TECHNOLOGY MANAGEMENT IN THE SOUTH AFRICAN INDUSTRIAL SECTOR

A Research Report
presented to
School of Business Leadership
University of South Africa

In partial fulfilment of the
requirements for the
MASTER'S DEGREE IN BUSINESS LEADERSHIP
UNIVERSITY OF SOUTH AFRICA

by

BRYAN JOHN BALLANTYNE

11 January 1993

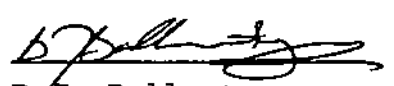
DEDICATION

This report is dedicated to my wife, Sharlon, and my two sons, Gordon and Craig, for the sacrifices that were made by them during the course of my studies.

ACKNOWLEDGEMENTS

I wish to acknowledge the assistance provided by my research supervisor, Anton Ferreira, of the School of Business Leadership, University of South Africa, in offering innumerable suggestions for improvements of the material. Rita Richter, for her kind assistance with much of the typing in this report. Chris van Rooyen, who was very helpful in preparing certain of the illustrations. Many of the staff in my section, for doing the odd task related to this research. My Dad, for his help with the editing of this report. For the encouragement and support which proved particularly helpful at critical stages whilst preparing the report, I extend sincere thanks to my boss, Gerry van Niekerk.

I certify that except as noted above, the report is my own work and all references used are accurately reported.



B.J. Ballantyne

ABSTRACT

The objectives of the research were to establish the role of technology in corporate operations and to determine how effectively companies are managing technology within certain segments of the South African industrial sector.

An extensive literature survey on aspects of importance to technology management was undertaken and two previous studies on technology management were reviewed. This was followed by a mail survey, dealing with technology management issues, in which questionnaires were mailed to 135 companies in the South African industrial sector, with a total of 38 questionnaires being returned.

A summary of the research conclusions follow:

- There is a lack of top management involvement in the technology process within many of the companies which participated in the survey.

- Top management from one in three participating companies monitor short-term profits and totally ignore technology.

- The corporate planning process of many participating companies is dominated by focussing on factors related more to the business issues of the company, as opposed to technology related matters.

- Separate business plans within the company is viewed as the major obstacle to the successful development of technology by the participating companies, followed by top management's short-term profit orientated perspective and top management's discomfort with technology.

- Top management's commitment to long-term results is seen by the participating companies as having the greatest impact, when it comes to enhancing the role of technology in the planning process.

- Factors geared to achieving better integration of technology into the planning process do not feature prominently in the findings as "approaches" used by the participating companies to ensure success in technology planning.

- Many of the participating companies appear to lack sufficient knowledge of the techniques currently available to perform the technology management function. Very few of these companies make use of the more sophisticated analytical techniques developed for technology management, and resort to using the more rudimentary and well-known management techniques, such as the SWOT analysis and brainstorming.

- Although many of the participating companies have a formal planning process, very few prepare a formal technology plan and incorporate it with the strategic planning process.

- Many of the participating companies could improve on their effectiveness in managing technology, especially related to the linking of technology with corporate strategic planning and the usage of analytical techniques in the technology management process.

Certain recommendations are presented in the report to assist companies in improving their effectiveness in the technology management process. Although these recommendations are specifically directed at the companies which participated in the survey, the researcher is of the opinion that most companies, irrespective of the industry, could also benefit through the adoption of some of the following recommendations:

- Companies must adopt a more formal and structured planning process, and consider (within reason) extending their strategic planning horizon.

- Technological issues must be integrated with corporate planning, following a similar process to that presented in the model in chapter 4 (see Figure 4.1).

- Companies need to become conversant and adept at using the more sophisticated technology management techniques that are available.

- Top management must become actively involved and offer overt support to the technology management process.

TABLE OF CONTENTS

Title page		(i)
Dedication		(ii)
Acknowledgements		(iii)
Abstract		(iv)
Table of contents		(vii)
List of Figures		(xvi)
List of Tables		(xviii)
CHAPTER 1 :	INTRODUCTION	1
1.1	BACKGROUND	1
1.2	OBJECTIVES OF THE RESEARCH	3
1.3	RESEARCH SCOPE	5
1.4	PURPOSE OF RESEARCH	5
1.4.1	Importance of research - General context	5
1.4.2	Importance of research - South African context	6
1.5	METHODOLOGY	8
1.6	REPORT CONTENTS	9
CHAPTER 2 :	TECHNOLOGY PLANNING AND MANAGEMENT	11
2.1	INTRODUCTION	11
2.2	THE MEANING OF TECHNOLOGY	11
2.3	CLASSIFICATION OF TECHNOLOGIES	14

2.3.1	Basic technologies	14
2.3.2	Key technologies	14
2.3.3	Pacing technologies	15
2.4	RELEVANCE OF TECHNOLOGY TO INDUSTRY	16
2.5	MANAGEMENT OF TECHNOLOGY	17
2.6	ELEMENTS OF TECHNOLOGY MANAGEMENT	21
2.6.1	Technology strategy	22
	* Technology situation assessment	24
	* Technology portfolio development and evaluation	25
	* Technology and corporate strategy integration	25
	* Technology investment priorities	26
2.6.2	Technology acquisition and development	27
2.6.3	Technology protection	28
2.6.4	Technology transfer and development	29
2.6.5	Technology utilisation	30
	* Technology implementation	30
	* Technology commercialisation	30
2.7	TECHNOLOGY AND THE STRATEGIC PLANNING PROCESS	30
2.7.1	Modified general planning model	31
2.7.2	R & D (technology) planning and business strategy	33
2.7.3	Strategic management of technology process	35
2.7.4	Integrated technology management	37
	* Assessment phase	39
	* Position-taking phase	39
	* Policy formulation phase	40
2.8	TOOLS USED IN THE TECHNOLOGY PLANNING PROCESS	44

2.9	EFFECTIVE TECHNOLOGY MANAGEMENT	45
2.9.1	Condition 1 : Top management orientation	46
	* Technical background of managers	46
	* Orientation and strategy	47
	* Pitfalls of technically strong top management	47
2.9.2	Condition 2 : Criteria for selection of technology investments	47
	* Support of business objectives	48
	* Technological leadership	49
	* Solving a "customer's" problem	49
	* A "window" on technology	49
	* Pursuing technological advance	49
2.9.3	Condition 3 : Systems and structure	49
	* Linking business to technology	50
	* Top management connection	50
	* Corporate Technical Officer	51
	* Planning systems	51
	* Timing	51
	* Structural ties	51
2.10	BENEFITS OF TECHNOLOGY MANAGEMENT	52
2.11	PERSONNEL INVOLVED IN TECHNOLOGY MANAGEMENT	53
2.12	TASKS OF THE TECHNOLOGY MANAGER	54
2.13	SUMMARY	55
CHAPTER 3 :	SURVEY OF RELEVANT LITERATURE	57
3.1	INTRODUCTION	57
3.2	BOOZ-ALLEN TECHNOLOGY MANAGEMENT SURVEY	57

3.2.1	Role of technology	57
	* Factors important in overall operations	58
	* Impact of technology on planning process	61
	* Barriers to integrating technology in planning process	62
	* Means of enhancing role of technology	63
3.2.2	Summary (Role of technology)	63
3.3	TECHNOLOGY MANAGEMENT IN THE SOUTH AFRICAN ELECTRONICS INDUSTRY	64
3.4	SUMMARY	66
CHAPTER 4 :	THE PROBLEM AND ITS SETTING	67
4.1	INTRODUCTION	67
4.2	ROLE OF TECHNOLOGY	67
4.2.1	Factors important in overall operations	68
4.2.2	Impact of technology in planning process	69
4.2.3	Barriers to integrating technology in planning process	70
4.2.4	Means of enhancing the role of technology	70
4.3	EFFECTIVENESS IN TECHNOLOGY MANAGEMENT	70
4.3.1	Proposed model for technology management	71
4.3.2	Approach to discussing effectiveness in technology management	74
	* Strategic planning process	75
	* Technology situation analysis	76
	* Technology gap analysis	76
	* Techniques used in technology management	76

* Integration of technology and strategic plans 76
* Technology acquisition 77

4.4 SUMMARY 77

CHAPTER 5 : RESEARCH METHODOLOGY 79

5.1 INTRODUCTION 79

5.2 TYPES OF DATA REQUIRED 79

5.3 ACQUISITION OF PRIMARY DATA 79

5.3.1 Method of research 79
5.3.2 Method of data collection 80

5.4 QUESTIONNAIRE CONSTRUCTION 81

5.4.1 Questionnaire questions 82
* Company particulars 90
* Company profile 91
* Importance of technology 91
* Role of technology 91
* Effective planning and management of technology 92
5.4.2 Pretesting 94

5.5 DISTRIBUTION 94

5.6 SAMPLING 95

5.6.1 Population to be studied 95
5.6.2 Sample frame 95
5.6.3 Sampling method 95
5.6.4 Choice of subjects 95

5.7 VALIDITY AND LIMITATIONS 97

5.8 ACQUISITION OF SECONDARY DATA 98

5.9 SUMMARY 99

CHAPTER 6 : ANALYSIS OF RESEARCH RESULTS 100

6.1 INTRODUCTION 100

6.2 RESPONSE RATES 100

6.3 ANALYSIS OF QUESTIONNAIRE RESPONSES 102

6.4 SUMMARY OF RESEARCH FINDINGS 138

6.4.1 Response rates 138
6.4.2 Company structure 138
6.4.3 Primary operations 139
6.4.4 Customer groups 139
6.4.5 Company size 139
6.4.6 Mission statement 139
6.4.7 Monitoring technology 140
6.4.8 Internal technology audits 140
6.4.9 Consideration given to existing and emerging technologies 140
6.4.10 Factors considered in planning corporate strategies 141
6.4.11 Barriers to integrating technology into the corporate strategic planning process 141
6.4.12 Top management's role in the technology process 141
6.4.13 Means of integrating technology in the planning process 142
6.4.14 Formality of strategic planning process 142
6.4.15 Strategic planning horizon 142
6.4.16 Formal technology plan 143

6.4.17 Contents of technology plan and its integration with the strategic plan 143
6.4.18 Planning and implementation of technology 143
6.4.19 Analysis of techniques used in the technology planning process 144
6.4.20 Technology acquisition 144

6.5 SUMMARY 145

CHAPTER 7 : TECHNOLOGY MANAGEMENT IN THE SOUTH AFRICAN INDUSTRIAL SECTOR 146

7.1 INTRODUCTION 146

7.2 SUMMARY OF SURVEY PARTICULARS 146

7.3 IMPORTANCE OF TECHNOLOGY 147

7.4 ROLE OF TECHNOLOGY 148

7.4.1 Top management involvement in the technology process 149
7.4.2 Impact of technology in the planning process 151
7.4.3 Barriers to integrating technology in the planning process 153
7.4.4 Means of enhancing the role of technology 154

7.5 EFFECTIVENESS IN TECHNOLOGY MANAGEMENT 157

7.5.1 Strategic planning process 158
7.5.2 Technology situation analysis 161
7.5.3 Technology gap analysis 162
7.5.4 Techniques used in technology management 163
7.5.5 Integration of technology and strategic plans 165
7.5.6 Technology acquisition 166

7.6 SUMMARY 170

CHAPTER 8 : CONCLUSIONS AND RECOMMENDATIONS 171

8.1 INTRODUCTION 171

8.2 SURVEY RESPONSES 171

8.3 IMPORTANCE OF TECHNOLOGY 172

8.4 ROLE OF TECHNOLOGY 173

8.4.1 Top management involvement in the technology process 173
8.4.2 Impact of technology in the planning process 173
8.4.3 Barriers to integrating technology in the planning process 174
8.4.4 Means of enhancing the role of technology 175

8.5 EFFECTIVENESS IN TECHNOLOGY MANAGEMENT 176

8.5.1 Strategic planning process 176
8.5.2 Technology situation analysis (assessment) 177
8.5.3 Technology gap analysis 177
8.5.4 Techniques used in technology management 177
8.5.5 Integration of technology and strategic plans 178
8.5.6 Technology acquisition 178
8.5.7 Summary of effectiveness in technology management 179

8.6 RECOMMENDATIONS 179

8.7 SHORTCOMINGS IN THE RESEARCH 180

8.8 RECOMMENDATIONS FOR FURTHER RESEARCH 182

REFERENCES 184

FURTHER READINGS 188

APPENDICES

APPENDIX A :

* A.1 : Covering letter (1st mailing) 192

* A.2 : Covering letter (2nd mailing) 193

* A.3 : Covering letter (SBL) 194

* A.4 : Questionnaire 195

APPENDIX B : Sample Frame 206

APPENDIX C : Questionnaire return information (summary) 210

APPENDIX D : Tools used in the technology management process 218

LIST OF FIGURES

Figure 2.1	Multidimensional technology perspective	13
Figure 2.2	Categories of technologies	16
Figure 2.3	Factors affecting technology decisions	29
Figure 2.4	Modified general planning model	32
Figure 2.5	Tracing the link between R & D and business strategy	34
Figure 2.6	Strategic Management of technology model	35
Figure 2.7	The integrated technology management framework	40
Figure 4.1	Proposed integrated technology management model	73
Figure 6.1	Company structure	103
Figure 6.2	Primary operations	105
Figure 6.3	Customer groups	106
Figure 6.4	Industrial sector segments	108
Figure 6.5A	Companies which scan technologies	111
Figure 6.5B	Company's effectiveness in scanning technologies	111
Figure 6.6A	Companies which make long-range technology forecasts	112
Figure 6.6B	Company's effectiveness in technology forecasting	113
Figure 6.7A	Companies which conduct internal technology audits	114
Figure 6.7B	Company's effectiveness in conducting internal technology audits	114
Figure 6.8A	Consideration given to existing technologies (Inside Company)	116
Figure 6.8B	Consideration given to existing technologies (Outside Company)	116
Figure 6.8C	Consideration given to emerging technologies (Inside Company)	118

Figure 6.8D	Consideration given to emerging technologies (Outside Company)	118
Figure 6.9	Factors considered in planning corporate strategies	121
Figure 6.10	Barriers to integrating technologies into the corporate strategic planning process	123
Figure 6.11	Role of top management in technology process	124
Figure 6.12	Means of integrating technology in planning process	126
Figure 6.13	Strategic planning horizon	127
Figure 6.14	Companies which prepare formal technology plans	129
Figure 6.15	"Aspects" contained in technology plan	130
Figure 6.16A	Who contributes towards technology planning	132
Figure 6.16B	Who contributes towards the implementation of technology	133
Figure 6.17A	Techniques employed in technology planning (all respondents)	135
Figure 6.17B	Techniques employed in technology planning (Chemical segment)	136
Figure 6.18	Technology acquisition methods	137
Figure D.1	Developing the technology profile	220
Figure D.2	Matching business and technology portfolios	222
Figure D.3	Technology investment matrix	223

LIST OF TABLES

TABLE 1.1	Economic performance of selected countries	7
TABLE 3.1	Role of top management in technology process	59
TABLE 3.2	Importance of functional areas to overall corporate performance	60
TABLE 3.3	Factors considered in the corporate planning process	62
TABLE 3.4	Barriers to integrating technology with corporate planning	63
TABLE 3.5	Means of integrating technology in planning process	64
TABLE 5.1	Questionnaires distributed	95
TABLE 6.1	Response rates	101
TABLE 6.2	Annual turnover figures	102
TABLE 6.3A	Employee statistics	109
TABLE 6.3B	Annual turnover statistics	109
TABLE 6.4	Mission statement details	110

Chapter 1

Introduction

CHAPTER 1 : INTRODUCTION

1.1 BACKGROUND

There is universal agreement that managing technology effectively is critically important to the success and survival of individual companies and to their economic well-being and growth (Steele, 1989 : 5).

Technological change is also seen as one of the principle drivers of competition and it can play a major role in changing the structure of industry, creating new industries and eliminating others. However, business strategy has historically been developed without a technology content because of the view that technology was not an allocatable resource which could be effectively managed (Lauglaug, 1987 : 21).

Since the early 1970's, it would seem that the basic principles underlying the strategic management of technology were well established. Unfortunately only in recent times have practical frameworks and principles been developed which address the critical issues involved in strategically managing technology (Lauglaug, 1987 : 21).

Managers are only now starting to recognise that technology should be used as a competitive weapon and as such form an integral part of the company's overall strategy (Porter, 1985; Frohman, 1982 : 97 - 104). This essentially involves integrating

technology planning into the strategic plan.

At the core of a technology strategy is the type of competitive advantage a company is trying to achieve. The technologies to be pursued by the company are those that would contribute to the company's generic strategy, offset against the chances of success in commercialising them. The three generic strategy options available to companies for achieving competitive advantage are : cost leadership, differentiation and focus. Technology strategy is, potentially, a powerful means with which the company can pursue any of these three generic strategies (Porter, 1985).

There are only three key factors needed to achieve competitive success, these are : the right cost, quality and service. The appropriate mix and continuous improvement in these three factors should result in success for any company. Technology can make inroads and effect improvements in all three areas.

Despite the importance of technology planning and management to the well being of organisations in terms of survival, profitability and growth, very few organisations seem to be effectively exploiting this field. The problem may lie in fact that companies experience difficulties in translating long-term technology considerations into short-term planning commitments, particularly since corporate goals most often seek short term positive bottom line results.

1.2 OBJECTIVES OF THE RESEARCH

The objectives of the research are two-fold:

- Firstly, to establish the role of technology in corporate operations within certain segments of the South African industrial sector, and
- secondly, to determine how effectively companies within these industrial sector segments are planning for technological change and managing technology.

These objectives will be conceptualised and discussed in more detail in chapter 4.

1.3 RESEARCH SCOPE

The focus of the research was directed towards the field of technology management as viewed from a corporate perspective. The emphasis, however, fell on the planning side of technology management, as well as the interplay between technology and the strategic planning process.

It is necessary to look at the strategic planning process and technology management from an integrated perspective, since this is the only way of ensuring the effective implementation of technology in the company's long-term strategic plans. This aspect will be addressed in more detail in chapter 2.

The research was undertaken within the chemical, electronics, engineering, industrial holding, pharmaceutical and medical, and steel segments of the industrial sector in the South African economy. A total of 135 listed JSE industrial sector companies were included in the study. The exact details regarding the number of companies for each of the industrial sector segments is given in Table 5.1 (see column headed "questionnaires distributed - first mailing").

Most economists acknowledge the central role played by technology in the economic growth of developed countries (i.e. countries that develop technologies mostly through their own R & D efforts). The situation in a developing country such as South Africa with its dualistic economy comprising of both first and third world economies, is however much more complex (Brews, 1988). Technology, and in particular capital intensive (hi-tech) technology, though making a positive contribution in the developed countries, may have unintended negative effects in developing countries. Within this context, the debate on affordability and the appropriateness of technology in South Africa must be considered. Notwithstanding the extreme importance of the inter-relationship between technology and dualism, and the issue of adopting appropriate technology, these issues will not be considered as they fall outside the scope of this study.

1.4 PURPOSE OF RESEARCH

This research is an exploratory study into technology planning

and management within the South African industrial sector. Within the context of the introductory statements made under section 1.2, there is a need to establish what is currently been prescribed in the field of technology management theory and to establish what is the present status regarding technology management in the delineated sector. By understanding the current situation with respect to the status of technology management and by means of a gap analysis, conclusions can be presented regarding technological issues that need addressing to ensure an improvement in the implementation of a more effective technology management approach.

1.4.1 Importance of research - General Context.

According to Thompson & Strickland (1987 : 134), "Any business strategy, to be capable of sustained success, must be predicted on building and maintaining a competitive advantage". Twiss & Gooderidge (1989) maintain that technology is one of the strategic strands for competitive advantage. Wills (1991) in his research into technology management reported individual companies in the industry certainly can improve their effectiveness in managing technology.

In the context of the above, it is evident that the effective management of technology within a company should become a vital aspect of the overall management approach.

1.4.2 Importance of research - South African Context.

South Africa has two distinct market areas to exploit outside of its normal domestic markets. These are:

- Export market
- Import market.

South Africa's reliance on the export of primary products to generate foreign exchange has proven to be a major reason for its poor economic performance. The export and import replacement market involve competing head-on with developed countries in global markets. In order to compete successfully, our products will have to be competitively priced, of at least comparable quality and supported by adequate service. The only logical way to succeed must at least involve upgrading of the necessary technologies.

Advisors on economic matters indicate that the country should shift away from its total dependence on raw material exports, and that beneficiation and high value products for export should become the core focus. Of significance in Table 1.1 is South Africa's negative GNP per capita growth and the high economic growth of South Korea over the past decade. One should learn from a country such as South Korea, which is not as well endowed with mineral deposits like South Africa, and which has achieved an impressive economic growth rate of 10,1% over the past decade by adopting new and mature technologies from abroad to convert

imported primary products into secondary products for export. A similar turn-around by South Africa in extending its range of activities and becoming an efficient convertor of primary products into secondary products will have to be technologically driven.

TABLE 1.1 : ECONOMIC PERFORMANCE OF SELECTED COUNTRIES
Source : Joubert, 1992

COUNTRY	GNP 1989 US $ BIL	Real Growth % 1980-1989	GNP per Capita 1989 US $	% Change
South Africa	86,0	1,5	2 460	-0,8
South Korea	186,5	10,1	4 400	8,8
Hong Kong	59,2	7,2	10 320	5,7
Singapore	28,0	6,9	10 450	5,7
Thailand	64,4	6,5	1 170	4,5
Italy	871,9	2,4	15 150	2,1
France	1 000,8	2,0	17 830	1,6
Germany	1 272,9	2,0	20 750	2,1
Japan	2 920,3	4,1	23 730	3,5
USA	5 237,7	3,2	21 100	2,2

In assessing the problems, two key issues stand out as ones that influence the success or failure of local industry in meeting the challenge - people and technology (Miller, 1988).

Although one should optimise on the utilisation of the country's labour pool, companies will not survive if the emphasis is to keep labour-intensive systems going irrespective of costs. Industry must be allowed to maximise efficiency, even if it means the introduction of some form of appropriate technology involving, for example, automation.

1.5 METHODOLOGY

A detailed study of the field of technology management was undertaken in an effort to establish what normative theory currently regards as accepted practice for technology management and identify the important elements of technology management.

To assist with the study, a literature review of several similar studies and related articles on technology management were undertaken. The purpose of these reviews was to establish what has already been done in the field of technology management in the past and to help in attacking the current research.

A model on the process of technology management was then proposed, based (primarily) on the survey of relevant theory discussed in chapter 2. This was used as a framework for discussions regarding how effectively the companies from the various industrial sector segments are planning and managing technology.

A questionnaire on technology management issues was constructed and mailed to listed JSE companies in several segments of South African industrial sector.

The findings of the technology management survey were then analysed and discussed in terms of the theory presented in the preceding chapters.

1.6 REPORT CONTENTS

The report consists of eight chapters, addressing five main areas of research execution, namely:

* Theoretical basis
* Problem definition
* Research methodology
* Research findings and discussions
* Conclusions and recommendations.

The research is defined in chapter 1 in which background and broad objectives to the research are given. The purpose and importance of research along with the overall methodology are also discussed.

Chapters 2 and 3 document the theoretical basis of the investigation and the literature review respectively.

The problem statement is conceptualised in chapter 4, in order to develop on the broad research objectives stated in chapter 1 and formulate a strategy for discussing the research findings.

Chapter 5 outlines the research methodology used for collecting both primary and secondary data.

The research findings are presented in chapter 6 along with a

brief analysis and discussion of the findings.

Chapter 7 discusses the role of technology and relates the findings to the proposed model on the process of technology management, and chapter 8 presents the researcher's conclusions and recommendations. Ideas for further research are also put forward.

Chapter 2

Technology planning and management

CHAPTER 2 : TECHNOLOGY PLANNING AND MANAGEMENT

2.1 INTRODUCTION

In this chapter, a literature survey of the current theory related to technology planning and management will be undertaken. It will be done with the emphasis on gaining a more systems orientated view of its role in, and inclusion into a framework for the strategic management of technology.

In essence, answers to the following questions will be sought:

- What it is?
- How it fits in with other activities in the company?
- What role it should play in a successful enterprise?

2.2 THE MEANING OF TECHNOLOGY

Perhaps the best place to start is by first trying to understand what is meant by "technology", before attempting to define the scope of technology. Numerous definitions abound, and several are given below:

Webster's International Dictionary (1971) states:

> "the science of the application of knowledge to practical purposes".

Collier (1985) considers technology as being the raison d'être for any business and defines it broadly as know-how, whereas

McGee & Thomas (1989) defines technology as information, amounting to merely blueprints or specifications for a product or process which, when built, will work. Betz (1987) expands on these definitions by relating technology to business and production by saying that technology underpins business, providing the technical knowledge for goods and services that a firm produces.

Bayraktar (1990) defines technology in terms of "created capability" by stating that technology is the totality of goods, tools, processes, methods, techniques, procedures that are invented and put into some practical use.

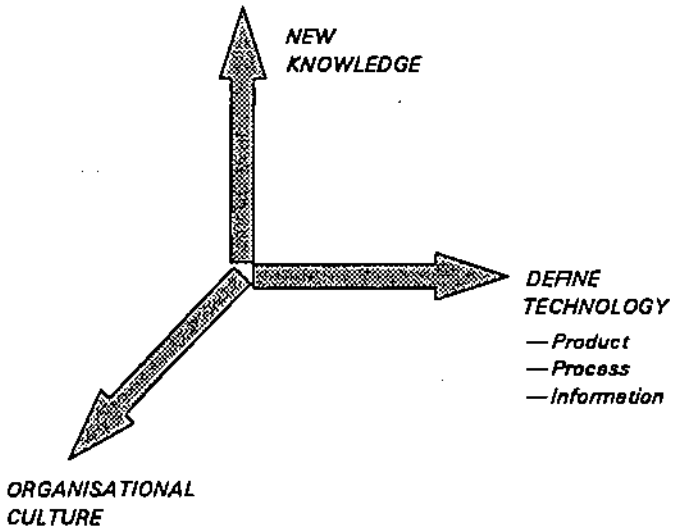
Sherman (1981 : 2) states that technology is the systematic application of fundamental, scientific phenomena and principles in a device, process or concept that performs a function useful to man.

Technology requires a multidimensional perspective, as illustrated by Figure 2.1 (Steele, 1989 : p.(xx)). In one dimension, it involves the search for new knowledge. This holistic approach views technology over an extended continuum, bringing the activities of science, engineering, basic research, manufacturing processes, and so on, under one umbrella.

Along the next dimension, is the need to define technology as encompassing three fields of activity; viz. product, process and information technologies.

The third dimension, is the role that organisational culture plays in guiding and constraining managerial action and decisions. An important goal for management is to balance the organisation's culture with its competitive goals. To successfully exploit technology, managers of technology must broaden their focus from just products and processes to the entire business (Monger, 1988 : 35).

Figure 2.1 : Multidimensional technology perspective
Source : Steele, 1989 : p.(xx)



Technology should therefore not be confused either with science or with product or process development. One could possibly stick to a simplistic definition and say that technology can best be characterised by a sentence like this: "We know how to do something" (Magee, 1982 : 56).

Thinking of technology in these terms, would allow one to begin

to identify some of the discrete technologies that go into a product or process and begin to see what changes in technology mean to a company's competitive position. If the technology changes, then the business must adapt itself to the new conditions if it is to survive.

2.3 CLASSIFICATION OF TECHNOLOGIES

It is useful, in looking at technologies (see Figure 2.2) that underlie a company's strengths, to break these technologies down into three broad groups: (Magee, 1982 : 56; Ericksen, Magee, Roussel & Saad, 1991 : 36 - 37).

2.3.1 Basic technologies

These technologies are existing technologies which are widely known and well developed, as well as being readily available to all competitors. If a company wants to be in business it must master and maintain competence in these technologies. They do not however give the company any particular competitive advantage.

2.3.2 Key technologies

These technologies are in the embryonic or growth stage of development and will replace existing (basic) technology within the next few years. They offer scope for innovation and differentiation, viz. product and process innovation, product and process improvements, improvements to the production process efficien-

cies, or differentiation to features or functions in the product. They also provide the potential for competitive advantages and should be given the highest priority amongst the company's investments in technology.

2.3.3 Pacing technologies

These are emerging technologies which are still in the process of being developed and may become the key technologies of the future. They have the potential of causing quantum technology changes in or to an industry. These technologies could displace today's key technologies as the prime source of competitive advantage in the future. Not every company can afford to invest in pacing technologies; this aspect typically differentiates the leaders (those who do invest in pacing technologies) from the followers (those who do not invest in pacing technologies).

The critical issue in technology management is ensuring a balance between support of key technologies to sustain current competitive advantage and support of pacing technologies to create significant competitive advantage for the future.

An effective research and development programme should include some investment to develop a core of competence in pacing technologies and some effort to gain intelligence to help identify and evaluate these technologies.

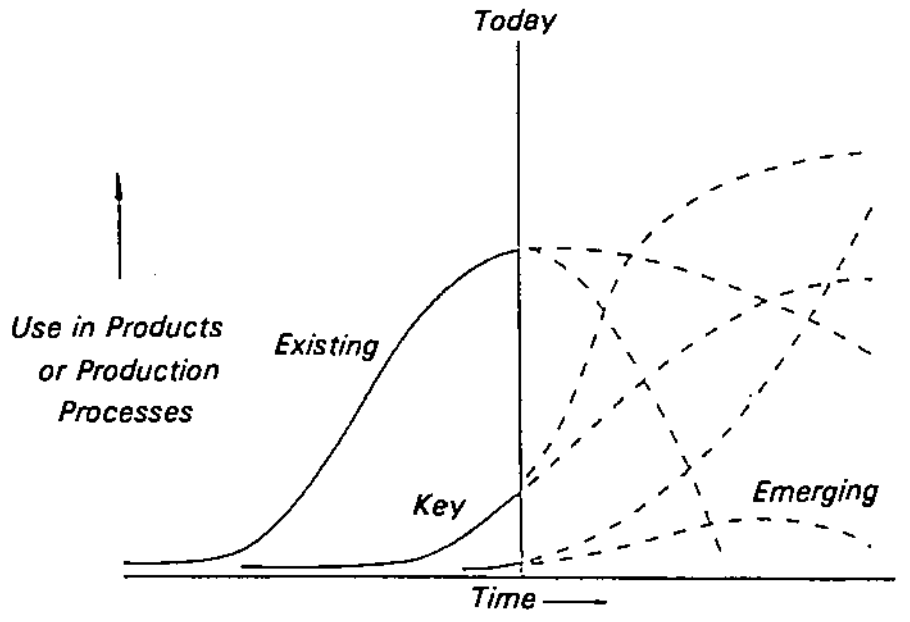
At the same time, judicious assessment about the commitment to

pacing technologies is necessary; overcommitment could mean an underspending on key technologies (Erickson, Magee, Roussel & Saad, 1991 : 37).

Figure 2.2 : Categories of Technologies

Schematic representation of the relationship among Basic (existing), Key and Pacing (Emerging) technologies

Source : Adapted from : Manahan, 1986 : 16



2.4 RELEVANCE OF TECHNOLOGY TO INDUSTRY

The relevance of technology to high-tech industries is unquestionable, however its relevance to low-tech industries may be an enigma to many people.

Porter (1985 : 165) takes the stand that "there is no such thing as a low technology industry", with the need for technology

existing throughout the value chain and extending beyond those technologies just associated directly with products.

Technology's impact reaches far beyond the "high technology" companies. Certain companies may appear to be insensitive to technology when considering their products, services and market requirements; however they are not immune to changes and from the impact of technology.

Technology still affects the activities of low technology industries, e.g. smokestack and service industries, in terms of the way they manage and control their businesses; particularly when one considers the impact which emerging technologies have on their efficiency, productivity and ability to provide quality products (Levine & Yalowitz, 1983 : 44 - 45).

2.5 MANAGEMENT OF TECHNOLOGY (MOT)

Certain conditions in the current business environment demand a new approach to effective technology management and a reassessment of traditional management techniques (Task Group on the Management of Technology, 1987). These are :

- The pace at which new product and process technology is generated has grown exponentially, creating new markets and altering sources of competitiveness.
- Increasingly sophisticated consumers and new developments in science and engineering have provided the

market incentives and technological capabilities to shorten product life cycles.

- Related to this reduction in product life cycles is the need to reduce product development times.

- Faced with global competition and the many sources of new technologies, companies must develop technology strategies for maximising competitiveness.

- With rapid changes in product lines and production technologies, the traditional basis for corporate decisions related to technology are no longer adequate.

