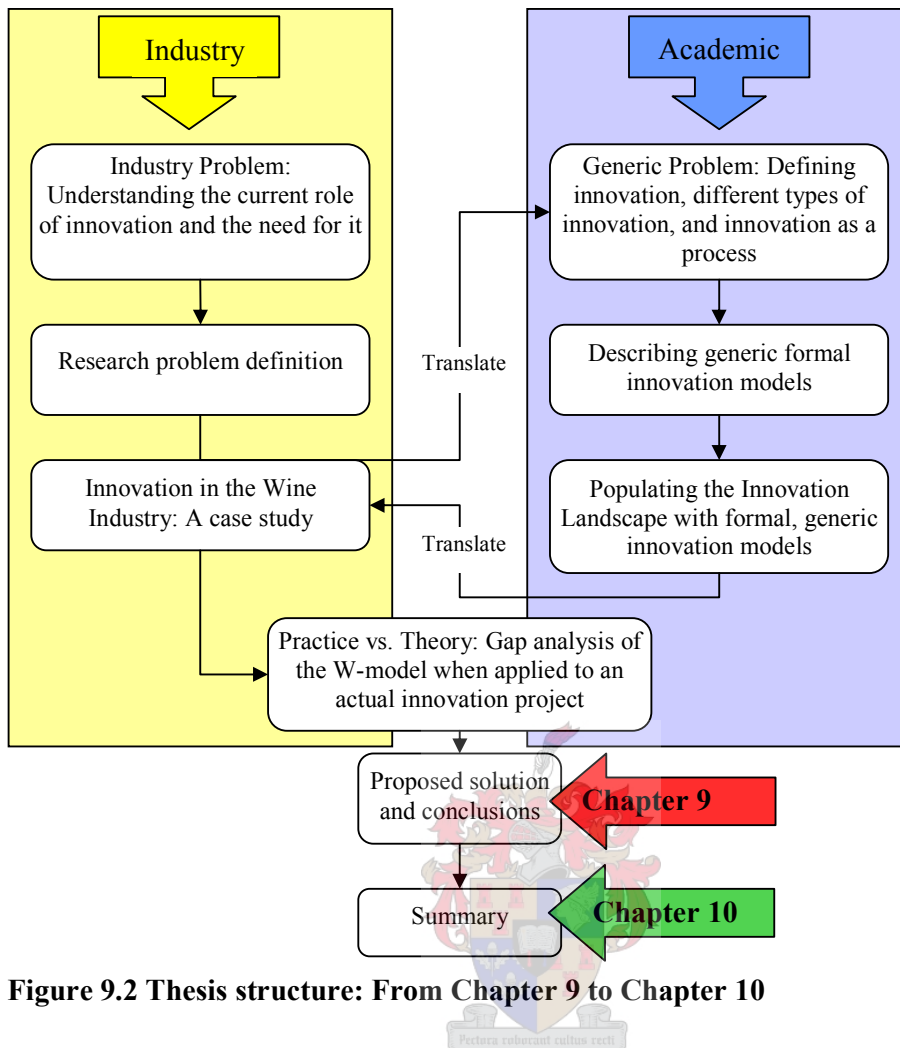


Figure 9.2 Thesis structure: From Chapter 9 to Chapter 10

Chapter 10

Thesis Summary

Innovation is currently the key to survival for most companies. Whether an enterprise is big or small, old or new, and whatever industry it is involved in, every company recognizes the need for innovation.

Innovation is also a complex matter, however, one that encompasses many paradoxes, which make it challenging for companies to derive the ultimate benefits from it. In order to change with the rapidly changing market demands and technological developments, a company needs to be flexible, which is a characteristic of the majority of smaller companies. Ironically, it is usually the bigger (and clumsier) companies that can afford to implement substantial innovation efforts. Although a successful innovation may put a company ahead of its competition, it also means taking great risks. While it is clear that innovation is vital, it is difficult to do successfully, and consequently companies need to manage their innovation process as they do a formal business process.

Although many formal innovation methodologies exist, companies still seem to prefer creating their own new way of managing innovation and most still do not feel that they are getting the value out of what they put into their innovation projects. Innovation models have been created for different environments, industries, viewpoints, and with varying levels of detail. These formal innovation models have been created from extensive experience and have been improved over the years. The populated Innovation Landscape can be of great value to a company seeking a model to structure and support their innovation projects. By using the populated Innovation Landscape, a company could position their innovation activities and match them to an innovation model that best suits their situation and requirements. It is also important that businesses modify the chosen generic innovation model to fit the characteristics of their industry, and, even more specifically, the unique attributes of their company.