As technology changes, the tools of management need to change. The above considerations emphasize the need to adapt the old approach to managing technological resources (which entailed treating technological matters as pheripheral issues outside of the business planning), and to seek ways of improving MOT through utilising an integrated approach and by adopting new strategies, techniques and methods. Technology management must be viewed from a corporate perspective, and not from the standpoint of managing the technical operation. This means that all technological issues must be integrated with strategic business planning and decision making in order to both achieve business synergy and technology leverage (Lauglaug, 1987).

The scope of MOT spans the entire R&D spectrum from basic research and applied research, through to technology diffusion and utilisation. Several definitions of MOT taken from literature are

given below:

Betz (1987 : xvii) understands technology management simply as:

> "means to use new technology to create competitive advantage".

Although the definition may be incomplete in its scope by not addressing all aspects of technology management, it certainly "highlights" where the emphasis should be placed.

Bayraktar (1990) describes technology management in the following way:

> "Management of Technology will be concerned with the decision problems, at all levels, related to the creation and utilisation of technological assets and capabilities, their impacts on individuals, organisations, societies and nature; and the reconciliation of economic, social and environmental consequences of technological innovations".

Cory (1989) focuses on the integrated process and states that technology management is:

> "the integrated practise, i.e. process, between business and the technical disciplines that are required to plan, develop, apply and install technological capabilities for products or services to form and achieve, successfully, the strategic and operational objectives in an enterprise".

A report by the Task Group on Management of Technology in 1987, which was initiated by the National Research Council (USA), entitled Management of Technology: The Hidden Competitive Advantage, accepted the traditional notion of technology:

> "Management of Technology is an industrial activity and an emerging field of education and research that is not generally well recognised or even consistently defined".

The Task Group subsequently offered the following formal definition:

> "Management of Technology links engineering, science and management disciplines to plan, develop and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organisation."

Expressed in other terms, the Management of Technology may be thought of as a rational and systematic way of responding to technological opportunities and innovations, and dealing with their consequences. In broad terms, Bayraktar (1990) summarises the activities related to Management of Technology into three categories:

- creation of new technologies, and effective and efficient use of existing and new technology
- responding to and coping with the impacts and the effects of technological changes on individuals, society and nature
- developing methods, techniques and procedures needed for dealing with technological issues and problems.

From an organisational level and a functional perspective, Bayaraktar (1990) describes Management of Technology as involving the following:

- understanding innovation processes that underlay technological changes
- predicting future technological developments
- identifying and assessing technological options
- developing new technologies; and/or adopting and implementing chosen technologies into operations
- predicting organisational, operational and human consequences of adopted technologies and taking necessary measures for efficient implementation
- adopting new management style, and supporting methods and procedures.

Management of technology is therefore concerned with finding out how the technological setting is changing, helping formulate strategies to dovetail the corporate mission with new technological opportunities, and building technology as a corporate-wide resource.

2.6 ELEMENTS OF TECHNOLOGY MANAGEMENT

Literature abounds with various ways of describing technology management in terms of its elements. The description below represents an attempt at a synthesis of that which appears in literature.

The elements of technology management will therefore be dealt with under the following four headings:

- technology strategy
- technology acquisition and development
- technology utilisation
- technology protection.

2.6.1 Technology strategy

Monger (1988) categorises the technology strategy element of technology management as being that of "position taking". This element encompasses the process of identifying technology options, evaluating these technology options in the light of corporate business objectives and determining investment priorities for technology implementation.

Technology strategy is crucial to the survival and success of any company and should complement business strategy in both mature and low-tech companies, drive business strategy in high-tech companies, and in most industries can be used to create technology and leverage to achieve sustainable competitive advantage (Sethi & Hickey, 1985 : 95).

Porter (1985) suggests that by adhering to the following analytical steps in formulating technology strategy, will help ensure that the firm is better equipped to use technology as a competi-

tive weapon rather than a scientific curiosity:

- Identify all the key technologies and subtechnologies employed by the firm and its competitors.
- Identify potentially relevant technologies in other industries or under scientific development.
- Determine the likely path of change of key technologies.
- Determine which technologies and potential technological changes are most significant for competitive advantage and industry structure.
- Assess the firm's relative capabilities in important technologies and the cost of making improvements.
- Select a technology strategy, encompassing all important technologies that reinforces the firm's overall competitive strategy.
- Reinforce business unit technology strategies at the corporate level.

Technology strategy should at least establish which technology to pursue into development and whether a position of leader or follower is to be sought. It should also dictate which areas of research and development to scale down on or abandon, what know-how to buy or license, and the desired balance of investment in basic, applied and development activity (Brownlie, 1987).

Planning technology strategy is a complex process which can be broken down into four steps (Manahan (1989 : 55 - 56); Pavitt (1990 : 24); Sethi & Hickey (1985 : 95) & Harris, Shaw & Sommers (1983 : 31)). These are:

* **Technology situation assessment**

The first step of the technology strategy process involves a technology situation assessment. The purpose of assessment is to set the stage for taking advantage of various competitive opportunities available to the company.

This assessment requires an ongoing internal and external scan of the technology environment beyond the limits of the traditional business portfolio. The technology situation assessment is a three step process which incorporates internal technology auditing, external monitoring and scanning, and a technology gap analysis.

As the first step of the technology assessment, an internal technology audit and analysis of the technologies employed by the company in its products, processes and such like, must be carried out. This amounts to the company doing a self assessment to determine its "baseline" technology capability, thereby establishing its strengths and weaknesses.

The next step of the technology assessment is the monitoring of the external environment to pinpoint the investment patterns of

competitors both on the product and process side of the company's key technologies, as well as scanning and forecasting new and emerging (pacing) technologies in the external environment. In this way technological opportunities and threats to the company can be identified.

The final step of the technology assessment involves a technology gap analysis to identify technology alternatives available to the company which offer opportunities or pose threats and to determine how these alternatives relate to the company's strengths and weaknesses.

* **Technology Portfolio Development and Evaluation**

The second step of the technology strategy process involves the development of a technology portfolio. The technology portfolio is used as a tool to identify and systematically analyse key corporate technology alternatives and to set technology priorities (See Appendix D).

* **Technology and corporate strategy integration**

The third step of the technology strategy process involves the integration of the technology portfolio into the overall corporate strategy; thus ensuring consistent objectives and improving the likelihood of successful implementation.

The business and technology portfolios (see Appendix D for de-

tails on matching business and technology portfolios) must be compatible if one expects to gain advantage in a technology-related company. This means that the technology portfolio will be effective only if it is compatible and consistent with the strategy demanded by the company's business portfolio. Incompatibility, for example, means the company runs the risk of developing a potentially attractive strategy in terms of economics and other business portfolio information, only to find out it lacks the technology strengths needed to achieve its objectives.

* **Technology Investment Priorities**

The final step of the technology strategy process is to evaluate the technology alternatives which meet the requirements of step 3, i.e. compatibility between the business and technology portfolios, and develop a specific technology strategy. The technology alternatives considered at this stage may then be referred to as technology investment options.

The technology investment matrix of strategic "plays" available versus relative technology expenditure (see Appendix D) can be used to establish where the technology investment option lies in terms of technology investment priorities and optimum range. Relative technology expenditures can be obtained from the portfolio analysis in step 2 and 3.

The investment strategy should move the company's current technology situation towards an optimum range. This generally means

that technology investment options with high technology importance and high leverage, will receive more serious consideration as investment opportunities; whereas options where the technology importance is low will either be scaled down or terminated.

2.6.2 Technology acquisition and development

Once an idea or technology investment option has been screened and selected for implementation or "commercial" development, the most appropriate means of acquiring the technology for the company must be selected.

Two broad approaches are available for acquiring technology, namely: develop the technology in-house or buy it from outside. Technology acquisition methods can include any of the following:

- in-house research and development
- reverse engineering
- collaborative research and development
- making use of intellectual property (internal experts, proprietary information, etc.)
- acquisition of intellectual property (consultants, seminars, etc.)
- technology purchasing (contract R&D, licensing, etc.)
- non-acquisition (buy-in parts, services, etc.)

- joint venture
- acquisition of innovative companies
- technology scanning.

The decision as to which technology acquisition method to use must also take cognizance of the technology life cycle (TLC) position of the overall technology in terms of its various stages, namely : embryonic (earliest), growth and mature (early), or aging (later); as well as cycles of any sub-technology representing a generation in the overall technology (Ford, 1988: 27).

During the process of making a technology acquisition decision various issues which affect the final decision must be considered; for example, the company's relative standing, the urgency attached to the acquisition, together with the applicability of the various acquisition methods under these circumstances must be considered. Figure 2.3 provides in tabular form an exposition of this process by showing the factors which affect this decision.

2.6.3 Technology protection

Vast sums of money are invested in developing new products and processes, and companies must ensure that their intellectual property is protected. Without strong patent or copyright protection, and even with it, the most expensive technology can be outmoded rapidly, almost overnight.

Figure 2.3 : Factors affecting technology decisions

Source : Ford, 1988 : 91

Acquisition Methods	(1) Company's Relative Standing	(2) Urgency of Acquisition	(3) Commitment/ Investment Involved in Acquisition	(4) Technology Life Cycle Position	(5) Categories of Technology
Internal R&D	High	Lowest	Highest	Earliest	Most Distinctive or 'critical'
Joint Venture		Lower		Early	Distinctive or Basic
Contracted-out R&D		Low		Early	Distinctive or Basic
License-inR&D		High	Lowest	Later	Distinctive or Basic
Non-aquisition i.e Buying Final Product or Part Production From Others	Low	High	No Commitment/ Investment	All Stages	External

2.6.4 Technology transfer and development

As part of the innovation process it is essential that acquired technology know-how through whatever means is transferred from the original point of creation or acquisition to an area where there is a potential need. The diffusion of technology is vital in ensuring benefits to the fullest extent from any technological changes and development.

Technology transfer may involve intra- or inter-firm diffusion viz. the transfer of know-how internally within the company to an area where it can be implemented or commercialised, or alterna-

tively selling the intellectual property to concerns outside the company.

2.6.5 Technology utilisation

Once technology has been acquired by the company it is necessary that it is effectively utilised.Technology utilisation can be seen to incorporate the implementation and commercialisation aspects.

* **Technology implementation**

Once technology transfer has been effected, technology implementation follows where the acquired technology is incorporated into improved and new products and processes.

* **Technology commercialisation**

Invention is the idea, whereas innovation is the process of commercialisation and adding to technological competence (Klein, 1991 : 251). Technology commercialisation occurs wherever technology implementation is undertaken for the ultimate purpose of commercial exploitation, albeit the development of products or processes.

2.7 TECHNOLOGY AND THE STRATEGIC PLANNING PROCESS

Technology is an essential input to the strategic planning process, rather than merely a way to implement strategy.

The company's overall strategic plans should include the technological position it wants to secure as part of the implementation of its long term business strategy. Technology planning will then represent the long term corporate objectives of the company in terms of its desired technical achievements. It will establish the long-term technology objectives and the means to achieve them (technology strategy) which is consistent with, and supportive of the company's strategic plan.

The company's needs for technological development (its technology needs) are determined by the gap (technology gap) that exists between its current "baseline" technology capability and the technological potential consistent with the technology objectives. Its technology strategy will dictate the manner in which the technology gaps are closed and also assign priorities to the closure of the various gaps.

Several models taken from literature which offer an integrated perspective on the strategic planning process and technology management will be discussed below:

2.7.1 Modified general planning model

The modified general planning model described by Sethi & Hickey (1985) incorporates the inclusion of technology strategies into the overall long term strategic planning (see Figure 2.4).

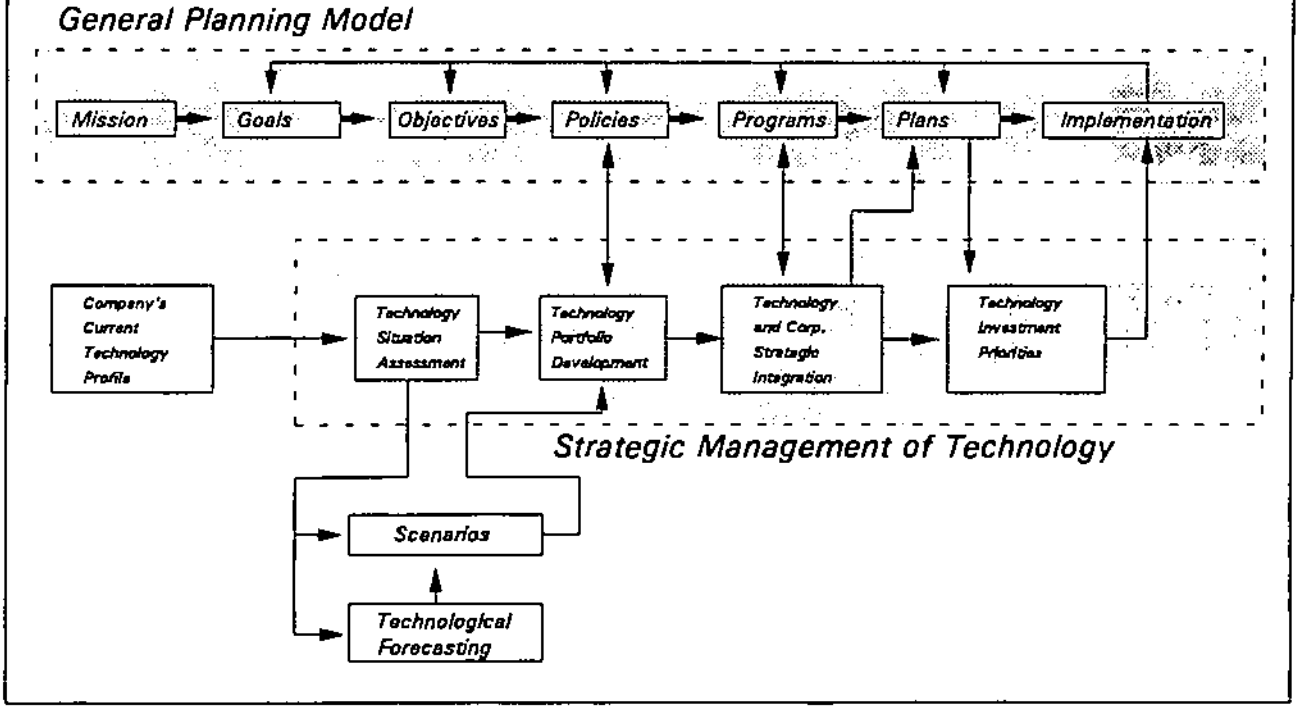
The process starts with the definition of the company's technolo-

gy profile. This includes an overall company assessment of current products, R&D investment and organisation.

Next, technology scanning of both the internal and external environment is undertaken. It is followed by technological forecasting and scenario development to establish various technology alternatives. At the same time a complete evaluation within a set time frame of the company's operations may be considered; bearing in mind factors such as economic and environmental considerations. Next, technology portfolio development is undertaken with key corporate technology alternatives and priorities being identified and systematically analysed.

Figure 2.4 : Modified General Planning Model

Source : Sethi & Hickey, 1985 : 91



This is followed by integrating the technology portfolio with the business portfolio describing the overall corporate strategy, thus assuring consistent objectives and effective implementation. During the last stage technology investment priorities are determined assuring success for the company in terms of survival, profitability and growth.

2.7.2 Link between R&D and Business Strategy

Brownlie (1987 : 50) sees a link between R&D (technology planning) and business strategy, as illustrated in Figure 2.5. He contends that strategic planning formulates and plans the implementation of overall business strategy, making decisions now which effect the long term future of the company. The anticipation of threats and opportunities in the technological environment which have their origin in long-term changes should be part of the strategic planning process which incorporates activities such as long-term forecasts of technological development, amongst others.

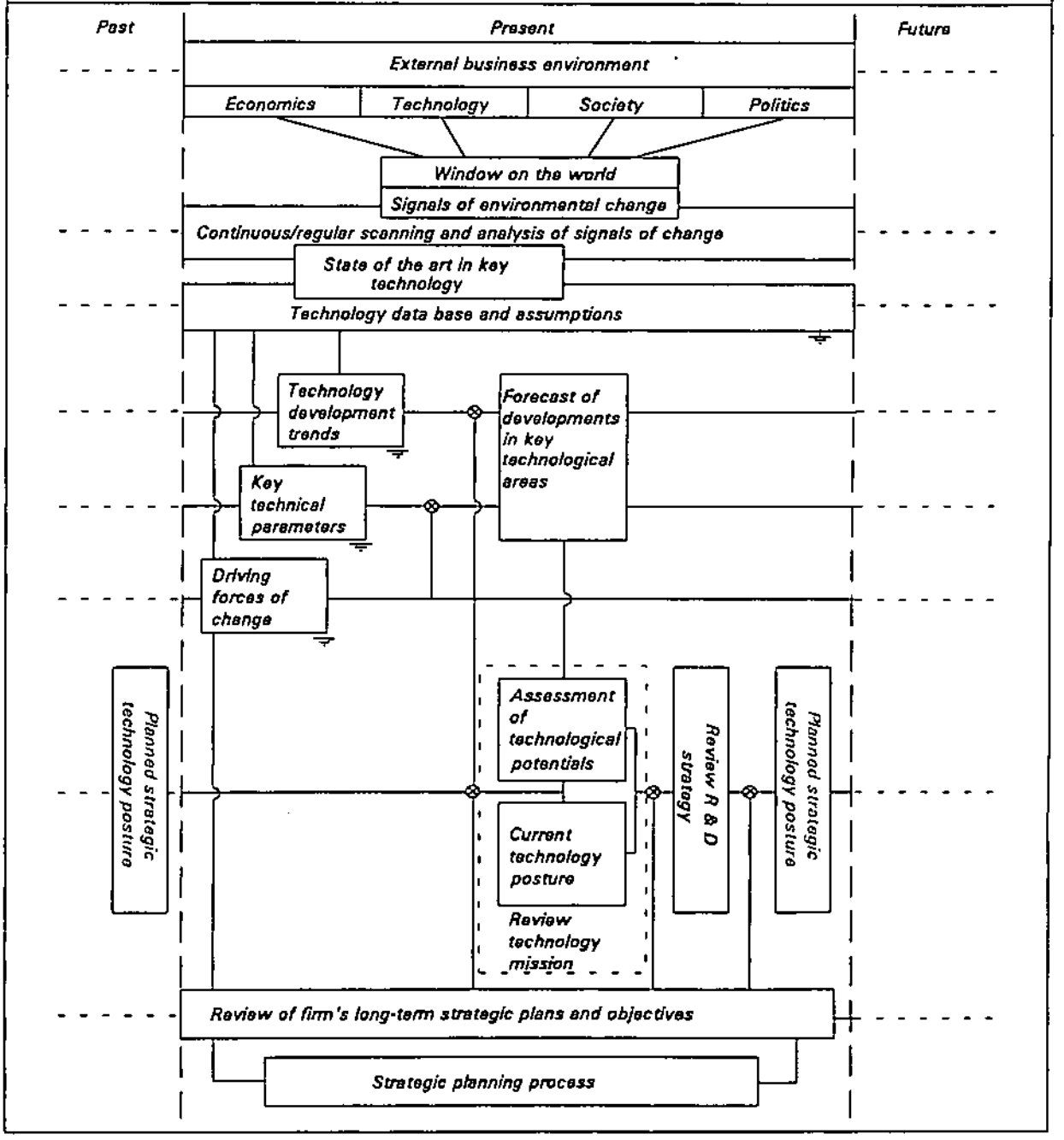
According to Brownlie's model the strategic planning process should therefore include:

- forecasting of technological change
- relating company's long-term objectives to the technology alternatives
- deciding what action to take on a technology forecast

- what research and development to initiate
- what to terminate
- what impact future developments might have on the company's prospects.

Figure 2.5 : Tracing the Link between R & D and Business Strategy

Source : Brownlie, 1987 : 50



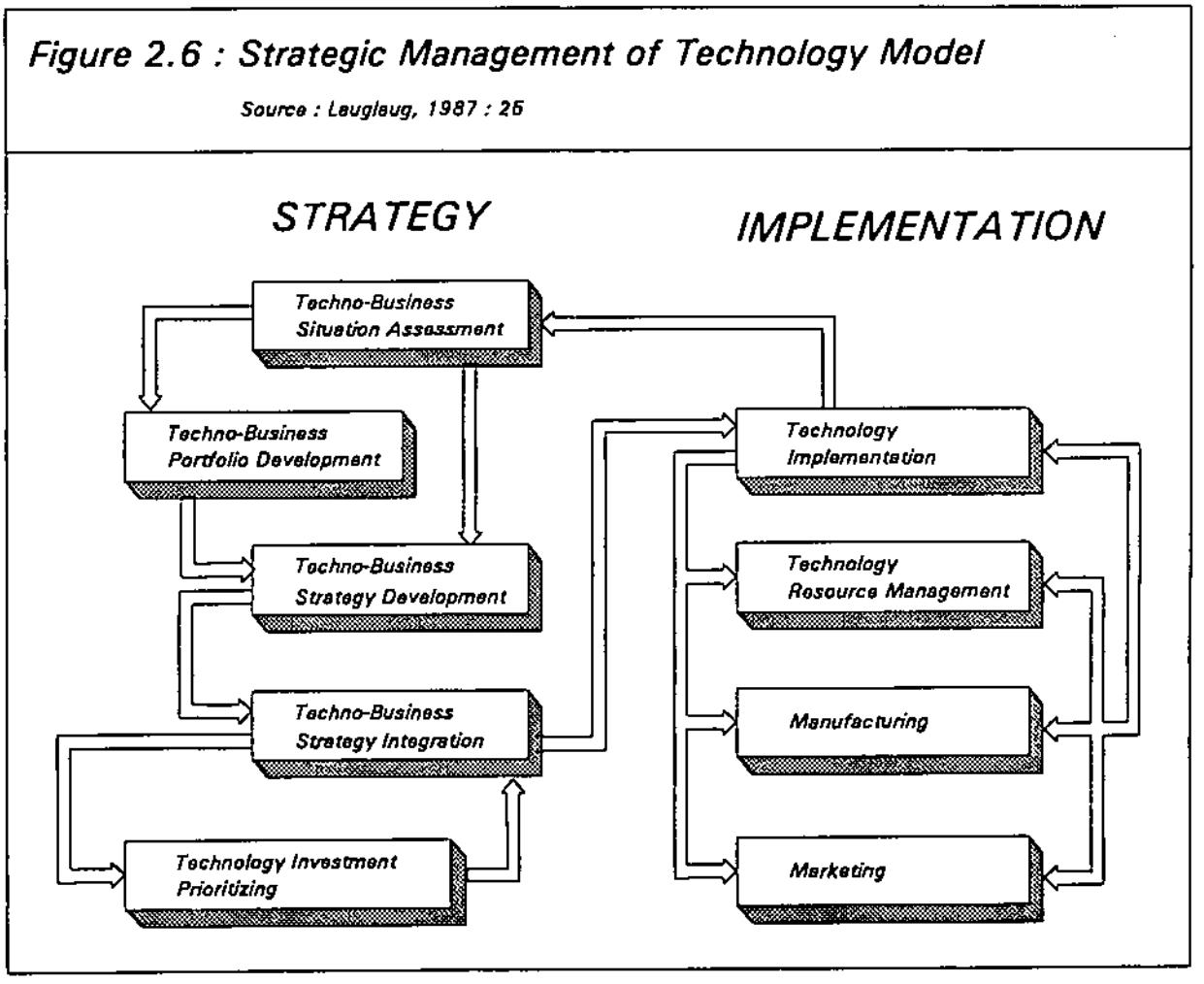
Essentially this means that all the potential technological threats and opportunities emanating from the external environment are first established and then related to the objectives of the company before finalising the strategic plan.

2.7.3 Strategic Management of Technology Model

The traditional approach to strategic planning has been an "ends-ways-means" model; viz. establish corporate objectives (ends), develop a strategy (ways) for achieving these objectives; and marshal the resources (means) necessary to implement the strategy.

Figure 2.6 : Strategic Management of Technology Model

Source : Laugleug, 1987 : 25



The strategic Management of Technology (SMT) model proposed by Lauglaug (1987: 24) utilises this approach, with the variation that the approach is reversed; viz. "means-ways-ends" (see Figure 2.6). For example, companies may frequently possess technological capabilities (i.e. the means) with which they seek:

- maximum near-term profitability as in the case of mature and maturing companies
- key technological capabilities which can provide competitive advantage and will replace the basic technology within the next few years
- pacing technologies capabilities which represent potential capabilities which could revolutionise current technologies or lead to new products, processes or industries.

The strategic analysis of such 'means' using the SMT process, leads on to the development of strategies (ways) to exploit technological capabilities. The end result after all these factors have been considered (see sections 2.6.1.1 to 2.6.1.4) is the establishment of realistic and viable objectives (ends).

The 'means-ways-ends' model is particularly appropriate to the strategic management of technology process because of strategic consideration which must be given to both current and potential technologies and technological capabilities. Here, the difference is one of scope: **technology considerations** are traditionally

based on business factors, e.g. capital investment requirements, efficiency improvements, production output and the like; while technological capabilities involve additional, more contemporary factors such as productivity, quality of working environment, human resources development and globalisation issues in addition to the traditional business factors.

2.7.4 Integrated Technology Management

Monger (1988) points out that certain companies have been attempting to develop for themselves a complete technology management perspective. At the time, Monger was of the opinion that a universally accepted perspective on technology management did not exist, since there is no commonly accepted body of knowledge such as in accounting, finance, marketing, production and management.

Companies have been left pretty much to their own devices in trying to piece together a conceptual framework for managing technology. This has lead many companies to borrow bits and pieces of their thinking and adapting elements of this thinking to suit their individual needs and culture.

A three phase integrated technology framework is provided by Monger as a conceptual framework for managing technology. This Integrated Technology Management (ITM) framework (see Figure 2.7) is an attempt to provide a single perspective at senior management level regarding the management of information technologies in the contemporary competitive environment. There seems to be no

valid reason why the same framework cannot be applied to other technologies.

The "integrated" part of the ITM framework refers primarily to the integration of technological issues with traditional management thinking. The framework incorporates mechanisms to deal with management's understanding of new and emerging technologies, organisational and workforce issues, and factors external to the company. The management of organisational issues related to technological innovation and implementation of technical aspects also forms part of the ITM framework. In Monger's opinion, these factors are just as important as the technology and investment decisions. By using this framework, the company's technology can be used as a strategic weapon to capture competitive advantage.

According to the ITM framework, management's major responsibility is to build a technology infrastructure appropriate to the competitive needs of the company. Technology cannot be managed in isolation, but must be managed as an infrastructure; which includes the workers, methods, structure, culture, management style, as well as technology.

The ITM framework entails three distinct phases:

- assessment
- position taking
- policy formulation.

* **Assessment Phase**

Assessment involves all activities related to gaining an understanding of technologies. This includes assessing both the company's current (baseline) capabilities with technology and new and emerging technologies; and mechanisms for transferring the knowledge gained from the assessment phase to the company as a whole.

The assessment phase itself, involves four components:

- assessment of industry and business environment
- self-assessment to determine "baseline" technology capability
- assessment of new and emerging technologies
- technology transfer.

* **Position-taking phase**

The position-taking phase refers to activities related to the actual investment in technologies. These are the activities traditionally emphasised in management and involve determining the potential economic performance of various technology alternatives and then, based on this knowledge, deciding on a portfolio of technology investments.

Position-taking attempts to resolve the trade-offs management has to make in finalising investment decisions and also to give

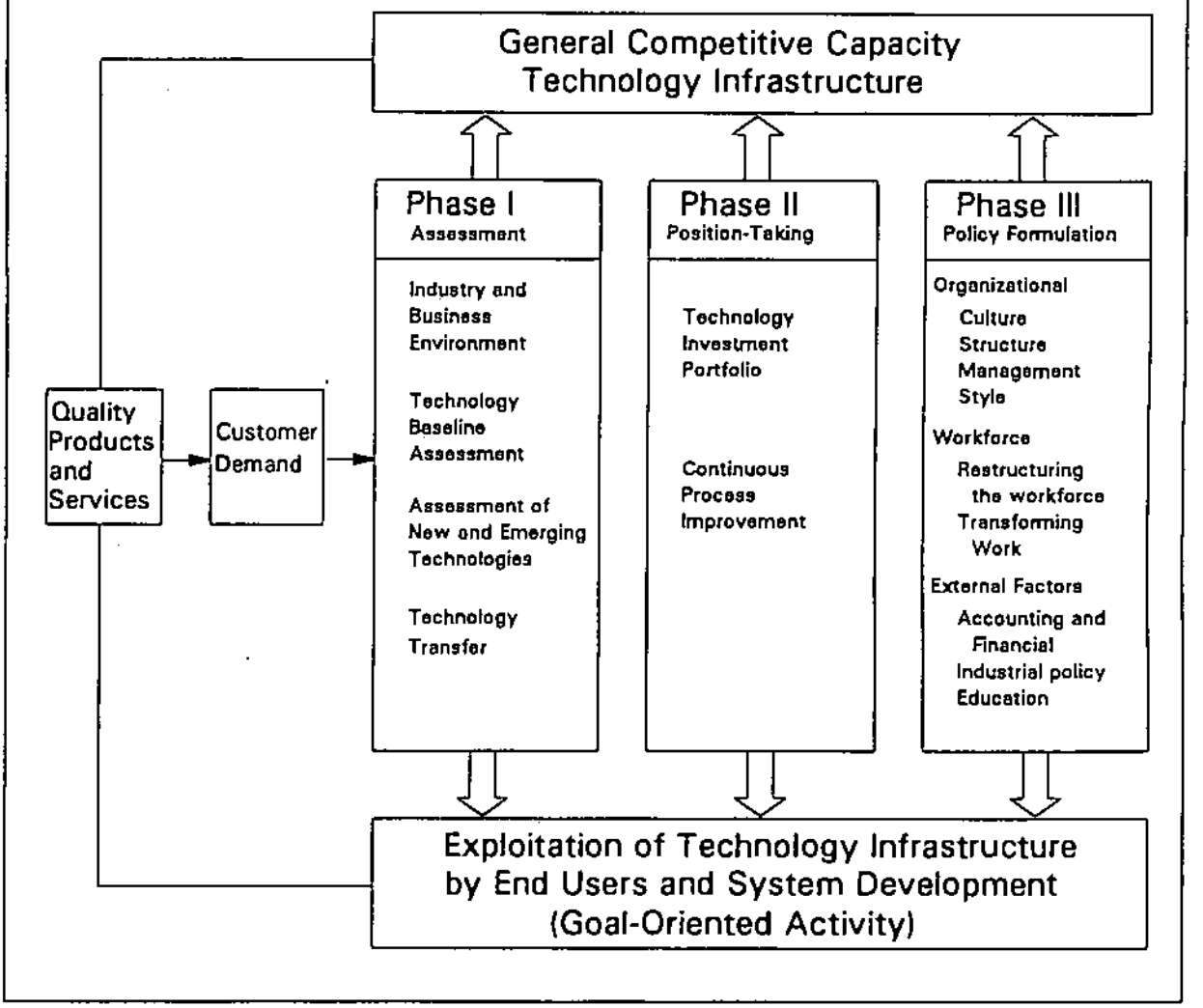
direction and purpose.

* **Policy formulation phase**

An important theme in the ITM framework is that changes in organisational culture and the like, are considered just as important as accurate assessment of technology and decisions about investments in technology.

Figure 2.7 : The Integrated Technology Management Framework

Source : Monger, 1988 :38



The policy formulation phase concerns the formulation of management policies orientated toward both internal and external factors which will be supportive of achieving the desired technological position. The ultimate objective in policy formulation is to match the form and content of the technology infrastructure to that of the form and content of the organisation. Many managers mistakenly believe that implementation of technology is separate from the process of managing the organisation. Certain components within the organisation need to be consistent with the technology infrastructure, e.g. culture, structure, management style, systems and workforce education.

Policy formulation provides a framework for dealing with organisational change as a means of facilitating technical change emanating from technological innovation and implementation. It involves three main issues:

- organisational
- workforce
- external factors.

Firstly, important components related to the **organisational issue** deal with culture, structure and management style. Implementation of technology is unlikely to be a success unless, for example, organisational culture and structures are consistent with the technological structure and business goals.

Technology and Organisational Culture

Culture in an organisation can be seen to deal with corporate philosophy and values that guide the business activities. Managing technology would not be complete without consideration being given to the alignment of technology with organisational culture.

There is growing recognition that companies must have an organisational culture in place that is compatible to the new exigencies in global competition. These exigencies may include the following (Monger, 1988 : 212) :

- Emphasis on customer satisfaction
- Improved quality
- Greater flexibility and responsiveness to changing market conditions
- Innovation and creativity.

Technology and structure

Technology infrastructure should match or serve structure, not the other way around.

Technology and management style

Management style in ITM framework is viewed as being essentially a policy tool for communicating or making known the appropriate

climate throughout the organisation. Effective technology management starts at the highest levels with management setting the direction of the company. Necessary changes to organisation culture and structure follow on the direction emanating from management, as do the needs to develop or change the technology infrastructure. All this intervention and interaction should be reinforced with the appropriate management style.

Secondly, management as part of their overall efforts to implement technology, must consider the implications that organisational change and technological change have on the workforce. These changes will inevitably impact on workers at all levels resulting in the restructuring of the workforce (job displacement) and changes in the nature of the work.

Thus, the workforce issue extends beyond reducing employee resistance to new technology, and should include how management prepares the workforce to accept new philosophies, such as improving customer satisfaction through quality, and how technology fits into that philosophy. The workforce issues should be dealt with in advance of technology implementation in order to maximise improvement in technology's performance.

Thirdly, managers must face one final reality when managing technology. In order to use technology effectively depends on **external factors** outside the organisation and their immediate sphere of influence.

It is not enough to monitor, scan and forecast technologies, nor plan the technological infrastructure, nor make investment decisions, nor create a climate for organisational change and prepare for the transformation of the workforce. Managers must understand the external factors that adversely affect technology-related decisions, and that require due consideration before making technology-related decisions that would benefit the company in the long term.

Thus, the ITM framework includes the management of factors in the external environment as a component equal in importance to any other issue that could possibly be considered. These factors are grouped in three categories

- accounting & financial
- industrial policy
- business education and research.

2.8 TOOLS USED IN THE TECHNOLOGY PLANNING PROCESS

Executives were asked to define the term technology in a survey conducted by HR & H Marketing Research International (Booz-Allen, 1984 : 3). One of the executives that was interviewed put forward the following definition:

> "Technology embraces a company in all its parts, without exception, its proper appraisal and application should ensure that the company uses the tools available, in the most efficient ways, to give it a competitive edge."

It has been said that Western management generally look for a fairly immediate return on investment, and most of their decisions are number driven. Any approach to managing technology that is based solely on current accepted measures of profitability as its goal, will more than likely result in a suboptimal outcome.

Managers involved in technology planning need techniques that allow them to perform the required activities, such as assessing their corporate resources, position them relative to market needs and the like. There are numerous techniques available to assist in the process of technology management (see Appendix A, question 20 of the questionnaire for a list of some of these techniques), but none of them will be specifically discussed in the report, except for the technology portfolio development technique which is discussed in Appendix D.

2.9 EFFECTIVE TECHNOLOGY MANAGEMENT

Effective management of technology links engineering, science and management disciplines by addressing issues which include the planning, development and implementation of technological capabilities to support the strategic and operational objectives of a company (Steele, 1989 : p. (ix)).

The major issue that emerges is that to compete effectively, management must build up a general technological capability. Through effective technology management, top management can ensure that their company's technology development programmes

focus on developing technologies that support its product and marketing strategy.

Based on studies undertaken by Peters and Waterman, Goldsmith and Clutterbuck, Ohmae, Okada, Drucker, Monger and Peters, amongst others, it appears that three major factors have contributed to ineffective technology management within companies (Ramamathan, 1990 : 414). These are as follows:

- inadequate understanding of the process of technological change
- inadequate top management involvement with technology
- inadequate appreciation of the importance of innovation.

Companies that exploit technology effectively will have three conditions in common (Frohman, 1982 : 98 - 104). These three conditions are discussed below under their separate headings.

2.9.1 Condition 1 : Top management orientation

*** Technical background of managers**

The majority of top managers in companies which rely heavily on technology as a competitive weapon have strong technical backgrounds.

* **Orientation and strategy**

If a company is to focus on technology and integrate technology into the business plan, it must place technology development in the hands of a competent senior technical manager well versed in the skills of technology management.

* **Pitfalls of technically strong top management**

  - emphasis on technology at the expense of other areas
  - top management's over-involvement in technical decisions
  - tendency to produce what the company can make technically, which is not necessarily what customers will buy.

2.9.2 Condition 2 : Criteria for the selection of technology investments

The criteria used by managers to select technology investments are the central factors in determining the extent to which they actively support the development of technology.

Criteria used for selection of technology investments should include:

  - support of business objectives
  - maintaining or building technological leadership

- solving a "customer's" problem
- developing a "window" on technology
- pursuing technological advance.

Each of the criteria listed above, will be discussed under separate headings below:

* **Support of business objectives**

Technology investments must support business objectives. The criteria embodied in business plans that underlie project selection must address some of the following aspects:

- reducing costs
- developing new products
- developing improved products.

Essentially the business strategy determines these criteria with a view to maintaining a desired market position (market pull). These criteria are likely to change being largely dependent on the growth stage of the product. A product at the beginning of the life cycle is likely to require projects involving improvement of distinctive features and performance, whereas a mature product is more likely to need process development and cost reduction projects to support it.

* **Technological leadership**

Protecting and establishing technological leadership is an important project selection criterion.

* **Solving a "customer's" problem**

By solving a "customer's" problem through providing technical support, technical staff can get ideas for new or improved products or process changes. A customer may be assumed to mean any user of product or process; i.e. a manufacturer or the person who buys the product.

* **A "window" on technology**

Gaining insight into emerging technologies to allow the company to be prepared when the right time comes to successfully exploit the new technology.

* **Pursuing technological advance**

Pursuit of technological advance with the purpose of developing products and processes which can be utilised (technology push) is a good criterion for allocating funds.

2.9.3 Condition 3 : Systems and structure

A company's decision making systems and structure must be orga-

nised to reinforce the technology strategy in two ways:

- must link the technology decision making process with business decisions
- the decision making systems and structure of the technology department must be compatible with those of the rest of the organisation.

* **Linking business to technology**

Companies which effectively manage technology must ensure the involvement of, and contribution from, their top business and technical managers in areas such as decision making, planning systems, the timing of decisions, and company structure, all combine to strengthen the link between technology and business goals.

* **Top management connection**

The top business managers in companies that exploit technology effectively see themselves as being responsible for making and approving technology decisions.

The importance of top management involvement is supported by industrial studies (Frohman, 1982) which indicate that their involvement is crucial to the development of a successful technology strategy.

* **Corporate Technical Officer (CTO)**

Companies which are effective in technology management, give the CTO a major role in business and technological decision making to strengthen the connection between business and technological decision making.

* **Planning systems**

In the companies where technology is high priority, the planning systems incorporate the technology plan as an integral part of the business plan.

* **Timing**

When the technology plan is actually presented for review can also reflect how important it is to the business plan. For example, does this occur before or after the strategic planning process.

In companies where the technology plan is presented first, management is likely to use it as an important factor in screening business ideas.

* **Structural ties**

Companies that rely heavily on technology to gain competitive advantages have their CTO report directly to the CEO.

2.10 BENEFITS OF TECHNOLOGY MANAGEMENT

Effective technology management provides several key benefits (Levine & Yalowitz, 1983 : 45). It helps to:

- Identify new technological opportunities.
- Alert management to threats emanating from technology developments.
- Determine the range of technology investment options available.
- Identify appropriate strategic actions relative to current and intended market position.
- Permit preemptive actions to capitalise on corporate technological assets.
- Pinpoint missing technological assets and resources and identify corrective actions required to ensure continued success.
- Allow the company to obtain a "leverage" effect from its technology assets.
- Provide a technology focus to coordinate traditional business planning activities.
- Identify and develop a market technology image, particularly in relation to competitors.

However, the overall benefit of effective technology management

must be to ensure long-term corporate survival via the effective and efficient use of technology.

2.11 PERSONNEL INVOLVED IN TECHNOLOGY MANAGEMENT

High-level involvement, management input and overview are required in technology activities at the earliest stage, to ensure there is commitment throughout the organisation (Gibson, 1986 : 75). Without the commitment and involvement of the Chief Executive Officer (CEO), it is unlikely that technological change will lead to satisfactory results.

To implement technological change, the CEO should be actively involved in the following tasks (Haywood, 1990 : 41) :

- Setting of technology-related objectives for the company.
- Creating dialogue within the company about the role of technology and its relevance to the company, and the possible impacts technology will have on customers, employees and suppliers.
- Assigning specific responsibilities for technology to senior management in their fields and ensure that they have the resources and authority to implement strategy.
- Providing funds for specific technological development of strategic significance to the company.

Vision for technological change should come from senior management, however not all top managers may understand what is involved in change and why it is necessary. Agents for technological change can and should come from throughout the company. The agents could include a technology manager who should be part of the senior management and be involved in both technology planning and its integration with business planning.

Various technical experts and other participants (financial, marketing, operations, human resources) from the business side should also be involved in the planning process; to ensure common purpose and commitment towards the successful implementation of any technological changes.

The responsibility for the implementation of new technology should resort under the control of one person, either a project manager or someone charged with the task. The person selected to implement new technology should be technically competent, as well as be given a specific mandate and adequate authority to perform the task.

2.12 TASKS OF THE TECHNOLOGY MANAGER

Many companies are finding that to give adequate attention to technology management, it is essential to appoint a person or group with designated responsibility, funding and a specific mandate to take charge of this function. Often a senior technical manager, i.e. Chief Technical Officer (CTO), takes on these

duties, reporting directly to the CEO. This gives the activity the visibility and influence it needs.

Van Wyk (1990) describes the tasks of such a manager, who he refers to as the technology manager, as follows:

- observe and interpret the changing technological setting
- probe the future of individual technologies
- diagnose corporate technology capabilities (strengths and weaknesses)
- guide research and development
- oversee the stock of intellectual property
- function as the custodian of innovation
- participate in strategic planning.

2.13 SUMMARY

This chapter deals with the theoretical issues related to technology management, such as the elements that constitute technology management, conditions required for effective technology management, and the like. Several theoretical models which offer an integrated perspective on the strategic planning process and technology were discussed, providing the theoretical basis for the development of a model which is proposed and presented in chapter 4 (see Figure 4.1).

The following chapter provides a literature survey of two studies on technology management for the purposes of establishing what has already been done in the field of technology management.

Chapter 3

Survey of relevant literature

CHAPTER 3 : SURVEY OF RELEVANT LITERATURE

3.1 INTRODUCTION

In this chapter, two studies in the field of technology management are discussed; firstly, a survey conducted by Booz-Allen & Hamilton Inc. into technology management, and secondly, a study undertaken by J.H. Wills on "Technology Management in the South African Electronics Industry".

3.2 BOOZ-ALLEN TECHNOLOGY MANAGEMENT SURVEY

In 1981 Booz-Allen & Hamilton Inc. conducted a survey (Booz-Allen & Hamilton Inc., 1981 & Pappas, 1984: 31) of top managers in Fortune 1000 firms into the role of technology in corporate operations in seven major sectors of the US business economy. The important findings of the survey with specific reference to the role of technology in American business, follows.

3.2.1 Role of Technology

The findings of the Booz-Allen survey were dealt with under four separate headings; viz.

- factors important in overall operations
- impact of technology on planning process
- barrier's to integrating technology in planning process

- means of enhancing role of technology.

The findings will now be discussed below under the very same headings.

* **Factors important in overall operations.**

Booz-Allen established during a previous sample survey certain factors which affect the importance of technology in the overall operations of a company. Their 1981 survey utilised these factors established during the sample survey. These factors are:

- extent of top-management involvement in the technology process
- the level of technology funding
- which functional areas are emphasised.

The findings of the survey concerning the "level of technology funding" and "which functional areas are emphasised" will not be discussed in great depth since these areas extend beyond the scope of the current study.

Top management involvement in technology process

The survey results shown in Table 3.1 indicate that relatively few top level managers review all R & D programmes early and often, or actively participate in the company's evaluation and management of the R & D programme.

TABLE 3.1 : ROLE OF TOP MANAGEMENT IN THE TECHNOLOGY PROCESS Source : Booz-Allen, 1981 : 8	% of Responses
Singles out and follows programmes of key importance	58
Reviews major development programmes above some dollar threshold	58
Focuses on projects "in trouble"	46
Actively participates in firm's evaluation and management of R & D programme	44
Monitors near-term projects, not technology	39
Reviews all R & D programmes early and often	34

It is also apparent that top management prefer a "focused" approach to their R & D programme reviews. Approximately three in five respondents indicate that top-management's role in the technology process is either reviewing major development programmes above some monetary limit, or singling out and following programmes of key importance.

Level of technology funding

The investment in technology functions are - or at least are perceived to be - significantly and chronically underfunded. Limited involvement of top management in the technology process may be a contributing factor.

Functional areas emphasised

Those functional areas that have more immediate impact on profits are in general regarded as being more important to overall corporate performance (see Table 3.2). In particular, marketing (sales) and production (manufacturing) are perceived to be the most important functional areas regarding overall performance of the company.

TABLE 3.2 : IMPORTANCE OF FUNCTIONAL AREAS TO OVERALL CORPORATE PERFORMANCE
Source : Booz-Allen, 1981 : 10

Function	% of Responses
Marketing/Sales	70
Production or manufacturing	49
Accounting and finance	25
New product development	22
Corporate planning	20
Research and development	17
Manufacturing engineering	11
Internal information systems	4

These results are probably biased by industries in which technology is less critical and management focus, along with the corporate orientation, is on short-term profits.

In contrast, functional areas which contribute to the company's long-term growth are de-emphasised. For example, only two in ten respondents ranked corporate planning and new product development

as being important to overall corporate performance.

* **Impact of Technology on planning process.**

Based on the survey results, most (nine out of ten) participating companies scan and monitor technologies outside their own company to identify threats and opportunities, and just over half (six in ten) respondents report their companies prepare technology forecasts. However, many feel monitoring and technology forecasting are not as effective as it should be.

The survey results also indicate that the planning process in most companies is apparently dominated by factors that contribute to the company's short-term profitability (see Table 3.3).

Out of the twelve factors identified, the three most important considerations cited for both short- and long-term planning are product performance, manufacturing economics, and competitive positions in the United States.

In short-term planning, capital requirements is also considered a key factor; whereas in long-term planning new product development is one of the most, if not the most important factor to be considered.

Interesting deductions can be made when relating the percentage change in the responses for short- versus long-term planning, in order to obtain a feel for the relative importance of each of the

factors considered (see Table 3.3). Firstly, with the exception of capital requirements, the importance of every factor increases when long-term planning is considered. Secondly, the extent of the increase for certain factors is significant, particularly "new technologies in other industries", "expected technology changes" and "new product development" which increase by 150, 138 and 80 percent respectively.

TABLE 3.3 : FACTORS CONSIDERED IN THE CORPORATE PLANNING PROCESS
Source : Booz-Allen, 1981 : 11

Factors	Percentage of Responses		
	Short-term	Long-term	% Change
Product performance	51	55	8
Manufacturing economics	50	56	12
Capital requirements	42	42	0
Competitive position in U.S.	42	52	24
Availability of qualified technical personnel	36	47	31
New product development	31	55	80
Market growth expectations	27	41	52
Manufacturing capacity and demand	23	31	35
Competitive positions world	13	21	62
Expected technology changes	13	31	138
Management compensation and rewards	9	15	67
New technologies in other industries	4	10	150

This seems to indicate that companies do recognise to some extent the importance of factors which will ensure their continued survival and allow them to compete on a global scale in the future.

* **Barriers to integrating technology in planning process**

The key barrier to integrating technology into the corporate

planning process is management's short term profit-orientated perspective (see Table 3.4).

Other important barriers are companies' lack of formal approach and lack of technical staff involvement in the planning process.

TABLE 3.4 : BARRIERS TO INTEGRATING TECHNOLOGY WITH CORPORATE PLANNING
Source : Booz-Allen, 1981 : 12

Barrier	Percent of Responses
Short-term profit - orientated management	28
Lack of formal analytic approach	14
Lack of technical personnel involvement	10
Separate business unit plans	9
Senior management's discomfort with technology	8
Technology doesn't fit planning process	6
Planning manager's discomfort with technology	3

* **Means of enhancing role of technology**

The survey results as shown in Table 3.5 indicate the need for greater top-management commitment to long-term results and improved long-term planning for technology.

3.2.2 Summary

The survey results indicate that there are significant barriers to integrating technology in the corporate strategic planning process.

The monitoring and forecasting of emerging technologies are not

adequately handled, an appropriate analytical approach to integrating technology into the planning process does not exist in most corporate environments, and there is insufficient top management commitment to long-term results.

The survey results also suggest that management must place more emphasis on integrating technology into the planning process, and developing a sound analytical approach for their technology planning.

TABLE 3.5 : MEANS OF INTEGRATING TECHNOLOGY IN PLANNING PROCESS
Source : Booz-Allen, 1981 : 13

Integration Technique	Percent of Responses
Greater top management commitment to longer term results	42
Improved long-range planning for technology	26
Higher R & D expenditures	23
Integration of technology and strategic planning	21
Tighten coupling of technology and strategic planning	19
More recognition for technical people	17
Incentive compensation for technical people	16
Dual ladder carrier path	13
Use of outside technical specialists on project basis	12
More university involvement	6
Promotion of technologist to senior management levels	6

3.3 TECHNOLOGY MANAGEMENT IN THE SOUTH AFRICAN ELECTRONICS INDUSTRY

A study was undertaken by J.H. Wills in 1991 on "Technology Management in the South African Electronics Industry". The objectives of this research were to identify important aspects of technology management, assess the application of technology in the South African electronics industry, and propose a methodology for planning technology for the electronics, as well as for other industries.

The main conclusions of the research were the following:

- Senior management involvement in technology is high.
- Poor usage of analytical techniques is generally applicable in quantifying technological variables for decision making.
- Most companies could improve their technology management by improved information gathering and more effective planning. This includes formalising the planning process.
- All companies could derive long-term strategic benefit from improved technology management.

Much of the discussion in the report concentrates on the application of technology management techniques, which in turn is dominated by discussions involving a matrix. The matrix is presented as a guide to assist with the selection of the various analytical

techniques, and is based purely on the researcher's subjective assessment on the subject. Too much emphasis is placed on these issues, which detracts from the rest of the report.

A methodology for technology planning is also proposed in the discussion. It once again relies on the researcher's opinion and does not dovetail all that well with the rest of the research.

3.4 SUMMARY

Two studies on technology management were reviewed to assist the researcher in attacking the research covered by this report. A survey conducted by Booz-Allen & Hamilton Inc. on the role of technology in corporations was reviewed first of all, followed by a study undertaken by J.H. Wills on technology management in the South African electronics industry.

In the next chapter, the objectives of this research are conceptualised in order to provide some structure to the discussions that follow later in the report (i.e. in chapter 7).

Chapter 4

The problem and its setting

CHAPTER 4 : THE PROBLEM AND ITS SETTING

4.1 INTRODUCTION

In this chapter, the two-fold objectives (problem) of this research will be conceptualised in order to develop a framework to be used in discussing the research findings later in the report. The overall intention of the research is to gain insight into technology management and to determine how effectively companies within certain segments of the industrial sector of the South African economy are planning for technological change and managing technology.

4.2 ROLE OF TECHNOLOGY

The first objective of the research is to establish the role of technology in corporate operations within certain segments of the South African Industrial Sector. This research follows on similar research undertaken by Booz-Allen & Hamilton Inc. into the role of technology in corporate operations in seven major sectors of the US business economy (Booz-Allen & Hamilton Inc., 1981). The findings of the Booz-Allen survey on the role of technology were dealt with under four separate headings, namely:

- factors important in overall operations
- impact of technology on planning process
- barrier's to integrating technology in the planning process

- means of enhancing the role of technology.

The same four headings will be used in this report to discuss the findings of this research on the role of technology planning and management. The research was restricted to six segments of the S.A. Industrial Sector, viz. chemical, electronics, engineering, industrial holding, pharmaceutical and medical, and steel.

The role of technology will be further conceptualised by discussing the above four headings:

4.2.1 Factors important in overall operations

As discussed earlier in chapter 3 (section 3.2.1), Booz-Allen established by means of a sample survey certain factors which affect the importance of technology in the overall operations of a company. The factors found to be important to the overall operations were as follows:

- extent of top management involvement in the technology process
- the level of technology funding
- which functional areas are emphasised.

The scope of the current research under this heading will be restricted to establishing the extent of top management involvement in the technology process, meaning that "level of technology

funding" and "which functional areas are emphasised" will not be discussed for reasons as stated under section 3.2.1.

4.2.2 Impact of technology in the planning process

The survey will establish whether companies perform the following functions during the planning process:

- monitor and scan technologies being developed or applied outside the company to identify threats and/or opportunities?
- make long-range forecasts of the potential impact of emerging technologies on the company?
- conduct internal technology audits to establish the company's "baseline" technology capability.

At the same time the participating companies will be asked to indicate how effectively they perceive their companies are carrying out the above three functions. In this way it will be possible to establish whether the participating companies are monitoring, forecasting and conducting internal technology audits as part of their planning process, as well as establish how effectively the respondent companies feel these activities are being performed. The involvement and degree of effectiveness in these activities will provide a clear indication of the impact of technology in the planning process.

In addition to the above, the participating companies will be

requested during the survey to indicate which factors are considered in the corporate planning process from a list comprising of eleven factors. The response to this specific question will provide insight into the emphasis placed on technology by the respondent companies during the planning process.

4.2.3 Barriers to integrating technology in planning process

It is important to establish whether any impediments or barriers exist which prevent technology from being integrated into the planning process. If the answers to the previous question (see section 4.2.2 - concerning the impact of technology on the planning process) establishes that technology has little impact on the planning process, then the answers to this question will provide certain insight into the reasons for this situation.

4.2.4 Means of enhancing the role of technology

Participating companies which have experienced successes in the area of technology management will be requested to indicate which "approaches" have contributed to the company's performance or success in this area.

4.3 EFFECTIVENESS IN TECHNOLOGY MANAGEMENT

The second objective of the research is to determine how effectively companies within the various industrial sector segments are planning for technological change and managing technology.

"Effectiveness" in the context of this study was assumed to mean "doing the right things"; i.e. the extent in which companies succeed in doing what is prescribed to them by normative theory relating to technology management.

In order to establish what is prescribed by theory with respect to current technology planning and management practice, an extensive literature survey was undertaken and is presented in chapter 2. The information gathered during the literature survey along with the researcher's own opinion on the subject was used to develop a model, with the emphasis on planning, which could assist in dealing with the process of integrating technology with strategic planning. The proposed Integrated Technology Management model (as it was called) is presented in Figure 4.1 and will be used as a framework in chapter 7 when discussing how effectively companies within the various industrial sector segments are managing technology.

4.3.1 Proposed model for technology management

The proposed model is a synthesis of various elements taken from the previously discussed modified general planning model as described by Sethi & Hickey (1985), the Strategic Management of Technology Model proposed by Lauglaug (1987 : 24), the Integrated Technology Management Framework developed by Monger (1988 : 35) and the researcher's own opinion on the subject. In the case of the Strategic Management of Technology Model or "means-ways-ends" approach, it has already been partially incorporated in the

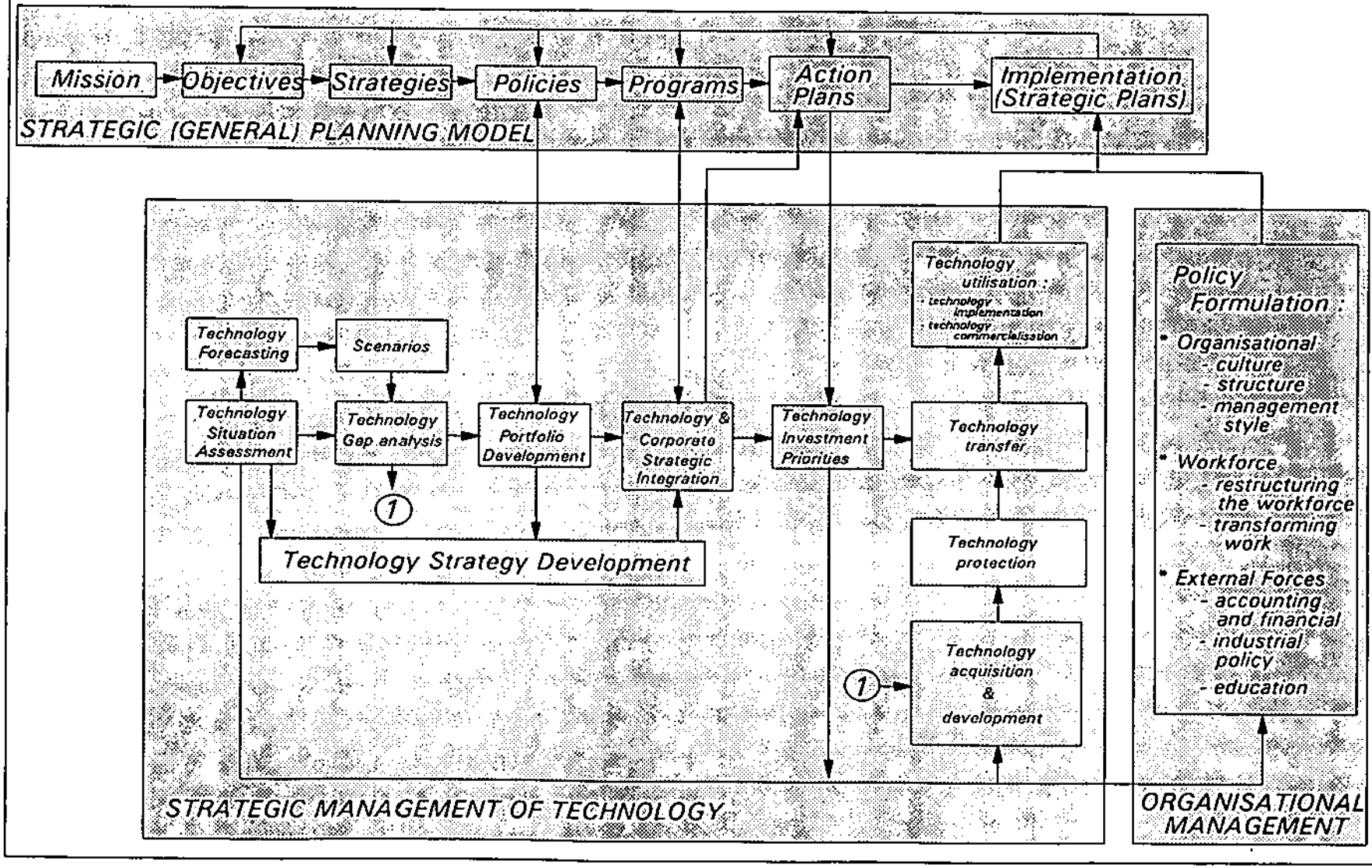
Modified general planning model under the heading of "Strategic Management of Technology". Therefore it would be true to say that the proposed model was based largely on the modified general planning model presented in Figure 2.4.

The three aforementioned models were previously discussed in chapter 2 and the discussion that now follows on the proposed model will be limited to the broad issues. Furthermore, as stated in chapter 5 under validity and limitations, it is not within the scope of this research to have the proposed model tested and validated.

The proposed model can be divided into three main management areas, namely the general (strategic) planning model, the strategic management of technology and organisational management aspects (which support the attainment of a desired technological position by the company).

The general (strategic) planning model, which forms a part of the modified general planning model as well as forming part of the proposed model, clearly describes what is normally dealt with under the traditional strategic planning process. In the case of the Strategic Management of technology area of the proposed model, this portion of the modified general planning model has been developed to include further refinements such as internal technology auditing and external scanning, as well as various other additional elements.

Figure 4.1 : Proposed Integrated Technology Management Model



The additional elements are presented below (see section 2.6):

- technology gap analysis
- technology acquisition and development
- technology protection
- technology transfer
- technology utilisation.

The organisational management aspects headed under policy formulation in Figure 4.1 are those aspects often ignored in planning and which Monger (1988) feels should receive equal importance as is the case with all the other issues dealt with during the traditional strategic planning and technology management processes. These organisational management aspects incorporate both internal and external factors which will be supportive of the attainment of a desired technological position, e.g. appropriate culture, structure, management style and the like (see section 2.7.4).

4.3.2 Approach to discussing effectiveness in technology management (Chapter 7)

The premise held is that for any company to be effective in the management of technology, it must at least incorporate the elements as presented in the proposed Technology Management model into their technology and strategic planning during the planning process and do what is prescribed to them in the theory relating

to technology management. Only certain key elements of the proposed model (see Figure 4.1) will be discussed in chapter 7, since the questionnaire was limited in its scope and did not include questions on all the elements. Comments pertaining to that which is prescribed by theory will be made in the discussion whenever it is deemed appropriate. Understanding how participating companies deal with the organisational management aspects presented in the proposed model under policy formulation also falls outside the scope of the survey and hence will not be discussed in chapter 7.

The elements of the proposed Integrated Technology Management model which will be discussed in chapter 7 in order to establish whether or not the companies are effectively managing technology (i.e. "doing the right things") are listed below. The specific elements of concern and the specific aspects to be considered, are:

* **Strategic planning process:**

  - Does the company have a mission statement?
  - Is the company's strategic planning process formal or informal?
  - What is the company's strategic planning horizon?
  - Consideration given to existing and emerging technologies?

* **Technology situation analysis** - During the planning process, does the company:

  - monitor and scan technologies being developed or applied outside the company to identify threats and/or opportunities?

  - conduct internal technology audits to establish the company's "baseline" technology capability?

  - make long-range forecasts of the potential impact of emerging technologies to the company?

* **Technology gap analysis:**

  - Does the company perform a gap analysis to establish if gaps exist between the company's "baseline" technology capability and the external technology developments established during the technology situation analysis?

* **Techniques used in technology management:**

  - Does the company use the appropriate techniques in the technology planning process?

* **Integration of technology and strategic plans:**

  - Is the company's strategic planning process formal or informal?

- Is a formal technology plan prepared by the company?
- If yes, what does the technology plan contain?
- If yes, is technology planning included as part of the strategic plan?
- Barriers to integrating technology into the strategic plan.

* **Technology acquisition:**

- How is technology acquired by companies?

4.4 SUMMARY

The two-fold objectives of this research were conceptualised in this chapter in order to develop a structure for the discussions that come later in the report. A decision was taken that the discussions on the role of technology in corporate operations (i.e. the first objective), would be dealt with under four headings, namely:

- Top management involvement in the technology process.
- Impact of technology in the planning process.
- Barriers to integrating technology in the planning process.
- Means of enhancing the role of technology.

A model dealing with the integrated technology management process was proposed in this chapter as well, to be used as a framework for the discussions on how effectively companies manage technology.

The following chapter discusses the research methodology to be used in this research. Aspects such as the acquisition of primary data, questionnaire construction and distribution, validity and limitations, amongst others, will all be dealt with in this chapter.

Chapter 5

Research methodology

CHAPTER 5 : RESEARCH METHODOLOGY

5.1 INTRODUCTION

This chapter discusses the research methodology, taking cognizance of the types of data required, namely that of primary and secondary data. The issue of the lack of "generalizability" of the research findings is discussed, and placed into perspective in the light of this being an exploratory study.

5.2 TYPES OF DATA REQUIRED

Two types of data were collected in this study, viz. (i) primary data collected for the purpose of giving insight into the research problem, and (ii) secondary data readily available in literature (published and unpublished works).

The primary data relating to the research objective involved facts and opinions, whereas the secondary data involved theory and writings on the field of research.

5.3 ACQUISITION OF PRIMARY DATA

5.3.1 Method of research

The descriptive survey method was employed in dealing with the primary data that arose from this study. This method of research looks at synchronic (transient) phenomena and then describes

precisely what the researcher "observes" through observation or communication (Leedy, 1989 : 140).

Salient characteristics relating to the descriptive survey as a method of research are as follows (Leedy, 1989 : 142):

- demands the technique of observation (or communication) as the principal means of collecting data
- the population must be carefully chosen, and specifically delimited
- attention must be given to safeguarding the data from the influence of bias
- data must be organised and presented systematically so that valid and accurate conclusions can be drawn from them.

The methodology adopted in the study made every attempt to comply with the above characteristics.

5.3.2 Method of data collection

The descriptive survey method is appropriate for data whether or not it is actually physically observed or observed through benefit of questionnaire or poll techniques.

A mail survey was selected as being the most appropriate method of data collection for the primary data. Mail surveys can reach a

geographically widely dispersed sample simultaneously without the worry of respondent accessibility (as is the case with interviews), as well as being the cheapest method of data collection based on the assumption that a reasonable response rate would be obtained.