Surveys show that many companies feel that the elements of formal models do not correspond sufficiently to the actual innovation conditions and that these models are too detailed for them

to apply in the fast-moving business world. This statement was then tested by the researcher by applying a formal model to a case study at Collotype Paarl Labels, who specialize in self-adhesive wine labelling.

Although the wine industry may not produce many innovation products in terms of new wine cultivars, it is a highly competitive industry where role-players need to innovate constantly, not only to meet national customer demands and beat local competition, but also to compete internationally.

The front-end of innovation was identified through the literature studied as a problem area within the innovation life cycle. The case study, therefore, focused on this area, from the invention phase to the innovation implementation phase. The W-Model was applied to a Collotype innovation project and proved to efficiently support the project.

The performance of the W-Model in supporting the Collotype Labels innovation project was then critically evaluated. This gap analysis indicated that the W-Model is lacking in operational translation from the implementation phase to the production phase. An Operational Related Innovation Roadmap was thus proposed as a solution that could satisfy this shortcoming. This Operational Related Innovation Roadmap contains all the operational related information produced at the different steps of the W-Model. It serves as a structured, value-added information management system that can be easily communicated between different business functions and can serve as a reference for possible, related, future projects.

From this study it is evident that innovation is complex and that it needs to be well supported and managed in order for companies to reap the optimal benefits. Existing formal innovation models developed through extensive experience and studies are therefore a suitable basis for a company's innovation activities. The model should be chosen carefully and transformed into a company specific innovation model.

Innovation projects should be managed on both an operational and strategic level. The strategic planning will allow a company to be recurrently innovative, satisfying the market at the required time, while exploiting leading-edge technology. Efforts at the operational level will result in the actual development of the planned innovation for the identified target niche. While the market leader cannot avoid being exposed to some risk when exploring new,

unfamiliar territories, it must be recognised that the one that exploits an opportunity first will also temporarily disarm the competition as they will have to catch up.

Paulo Coelho (2004) describes a paradox that could be applied to the innovation paradox by saying: “When the doubts stop, it is because you have stopped journeying”.

In conclusion, a company needs to keep on moving forwards, recurrently innovating, but at the same time minimizing the risks and doubts involved through the employment of a reliable, supportive innovation model.



Reference List

ARIS Framework Concept 2005, IDS Scheer – ARIS Platform. Available from: www.ids-scheer.com. (Accessed on 3 October 2005)

Baessler, E, Breuer, T & Grawatsch, M 2002, *Combining the Scenario Technique with QFD and TRIZ to a Product Innovation Methodology*, Fraunhofer Institute of Production Technology IPT, Aachen, Germany. Available from: <http://www.triz-journal.com/archieves/2002/01/b/>. (Accessed on 26 April 2005)

BCG Senior Management Survey 2005, The Boston Consulting Group (BCG), Inc., USA. Available from www.bcg.com (Accessed on 19 April 2005)

Bernus, P, Nemes, L & Schmidt, G 2003, *Handbook of Enterprise Architectures (International handbooks on information systems)*, Springer, USA.

Biemans, W 1992, *Managing innovation within networks*, Routledge, UK.

Blanchard, B & Fabrycky, W 2006, *Systems Engineering and Analysis*, Prentice Hall, USA, 4th edition.

Campbell, R 2004, *Architecting and Innovating*. Available from: cipd.mit.edu. (Accessed on 12 July 2005)

Challenges facing the wine industry 2005, Deloitte & Touché, South Africa. Available from: www.deloitte.com. (Accessed on 6 January 2005)

Christensen, C 1997, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Harvard Business School Press, USA.

Cleveland, J 2005, *A Framework for Manufacturing Innovation*, Prepared for The Right Place, Inc. Manufacturers Council.

Coelho, P 2004, *Alchemy*, HarperCollins Publishers, United Kingdom.

Cross, N 1994, *Engineering Design Methods, Strategies for Product Design*, John Wiley and Sons, second edition.

Drucker, P 1985, *Innovation and Entrepreneurship: practise and principles*, Heinemann, London.

Forrest, J 1991, *Models of the Process of Technological Innovation*, Technology Analysis & Strategic Management, vol.3, no. 4, pp. 439.

Global benchmarking survey launched in the South African wine industry 2004, Deloitte & Touché, South Africa. Available from: www.deloitte.com. (Accessed on 6 January 2005)

Henry, J & Walker, D 1991, *Managing Innovation*, SAGE Publications Ltd., London.