5.4 QUESTIONNAIRE CONSTRUCTION

The questionnaire was designed to take no more than 20 to 30 minutes to complete. Consideration was given to aspects such as question content and phrasing, question sequence, question response format and physical characteristics, such as appearance and layout of the questionnaire. Only structured questions with structured responses were included, except for questions 5 and 6 (refer to Appendix A.4). Question 5 requested the respondent to give details of the actual figures for the approximate total number of employees and total annual turnover, whereas question 6 required the respondent to state the company's mission.

Structured questions in the questionnaire included:-

- dichotomous questions, e.g. 'yes'/'no' type questions
- multiple choice questions with single answers
- scaled questions (using four-point scales).

The total number of (numbered) questions was limited to 22 (twenty-two), however substantially more questions were actually asked, viz. 72 (seventy-two) in total, due to the way the ques-

tions were compiled.

The questionnaire comprised of three main sections, namely:

(i) **Company particulars and demographics:** viz. structure, activity, sector, size, market and customer group.

(ii) **Technology planning and management issues:** viz. commitment and role, planning and strategy, barriers, managements involvement, techniques employed, and sources of technology acquisition.

(iii) **Respondent information:** viz. name, designation and company name.

5.4.1 Questionnaire questions

A copy of the questionnaire is presented in Appendix A.4.

Certain questions (approximately 45%) appearing in the questionnaire were adapted and taken from a previous survey of senior managers in Fortune 1000 companies into Technology Management undertaken by Booz-Allen & Hamilton Inc. in 1981.

A brief discussion regarding the information being sought from the respective companies participating in the study for each of the questions appearing in the questionnaire, follows.

Question 1 : Company structure in terms of Holding, Independent or Subsidiary Company.

This question aims at establishing whether or not the respondents are completing the questionnaire from a holding company point of view. A generalised response made at this level may not best describe the viewpoints of its subsidiary companies. Any response from a holding company will suffer this limitation.

Question 2 : Primary operations.

The exact nature of the companies' activities in the value chain, and their degree of vertical integration are identified.

Question 3 : Major customer groups.

The major customer groups of the companies, and the extent of market diversification are determined.

Question 4 : Industrial sector segments.

This question establishes in which segment of the industrial sector the companies operate.

Question 5 : Company size.

Company size information in terms of approximate number of employees and total annual turnover was requested in order to gain some insight into the company size of those companies that participated in the study and to assist in providing possible reasons for vastly differing responses, if the need should arise.

Question 6 : Mission statement.

The answer to the question , "What is the company's business and what will it be?", should be provided. The aspect that is of importance to this study is to establish whether companies are actually addressing technology and technology issues in their mission statement; accepting the premise that there is a correlation between those companies that do include technology in their mission and the importance that it attaches to technology and the management thereof.

Question 7 (a) : Monitoring technology.

This question aims at establishing whether the companies formally monitor technologies being developed or applied outside the companies in order to identify potential threats and opportunities.

Question 7 (b) : Effectiveness in monitoring technology.

A subjective assessment is sought from the companies on how effectively they undertake the process of monitoring technology for the purposes of identifying potential threats and opportunities.

Question 8 (a) : Long-range technology forecasts.

This question aims at establishing whether the companies formally undertake long-range forecasts on the potential impact of emerging technologies.

Question 8 (b) : Effectiveness in technology forecasting.

A subjective assessment is sought from the companies on how effectively they undertake the process of forecasting technology for the purposes of assessing the potential impact of emerging technologies.

Question 9 (a) : Internal technology audits.

This question aims at establishing whether the companies formally undertake internal technology audits to determine the companies' "baseline" technology capability. The internal technology audit may be thought of as a self assessment of the companies' technology base for the purposes of diagnosing its technological strengths and weaknesses.

Question 9 (b) : Effectiveness in internal technology auditing.

A subjective assessment is sought from the companies on how effectively they are performing the internal technology audit for the purposes of diagnosing their technological strengths and weaknesses.

Question 10 : Consideration given to existing and emerging technologies.

This question aims at establishing whether the companies formally give consideration to existing and emerging technologies available both inside and outside the companies for the following

applications:

- improving existing products
- developing new products
- reducing costs of existing products
- improving existing processes
- developing new processes
- reducing process costs.

The answers to these questions essentially cover the same aspects that would come up in a gap analysis of a company when considering technology matters.

Question 11 : Factors considered in planning corporate strategies.

The relative importance attached by the companies to technology when planning their corporate strategies is established. It will provide some insight into the companies' vision for the future by indicating whether their planning horizon includes mainly short- or long-term issues.

Question 12 : Barriers to integrating technology into the corporate strategic planning process.

Obstacles to integrating technology into the corporate strategic planning process are identified. The answer to this question will

be related to what theory suggests as being the barriers.

Question 13 : Top management's role in the technology process.

The factors which characterise top management's role in the planning process are established. This will provide insight into how effectively top management are performing their technology management function.

Question 14 : Means of integrating technology in the planning process.

This question assumes the respondents have had previous successes in the area of technology management and attempts to establish which "approaches" have contributed to the companies' performance or success in this area. The answer to this question will be compared to that which is prescribed in theory.

Question 15 : Formality of strategic planning process.

This question aims at determining whether the companies' strategic planning process is handled formally or informally. It follows that the success of incorporating technology planning and management issues into the strategic planning process will be dependent on whether the latter process is adequately handled. A formal strategic planning process has a far greater chance of succeeding than an informal process which may suffer the limitation of being superficial.

Question 16 : Strategic planning horizon.

What strategic planning horizon is being used by the companies participating in the survey, is established. The answer to this question will give a clear indication of whether the companies are considering long term issues such as those coupled to emerging technologies.

Question 17 : Formal technology plan.

Whether the companies prepare a technology plan is determined. Companies which indicate by means of their responses that they undertake most of the technology planning and management functions mentioned in the questionnaire, but do not prepare a technology plan will be treated with a degree of circumspection. However, negative answers do not preclude that the technology process is handled informally and therefore does not necessarily invalidate the remaining questions.

Question 18 (a) : Contents of the technology plan.

The contents of the companies' technology plan is established. The answer to this question will provide an indication whether the technology plan is being used in a constructive and effective manner.

Question 18 (b) : Integration of technology plan with strategic plan.

Whether the companies integrate their technology planning into

the corporate strategic plan is established. The answer to this question will indicate the degree to which strategic issues in the companies are coordinated by top management.

Question 19 (a) & (b) : Planning and implementation of technology.

Who contributes towards the planning and implementation of technology in the companies is established; irrespective of whether this is by means of an informal or formal contribution to the strategic plan or otherwise. The answer to this question will indicate which personnel contribute to determining the long term direction of the companies with respect to technology, and who puts these plans into action. Information regarding both the depth (levels of seniority) and breadth (different functional areas) of personnel involved in these two functions will also be established.

Question 20 : Analysis techniques used in the technology planning process

The companies' position regarding depth and knowledge of analytical techniques and methods used in technology planning and management is established. The answers to this question could be taken to infer the degree of importance that the companies attach to technology.

Question 21 : Technology acquisition.

The methods used by companies to acquire intellectual property

and knowledge on technology is established. Answers to this question would give an indication on the extent of the companies' in-house technological strengths, as well as some insight into the culture and management style of the companies.

* **Company particulars.**

Three questions were put to the respondents, namely:

- Name of respondent
- Name of company
- Position held by respondent.

The respondent's name was asked since it was felt that this would illicit a more thoughtful and well considered response. The company's name was required for control purposes to determine which companies had returned their questionnaires. The position or job title held by the respondent was requested. The significance of this information revolved around whether the respondent was from the corporate planning group, the research and development group, or otherwise. Minor differences in emphasis and approach were anticipated in the responses from the various functional groups.

Although these company particulars were asked for, full confidentiality was guaranteed to the respondents with an undertaking that this information would not be included in any research

The final question asked in the questionnaire was whether or not the respondent wanted a summary of the research findings forwarded to them upon completion of the study. This was done to provide an incentive to the respondent to complete the questionnaire; knowing full well that many of the companies included in the survey have a keen interest in this field of study.

Additional information is available for analysis from the responses by considering various combinations of responses collectively to gain insight into areas such as the company background, importance of technology, role of technology and how effectively companies plan and manage technology.

* **Company profile.**

Questions 1 to 5 will provide a complete profile of each company participating in the survey, and provides all the necessary information required to make certain deductions regarding the findings of the study.

* **Importance of technology.**

Questions 6 (mission) and 11 (factors considered in planning corporate strategies) may be helpful in revealing the companies' orientation and commitment towards technology and provide evidence of the importance attached to technology.

* **Role of technology.**

Questions 13 (top management involvement in the technology process), 11 (factors considered in the corporate planning process), 12 (barriers to integrating technology in the corporate strategic planning process) and 14 (means of integrating technology in the planning process) provide certain insights into the role of technology for the companies surveyed.

* **Effective planning and management of technology.**

Various areas need to be considered in order to determine how effectively the participating companies in the survey are planning and managing technology, namely:

Questions 6 (mission), 15 (formality of strategic planning process) and 16 (strategic planning horizon) provide some insight into whether the companies are effective in their strategic planning.

Questions 7 (external technology scanning), 8 (long-range forecasts), 9 (internal technology auditing), 10 (identifying technology gaps) and 20 (technology analysis techniques and methods) establish the extent to which companies effectively practise what is prescribed by theory, as well as providing some insight into how the participating companies deal with the process of technological change.

Questions 15 (formality of strategic planning process), 17 (preparation of formal technology plan) and 18 (a) (contents of technology plan) identify whether the companies prepare a technology plan, either formally or informally.

Questions 15 (formality of strategic planning process), 12 (barriers to integrating technology into strategic plan), 17 (preparation of formal technology plan), and 18 (b) (integration of technology plan with strategic plan) aim at establishing the companies' effectiveness in integrating technology and strategic plans.

Questions 21 (technology acquisition) and 8 (a) (external technology scanning) provide insight into technology acquisition and the continued access to existing and emerging technologies.

Questions 16 (strategic planning horizon) and 10 (consideration given to existing and emerging technologies) help identify whether companies seek a long term, say 5 to 10 year, vision of key business segments and critical technologies.

Questions 13 (top management's involvement in technology process) and 19 (staff contributing towards planning and implementation of technology) establish the involvement and contribution made by top management. In companies that exploit technology effectively, senior managers see themselves as being responsible for making and approving technology decisions.

5.4.2 Pretesting

The questionnaire was pretested in a pilot survey to ascertain whether the respondents would understand the questions correctly, would be able and prepared to answer them, and whether the answers would provide useful information for the purposes of this research. Two managers occupying senior positions in the industrial sector and who were regarded by the researcher as being knowledgeable on technology management issues and practises were asked to complete the questionnaire. In this way certain problems with the questionnaire were identified and rectified before the first mailing.

5.5 DISTRIBUTION

The questionnaire was distributed to a total of 135 listed JSE industrial sector companies.

Two mailings were made one month apart to ensure a reasonable response rate. Both mailings were accompanied by covering letters. In the case of the second mailing, both the initial covering letter and a reminder letter were included (see Appendix A.1 and A.2).

The breakdown of the number of questionnaires sent out to industrial sector companies for the respective mailings is presented in Table 5.1.

TABLE 5.1 : QUESTIONNAIRES DISTRIBUTED		
Industrial sector segment	First mailing	Second mailing
Chemical	9	6
Electronics	37	32
Engineering	32	23
Industrial Holding	45	35
Pharmaceutical & Medical	8	5
Steel	4	3
Total	135	104

5.6 SAMPLING

5.6.1 Population to be studied

The population studied was the industrial sector of the S.A. economy and was delimited to a survey population comprising of chemical, electronics, engineering, industrial holding, pharmaceutical and medical, and steel segment companies of the S.A. industrial sector listed on the Johannesburg Stock Exchange (JSE).

5.6.2 Sample frame

The sample frame from which the sample was drawn was based on JSE listings of companies in the aforementioned industrial sector segments (see Appendix B - for exact details regarding survey population).

5.6.3 Sampling method

A non probability method, viz. convenience sampling, was utilised in the collection of the primary data.

Questionnaires were sent to all companies listed in the sample frame (see Appendix B) and varying response rates were obtained for each of the industrial sector segments that were included in the survey (see Table 6.1).

Attempts were initially made to get a comprehensive address list of all companies in the identified segments of S.A. industrial sector. Such an address list was sourced through CSIR's Infosource services for companies classified under the Standard Industrial classification for engineering workshops (SIC: 3819400) to establish the merits of utilising these address lists as the sample frame. Upon close scrutiny, it was established that few of the major industrial sector companies appeared on the address list. In terms of turnover and number of employees, one could say that the companies that appeared on the address list were all small companies. For this reason it was decided to restrict the study and use only listed JSE companies in the already defined segments as the sample frame.

5.6.4 Choice of subjects

The ideal respondent was felt to be the technical director of the company. However, as many of the companies don't have such a

post, or operate as holding company, a decision was taken to address the questionnaire to the managing director of the company.

Where the questionnaire was passed on to another staff member, it was accepted that the respondent had an adequate knowledge of the company and the technical process to answer the questionnaire.

5.7 VALIDITY AND LIMITATIONS

This study involved focused data collection on technology management issues within certain S.A. industrial sector segments and suffers from several research limitations.

There is the issue of the "generalizability" of research findings. The research methodology did not ensure that each element in the population would be represented in the sample, and the sample was therefore not representative of the total population. Since this was an exploratory study in which information and insights on technology management were being sought, the sample was felt to be appropriate. However, it will rest on future research to determine the external validity of this report's findings.

The survey data suffer the standard limitations such as: were all the respondents interpreting the survey questions in similar ways, did the right person complete the questionnaire, to what degree did responses reflect actual policy and behaviour within

the company, and would the responses of the non-respondents be significantly different from those who completed and returned the survey?

This study did not attempt to ascertain answers to these questions and validate the results by establishing whether the responses of those who have not answered the questionnaire (i.e. non-respondents) differ significantly from those who have (i.e. respondents). Nevertheless, the findings have provided a degree of insight and understanding into technology management and its effective implementation.

The model proposed as a methodology for the process of integrated technology management is presented in chapter 4 for the purpose of being used as a framework for the discussions on how effectively the companies in the sample are managing technology. Validation and testing thereof is not addressed in this research.

5.8 ACQUISITION OF SECONDARY DATA

An extensive literature search was conducted through the Unisa Library and the CSIR's Infosource Service to obtain information on any technology management related article or publication. Details on unpublished documents such as research studies, dissertations and theses were also obtained.

Photostat copies of the vast majority of the magazine articles identified as being relevant during the literature survey were

duly obtained; and the published writings were loaned from various libraries for the purpose of undertaking the literature survey.

5.9 SUMMARY

The research methodology was presented, dealing with both primary and secondary data. Particular attention was paid to the questionnaire construction, namely: the phrasing of specific questions, the distribution of the questionnaire, and the validity and limitations of the primary research data.

The chapter that follows includes the analysis and interpretation of the research results obtained by means of the mail survey.

Chapter 6

Analysis of research results

CHAPTER 6 : ANALYSIS OF RESEARCH RESULTS

6.1 INTRODUCTION

In this chapter, the mail survey response rates and the results of each of the questions from the returned questionnaires are interpreted and briefly discussed.

6.2 RESPONSE RATES

A total of 135 questionnaires were sent out to JSE listed companies in the various industrial sector segments (see Table 6.1). Two mailings were made and in total 38 usable responses were received. This represents a response rate of 28% for the entire survey. A very good response rate was received from the chemical segment, namely 56%.

Nel, Rädel & Loubser (1988 : 187) present a table of response rates of recent mail surveys in the business and public sectors. The distribution of response rates from these surveys varied between 28,9 to 65,2% for the manufacturing sector; with no mention being made of follow-up mailings. These figures provide a good indicator against which the response rates from this research can be compared. The vast majority of response rates for the various segments surveyed fell within these limits after two mailings, albeit the bottom end of the range. The industrial holding and steel segments were two notable exceptions.

TABLE 6.1 : RESPONSE RATES

Industrial Sector Segments	First Mailing			Second Mailing			Total: Completed Responses (A2) + (B2) = (C)	"Incomplete" Responses (D)	Total: Responses (C) + (D)
	Question-naires Distributed	Completed Responses (A2)	% (A2) + (A1)	Question-naires Distributed	Completed Responses (B2)	% (B2) + (B1)			
Chemical	9	4	44	6	1	17	5 (56%)	-	5 (56%)
Electronics	37	5	14	32	4	13	9 (24%)	3	12 (32%)
Engineering	32	8	25	23	2	9	10 (31%)	4	14 (44%)
Industrial Holding	45	6	13	35	4	11	10 (22%)	7	17 (38%)
Pharmaceutical & Medical	8	2	25	5	1	20	3 (38%)	1	4 (50%)
Steel	4	1	25	3	-	-	1 (25%)	0	1 (25%)
Total	135	26	19	104	12	12	38 (28%)	15	53 (39%)

Based on the 1991 annual turnover figures (see Table 6.2), the respondent companies participating in the survey represented 56,1% of the JSE listed industrial companies (see Appendix B for sample frame). Once again the chemical segment featured prominently with the respondent companies representing 96,2% of the total annual turnover for this segment, and being poorly represented in the case of the steel segment with the only participating company representing 1,2% of the total annual turnover of this segment.

A total of 15 companies responded by returning uncompleted questionnaires (see Table 6.1), or by means of telephonic reply. The greater majority cited as their reason for not participating in

the survey the fact that their company is a diversified holding company, making it extremely difficult to provide a single generalised response for all their separate business units; since they often operate as semi-autonomous units.

TABLE 6.2 : ANNUAL TURNOVER FIGURES

Industrial Sector Segment	Total Annual Turnover (1991)	
	Sample	Respondents
Chemical	19 964 105	19 198 024 (96,2%)
Electronics	13 847 913	6 936 794 (50,1%)
Engineering	13 855 789	7 427 430 (53,6%)
Industrial Holding	91 103 220	50 380 703 (55,3%)
Pharmaceutical & Medical	2 815 257	712 825 (25,3%)
Steel	9 527 547	118 435 (1,2%)
	151 113 831	84 774 211 (56,1%)

6.3 ANALYSIS OF QUESTIONNAIRE RESPONSES

The raw data taken from the returned questionnaires was captured on computer under each of the respective industrial sector segments. This data was then processed to provide the necessary information for the survey. A summarised listing of questionnaire response information was compiled and is shown in Appendix C.

Absolute confidentiality was guaranteed to all respondents. This explains why no specific reference is made to individual companies in the findings of this report.

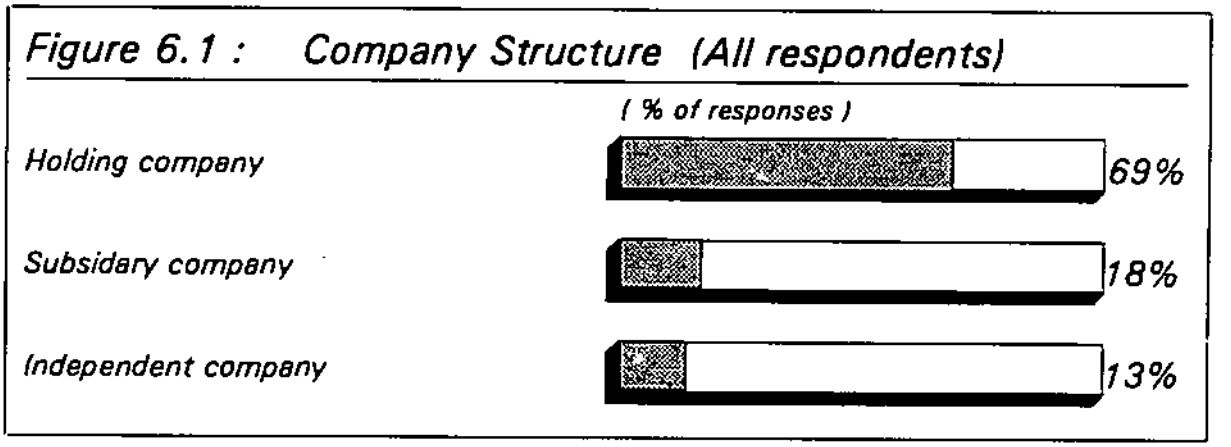
Each of the questions appearing in the questionnaire will be discussed and analysed below:

* **Company structure (Question 1)**

Figure 6.1 indicates that the companies participating in the survey were mainly holding companies, namely 69%.

In section 5.4 it was mentioned that a generalised response from a holding company may not best describe the viewpoints of its separate business units. The fact that the majority of responses came from holding companies suggests that the validity of the research findings may suffer because of this factor (see Table 6.1). Certain of the companies participating in the survey confirmed this point and responded by saying that a single generalised response from their holding company would not be appropriate and be of no value to the survey.

Figure 6.1 : Company Structure (All respondents)



* **Primary operations (Question 2)**

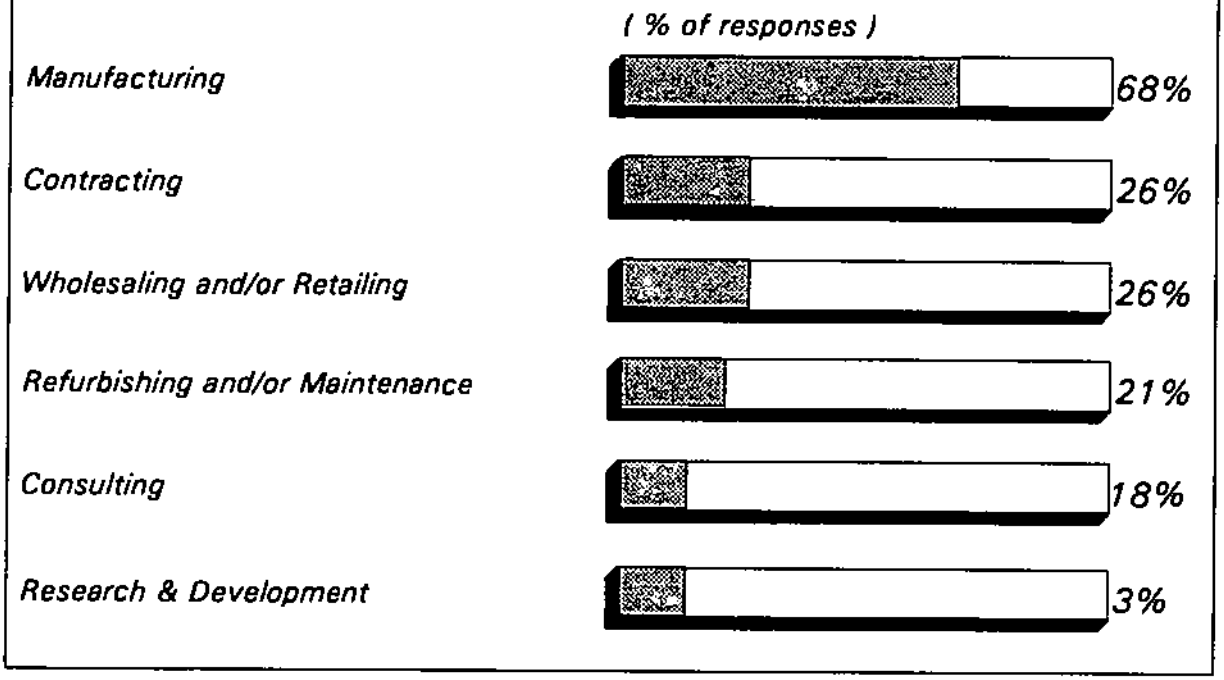
The purpose of this question was to establish the exact nature of

the companies' activities in the value chain, and not to determine the extent of these activities in terms of importance to the companies' bottom line. The findings show the primary operations of the participating companies vary to some extent between the various industrial sector segments (see Appendix C). The primary operation in which most of the participating companies are involved is manufacturing, this being true for all segments. All the respondent companies from the chemical, pharmaceutical and medical, and steel segments, without exception, indicated that they were involved in manufacturing as a primary operation; whereas the figure for the industrial holding segment was 50% (see Appendix C).

By referring to Figure 6.2 one can gain a much clearer and more meaningful picture of the primary operations applicable to the industrial sector. Figure 6.2 clearly shows that 68% of the respondent companies are involved in manufacturing, and to a much lesser degree : contracting, wholesaling and/or retailing, refurbishing and/or maintenance, and consulting. Only 3% of the respondent companies stated that research and development is a primary operation of the business.

Vertical integration is evident, particularly in the electronics, and pharmaceutical and medical segments. Both segments are involved in manufacturing, wholesaling and/or retailing operations. The information provided by the survey does not however describe the extent of this vertical integration.

Figure 6.2 : Primary operations (All respondents)



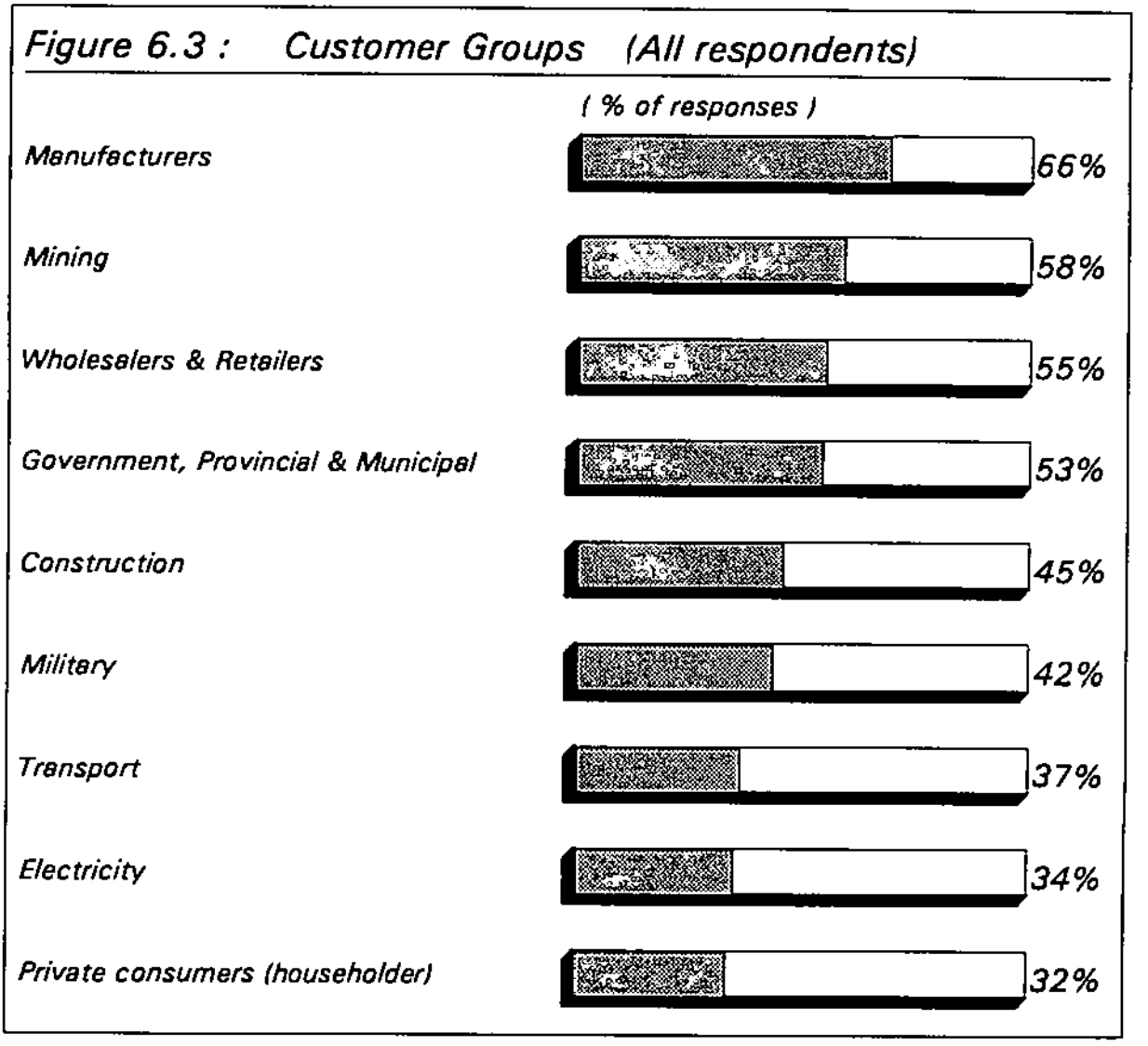
* **Major customer groups (Question 3)**

The purpose of this question was to determine the major customer groups for the various industrial sector segments, and the extent of market diversification. The profile of the major customer groups for all the participating companies in the survey is shown in Figure 6.3. It shows that the participating companies in the survey serve all the identified customer groups, ranging from a maximum of 66% of the respondent companies that serve manufacturers to a minimum of 32% that serve private consumers (householders).

The survey shows a slight variation in the number of customer groups served by the various industrial sector segments (see Appendix C). Of note is the steel segment which serves a single

customer group; namely that of manufacturer. The profile of customers served by this segment is notably biased by the fact that only one questionnaire response was received from this segment. The respondent information shows that the pharmaceutical and medical segment serves four customer groups, with the remainder of the industrial sector segments serving more than four groups (see Appendix C).

Figure 6.3 : Customer Groups (All respondents)



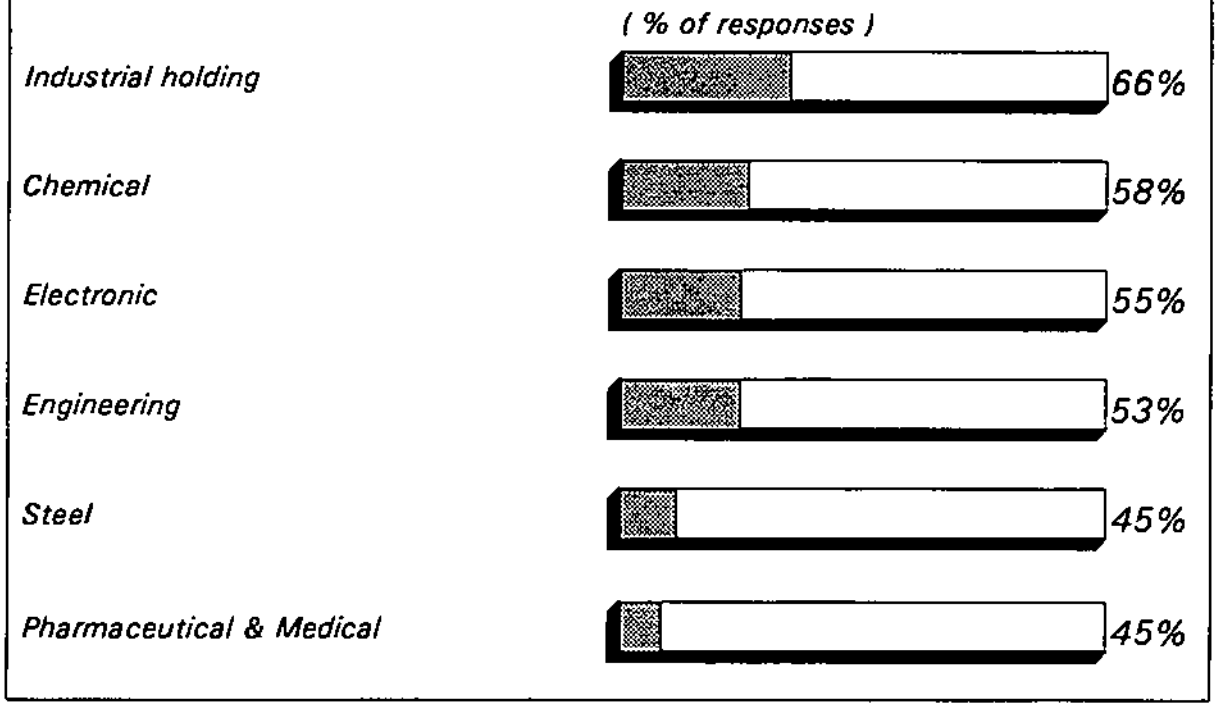
* **Industrial sector segments (Question 4)**

Notwithstanding the fact that information was readily available regarding the industrial sector segments under which the respective respondent companies resort (McGregor, 1992), respondents were still requested to indicate the segment applicable to their company. This was done purely to expedite the data capturing process.

The actual responses differed from the available information in the sense that certain companies, particularly diversified holding companies, saw themselves as operating in more than one industrial sector segment (see Appendix C). This explains why respondents from the electronics, engineering, industrial holding, and pharmaceutical and medical segments indicated that their company operated in several segments; not just their core industrial sector segment. Only the chemical and steel segments indicated operations exclusively in a single industrial sector segment. This confirms that many of the respondents were making generalised responses on behalf of their holding company which operates many diverse and separate business units.