Howells, J, Andersen, B, Hull, R, Miles, I & Roberts, J 2000, *Knowledge and Innovation in the New Service Economy: Services and Systems of Innovation*, Edward Elgar Publishing Limited, UK.



Leibold, M 2005, *Global Impacts of Innovations in the South African Wine Industry: How the SA wine industry is embedding leading-edge innovative capabilities for sustainable profitability*, Presentation at SAWIIC wine conference, South Africa.

Mastering the Innovation Paradox 2004, Deloitte & Touché, South Africa. Available from: www.deloitte.com/globalbenchmarking. (Accessed on 6 January 2005)

Measuring innovation for national prosperity 2004, NII Innovation framework report. Available from: www.compete.org. (Accessed on 26 April 2005)

Mahdjoubi, D 1997, *The mapping of innovation*. Available from: www.ischool.utexas.edu/~darius/ (Accessed on 6 January 2005)

Nazzal, D 2004, *Reference Architecture for Enterprise Engineering: CIMOSA, GRAI/GIM, PERA*, Presentation for: The School of Industrial and Systems Engineering at the Georgia Institute of Technology (ISyE). Available from: www2.isye.gatech.edu. (Accessed on 3 October 2005)

Patterson, M 1993, *Accelerating Innovation: improving the process of product development*, Van Nostrand Reinhold, USA.

Planting, S 2003, *Maturity and blending release creative juices*, Financial Mail Innovations Outfront. Available from: www.free.financialmail.co.za. (Accessed on 24 October 2005)

Rothberg, R 1981, *Corporate strategy and product innovation: The importance of innovation*, The Free Press, USA, second edition.

Salvendy, G 1992, *Handbook of industrial engineering*, John Wiley & Sons, Canada.

Schekkerman, J 2004, *A Comparative Survey of Enterprise Architecture Frameworks*, Institute for Enterprise Architecture Developments/Capgemini. Available from: www.enterprise-architecture.info. (Accessed on 3 October 2005)

Schilling, M 2005, *Strategic Management of Technological Innovation*, McGraw-Hill/Irwin, New York University.

Smartpros Editorial Staff 2005, *Companies Say Innovation a Priority but Lack R&D Budget*. Available from: <http://accounting.smartpros.com/x47403.xml>. (Accessed on 19 April 2005)

Sterling, B 2005, *Bi-polar innovation*, Wired Magazine Issue, June. Available from: www.wired.com. (Accessed on 6 June 2005)

Stevens, G & Burley, J 1997, *3000 raw ideas equal 1 commercial success!* Research technology management, vol. 40, no.3, pp 6-27.

Suireg, A 1981, *Methodology of mechanical systems design*, Review of Design Methodology, Heurista.

The practice of Innovation – Seven Canadian Firms in Profile 2003, Industry Canada. Available from: <http://napoleon.ic.gc.ca/gol/innovation/site.nsf/en/in04262.html>. (Accessed on 25 April 2005)

Tregurtha, N 2004, *Agro-processing Studies: South African Wine Industry*, pp 2 – 6, The Presidency / Commark Sector Workshop.

Tucker, R 2004, *American Manufacturers – It's Time to Innovate or Evaporate*. Available from: www.innovationtools.com. (Accessed on 18 September 2005)

Ullman, D 2003, *The Mechanical Design Process*, McGraw-Hill, USA, 3rd edition.

Utterback, J 1994, *Mastering the Dynamics of Innovation*, Harvard Business School Press, USA.

Verhaeghe, A & Kifr, R 2002, *Managing Innovation in a Knowledge Intensive Technology Organisation*, *R&D Management*, vol.32, no. 5, pp. 409.

Williams, T, Li, H, Bernus, P, Uppington, G & Nemes, L 1998, *The life cycle of an enterprise*. Available from: www.mit.edu. (Accessed on 12 July 2005)

Wood, E & Kaplan, D 2004, *Marketing, Innovation and Performance in the South African Wine Industry*, Paper delivered at the Innovation Systems and Development: Emerging opportunities and Challenges, 2nd Global Conference, Beijing China.

Bibliography

Albers, J & Brewer, S 2003, *Knowledge Management and the Innovation Process: The Eco-innovation model*, Journal of Knowledge Management Practices, June 2003.

ARIS Framework Concept 2005, IDS Scheer – ARIS Platform. Available from: www.ids-scheer.com. (Accessed on 3 October 2005)

Baessler, E, Breuer, T & Grawatsch, M 2002, *Combining the Scenario Technique with QFD and TRIZ to a Product Innovation methodology*, Fraunhofer Institute of Production Technology IPT, Aachen, Germany. Available from: <http://www.triz-journal.com/archives/2002/01/b/>. (Accessed on 26 April 2005)

BCG Senior Management Survey 2005, The Boston Consulting Group (BCG), Inc., USA. Available from: www.bcg.com. (Accessed on 19 April 2005)

Bernus, P, Nemes, L & Schmidt, G 2003, *Handbook of Enterprise Architectures (International handbooks on information Systems)*, Springer, USA.

Biemans, W 1992, *Managing innovation within networks*, Routledge, UK.

Blanchard, B & Fabrycky, W 2006, *Systems Engineering and Analysis*, Prentice Hall, USA, 4th edition.

Campbell, R 2004, *Architecting and Innovating*. Available from: cipd.mit.edu. (Accessed on 12 July 2005)

Challenges facing the wine industry 2005, Deloitte & Touché, South Africa. Available from: www.deloitte.com. (Accessed on 6 January 2005)

Christensen, C 1997, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Harvard Business School Press, Boston, USA.

Cleveland, J 2005, *A Framework for Manufacturing Innovation*, Prepared for The Right Place, Inc. Manufacturers Council.

Coelho, P 2004, *Alchemy*, HarperCollins Publishers, United Kingdom.

Cormican, K & O'Sullivan, D 1999, *Systems innovation tools*, Computer Integrated Manufacturing Research Unit (CIMRU), National University of Ireland, Galway, Ireland. Available from: cimru.nuigalway.ie (Accessed on 26 April 2005)

Cross, N 1994, *Engineering Design Methods, Strategies for Product Design*, John Wiley and Sons, 2nd edition.

Drucker, P 1985, *Innovation and Entrepreneurship: practise and principles*, Heinemann, London.

Florida, R & Kenney, M 1993, *The new age of capitalism: Innovation-mediated production*, Futures, vol. 25, no. 6, pp. 637 – 651.

Forrest, J 1991, *Models of the Process of Technological Innovation*, Technology Analysis & Strategic Management, vol.3, no. 4, pp. 439.

Fritz, P 2005, *Managing the Fuzzy front End – Idea capturing and Management*, Society of Concurrent Product Development (SCPD) paper. Available from: www.us-mindmatters.com. (Accessed on 18 April 2005)

Frombach, R 2003, *Supporting Collaborative Innovation*, Thesis presented for the degree of Diploma-Engineer of Mechanical Engineering at the University of Dortmund/Germany in cooperation with the Department of Industrial Engineering of the University of Stellenbosch/South Africa.

Global benchmarking survey launched in the South African wine industry 2004, Deloitte & Touché, South Africa. Available from: www.deloitte.com. (Accessed on 6 January 2005)

Harichandan, A 2005, *Reinvent innovation models to win global game, Forrester tells US firms*. Available from: www.business-standard.com. (Accessed on 25 July 2005)

Henry, J & Walker, D 1991, *Managing Innovation*, SAGE Publications Ltd., London.

Howells, J, Andersen, B, Hull, R, Miles, I & Roberts, J 2000, *Knowledge and Innovation in the New Service Economy: Services and Systems of Innovation*, Edward Elgar Publishing Limited, UK.

Leibold, M 2005, *Global Impacts of Innovations in the South African Wine Industry: How the SA wine industry is embedding leading-edge innovative capabilities for sustainable profitability*, Presentation at SAWIIC wine conference, South Africa.

Mahdjoubi, D 1997, *The mapping of innovation*. Available from: www.ischool.utexas.edu/~darius/ (Accessed on 6 January 2005)

Martin, M 1994, *Managing innovation in technology-based firms*, John Wiley & Sons, New York, USA.

Mastering the Innovation Paradox 2004, Deloitte & Touché, South Africa, available from: www.deloitte.com/globalbenchmarking. (Accessed on 6 January 2005)

Measuring innovation for national prosperity 2004, NII Innovation framework report. Available from: www.compete.org. (Accessed on 26 April 2005)

Milier, P 1999, *Marketing the Unknown: Developing market strategies for technical innovations*, John Wiley & Sons, London, UK.

Morton, J 1971, *Organizing for innovation*, McGraw-hill, New York, USA.

Mulkay, M 1972, *Social process of innovation*, Macmillan Press Ltd., London, UK.

Nazzal, D 2004, *Reference Architecture for Enterprise Engineering: CIMOSA, GRAI/GIM, PERA*, Presentation for: The School of Industrial and Systems

Engineering at the Georgia Institute of Technology (ISyE). Available from: www2.isye.gatech.edu. (Accessed on 3 October 2005)

Noori, H 1990, *Managing the dynamics of new technology*, Prentice-Hall, New York, USA.