Figure 6.4 illustrates the industrial sector segments involved in the survey and provides the percentage breakdown of respondents from each of these segments.

Figure 6.4 : Industrial sector segments (All respondents)



* **Company size (Question 5)**

The respondent companies varied widely in terms of company size, based on number of employees and annual turnover. Tables 6.3A and 6.3B illustrate the variation in size of the respondent companies for each of the industrial sector segments.

In terms of employees, the companies varied from large (more than 50 000), to small (less than 500). Eight of the respondent companies, from a total of four industrial sector segments, had in excess of 10 000 employees and twenty-three had in excess of 1 000 (representing 21% and 61% respectively, of the total number of respondents). In terms of annual turnover, sixteen of the respondent companies have turnovers in excess of one billion Rand, representing 42% of the total number of respondents.

TABLE 6.3A : EMPLOYEE STATISTICS (RESPONDENT COMPANIES)						
Interval : Number of employees	Frequency (%)					
	Industrial Sector Segment					
	Chemical	Electri-cal	Engineer-ing	Industrial Holding	Pharma-ceutical	Steel
More than 50 000				2 (20%)		
10 001 to 50 000	2 (40%)	1 (11%)	1 (10%)	2 (20%)		
1 001 to 10 000	3 (60%)	4 (44%)	3 (30%)	4 (40%)	1 (33%)	
501 to 1 000		1 (11%)	2 (20%)	1 (10%)	1 (33%)	1 (100%)
Less than 500		3 (33%)	3 (30%)		1 (33%)	
Unknown			1 (10%)	1 (10%)		

TABLE 6.3B : ANNUAL TURNOVER STATISTICS (RESPONDENT COMPANIES)						
Interval : Annual turnover (Amounts in Rands'million)	Frequency (%)					
	Industrial Sector Segment					
	Chemical	Electri-cal	Engineer-ing	Industrial Holding	Pharma-ceutical	Steel
More than R1000 m	4 (80%)	4 (44%)	2 (20%)	6 (60%)		
R501 m to R1000 m		1 (11%)	1 (10%)		1 (33%)	
R101 m to R500 m	1 (20%)	1 (11%)	3 (30%)	4 (40%)	1 (33%)	1 (100%)
R11 m to R100 m		3 (33%)	4 (40%)		1 (33%)	
Less than R10 m						
Unknown			1 (10%)	1 (10%)		

* **Mission statement (Question 6)**

The purpose of this question was primarily to establish whether companies address technology issues in their mission statement. The premise behind having technology or technological issues mentioned in the mission was that it could be taken to signify the importance which a company attaches to technology as a key to its success.

A total of twenty-six respondents (i.e. 68% of the total number

of respondents) indicated that their companies had a mission statement, whereas it was found that only two of these companies (i.e. 5% of the total number of respondents) referred to technology matters in their mission statement (see Table 6.4). Both companies came from the engineering segment of the industrial sector.

TABLE 6.4 : MISSION STATEMENT DETAILS

	No. of Responses	% of Responses
Company has mission statement	26	68
Has no mission statement	10	26
Unknown	2	5
Reference made to technology in mission statement	2	5

Monitoring technology (Questions 7(a) & 7(b)

Although most (92%) participating companies from the various industrial sector segments monitor and scan technologies being developed or applied outside their own company during the planning process to identify threats and/or opportunities (see Figure 6.5A), many (47%) of these companies do not feel their technology monitoring activity is totally effective, i.e. somewhat or not at all effective (see Figure 6.5B).

The effectiveness as perceived by these respondent companies of the scanning activity varied considerably between the various

Figure 6.5A : Companies which scan technologies

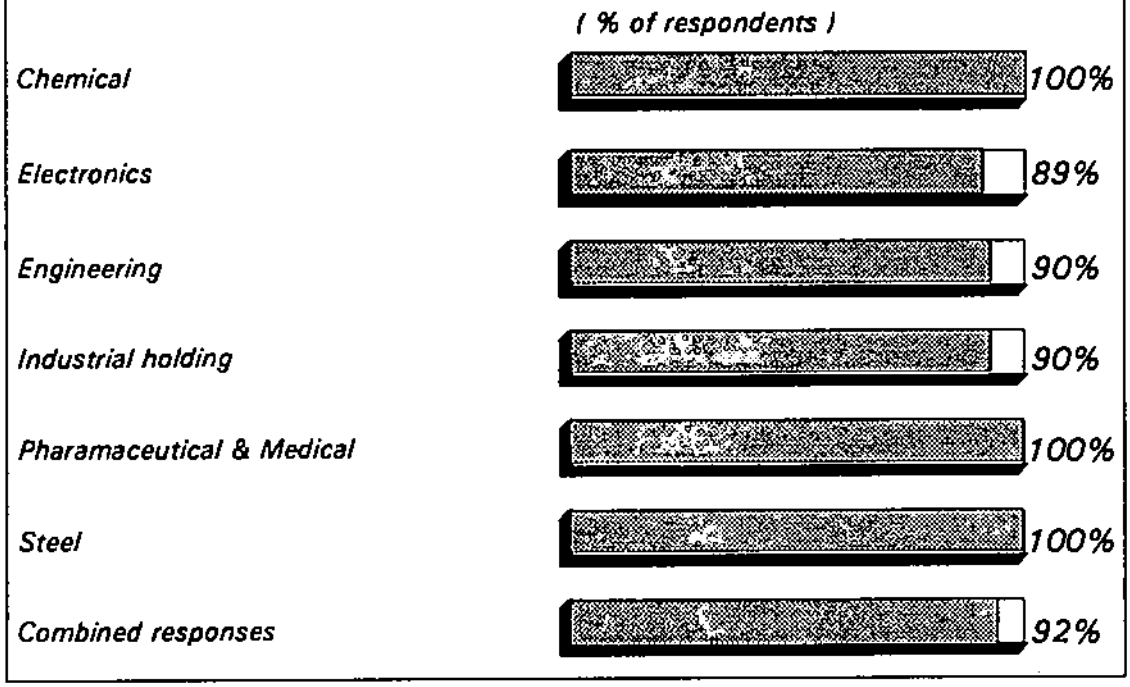
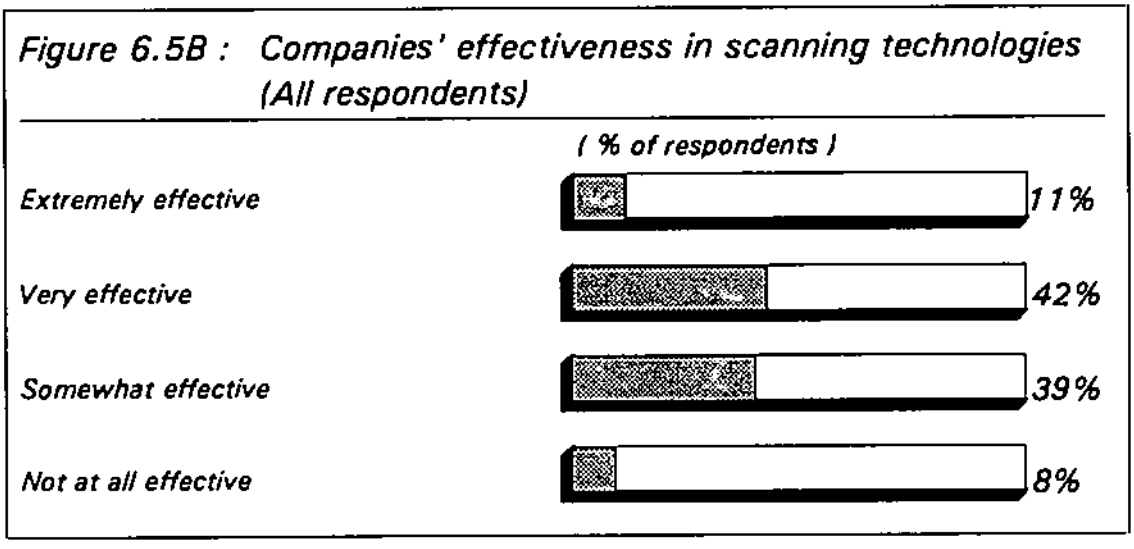


Figure 6.5B : Companies' effectiveness in scanning technologies (All respondents)



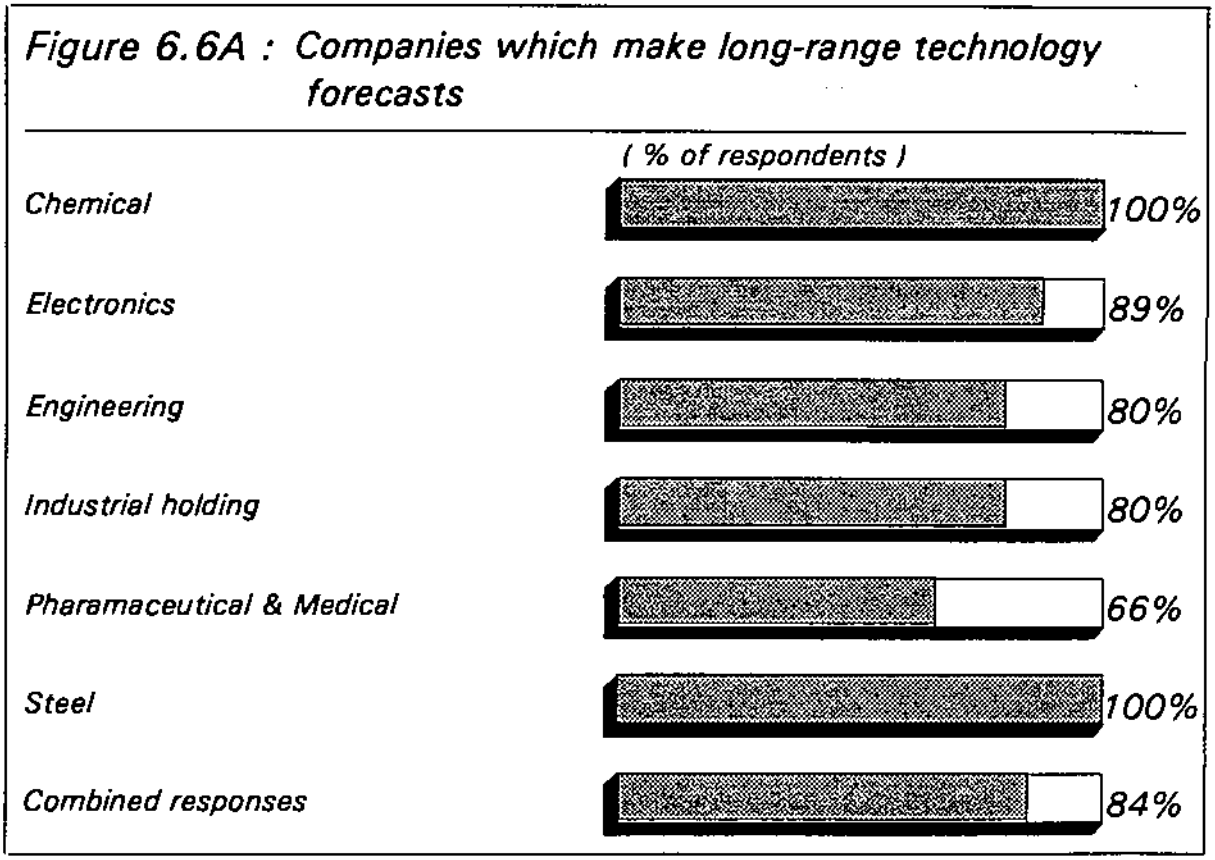
industrial sector segments (see Appendix C). The majority of participating companies from the electronics, industrial holding and steel segments feel that their scanning activities are very effective or better, whereas in the case of participating companies from the chemical, engineering and pharmaceutical and medi-

cal segments, the majority feel that they are either somewhat or not at all effective in this area.

* **Long-range technology forecasts (Questions 8(a) & 8(b))**

Much the same can be said about long-range technology forecasting, as to that which was mentioned above under monitoring technology. In this case 84% of the participating companies from the various industrial sector segments make long-range forecasts of the potential impact of emerging technologies on their company. (See Figure 6.6A).

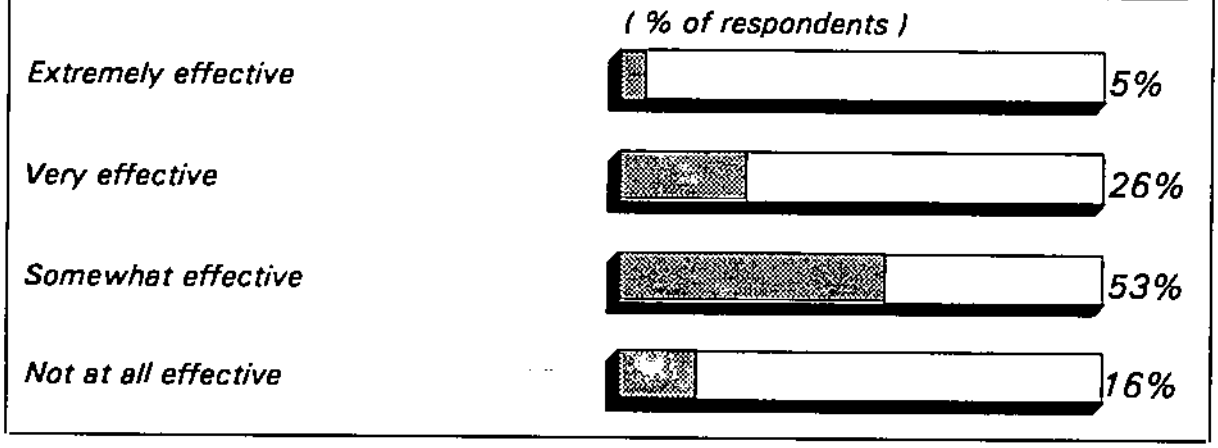
Figure 6.6A : Companies which make long-range technology forecasts



The main difference lay with the fact that more participating companies feel that their long-range technology forecasting is

not effective (69%), in comparison to monitoring technology (47%) (see Figures 6.5B and 6.6B). Once again the respondent companies' opinions varied between the industrial sector segments as to their companies' effectiveness in performing technology forecasting (see Appendix C).

Figure 6.6B : Companies' effectiveness in technology forecasts (All industrial sector respondents)



* **Internal technology audits (Questions 9(a) & 9(b)**

Only 50% of the participating companies from the various industrial sector segments conduct internal technology audits to establish their companies' "baseline" technology capability and ultimately the companies' technological strengths and weaknesses. The percentages applicable to the specific industrial sector segments are shown in Figure 6.7A. Very few of the participating companies feel that their companies handle this activity effectively, namely only 27% feel that their companies handle this activity extremely or very effectively (see Figure 6.7B). The remainder (70%) do not feel internal technology auditing is effective.

Figure 6.7A : Companies which conduct internal technology audits

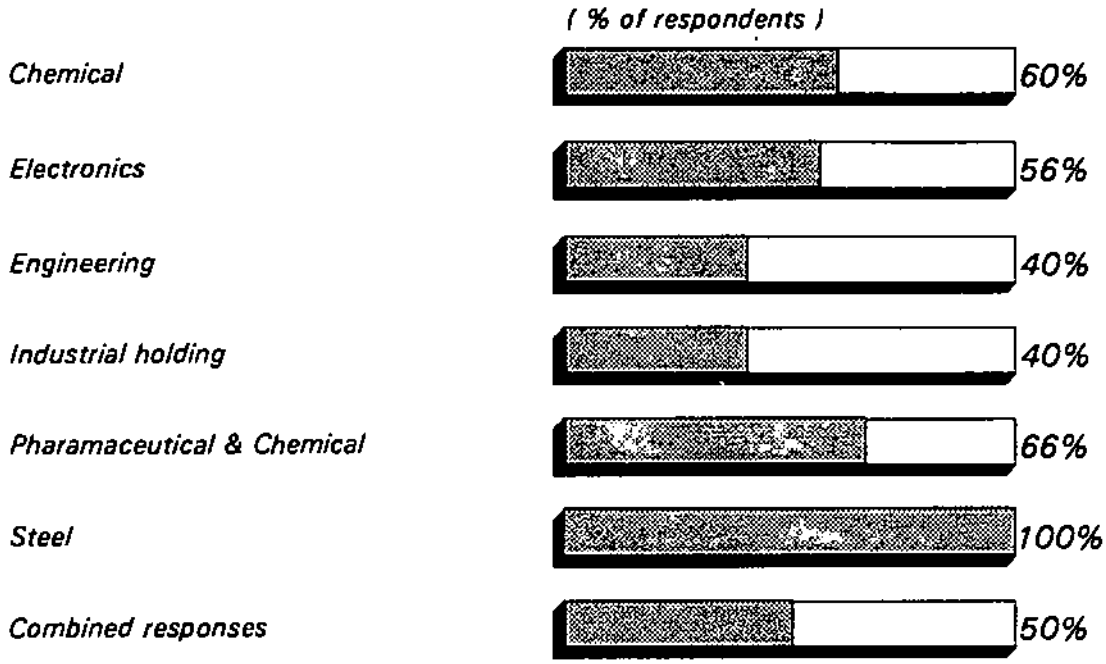
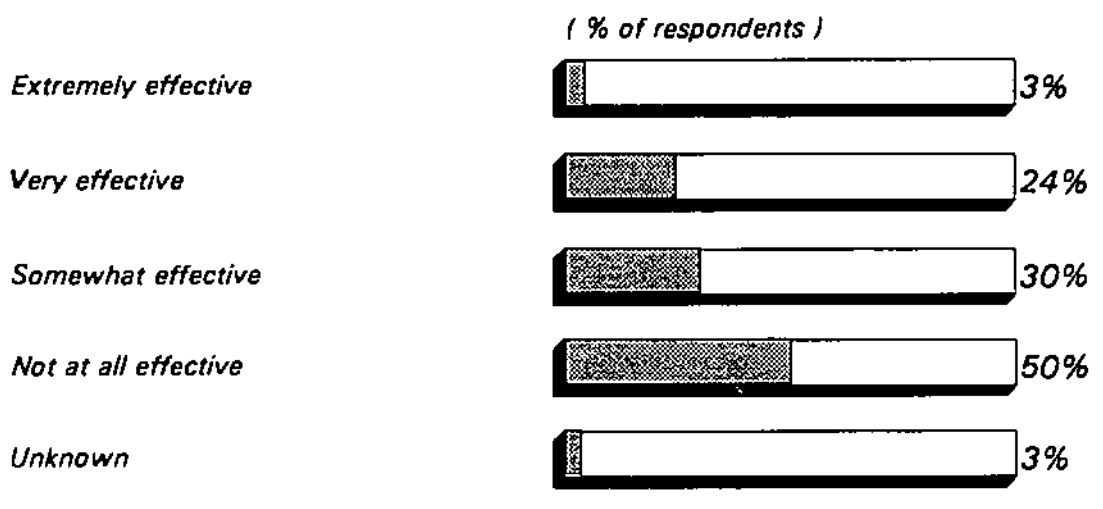


Figure 6.7B : Companies' effectiveness in conducting internal technology audits (All respondents)



As with monitoring and forecasting technology, the findings show variations between the various industrial sector segments on how effectively this function is perceived to be carried out. The one and only participating company from the steel segment feels this function is being handled extremely effectively, but the opinion suffers from the limitation of being based on the response of a single company.

* **Consideration given to existing and emerging technologies (Question 10)**

The respondents were asked to indicate whether their companies formally give consideration to existing and emerging technologies available both inside and outside the company for the following applications:

- improving existing products
- developing new products
- developing new processes
- reducing process costs.

The questionnaire results for all four parts of question 10 were weighted on a four point scale on the following basis:

Extensive consideration - weight of 4.

Moderate consideration - weight of 3.

Minimal consideration - weight of 2.

No consideration - weight of 1.

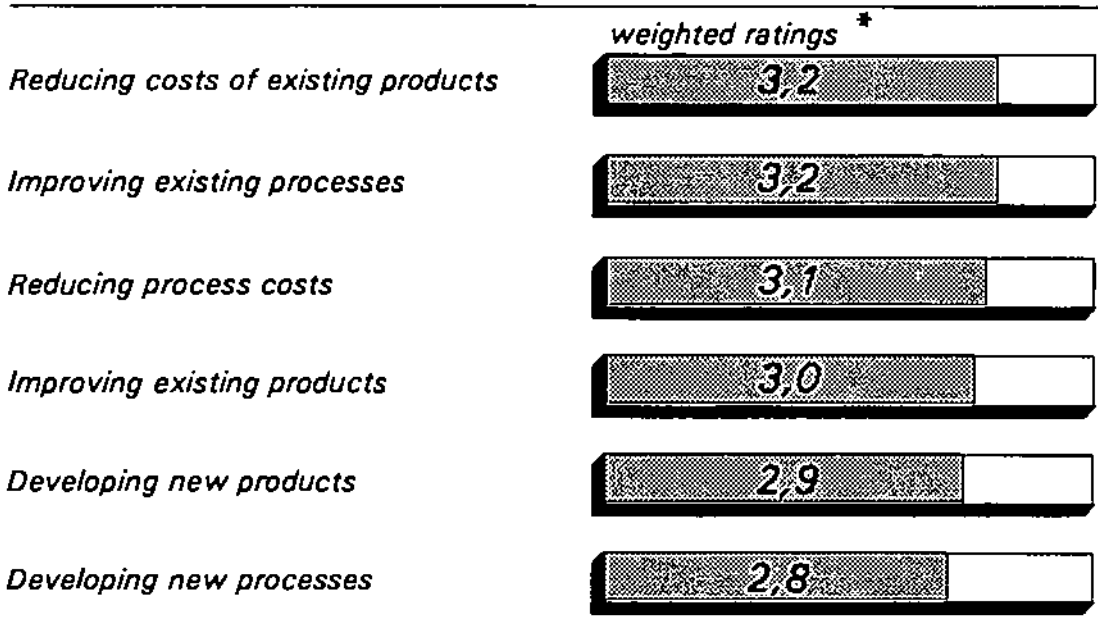
The ranked (average) weighted ratings for each of the applications are presented for four different conditions as shown in Figures 6.8A to 6.8D. Small variations are evident in the weighted ratings of the applications when comparing the different conditions.

This question produced some interesting results. Figure 6.8A shows how much consideration, during the planning process, participating companies give existing technologies which are available to them inside their own companies for the various applications under discussion. The applications which received the highest rankings all involved improvements and reductions in costs to existing products and processes. Consideration given to new products and processes appear to rank as secondary when it comes to existing technologies inside the company.

The findings were similar when it came to consideration given to emerging technologies inside the company (see Figure 6.8C). Once again the applications that received the highest rankings all had to do with existing products and processes, with new products and processes getting the lowest rankings.

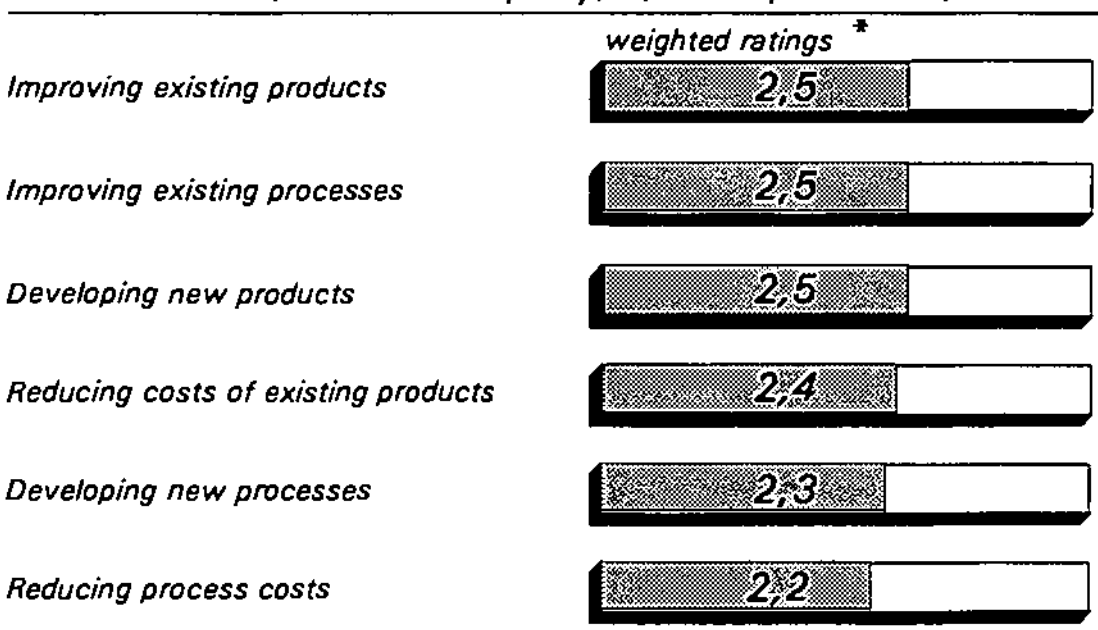
The findings show that the same three applications ranked highest when it came to the respondent companies giving consideration to existing and emerging technologies outside the company (see Figures 6.8B and 6.8D). These applications were: improving exist-

Figure 6.8A : Consideration given to existing technologies (inside company) (All respondents)



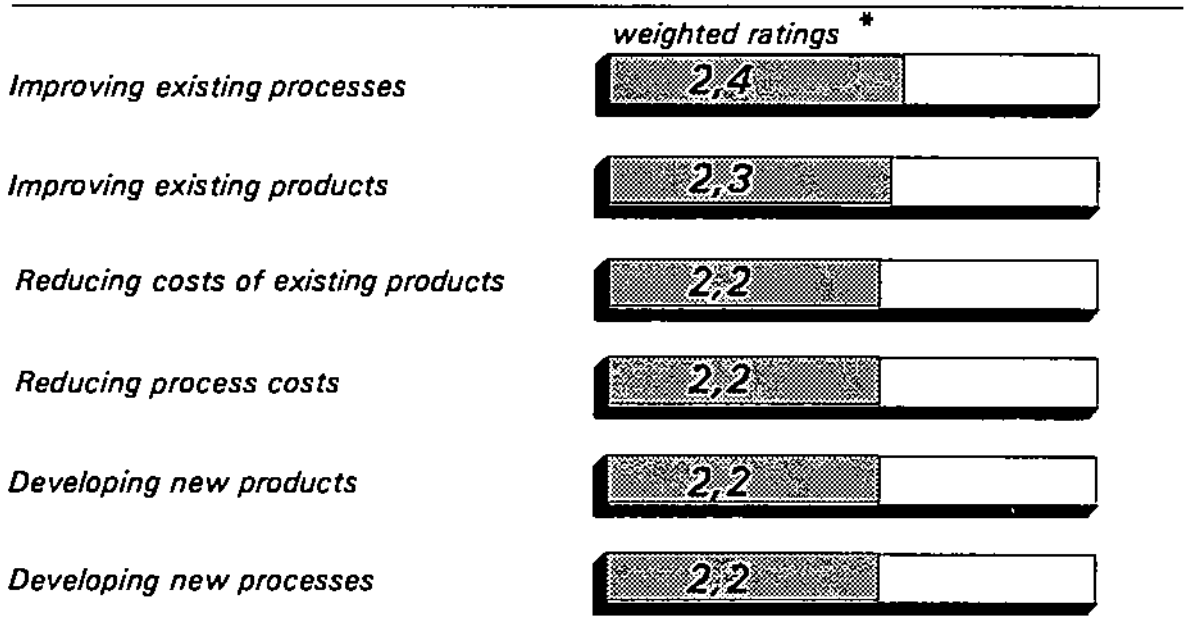
* on a scale of 1 (no consideration) to 4 (extensive consideration)

Figure 6.8B : Consideration given to existing technologies (outside company) (All respondents)



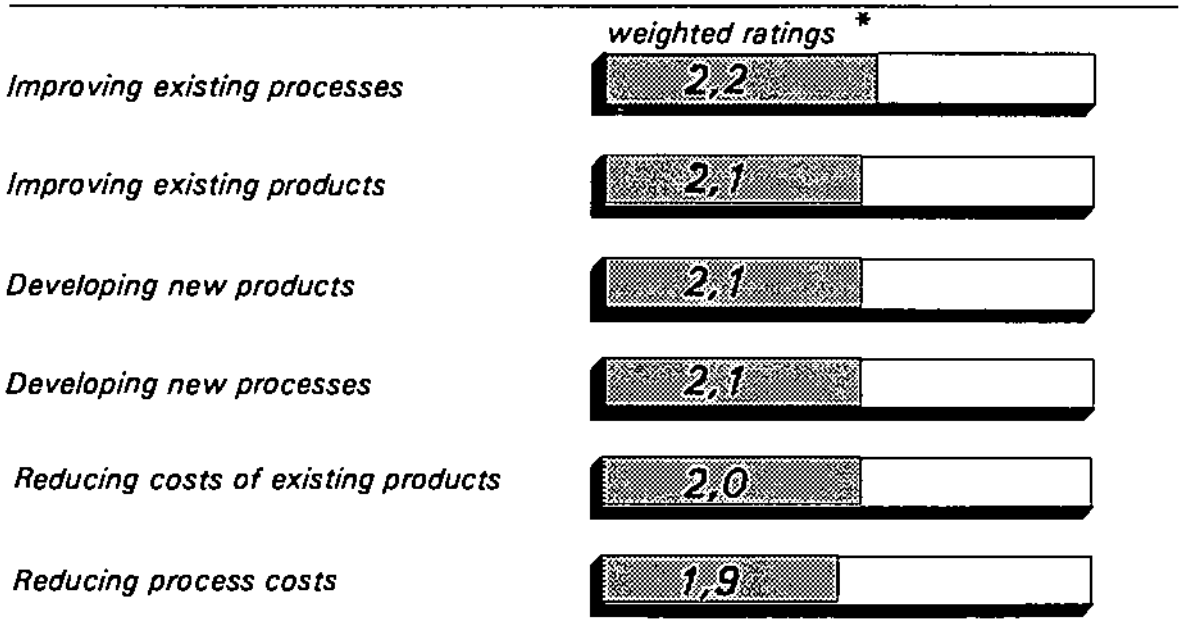
* on a scale of 1 (no consideration) to 4 (extensive consideration)

Figure 6.8C : Consideration given to emerging technologies (inside company) (All respondents)



* on a scale of 1 (no consideration) to 4 (extensive consideration)

Figure 6.8D : Consideration given to emerging technologies (outside company) (All respondents)



* on a scale of 1 (no consideration) to 4 (extensive consideration)

ing products, improving existing process and developing new products. Reducing process costs ranked lowest when it came to the respondent companies giving consideration to emerging technologies outside the company, probably because the respondents saw a difference between improving existing processes and reducing process costs.

By relating the weighted ratings of the applications concerned with the development of new products and processes for the four conditions considered (see Figures 6.9A,B,C & D), it is apparent that the rankings in terms of preferred source of technology are as follows:

- existing technologies (inside company)
- existing technologies (outside company)
- emerging technologies (inside company)
- emerging technologies (outside company).

The consideration given to existing and emerging technologies during the planning process, both inside and outside the company, essentially describes the technology gap analysis (process) where the opportunities and threats available in the external environment are related to the strengths and weaknesses existing inside the company. From the findings it can be established that the consideration given by the participating companies to technology gap analysis, albeit formal or informal, ranges from moderate to minimal consideration (refer to question 10 in the

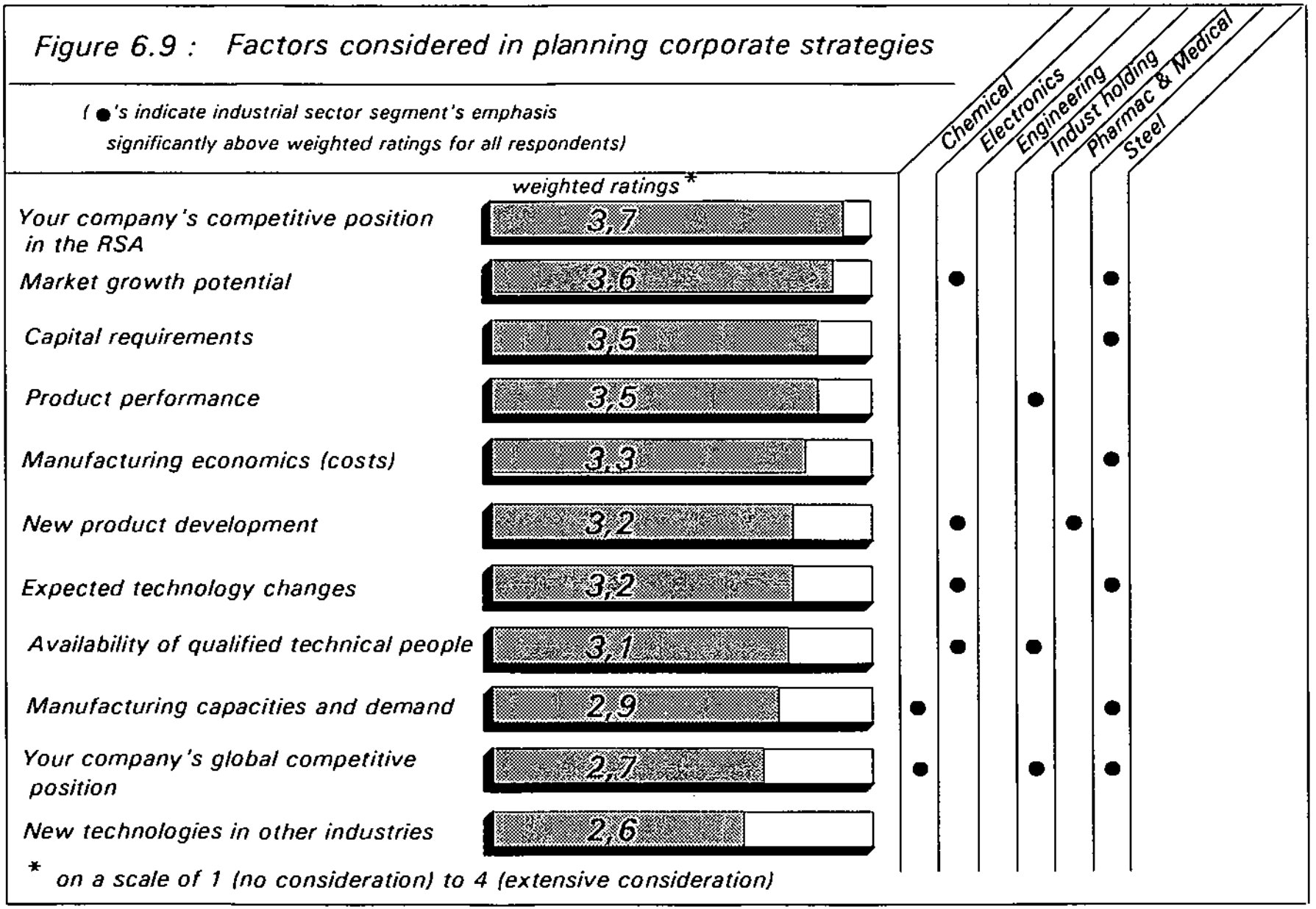
questionnaire).

While the findings from this question were far from conclusive, it provided certain insights into the consideration given to various technologies and their generic sources. The variations in the weighted ratings within each industrial sector segment are shown in Appendix C, but will not be discussed due to the difficulty of meaningfully interpreting these results. The above discussion was therefore restricted only to the collective results of all the respondent companies in the industrial sector.

* **Factors considered in planning corporate strategies (Question 11)**

The questionnaire requested the respondents to indicate their response to each of the factors which they consider in planning corporate strategies for the future by using a four point scale, namely 4 (very important) to 1 (not at all).

The average weighted rating for all the participating companies in the survey was determined for each factor and then ranked. The findings as illustrated by Figure 6.9 indicate that factors which are related more to the business side of the company, as opposed to technology related matters (e.g. company's competitive position in the RSA, market growth potential and the like), receive most of management's attention. The factors which have a technology connection, appear much lower down in the rankings (e.g. new product development, expected technology changes and new


Figure 6.9 : Factors considered in planning corporate strategies
(● 's indicate industrial sector segment's emphasis
significantly above weighted ratings for all respondents)
weighted ratings *
Your company's competitive position in the RSA
3,7
Market growth potential
3,6
Capital requirements
3,5
Product performance
3,5
Manufacturing economics (costs)
3,3
New product development
3,2
Expected technology changes
3,2
Availability of qualified technical people
3,1
Manufacturing capacities and demand
2,9
Your company's global competitive position
2,7
New technologies in other industries
2,6
Chemical
Electronics
Engineering
Indust holding
Pharmac & Medical
Steel
* on a scale of 1 (no consideration) to 4 (extensive consideration)

technologies in other industries). It is also interesting to note that the majority of the average weighted ratings fell above 3, signifying that the respondents felt the importance of these factors in planning corporate strategies is moderate to very important.

The survey findings indicate that certain of the factors are more important to participating companies from particular industrial sector segments (see Figure 6.9 & Appendix C). For example, the emphasis of the factor "expected technology changes" is significantly much higher for the participating companies from the electronics and steel segments in comparison to that of the industrial sector as a whole.

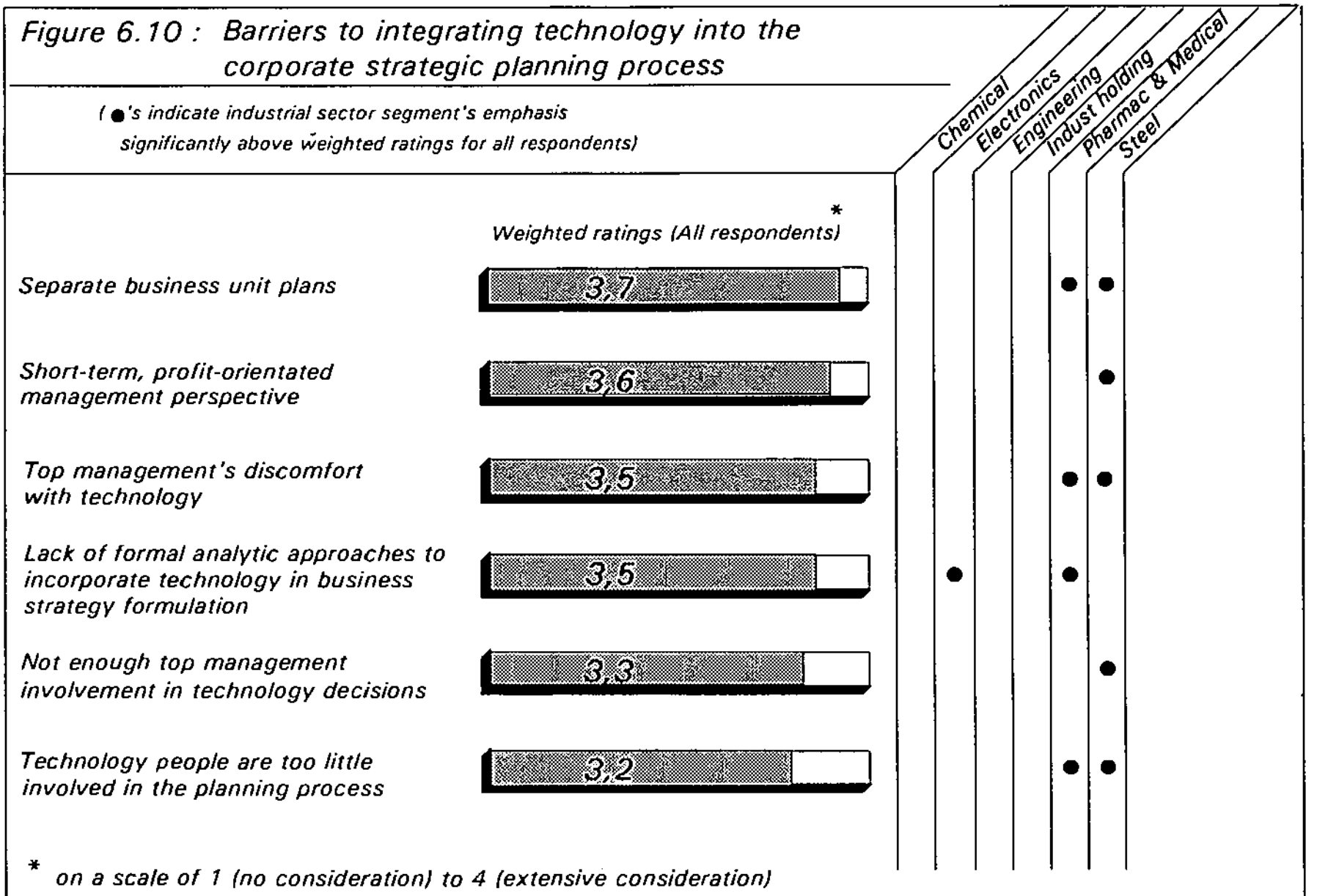
* **Barriers to integrating technology into the corporate strategic planning process (Question 12)**

A four point scale was used once again in the questionnaire as was the case with the previous two questions. The findings indicate that all the considered factors (see Figure 6.10) acted minimally to moderately as barriers to integrating technology into the corporate strategic planning process. Separate business unit plans ranked highest as a factor which serves as a barrier to integrating technology into the strategic plan.

Figure 6.10 also shows which industrial sector segments are influenced by factors which act as barriers to integrating technology into the corporate strategic planning process where the emphasis is significantly above the overall weighted rating (for

Figure 6.10 : Barriers to integrating technology into the corporate strategic planning process

(●'s indicate industrial sector segment's emphasis significantly above weighted ratings for all respondents)



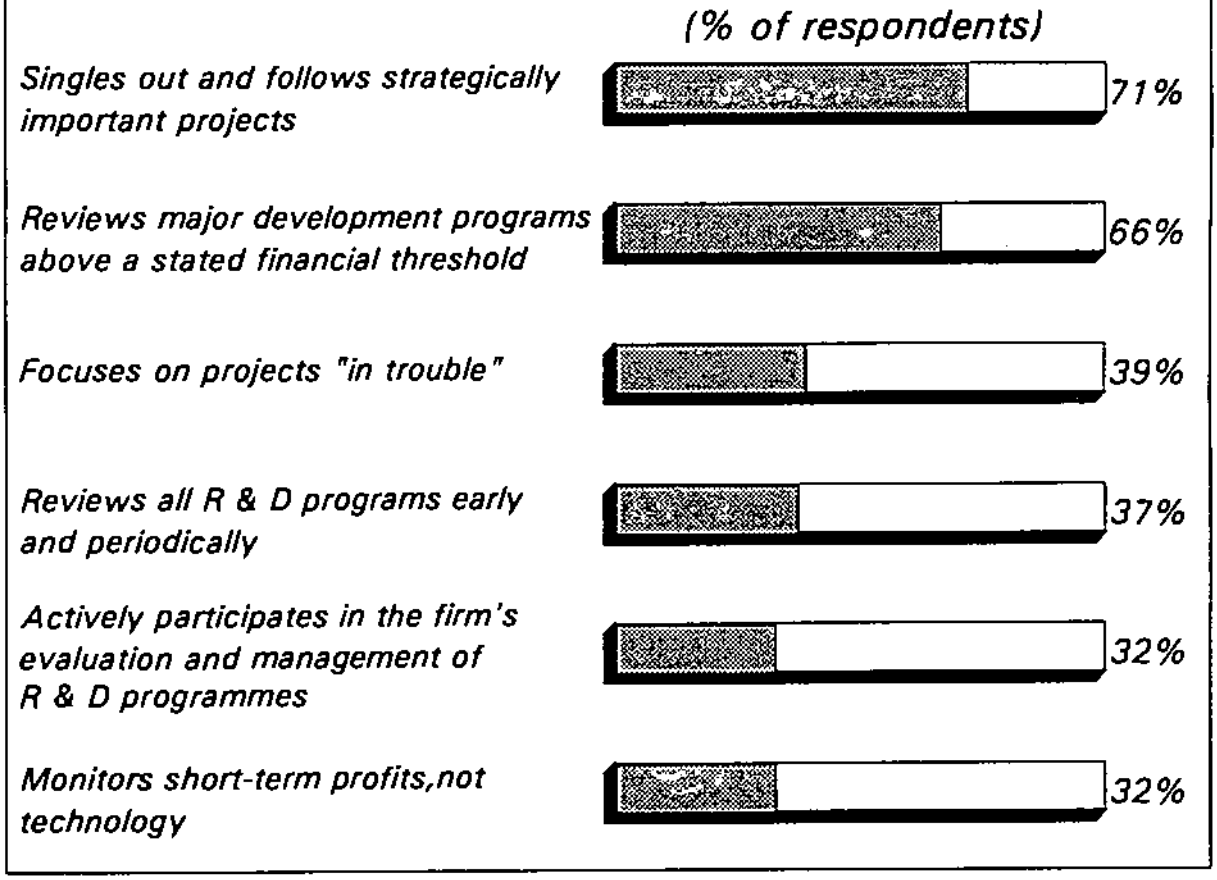
* *on a scale of 1 (no consideration) to 4 (extensive consideration)*

all the industrial sector respondents). As an example, the survey indicates the factor which is ranked fourth, namely "Lack of formal analytic approaches to incorporate technology in business strategy formulation", is of greater importance to the respondent companies from the electronics and pharmaceutical and medical segments, in comparison to the respondent companies from all the industrial sector segments taken as a whole.

* **Top management's role in the technology process (Question 13)**

Certain roles performed by top management in the technology process of the participating companies are shown in Figure 6.11.

Figure 6.11 : Role of top management in technology process (All respondents)



Significantly, the top management from 32% of the participating companies monitor short-term profits and totally ignore technology, while 71% follow their strategically important technological projects.

* **Means of integrating technology in the planning process (Question 14)**

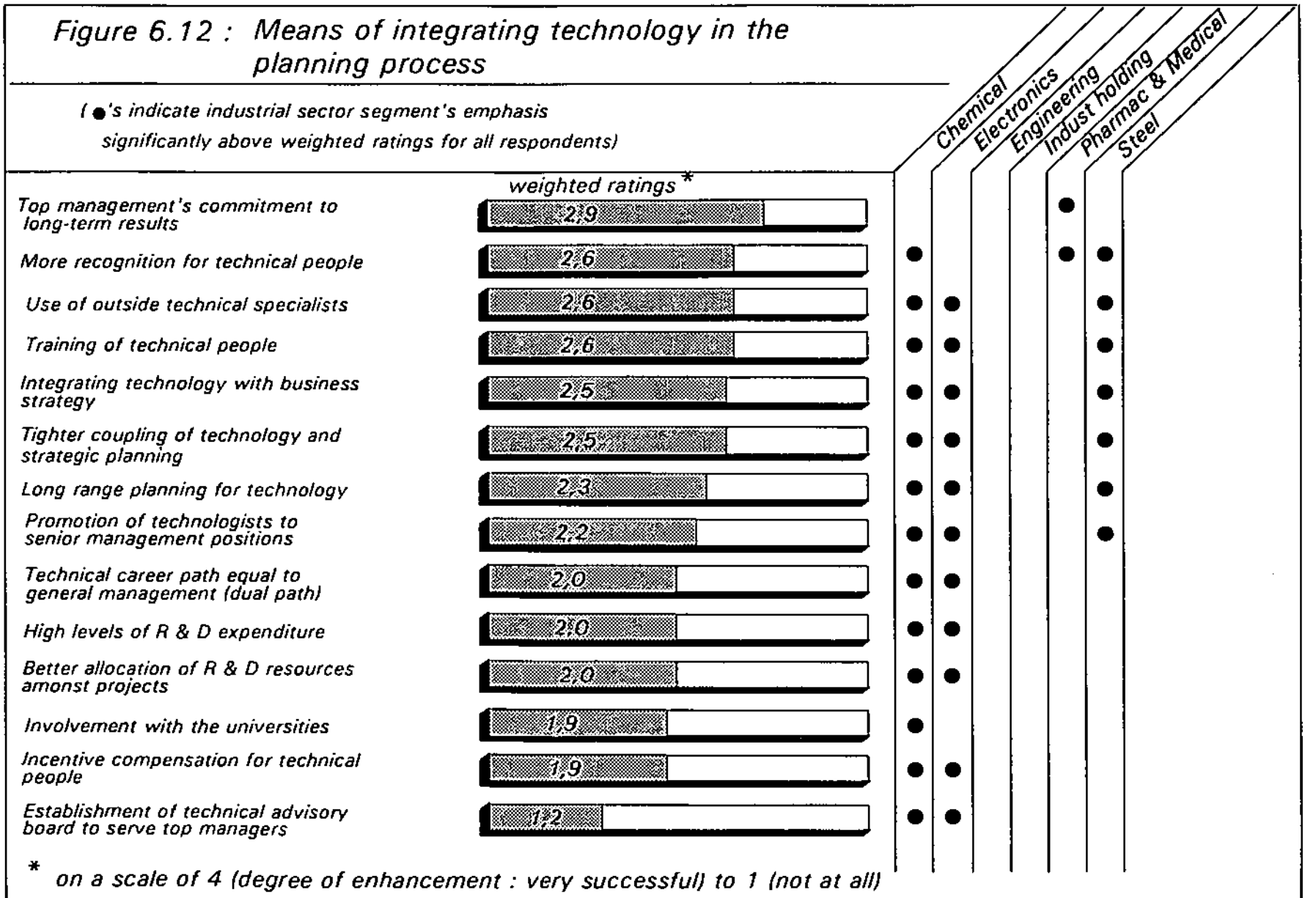
The intention of this question was to establish which "approaches" have ensured success in the area of technology planning in the past and have contributed in enhancing the respondent companies' performance. The findings illustrated by Figure 6.12 show that the identified "approaches" have contributed "minimally" to "moderately" to the participating companies performance or success in technology management. It appears that the participating companies have either not been very successful in the past utilising these "approaches" to ensure success in the area of technology planning, or the participating companies are not active in this area of planning.

Figure 6.12 also shows the emphasis of many of these "approaches" is significantly higher from the respondent companies in the chemical, electronics and steel segments in comparison to that which is applicable for all respondents in the survey.

Notwithstanding the above, the survey findings show that the "approaches" which fall in the top half of the rankings deal mainly with top management's commitment to longer term results

Figure 6.12 : Means of integrating technology in the planning process

(● 's indicate industrial sector segment's emphasis
significantly above weighted ratings for all respondents)



* on a scale of 4 (degree of enhancement : very successful) to 1 (not at all)

and the integration or tighter coupling of technology and strategic planning.

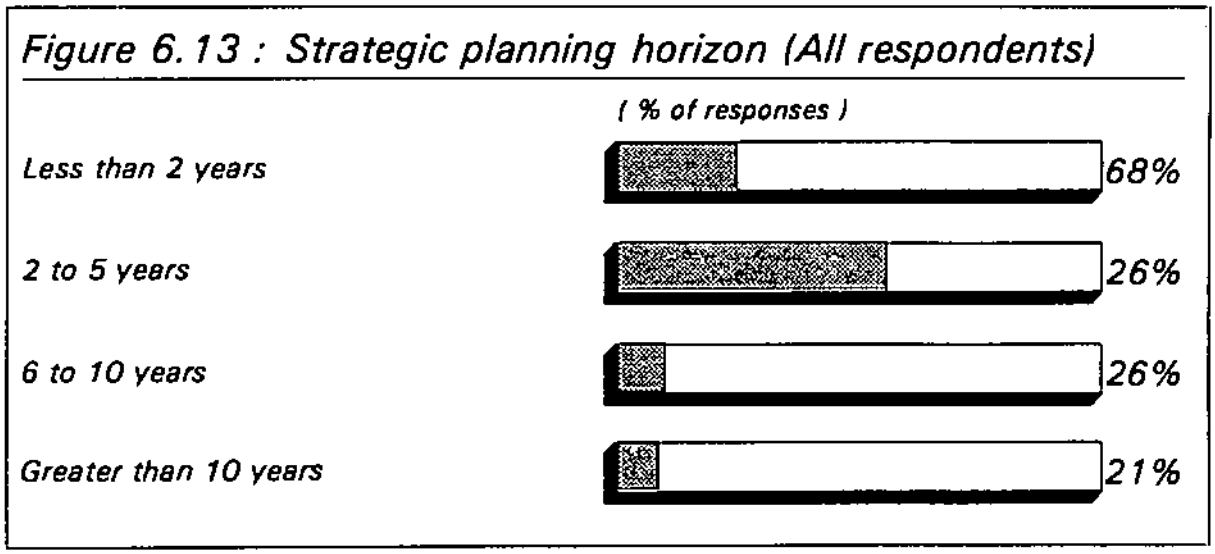
* **Formality of strategic planning process (Question 15)**

A total of 71% of the participating companies replied that their planning process is formal and structured. No definite correlation between company size and the formality of the strategic planning could be established. In the process of trying to interpret these findings, reference was made to techniques used in the technology management process, as well as the formality applicable to the strategic planning process. Once again no conclusive interpretation could be made, although it appears that formal planners are more extensive users of the available technology management techniques.

* **Strategic planning horizon (Question 16)**

The majority of the participating companies use a 2 to 5 year planning horizon, namely 57%; and 82% of the participating compa-

Figure 6.13 : Strategic planning horizon (All respondents)



nies use a planning horizon of 5 years or less. Certain companies are using a planning horizon of less than 2 years. The electronics segment had the highest percentage of participating companies, out of all the industrial sector segments, using a planning horizon of less than 2 years (i.e. 44% - Appendix C).

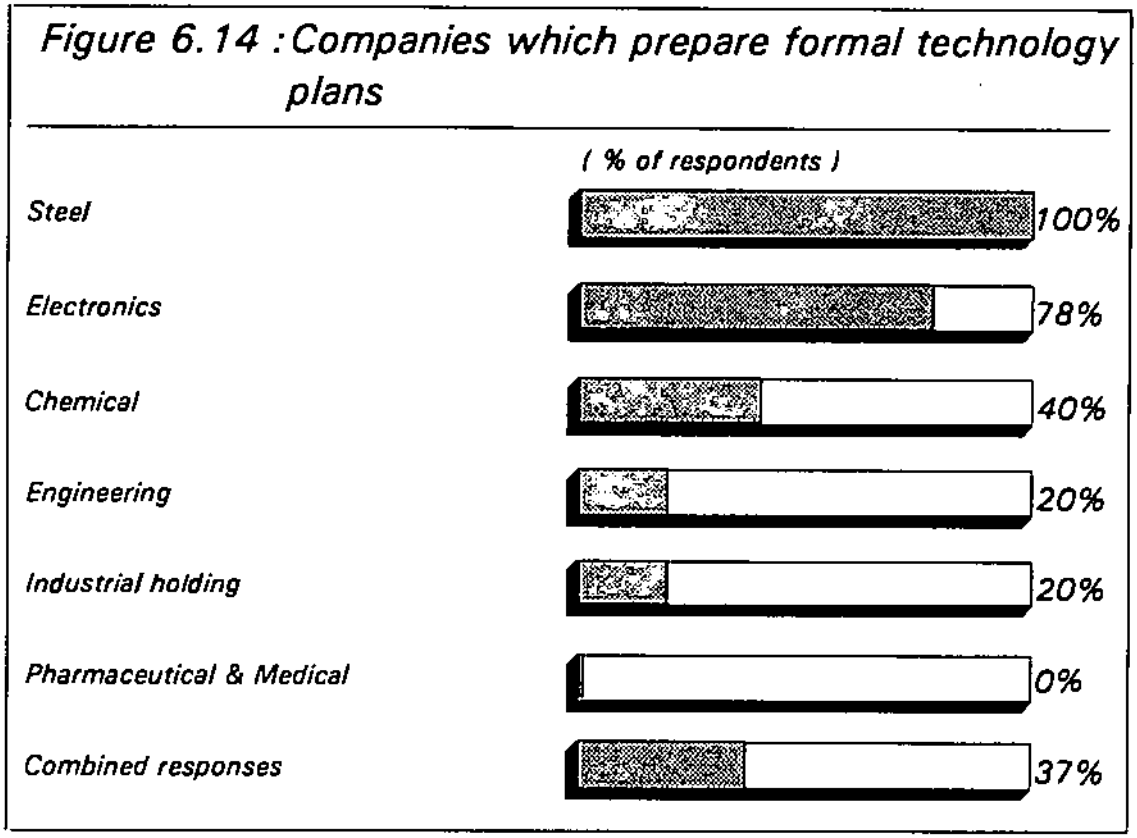
* **Formal technology plan (Question 17)**

Twenty-seven companies prepare a formal technology plan, representing 37% of total number of responses. The participating companies from the steel segment showed the highest percentage of respondents from a segment which prepare a formal technology plan. As previously mentioned, these findings are not meaningful since only one response was received from the steel segment. Both the chemical and electronic segments rate high in terms of the number of participating companies which prepare formal technology plans (see Figure 6.14).

It is interesting to note that a high percentage of the participating companies in the survey indicated, whilst answering some of the other questions in the questionnaire, that their companies' perform certain of the basic activities necessary to allow one to prepare a formal technology plan, namely monitoring technology, conducting long-range forecasts, performing internal technology audits and the like. The matter which is difficult to reconcile is the low percentage of participating companies which prepare formal technology plans (i.e. only 37% of all respondents) with the fact that many of them perform certain of the

basic activities necessary in preparing a technology plan. This seems to indicate that technology management and planning is not presently being considered by the majority of participating companies in their planning process, not ignoring the possibility that there may be certain participating companies which deal with technology on an informal basis.

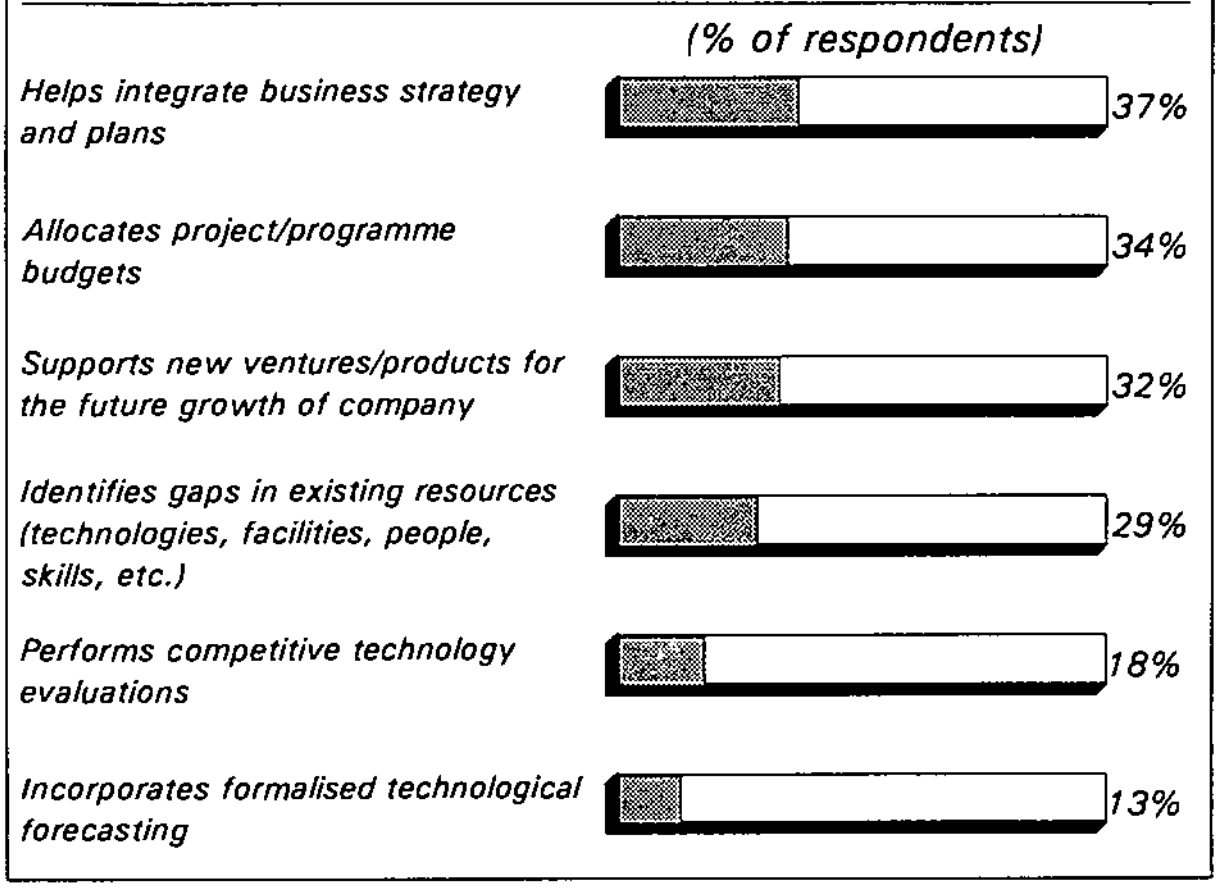
Figure 6.14 : Companies which prepare formal technology plans



* **Contents of the technology plan and its integration with the strategic plan (Question 18(a) & (b))**

The respondents which indicated that their company do prepare a technology plan, were requested to indicate whether the technology plan contained any of the aspects listed in the questionnaire. Although not stated, the question really was trying to establish the benefits accruing from having a technology plan.

Figure 6.15 : "Aspects" contained in the technology plan (All respondents)



If one bears in mind that 37% of the participating companies prepare a formal technology plan and 34% of the participating companies integrate the technology plan with the strategic plan, it is apparent from Figure 6.15 that the majority of these respondent companies at least benefit by including the following "aspects" in their technology plans (or alternatively prepare a technology plan for the following reasons):

- helps integrate business strategy and plans
- allocates project/programme budgets

- supports new ventures/products for the future growth of company

- identifies gaps in existing resources.

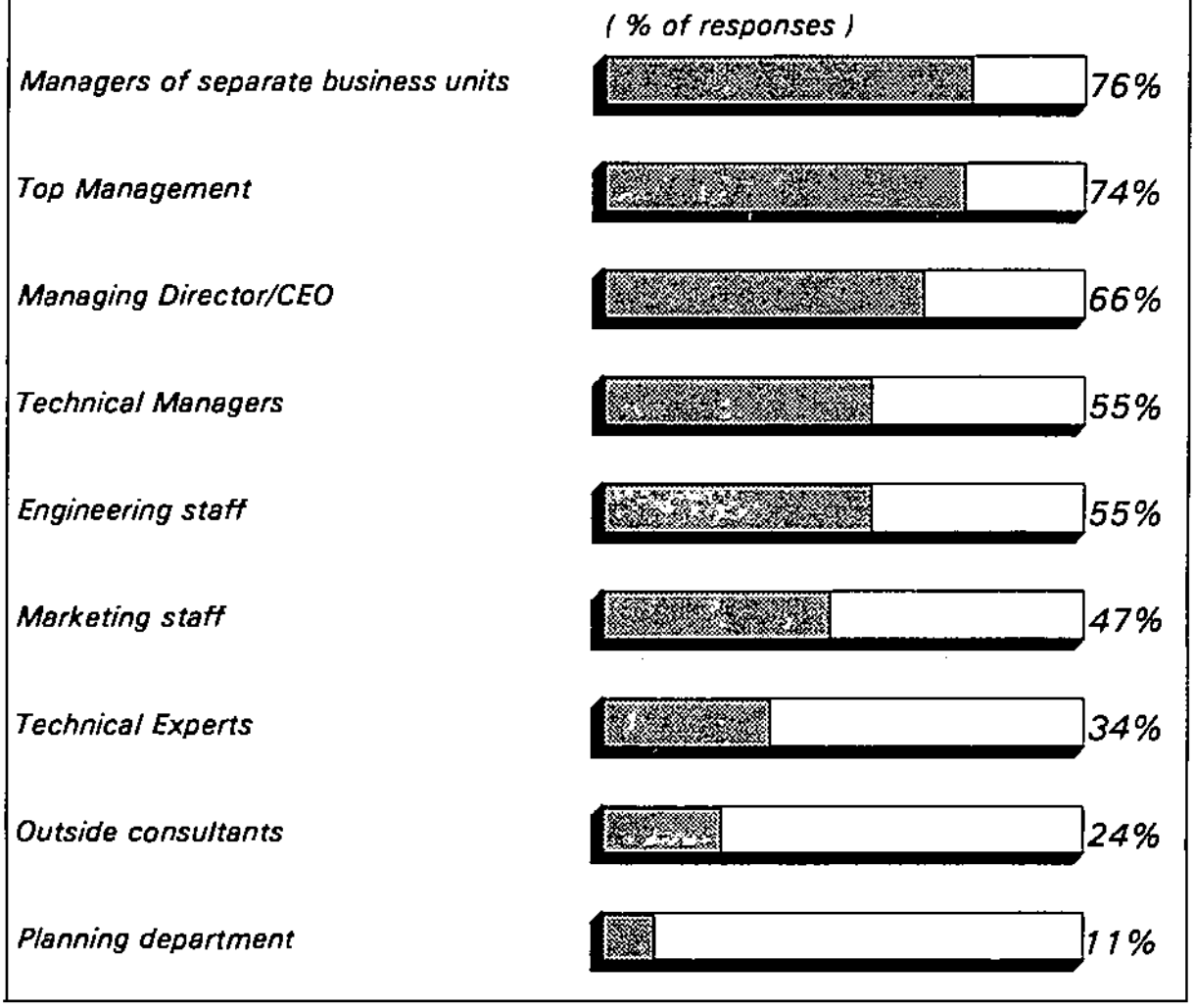
The findings of the electronics segment indicate that this segment makes the most extensive use of technology planning in the planning process, with approximately 78% of the respondents from this segment making use of technology plans which contain the four "aspects" listed above.