Oakley, P, Jones, S & Wise, R 2001, *Innovation management processes for technology based knowledge transfer companies – the impact of the results of the ESRC (Economic and Social Science Research Council) Innovation Programme*, Association of Independent Research and Technology Organisations (AIRTO), AIRTO Paper 2001/2, TWI, Cambridge.

Patterson, M 1993, *Accelerating Innovation: improving the process of product development*, Van Nostrand Reinhold, USA.

Phillips, J & Hering, D 2005, *Innovate on Purpose™: A systematic approach to sustainable, repeatable innovation using the Concept to Cash™ business process*, NetCentrics Corporation. Available from: www.innovate.netcentrics.com. (Accessed 31 August 2005)

Pistorius, C & Mentz, J 2001, *Modelling the innovation process*, Paper presented at the International Association for Manufacturing technology (IAMOT) conference. Available from: www.iamot.org. (Accessed on 26 April 2005)

Planting, S 2003, *Maturity and blending release creative juices*, Financial Mail Innovations Outfront. Available from: www.free.financialmail.co.za. (Accessed on 24 October 2005)

Quinn, J, Baruch, J & Zien, K 1997, *Innovation explosion*, The Free Press, New York, USA.

Rothberg, R 1981, *Corporate strategy and product innovation: The importance of innovation*, The Free Press, USA, second edition.

Salicru, S 2003, *Innovation: Myths and Realities*, Professional Consulting & Training Services (PTS) Pty Ltd, Australia. Available from: www.pts.net.au. (Accessed on 26 April 2006)

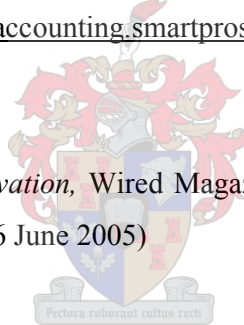
Salvendy, G 1992, *Handbook of industrial engineering*, John Wiley & Sons, Canada.

Schekkerman, J 2004, *A Comparative survey of Enterprise Architecture Frameworks*, Institute for Enterprise Architecture Developments/Capgemini. Available from: www.enterprise-architecture.info. (Accessed on 3 October 2005)

Schilling, M 2005, *Strategic Management of Technological Innovation*, McGraw-Hill/Irwin, New York University.

Smartpros Editorial Staff 2005, *Companies Say Innovation a Priority but Lack R&D Budget*. Available from: <http://accounting.smartpros.com/x47403.xml>. (Accessed on 19 April 2005)

Sterling, B 2005, *Bi-polar innovation*, Wired Magazine, June issue. Available from: www.wired.com. (Accessed on 6 June 2005)



Stevens, G & Burley, J 1997, *3000 Raw ideas equal 1 commercial success!* Research Technology Management, vol. 40, no.3, pp.16-27.

Suireg, A 1981, *Methodology of mechanical systems design*. Review of Design Methodology, Heurista.

The practice of Innovation – Seven Canadian Firms in Profile 2003, Industry Canada. Available from: <http://napoleon.ic.gc.ca/gol/innovation/site.nsf/en/in04262.html>. (Accessed on 25 April 2005)

Tregurtha, N 2004, *Agro-processing Studies: South African Wine Industry*, pp 2 – 6, The Presidency / Commark Sector Workshop.

Tucker, R 2004, *American Manufacturers – It's Time to Innovate or Evaporate*. Available from: www.innovationtools.com. (Accessed on 18 September 2005)

Ullman, D 2003, *The Mechanical Design Process*, McGraw-Hill, USA, 3rd edition.

Utterback, J 1994, *Mastering the Dynamics of Innovation: How companies can seize opportunities in the face of technological change*, Harvard Business School Press, USA.

Verhaeghe, A & Kifr, R 2002, *Managing Innovation in a Knowledge Intensive Technology Organisation*, R&D Management, vol.32, no. 5, pp. 409.

Williams, T, Li, H, Bernus, P, Uppington, G & Nemes, L 1998, *The life cycle of an enterprise*. Available from: www.mit.edu. (Accessed on 12 July 2005)

Wood, E & Kaplan, D 2004, *Marketing, Innovation and Performance in the South African Wine Industry*, Paper delivered at the Innovation Systems and Development: Emerging opportunities and Challenges, 2nd Global Conference, Beijing, China.



Appendix A:

A detailed W-Model representation