* **Planning and implementation of technology (Question 19)**

The findings show that the managers of separate business units along with top management (including Managing Director/CEO) are primarily responsible for contributing to technology planning within the companies participating in the survey (see Figure 6.16A). To a lesser extent, the technical managers, engineering staff and marketing staff also contribute in the technology planning.

Regarding who contributes towards the implementation of technology within these participating companies, it appears that this comes mainly from the managers of separate business units, technical managers, top management, engineering and marketing staff (see Figure 6.16B). The Managing Director/CEO from the participating companies are not as extensively involved with the implementation of technology, as with the planning process.

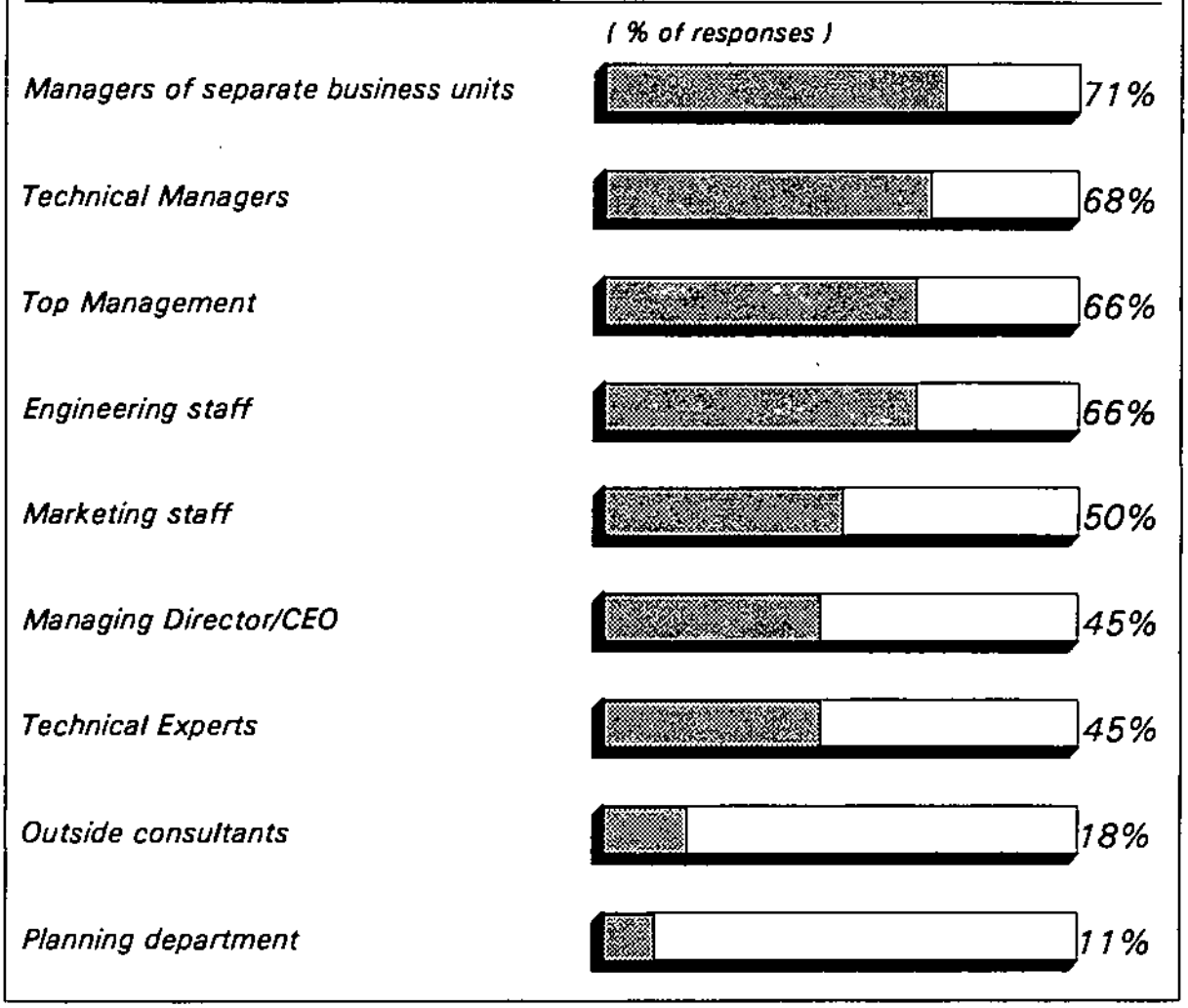
Figure 6.16A : Who contributes towards technology planning (All respondents)



The fact that senior management members appear to support (actively, overtly or otherwise) and contribute extensively in both the technology planning and implementation processes in many of the respondent companies, must assist greatly with any new technology introduction from the standpoint of gaining approval and commitment of the staff within the company, as well as enhance the chances of success when it comes to the implementation of new technology. The involvement in technology planning and technology

implementation by many of the functional areas within the participating companies is encouraging, since this should help to provide a universal sense of ownership and commitment in meeting technology and company goals.

Figure 6.16B : Who contributes towards the implementation of technology (All respondents)



The findings show that engineering staff and marketing staff contribute both to the planning and implementation of technology

in many of the participating companies. This is the ideal situation for any company to experience and lends itself to satisfying both market push and technology pull opportunities.

* **Analysis of techniques used in the technology planning process (Question 20)**

The purpose of this question was to establish where companies stand in terms of their depth and knowledge of techniques used in technology management. The findings show that the SWOT analysis ranks highest as the technique used most extensively in the technology planning process by companies participating in the survey, i.e. 68% of the respondents use this technique (see Figure 6.17A).

The seven highest ranked techniques (e.g. SWOT analysis, brainstorming, etc) are all rudimentary techniques which originate from many of the other disciplines of management. The more sophisticated techniques which could almost be regarded as exclusive to technology management are not extensively used by the participating companies.

The survey findings indicate variations in the usage of the identified techniques by the respondent companies when considering the individual industrial sector segments (see Appendix C). It is interesting to note that the findings show the respondent companies from the chemical segment are the most extensive users of these techniques when considering all the segments (see Figure 6.17B and Appendix C).

Figure 6.17A : Techniques employed in the technology planning process

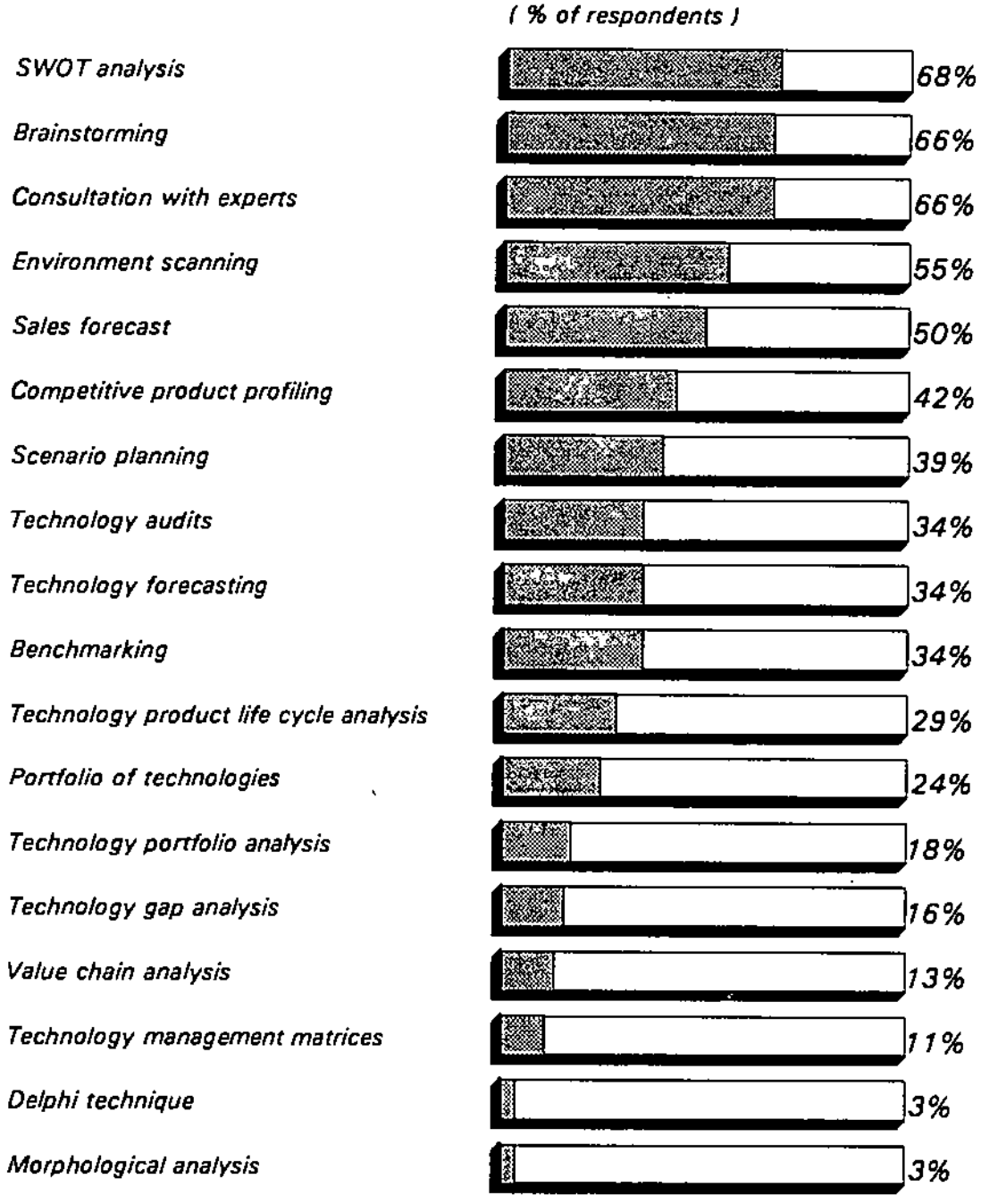
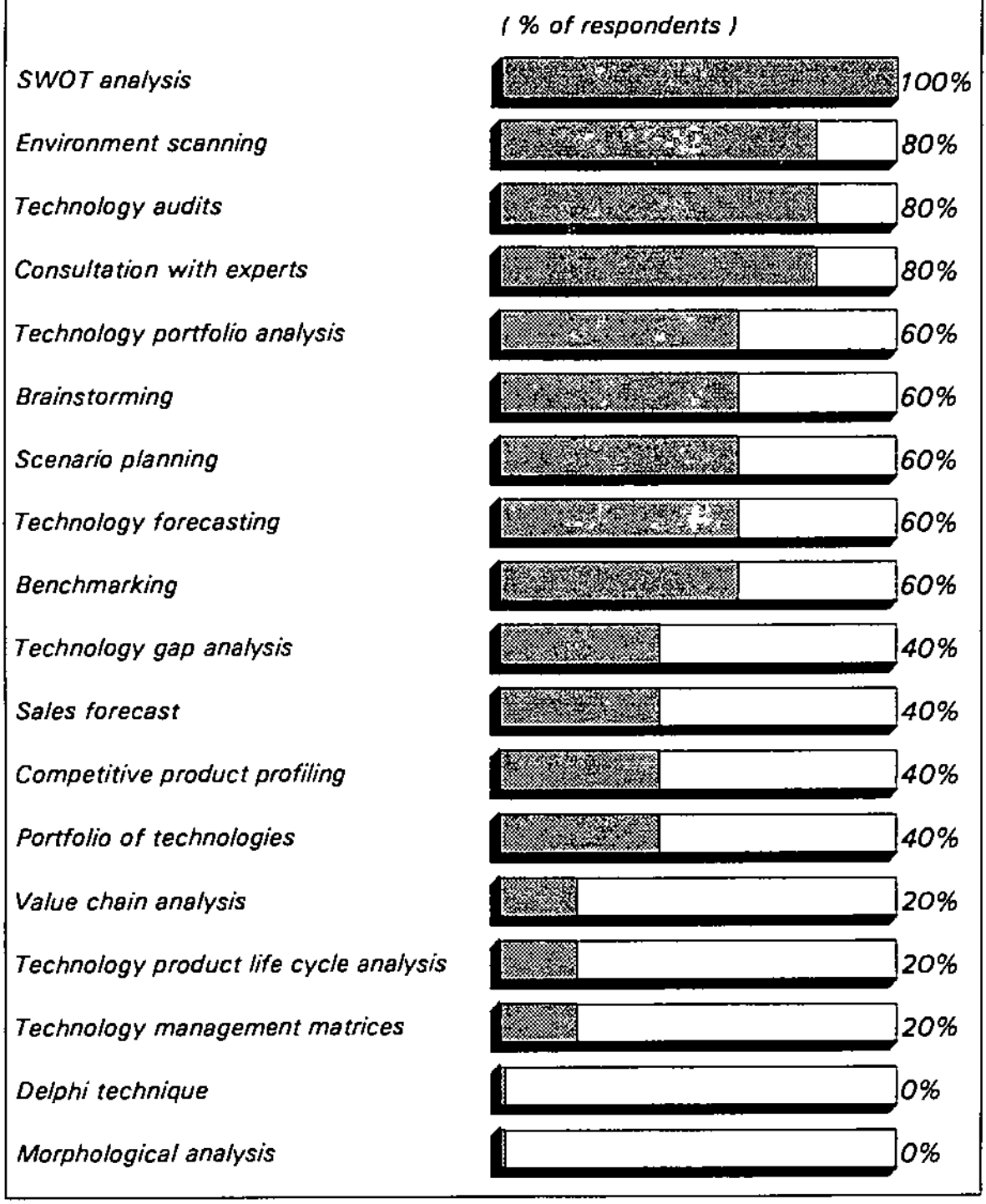


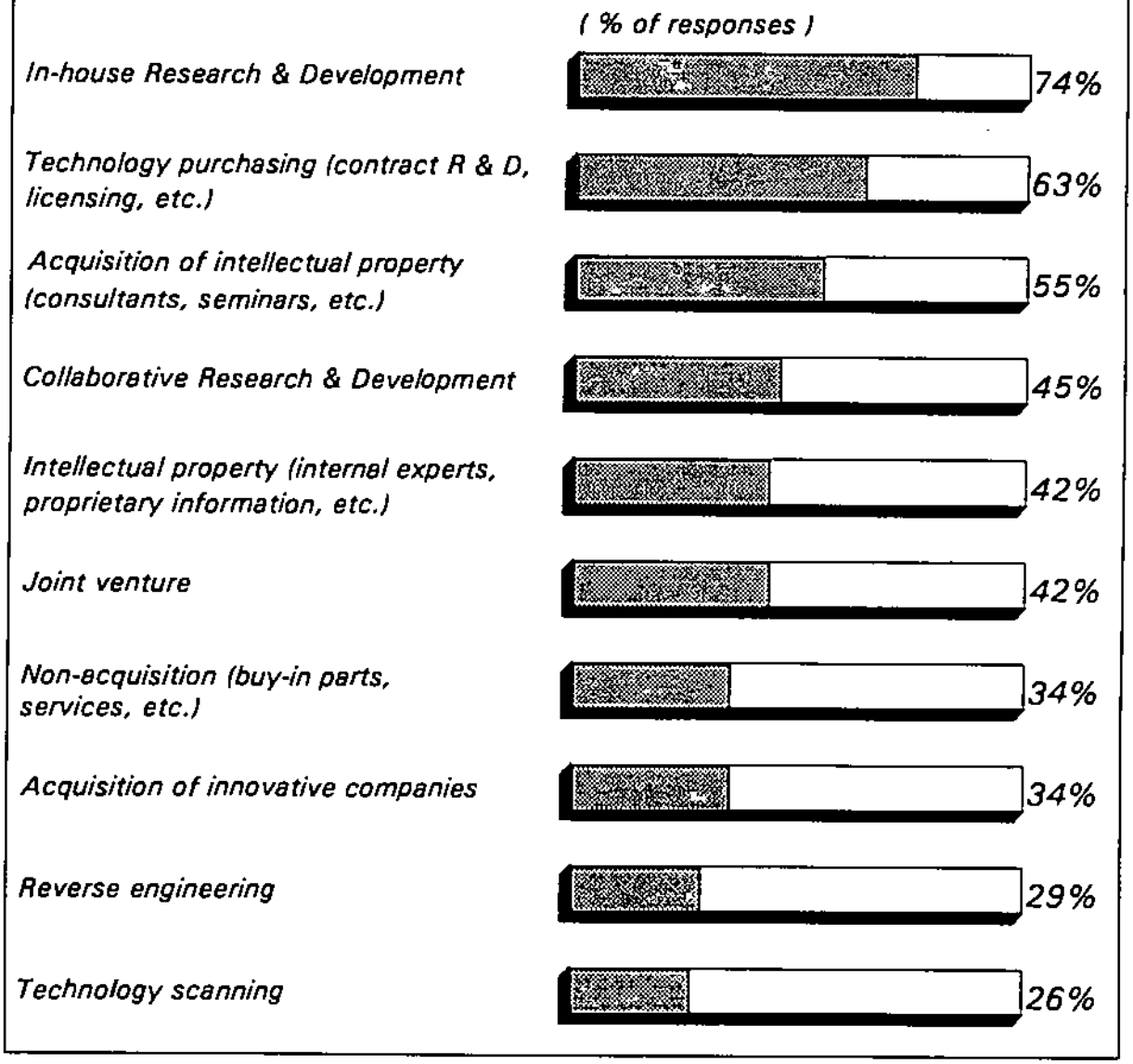
Figure 6.17B : Techniques employed in the technology planning process (Chemical segment)



* **Technology acquisition (Question 21)**

The methods used by the participating companies in the survey for acquiring technology are presented in Figure 6.18. In-house research and development (R & D) was ranked the highest of all the identified methods for acquiring technology. In total 74% of the participating companies in the survey make use of this method.

Figure 6.18 : Technology acquisition methods (All respondents)



The method of technology acquisition which ranked second highest for the participating companies, was technology purchasing. Technology purchasing incorporates such methods as contracting R & D out to external firms, securing license-rights to manufacture certain products, purchasing technical know-how (albeit product or process related), and the like.

6.4 SUMMARY OF FINDINGS

6.4.1 Response rates

A response rate of 28% was achieved in the survey on technology management of the S.A. industrial sector.

The limited responses from certain of the industrial sector segments (in one case only one response was received for the segment) made it difficult to interpret the findings received from the individual segments (the main conclusions therefore relate to the industrial sector as a whole).

6.4.2 Company structure

The majority of companies participating in the survey were diversified holding companies (more than two in three) involved in manufacturing from six segments of the South African industrial sector, namely: chemical, electronics, engineering, pharmaceutical and medical, industrial holding and steel.

6.4.3 Primary operation

Manufacturing is the most important primary operation for most of the companies participating in the survey. The involvement by the participating companies in the identified primary operations varied between the various industrial sector segments. It was also established that very few participating companies (3% of the sample) view R & D as a primary function.

6.4.4 Customer groups

The survey showed the participating companies serve a wide spectrum of customer groups with manufacturers being the most important (i.e. two in three participating companies serve manufacturers).

6.4.5 Company size

Respondent companies varied widely in terms of company size, with the majority of companies having an annual turnover in excess of R11 million and staff complement of more than 500 employees (representing 76% and 95% of the sample respectively).

6.4.6 Mission statement

Approximately seven in ten (68%) of the respondents have a mission statement, whilst only 5% of the respondents refer to technology matters in their mission statement.

6.4.7 Monitoring technology

Although most (more than nine in ten) participating companies monitor and scan technologies outside their own company, many (approximately one in two) do not feel their technology monitoring activity is totally effective. Similar comments apply to long range technology forecasting.

6.4.8 Internal technology audits

Half the participating companies conduct internal technology audits to establish their companies' "baseline" technology capability and very few (seven in ten) feel that this activity is handled effectively.

6.4.9 Consideration given to existing and emerging technologies

Respondent companies rely mainly on their own existing and emerging technologies (inside their company) to improve existing processes and products and to reduce costs.

In the case of developing new products and processes, the preferred technology source is in-house existing technologies, followed by existing technologies from outside the company.

Moderate to minimal consideration is given to technology gap analysis by the participating companies.

6.4.10 Factors considered in planning corporate strategies

The factors considered by the participating companies in planning strategies focus mainly on the business side of the company as opposed to technology related matters. The company's competitive position in the RSA and market growth potential are examples of some of the factors considered by the participating companies which focus on business aspects.

6.4.11 Barriers to integrating technology into the corporate strategic planning process

Separate business unit plans, short-term profit-orientated management perspective and top management's discomfort with technology ranked highest (in this order) as barriers to integrating technology into the corporate strategic planning process; although the participating companies perceive their influence as being minimal to moderate.

6.4.12 Top management's role in the technology process

Singling out and following strategically important projects characterises top management's prime role out of all the identified factors. Top management from approximately one in three participating companies monitor short-term profits, and totally ignore technology.

6.4.13 Means of integrating technology in the planning process

On the whole, participating companies have either not had much success in the past, utilising the identified "approaches" to ensure success in the area of technology management, or alternatively they are not active in this area of management at present. A further reason can be cited that the participating companies may not see a need to integrate technology with the planning process. The five "approaches" which ranked highest, in order of importance, follow:

- top management's commitment to long term results
- more recognition for technical specialists
- training of technical people
- integrating technology with strategy.

6.4.14 Formality of strategic planning process

Almost three-quarters of the participating companies conduct formal and structured planning.

6.4.15 Strategic planning horizon

More than half (57%) of the participating companies use a 2 to 5 year planning horizon, and more than eight in ten use a planning horizon of 5 years or less.

6.4.16 Formal technology plan

Most (63%) of the participating companies do not prepare a technology plan, although many perform the basic activities necessary in preparing a formal technology plan, albeit formally or informally.

This leads one to conclude that technology management and planning is not being considered presently by the majority of participating companies in their planning process, not ignoring the possibility that there may by certain participating companies which deal with technology planning on an informal basis.

6.4.17 Contents of the technology plan and its integration with the strategic plan

The main benefit cited by the participating companies for having a technology plan was that it helps integrate business strategy and plans.

6.4.18 Planning and implementation of technology

The managers of separate business units along with top management (including the CEO/Managing Director) are primarily responsible for contributing to technology planning within the participating companies.

Implementation of technology is the responsibility of the managers of separate business units, technical managers, top

management (in this case, excluding the CEO/Managing Director) and marketing staff.

6.4.19 Analysis of techniques used in the technology planning process

Participating companies use mostly rudimentary techniques such as the SWOT analysis, brainstorming and the like, and not the more sophisticated techniques developed almost exclusively for the purpose of technology management.

6.4.20 Technology acquisition

In-house R & D ranked the highest of all the identified methods for acquiring technology, followed by technology purchasing.

6.5 SUMMARY

A summary of the research findings relating to the survey response rates and the analysis of the questionnaire results for each of the individual questions, is presented in section 6.4.

Technology management in the South African industrial sector will now be discussed in the next chapter, using the research findings reported in this chapter.

Chapter 7

Technology management in the South African industrial sector

CHAPTER 7 : TECHNOLOGY MANAGEMENT IN THE SOUTH AFRICAN INDUSTRIAL SECTOR

7.1 INTRODUCTION

The objectives of this research were conceptualised in chapter 4 in order to provide some structure to the discussions in the report. This chapter will now take the framework developed in chapter 4 and use it to discuss the research findings from chapter 6 and address the research problem areas concerning technology management in the South African industrial sector.

7.2 SUMMARY OF SURVEY PARTICULARS

A total of 38 companies participated in the survey, representing a response rate of 28% for the industrial sector as a whole. Of the participating companies, the vast majority were holding companies (i.e. 69% of all respondents - see Figure 6.1) involved in manufacturing as their primary operation (i.e. 68% of all respondents - see Figure 6.2). They do business with various customer groups (see Figure 6.3) with the major and minor customer groups being that of manufacturers and private consumers respectively. The participating companies came mainly from the industrial holding, chemical, electronic and engineering segments.

A poor response was received from the steel, and pharmaceutical and medical segments, namely a total of one and three responses respectively were received from each of these segments (see

Figure 6.4). The respondent companies varied widely in their size based in terms of the number of employees and annual turnover, with eight of the companies having in excess of 10 000 employees and sixteen companies having annual turnovers in excess of one billion Rand (see Tables 6.3A & 6.3B).

7.3 IMPORTANCE OF TECHNOLOGY

The literature survey confirmed that effective management of a company's technology is vital to its survival as well as its economic well-being and growth. Managers are only now starting to recognise that technology should be used as a competitive weapon and as such form an integral part of the company's planning process (Porter, 1985 ; Frohman, 1982 : 92 - 104). These aspects have been extensively dealt with in chapters 1 and 2.

The intention now is to establish whether certain of the research findings can reveal the orientation and commitment of the participating companies towards technology, and provide evidence of the importance attached to technology.

A total of 68% of the participating companies responded that their company has a mission statement, with only 8% of these companies making reference to technology in their mission statements. In section 6.3 (question 6), a premise was put forward by the researcher that by having technology or technological issues mentioned in the mission statement could be taken to signify the importance which a company places on technology as a key factor

in its success. The findings indicate that only 2 companies out of the total of 38 respondent companies, made mention of technology in their mission statements. If the premise can be accepted, then one should agree that the participating companies involved in this survey do not seem to attach great importance to technology as a key success factor in their planning process.

Supporting this claim are the actual research findings which indicate that most (almost two in three) of the participating companies do not prepare a technology plan. Without a technology plan it is therefore not possible to effectively integrate technology planning with strategic planning.

The respondents were also requested to indicate which factors were considered by their companies in planning corporate strategies for the future (see section 6.3, question 11). The findings indicate an emphasis on factors which relate to the business side of the company as opposed to technology related matters. Factors which involve a technology connection feature lower down in the rankings, confirming that there is a preponderance in focussing on business issues amongst the management of the participating companies when planning corporate strategies for the future.

7.4 ROLE OF TECHNOLOGY

In chapter 4 it was outlined that the role of technology would be discussed under the following four headings:

7.4.1 Top management involvement in the technology process

The extent of top management involvement in the technology process is important in determining the role technology plays in the overall operations of a company. Companies which effectively manage technology ensure top management involvement in technology activities at the earliest stage to strengthen the link between technology and business goals and ensure commitment throughout the organisation. These technology activities may include decision making, planning systems, the timing of decisions, company structure and the like. (Frohman, 1982 : 98 - 104; Gibson, 1986 : 75).

Without the involvement and commitment of the Chief Executive Officer (CEO), it is unlikely that technology change will produce the desired results. The findings show that managers of separate business units along with top management (including the CEO or Managing Director) are primarily responsible for contributing to technology management process within the participating companies. Approximately a quarter of these companies indicated their top management do not contribute to the process, and this figure increases to one in three in the case of the Managing Director/CEO (see Figure 6.16A). These findings are confirmed by Figure 6.11 which shows that the top management from 32% of the participating companies monitor short-term profits and totally ignore technology.

The findings on who contributes towards technology implementation

also shows that two in three participating companies have top management involved in the implementation of technology (see Figure 6.16B).

Significantly, the top management from one in three participating companies monitor short-term profits and totally ignore technology. They appear to favour "focused" reviews in the technology process, with 71% following strategically important technological projects (see Figure 6.11).

For example, the top management roles which received the three highest rankings and confirm the occurrence of "focused" reviews in the technology process, were:

- singling out and following strategically important projects
- reviewing major development programmes above a stated financial threshold
- focusing on projects in trouble.

The findings also show that relatively few (approximately one in three) top-level managers (see Figure 6.12):

- review all R&D programmes early and periodically
- actively participate in the firm's evaluation and management of the R&D programme
- monitor short-term profits at the expense of technology.

The findings on the role of top management in this research are very similar to those obtained in the 1981 Booz-Allen study (see Table 3.1 and Figure 6.11). The only major difference in the findings of the two studies lies in the ranking of the specific top management role described as "reviews all R & D programmes early and periodically"; it ranks lowest in the Booz-Allen study and fourth (out of six) in this research.

It is apparent from the research findings that there is a lack of top management involvement in the technology process within many of the participating companies.

7.4.2 Impact of technology in the planning process

Although many (more than nine out of ten) participating companies scan technologies outside their own companies to identify threats and/or opportunities, and more than eight in ten respondents indicated that their companies make long-range technology forecasts of the potential impact of emerging technologies on the company, most (more than four in ten) do not feel technology scanning is effective, and almost seven in ten do not feel that long-range technology forecasting is especially effective. Similar findings were obtained regarding the conducting of internal technology audits within companies to establish the companies' "baseline" technology capability. In this case, five in ten participating companies conduct internal technology audits, and many (more than seven in ten) do not feel that these audits are especially effective.

Based on the findings pertaining to the factors considered in planning corporate strategies for the future, it appears that the planning process in many of the participating companies are dominated by factors which are related more to the business side of the company as opposed to technology related matters (see Figure 6.9). Of the eleven factors listed, the three most important considerations cited by the participating companies are the "company's competitive position in the RSA", "market growth potential", and "capital requirements". Factors with a technology connection rate much lower down in the rankings.

The Booz-Allen study established that the companies which participated in their survey focus more on factors which contribute to a company's short-term profitability during the planning process. This occurrence could not be conclusively established in this research, since the respondents were not asked to indicate which factors were considered in the corporate planning process for both short- and long-term planning, as was the case in the Booz-Allen study. Thus, no clear-cut conclusions can be made regarding the emphasis placed on short-term profits in the planning process. Notwithstanding the different way in which the question (on factors considered in planning strategies) was framed in the two studies, the findings were quite similar (see Table 3.3 and Figure 6.9).

The overall lack of effective technology scanning, technology forecasting and internal technology auditing, may contribute to the respondent companies' perception that technology has less

impact on the corporate planning process.

7.4.3 Barriers to integrating technology in the planning process

The key barriers or obstacles to integrating technology into the corporate planning process within the participating companies were established as being: separate business plans within the company, followed by top management's short-term profit-orientated perspective, and its discomfort with technology. The findings show that the respondent companies perceive the factors identified in Figure 6.10 acting minimally to moderately as barriers to integrating technology into the corporate strategic planning process.

The findings of this research on the barriers to integrating technology in the planning process did differ from those determined in the Booz-Allen study. The Booz-Allen study established the major barrier to integrating technology into the corporate planning process as being management's short-term profit-orientated perspective. The respondents in the Booz-Allen study cited this factor at least twice as often as any other factor, although (in order to gain some perspective) only 28% of the respondents saw this factor as being a barrier to integrating technology in the planning process.

It is not easy to explain why the findings of the Booz-Allen study clearly indicated that management's short-term profit

orientated perspective is by far the greatest barrier to integrating technology in the planning process, and for this not to be the case in this research. Possible explanations, amongst others, for this variation in the findings may lie with the fact that companies in the USA operate in a more highly competitive environment in which a short-term, profit-orientated perspective is much more prevalent, or alternatively in the fact that the two surveys covered slightly different segments of the industrial sector.

A possible explanation for the participating companies not viewing the identified factors as major barriers to integrating technology in the strategic plan is the fact that only a small percentage of these companies are actively involved in formalised technology planning. The participating companies which do not prepare formal technology plans may have found it difficult to comprehend and identify with these barriers due to their lack of, or limited, experience in the field of technology planning. Another reason for seeing the identified factors as acting as minimal to moderate barriers to integrating technology with strategic planning, is the mere fact that at this point in time the companies may not see the need for technology planning in their company.

7.4.4 Means of enhancing the role of technology

Participating companies were asked to rank a number of "approaches" to enhancing technology success in terms of their relative

contribution to corporate performance.

The findings show that the participating companies in the survey recognise the need for greater top management commitment to long-term results (see Figure 6.12). Most companies believe this factor has the greatest impact, of all factors considered, when it comes to enhancing the role of technology in the planning process. Somewhat less important in enhancing the role of technology are factors such as more recognition for technical people, use of outside technical specialists and training of technical people. Only then do a variety of factors appear in the rankings which are geared to achieving better integration of technology into the planning process, namely:

- integrating technology with business strategy
- tighter coupling of technology and strategic planning
- long range planning for technology.

Theory suggests that the above three factors should play a more prominent role in ensuring the company's performance and success in technology management (see Chapter 2, sections 2.7 and 2.9). Several possible reasons for these factors not featuring so prominently may be:

- lack of success in the past by the participating companies in their previous attempts at employing the identified "approaches" (to ensure success in the area of technology management)

- the participating companies have never been actively involved in technology management in the past, and lack experience in this field

- the participating companies do not see the need to integrate technology with the planning process.

Regarding the latter two reasons put forward above, the research findings support these statements (see section 6.3, question 17 & 18), in that only 37% of the respondent companies prepare a technology plan, and only 34% of all the respondent companies integrate technology planning with their strategic planning process.

The findings also show that all the identified "approaches" contributed minimally to moderately to the company's performance and success in the management of technology, with the exception of the last three "approaches" (out of a total of fifteen factors). Due to the narrow spread in the weighted ratings from the second to the seventh highest ranked factor, one can only conclude that there is very little significance in the rankings in this region; i.e. this covers the range which includes most of the factors geared to achieving better integration of technology into the planning process.

The means of integrating technology in the planning process differ within several industrial sector segments surveyed. The findings show that the pharmaceutical and medical segment is

especially supportive of top management commitment to long-term results and more recognition for technical people (see Appendix C). The emphasis of many of these "approaches" is also significantly higher with the respondent companies in the chemical, electronics and steel segments in comparison to that which is applicable to the overall survey (see Figure 6.12).

In the light of the aforementioned comments regarding the narrow spread in a certain range of the results, the Booz-Allen study and the research findings in this report can be regarded as being very similar (see Table 3.5 and Figure 6.12). Both survey results recognise the need for greater top-management commitment to long-term results and, to a much lesser degree, for more focus on technological issues in the planning process.

7.5 EFFECTIVENESS IN TECHNOLOGY MANAGEMENT

In chapter 4, a model on the integrated technology management process was proposed (see Figure 4.1) for the purpose of being used as a framework for the discussions in this section on how effectively companies within the various industrial sector segments are managing technology.

The premise held was that for any company to be effective in the management of technology, it must at least incorporate the elements described in the proposed Technology Management Model. This follows on the definition of "effectiveness" which was assumed for the purposes of this section of the report to mean "doing the

right things", i.e. the extent in which companies succeed in doing what is prescribed in theory relating to technology management.

As discussed in section 4.3.2, only certain key elements of the proposed model will be dealt with and related to the findings of this research. This is because the research was limited in its scope and the questionnaire was not designed to measure all aspects. For example, the organisational management aspects, (e.g. appropriate culture, structure, management stage and the like) described in the proposed model under heading of policy formulation will not be discussed.

The discussions on how effectively companies are managing technology will commence, firstly, with discussions on the strategic planning process as a whole.

7.5.1 Strategic planning process

A well conceived long-term vision of what is the company's business and what will it be is a normal prerequisite of any successfully managed company. Following on this is the need for clearly defined and achievable corporate objectives and strategies to ensure that these objectives are achieved. These three components need to be in place to ensure effective execution of the strategic planning process. It is highly unlikely that any attempts at technology planning will succeed without a well-executed strategic planning process acting as the cornerstone.

Although it may be possible to successfully manage a company without having a mission statement and a planning process which is formal, it still remains a difficult task to develop a long term vision, corporate objectives and strategies, and such like without resorting to some degree of formality. This is particularly true when companies are highly diversified and large in size, as is the case with the majority of the companies which participated in the research.

Approximately seven in ten of the participating companies have a mission statement and a planning process which is formal and structured. This means that in the order of 30% of the participating companies could be ineffective in their strategic planning process since they either resort to an informal and unstructured strategic planning process or alternatively do nothing in this area.

More than half (57%) of the participating companies use a 2 to 5 year planning horizon, and more than four in five respondents make use of a planning horizon of less than 5 years.

The planning horizon has much to do with the type of industry which is involved. As expected, the participating companies from the electronics segment reflected the highest percentage of companies out of all the industrial sector segments (viz. 44%) using a planning horizon of less than 2 years. Conversely, the highest percentage respondents using a planning horizon of 6 years or greater, came from the chemical and steel segments.

These findings are consistent with what one would expect in that the electronics industry requires a short planning horizon due to the high obsolescence and the short product and technology life cycles, and the chemical and steel industries needs to have a medium- to long-term planning horizon since these are both highly capital intensive industries which must base their planning on reasonably long-term planning horizons.

The strategic planning in certain of the respondent companies could probably be improved by the adoption of a longer planning horizon, say 5 to 10 years. Notwithstanding what was said in the previous paragraph, the respondent companies from the electronics segment could also benefit by extending their planning horizon to take advantage of potential opportunities and reduce potential threats emanating from emerging technologies. Another possible explanation for participating companies from the electronics segment having such a short planning horizon is since almost all these companies are heavily dependent on developed countries for much of their technology requirements and do not see the need to extend their planning horizon. The fact that many of the participating companies are basing their planning on a very short planning horizon must at times lead to opportunities being forgone or threats being overlooked until its too "late". Irrespective of where and how technology is acquired, most companies should benefit by extending their planning horizon.

Participating companies may improve their effectiveness in the strategic planning process by adopting a more formal and struc-

tured planning process and extending their planning horizon in order to take full advantage of potential opportunities and reduce threats emanating from emerging technologies.

7.5.2 Technology situation analysis

The proposed Integrated Technology Management model calls for external technology scanning and internal technology auditing as part of the technology situation assessment process. In addition, the model also requires companies to conduct technology forecasting during the planning process. To be effective in their planning process, companies must ensure that technology situation assessment and technology forecasting is incorporated into the planning process on an ongoing basis.

All three activities have already been extensively discussed in chapter 6 and under section 7.4.2. Both external technology scanning and internal technology auditing are practised widely by the participating companies in the survey, and to a lesser degree, so is internal technology auditing. One can conclude that most of the participating companies in the survey effectively manage technology situation analysis through performing the activities prescribed by the proposed model, but the findings also show that most of the participating companies do not perceive their companies as being especially effective in the execution of these activities.

7.5.3 Technology gap analysis

The technology gap analysis is an essential element in the strategic management of technology, as shown by the proposed Integrated Technology Management model (see Figure 4.1). The purpose of performing the technology situation assessment is to identify the technological opportunities and threats facing the company (technology scanning) and relate these alternatives to the company's strengths and weaknesses (internal technology auditing). Technology forecasting should also form part of this process to ensure the company is aware of all emerging technological opportunities. The above process essentially describes the technology gap analysis process used in identifying technology alternatives which offer potential benefits to the company.

The first stage of the technology gap analysis has been discussed under section 7.5.2, namely: undertaking technology scanning, internal technology auditing, and technology forecasting. As discussed above, most of the participating companies perform these activities, albeit ineffectively. The second stage amounts to a SWOT analysis where all the information gleaned in the first stage is brought together, and the technology alternatives identified. The findings (see section 6.3: question 10) show however that only 16% of the participating companies undertake a technology gap analysis in the planning process, whereas 68% indicated they make use of the SWOT analysis technique. The findings indicating a low usage of technology gap analysis may be ascribed to lack of knowledge of this method on the part of the participating

companies, but the activity could still be performed under the banner of a SWOT analysis. Either way, many companies (at least 3 in 10) do not make use of the technology gap analysis technique in their planning process.

Since the technology gap analysis is an integral part of the technology planning process, no company can be effective in their planning without performing this activity. It follows that many of the participating companies are therefore not very effective in the execution of their planning process, for this very reason.

7.5.4 Techniques used in technology management

The proposed model incorporates various elements or activities which require some form of analytical techniques to effect their execution. For example, technology forecasting, technology situation assessment, technology gap analysis, technology portfolio development and the like, are all activities which require appropriate analytical techniques.

The findings on techniques used in technology management show the seven highest ranked techniques utilised by the participating companies (see Figure 6.17A), as well as many of the other techniques identified in the survey (see section 6.3: question 20), originate from many of the other disciplines of management; e.g. general, strategic and marketing management, to name a few. In recent times these techniques have been incorporated into technology management due to their applicability and usefulness as

management and planning tools. It is surmised that the seven highest ranked techniques were all well known to the vast majority of respondents due to their rudimentary nature. This is in contrast to certain of the other technology management techniques put to the participating companies during the survey which are exclusively associated with technology management. Familiarity with the seven highest ranked techniques by the respondent companies probably accounts for why these (rudimentary) techniques elicited such a high response, compared to the more sophisticated techniques which are exclusive to technology management.

One would expect that a company which has intentions of effectively and successfully managing technology, would use the most up to date techniques; such as technology portfolio analysis, technology gap analysis and technology matrices. Part of the problem may lie with the respondents not understanding certain of the terminology used in the survey, but on reflection it is felt that the reason lay rather with the level of sophistication of the companies' technology management process. The findings seem to confirm that technology on the whole is managed by the participating companies using very rudimentary techniques drawn from the other management disciplines. Lack of knowledge of the more sophisticated techniques probably accounts for the limited use of these techniques.

In general, most of the participating companies in the survey are not effectively utilising the sophisticated technology management techniques which are available today (see Figure 6.17A).

7.5.5 Integration of technology and strategic plans

Porter (1985) and Frohman (1982 : 97 - 104) believe that technology should be used as a competitive weapon and as such form an integral part of the company's overall strategy. Success in this area essentially involves integrating technology planning into the strategic plan. Porter (1985 : 165) also takes the stand that "there is no such thing as a low technology industry", with the need for technology existing throughout the value chain.

The findings show that although approximately seven in ten of the participating companies have a formal planning process, less than four in ten of these companies prepare a formal technology plan and incorporate it into the strategic plan.

The research attempted to establish possible barriers to integrating technology in the corporate strategic planning process. This aspect has been discussed and dealt with extensively under section 7.4.3. The findings show that separate business unit plans, short-term profit orientated management perspective and top managements discomfort with technology were found to be the key barriers, albeit limited in extent.

Interpretation of the findings leads one to conclude that very few of the participating companies are effective in their planning process. One of the factors which supports this statement is that very few of the participating companies ensure technology gets integrated with the planning process.

7.5.6 Technology acquisition

It was discussed under section 2.6.2 that two broad approaches are available to companies seeking to acquire technology, these being, to develop technology in-house (i.e. "make") or to "buy-in" technology from external sources.

The findings on technology acquisition methods show that in-house R & D ranks as the method most widely used by the participating companies for acquiring technology (with approximately three in four companies making use of this means of technology acquisition). Technology purchasing then follows in the rankings as the method most widely used by the participating companies for their technology requirements (with approximately one in three companies using this method).

It is very difficult to interpret these findings if one considers that in-house R&D is apparently the main technology acquisition method used by the participating companies, and relate this to the fact that the participating companies come from the industrial sector whose main focus is manufacturing and which traditionally act as "followers" (i.e. those who do not invest in pacing technologies and rely heavily on "buying-in" their technology requirements from the developed countries), as opposed to being "leaders" (i.e. those who do invest in pacing technologies and rely heavily on in-house R & D), for most of the major new technological developments. The anticipated response was that the participating companies rely primarily on "buying-in" their

technology requirements, or alternatively enter into collaborative agreements.

In seeking an explanation, one must take note that the variation in response by the participating companies for the two aforementioned technology acquisition methods is in the order of 15%. Perhaps it is best not to read too much into in-house R & D being the major source of technology acquisition in the light of this small variation, however it is still surprising to think that in-house R & D ranks so high.

The findings discussed in section 6.3 (question 10) indicate that the participating companies rely mainly on existing technologies, particularly from within the company, when wanting to improve existing processes and products, and to reduce costs. In the case of developing new products and processes, the preferred source of technology is once again, in-house existing technologies, followed by existing technologies from outside the company. Emerging technologies do not feature prominently as a source of technology, and are given the least consideration when it comes to making decisions regarding sourcing technologies. By far the most consideration is given to existing technologies from within the company, particularly relating to improving existing processes and products, and to reducing costs.

These findings therefore shed some light on where the participating companies are focusing their in-house R & D. It may therefore be concluded that the participating companies utilise their in-

house R & D efforts (focused in the field of applied research and engineering) primarily to sustain their existing products and processes, and to a lesser extent, developing new products and processes. The remainder of their technology requirements must therefore be acquired via some other means of technology acquisition as illustrated by Figure 6.18, with technology purchasing (i.e. contract R & D, licensing, and the like) being the most widely used method of "buying-in" technology.

The fact that South Africa is a developing or less developed country (LDC) in terms of the development of technologies, suggests that one should expect the participating companies to buy-in a good deal of their technology requirements. This is consistent with what one would normally expect, since most of the pacing technologies of importance (see section 2.3.3), in both the product and process areas, will more than likely emanate from developed countries due to high development costs, the technology infrastructure required and the like.

Bearing in mind what was said above regarding the participating companies focusing a major part of their technology acquisition efforts on in-house R & D to sustain existing products and processes, leads one to conclude that the planning effort of many of these companies may suffer the problem of (inwardly) focusing too much on technologies from within the company, and with not enough emphasis being placed on technologies outside the company. Loss of technological opportunities and being prey to technological threats may indeed be the order of the day amongst many of the

participating companies, due to placing too much emphasis on internal technology sourcing.

Although many of the participating companies are utilising the various technology acquisition methods available to them, it felt more progress in this area of technology management can be made. Success in this area is much dependent on the manner in which technology and the planning process is dealt with by the company. A structured approach along the lines of the proposed integrated technology management model is required (see Figure 4.1). Once potential opportunities have been identified and received the support of top management, optimum technology solutions, albeit product or process related, must be found. Companies should pay careful attention to the technology acquisition stage of the process and ensure that the most appropriate method of sourcing technology is implemented. Decisions on which means of technology acquisition is selected should be based on rational thinking utilising techniques such cost-benefit analysis, and the like.

Since very few of the participating companies are effectively managing technology in terms of performing all the activities prescribed in the proposed model (see Figure 4.1), it follows that very few companies are likely to be working through the right steps in selecting how to acquire their technology. Accepting this as being the case, leads one to conclude that the participating companies are therefore not effectively managing their technology acquisition.

7.6 SUMMARY

The main focus of this chapter was to discuss two aspects, namely that of the role of technology in corporate operations and how effectively companies are planning for technological change and managing technology. The discussions were based extensively on the research findings obtained from a mail survey, with the sample coming from JSE listed companies in the South African industrial sector.

The next chapter deals with the research conclusions and recommendations. The shortcomings in this research, as well as recommendations regarding topics for future research, are also dealt with in chapter 8.

Chapter 8

Conclusions and recommendations

CHAPTER 8 : CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

The research undertaken to establish the role of technology in corporate operations and how effectively companies within the South African industrial sector are managing technology, was based on exploratory research. An extensive literature survey on aspects related to technology management was undertaken, followed by a mail survey dealing with technology management issues. The conclusions presented below are dealt with under much the same headings used for the discussions in chapter 7.

8.2 SURVEY RESPONSES

A response rate of 28% was recorded for the mail survey of the industrial sector as a whole, representing 56,1% of the total annual turnover of the sample frame, i.e. JSE listed companies from the identified industrial sector segments.

As discussed in section 5.7.4, the research methodology did not ensure external validity of the research findings and are therefore not representative of total South African industrial sector. However, since this was an exploratory study seeking insight into the process of technology management, the achieved sample was considered adequate for the purposes of this research.

Limited responses were received from the pharmaceutical and

medical, and steel industrial segments, however the actual response rate from these segments was much the same as was the case for the industrial sector as a whole (due to the limited number of JSE listed companies from these segments).

8.3 IMPORTANCE OF TECHNOLOGY

The following conclusions can be drawn from the findings of the literature survey relating to the importance of technology:

- effective technology management is vital to a company's survival as well as its economic well-being and growth
- competitive advantages can be derived through the introduction of new technology
- managers are starting to recognise that technology should be used as a competitive weapon and as such form an integral part of a company's planning process
- technology, albeit in low- or high-tech industries, pervades throughout the value chain and is associated with both products and processes
- no company is immune to technological changes and from the impact of technology.

Most of the participating companies do not mention technology or technological issues in their mission statement and one may interpret this as meaning the participating companies are not attaching much significance to technology being one of the key

success factors in their planning process.

8.4 ROLE OF TECHNOLOGY

The analysis of the research findings on the role of technology in corporate operations within certain segments of the South African industrial sector led to the following conclusions:

8.4.1 Top management involvement in the technology process

There is a lack of top management involvement in the technology process within many of the participating companies. Significantly, the top management from one in three participating companies monitor short-term profits and totally ignore technology, while 71% follow strategically important technological projects. In contrast, theory calls for the active involvement and support of top management to ensure effective technology management.

8.4.2 Impact of technology in the planning process

Although many participating companies scan the technology horizon, and make long-range technology forecasts, most do not feel they are especially effective in performing these activities. Similar findings were obtained regarding the internal technology audit activity, excepting that in this case fewer participating companies perform this activity.

This overall lack of effective technology-scanning, technology

forecasting and internal technology auditing (as perceived by the participating companies themselves) may explain why the participating companies rate technology as having little impact on the corporate planning process.

The corporate planning process of many participating companies is dominated by focusing on factors related more to the business issues of the company, as opposed to technology related matters. Factors with a technology connection are given much less consideration.

8.4.3 Barriers to integrating technology in the planning process

Separate business plans within the company is viewed as the major obstacle to the successful development of technology by the participating companies. The next two key barriers to integrating technology into the planning process (in priority order) were established as being:

- top management's short-term profit orientated perspective
- top management's discomfort with technology.

The factors presented above, amongst others, were perceived as acting minimally to moderately as barriers to integrating technology into the corporate planning process. Possible reasons for the perceptions that the identified barriers do not present a

major problem to the companies in their planning process may be the fact that only a small percentage are actively involved in formalised technology planning and lack insight into this field, as well as most of the companies at this point in time may not see the need for technology planning within their company.

8.4.4 Means of enhancing the role of technology

Many participating companies recognise that top management commitment to long-term results has contributed most to their company's technology success in terms of contributing to corporate performance. It is also seen as having provided the greatest impact, of all factors considered, when it comes to enhancing the role of technology in the planning process.

Factors geared to achieving better integration of technology into the planning process, as called for in theory, did not feature prominently in the findings as "approaches" used by the participating companies to ensure success in technology planning. The factors in question are:

- integrating technology with strategy
- tighter coupling of technology and strategic planning
- long range planning for technology.

Several possible reasons for these factors not featuring prominently in the participating companies planning process may be:

- lack of success in their previous endeavours to introduce these "approaches"
- never been actively involved in technology management in the past and lack experience in the field
- do not see a need to integrate technology with the planning process.

8.5 EFFECTIVENESS IN TECHNOLOGY MANAGEMENT

The conclusions arrived at after analysing the research findings to determine how effectively companies within the various industrial sector segments are managing technology, follow:

8.5.1 Strategic planning process

Many (three in ten) participating companies either resort to an informal and unstructured strategic planning process or alternatively do not practice strategic planning. This confirms the likelihood that ineffective strategic planning is being practised in many of the companies.

More than half (57%) of the participating companies use a 2 to 5 year planning horizon and more than four in five make use of a planning horizon of less than five years. Strategic planning within these companies could probably benefit by adopting a longer planning horizon to take full advantage of the potential opportunities and reduce the threats emanating from emerging

technologies.

Many participating companies may benefit and improve their effectiveness in the strategic planning process by adopting a more formal and structured planning process and extending their planning horizon.

8.5.2 Technology situation analysis (assessment)

Most participating companies effectively manage technology situation analysis from the point of view that they perform the activities prescribed in the proposed model, but most of them also perceive that they are not especially effective in its execution. The explanation for this situation probably has much to do with the participating companies not having sufficient knowledge of the techniques currently available to perform this activity.

8.5.3 Technology gap analysis

Although most participating companies perform the technology situation analysis activities which proceeds the technology gap analysis, many companies do not perform a technology gap analysis during the planning process, resulting in they not being effective in the execution of the technology planning process.

8.5.4 Techniques used in technology management

Many (between 68% to 39% of the respondents, depending on the

technique considered) participating companies make use of the more rudimentary and well-known techniques (e.g. SWOT analysis, brainstorming, etc.) originating from other management disciplines for use in their technology management process and make little use of the more sophisticated techniques which have been exclusively developed for technology management. Lack of knowledge of the more sophisticated techniques probably accounts for the limited use of these techniques.

On the whole, the participating companies are not effectively utilising the currently available technology management techniques.

8.5.5 Integration of technology and strategic plans

Although many (more than seven in ten) of the participating companies have a formal planning process, very few (less than four in ten) prepare a formal technology plan and incorporate it with the strategic planning process.

The planning process of the participating companies is not very effective at present due to the limited number of companies (approximately one in three) which ensure their technology considerations are integrated with the planning process.

8.5.6 Technology acquisition

In-house R & D ranks as the most widely used method of acquiring

technology by the participating companies (approximately three in four companies use this method), followed by technology purchasing (approximately two in three companies use this method). The main focus of in-house R & D efforts is to support and sustain the existing products and processes.

Participating companies rely primarily on their own existing technologies to improve existing products and processes, and to reduce costs, as well as to develop new products and processes.

Existing technologies from outside the company, and emerging technologies (both inside and outside the company), in this priority order, are also used as sources of technology, but to a lesser extent.

8.5.7 Summary of effectiveness in technology management

Analysis of the research findings leads one to conclude that many of the participating companies from the South African industrial sector could improve their effectiveness in managing technology, especially regarding the link between technology and corporate strategic planning and the techniques being used to manage technology.

8.6 RECOMMENDATIONS

Many of the participating companies, as well as other S.A. industrial sector companies and industries not included in the re-

search, could benefit by and improve their effectiveness in technology management through the adoption of some of the following recommendations:

Firstly, companies must adopt a more formal and structured planning process, and consider (within reason) extending their strategic planning horizon.

Secondly, regarding the integration of technology and the strategic planning process, the following must happen:

- technology management must be viewed from a corporate perspective
- all technological issues must be integrated with corporate strategic planning following a similar process to that presented in the model proposed in chapter 4 (see Figure 4.1).

Thirdly, companies need to become conversant and adept at using the more sophisticated technology management techniques that are available.

Fourthly, top management must become actively involved and overtly support the technology management process.

8.7 SHORTCOMINGS IN THE RESEARCH

In order to enlighten the reader of the report and put the re-

search in perspective, several shortcomings in the research are presented below:

- Discussions on the role of technology in corporate operations were limited to discussing four main areas. Broadening the scope of the research to include certain other aspects, such as, technology funding, technology transfer, technology commercialisation and the like, would have provided a better and more holistic view of the role of technology.

- The question concerning "factors considered in planning corporate strategies" should have been posed in such a way as to establish how important these factors are to the short- and long- term planning processes (see section 7.4.2).

- The research was limited in its scope from the point of view that not all the elements or activities presented in the proposed model (see Figure 4.1) on integrated technology management were touched on in discussing the effectiveness of participating companies in managing technology.

- Although the findings dealt with both the individual industrial sector segments and the industrial sector as a whole, the main discussions and conclusions focused almost exclusively on the industrial sector as a whole.

- A more sensitive measuring instrument, than the four point scale used for many of the questions in this research, was required.

8.8 RECOMMENDATIONS FOR FURTHER RESEARCH

In performing this research it became clear that there were certain areas that needed further research to substantiate what had been done in this report, but also to take this research one step further. Some of these areas are mentioned below:

A more in depth study is required into the role of technology in corporate operations within the South African industrial sector in order to ascertain what influence other factors such as technology funding, technology transfer, technology commercialisation and the like, have on the technology management process. Future research can also verify the external validity of the findings of this research.

Another area for further research involves testing and validating the model proposed in chapter 4 on the integrated technology management process. Most of the models studied during the course of this research, focused more on technology planning and none seemed to include all the activities of technology management. The effectiveness of companies, from the South African industrial sector, in managing all the activities of technology management as presented in the model in chapter 4 (see Figure 4.1), also needs to be established.

Finally, there is a school of thought, supported by such people as Porter (1985 : 165), who believe that "there is no such thing as a low technology industry" and state that technology pervades throughout the value chain, albeit low- or high-tech industries. The researcher therefore feels that a worthwhile research topic would be to establish the validity of the above statements concerning the relevance of technology, irrespective of the industry involved, and also relate it to the South African industrial sector.

The importance of this research would come from proving the validity of such aforementioned statements and providing irrefutable evidence to companies, particularly in the South African industrial sector, on the benefits of becoming more effective in their management of technology.

REFERENCES

REFERENCES

Bayraktar, B.A. 1990. On the concept of Technology and Management of Technology. In: Management of technology II. Proceedings of the Second International Conference on Management of Technology; edited by Tarek M. Khalil and Bulent A. Bayraktar, Industrial Engineering Management Press, Institute of Industrial Engineers Norcross, 6a, 1990, p. 1167.

Betz, F. 1987. Managing Technology. New York : Prentice-Hall, p. xvii.

Booz-Allen & Hamilton Inc. 1981. Technology Management Survey Results. New York.

Booz-Allen & Hamilton Inc. 1984. Management and Technology - A survey of European Chief Executives. London : Pauline George Processing and Philip Dunster Designs.

Brews, Peter. 1988. South Africa. Hi-Technology and the future: Affordable imperative or fantastic folly. Business Alert, Wits Business School, vol. 98, p. 1 - 13.

Brownlie, Douglas T. 1987. The strategic management of technology: A new wave of market-led pragmatism or a return to product orientation? European Journal of Marketing (UK), vol. 21, no. 9, p. 45 - 65.

Collier, Donald W. 1985. Linking business and technology strategy. Planning Review, vol. 13, p. 28 - 34.

Cory, Joseph P. 1989. Strategic planning process and technology management. International journal of technology management, vol. 4, no. 6, p. 613 - 624.

Erickson, Tamara J.; Magee, John F.; Roussel, Philip A. & Saad, Kamal N. 1991. Managing Technology as a Business Strategy. IEEE Engineering Management Review, vol. 19, no. 1, p. 34 - 38.

Ford, Dawid. 1988. Develop your technology strategy. Long Range Planning, vol. 21, no. 5, p. 85 - 95.

Frohman, Alan L. 1982. Technology as a competitive weapon. Harvard Business Review, Jan - Feb, p. 97 - 104.

Gibson, W. Dawid. 1986. A maze for management : choosing the right technology. Chemical Week, vol. 138, p. 74 - 78.

Gove, Philip Babcock. 1971. Webster's third new international dictionary of the English language. Springfield : Mass G. & Merrian G., p. 2348.

Harris, J.; Shaw, R. & Sommers, W. 1983. The strategic management of Technology, Planning Review, vol. 11, no. 1, p. 28 - 35.

Haywood, K. Michael. 1990. A strategic approach to managing technology. The Cornell Hotel and Restaurant Administration Quarterly, vol. 31, p. 39 - 45.

Joubert, D. 1992. Technology : major impact on South African skills market. HRM, vol. 8, no. 2, p.5.

Klein, Jeremy A. 1991. Why strategists shun technologists. Technology Analysis & Strategic Management, vol. 3, no. 3, p. 251 - 256.

Lauglaug, Antonia S. 1987. A framework for the strategic management of future tyre technology. Long Range Planning (UK), vol. 20, no. 5, p. 54 - 60.

Leedy, Paul D. 1989. Practical research. 4th edition. New York: Macmillan.

Levine, Susan J. & Yalowitz, Michael S. 1983. Managing technology: The key to successful business growth. Management Review, vol. 72, p. 44 - 48.

Magee, John F. 1982. Assessing a company's technological programme. Financial Analysts Journal, vol. 38, Jul - Aug, p. 56 - 59.

Manahan, Michael P. 1989. Technology acquisition and research prioritisation. International Journal of Technology Management, vol. 4, no. 1, p. 9 - 19.

McGee, John & Thomas, Howard. 1989. Technology and strategic management progress and future directions. R & D Management (UK), vol. 19, no. 3, p. 205 - 213.

McGregor, Robin. 1992. McGregor's Who Owns Whom, 12th edition. Juta & Co, Ltd.

Miller, J.S. 1988. New Technologies - Their effect on motivation and attitudes. FWP Journal, Oct, p.23.

Monger, Rod F. 1988. Mastering Technology - A management framework for getting results. New York : The Free Press.

Nel, P.A.; Rädel, F.E. & Loubser, M. 1988. Researching the South African Market. Pretoria: University of South Africa. p. 187.

Pappas, C. 1984. Strategic Management of technology. Journal of Product Innovation Management, no. 1, p. 30 - 35.

Pavitt, K. 1990. What we know about the strategic management of technology. California Management Review, Spring, vol. 32, no. 3, p. 17 - 26.

Porter, M. 1985. Competitive Advantage : Creating and sustaining superior performance. New York : The Free Press.

Ramanathan, K. 1990. management of technology : Issues of management skill and effectiveness. International Journal of Technology Management, vol. 5, no. 4, p. 409 - 422.

Sethi, Narendra K. & Movsesian, Bert & Hickey, Kirk D. 1985. Can technology be managed strategically? Long range planning, vol. 18, no. 4, p. 89 - 99.

Sherman, Philip. 1981. Strategic planning for technology industries. New York : Addison - Wesley Publishing Company.

Steele, Lowell W. 1989. Managing Technology - The strategic view. New York : McGraw - Hill Book Company.

Task Group on the Management of Technology. 1987. Management of Technology : The hidden competitive advantage, Washington, D.C. : National Academy Press.

Thompson, A.A. Jr. & Strickland, A.J. III. 1987. Strategic management concepts and cases. 4th edition. Plano, Texas : Business Publications Inc.

Twiss, Brian C. & Gooderidge, Mark. 1989. Managing technology for competitive advantage. London: Pitman.

Van Wyk, R.J. 1990. The Technology Manager - tasks and training. In : Management of technology II. Proceedings of the Second International Conference on Management of Technology; edited by Tarek M. Khalil ad Balent A. Bayraktar, Industrial Engineering Management Press, Institute of Industrial Engineers Norcoss, Ga, 1990, p. 1167.

Wills, J.H. 1991. Technology management in the South African electronics industry. MBL Research Report, Unisa, Pretoria.

FURTHER READINGS

FURTHER READINGS

Ansoff, H. Igor. 1987. Strategic Management of technology. Journal of business strategy, vol. 7, p. 28 - 29.

De Meyer, Arroud. 1988. The way forward in the strategic management of technology. R & D Management (UK), vol. 18, no. 2, p. 107 - 109.

Englert, Robert D. 1991. Strategic R & D Planning. Engineering Management Review, vol. 19, no. 2, p. 42 - 53.

First International Forum on Technology Management - proceedings of First IFTM conference July 17th - 19th 1989; edited M.A. Dorgham, Inderscience Enterprises Ltd.

Flores, Benito & Whybark, D. Clay. 1989. The strategic management of manufacturing technology. Engineering costs & Production Economics (Netherlands), vol. 17, no. 1 - 4, p. 293 - 304.

Forrest, Janet E. 1990. Strategic alliances and small technology-based firm. JSBM Journal of Small Business Management, vol. 28, no. 3, p. 37 - 45.

Frohman, Alan L. 1985. Putting technology into strategic planning. California management review, vol. 27, p. 48 - 59.

Fusveld, Alan R. 1989. Formulating technology strategies to meet the global challenges of the 1990's. International journal of technology management, vol. 4, no. 6, p. 601 - 612.

Gluck, I.F.W.; Kaufman, P. & Walleck, A.S. 1980. Strategic management for competitive advantage. Harvard Business Review, Jul-Aug, p. 154 - 161.

Khalil, T.M. & Bayraktar, B.A. 1988. Challenges and opportunities

for research in management of technology. In: Report of the Workshop sponsored by the National Science Foundation and the University of Miami, 1988, p. 3.

Lor, P.J., University of South Africa, Department of Library and Information Science, [s.a.] Library science : Study guide for BIB302-G. Pretoria

Manahan, M.P.; Ashton, W.B. & Stacey, G.S. 1989. Who's on watch? (How do US manufacturers select new technologies?). Manufacturing Engineering, vol. 102, p. 54 - 57.

Messina, Andrew. 1989. Technology Management for the 1990's. Manufacturing Engineering, vol. 102, p. 49 - 51.

Mitchell, Graham R. 1988. Options for the Strategic Management of Technology. International Journal of Technology Management (Switzerland), vol. 3, no. 3, p. 253 - 262.

Mouton, Johann & Marais H.C. 1988. Basic concepts in the methodology of social sciences. Pretoria: Human Sciences Research Council.

Nevens, T.M., Summe, G.L. & Uttal, B. 1990. Commercialising technology : What the best companies do. Harvard Business Review, May - June, p. 154 - 163.

Olesen, Douglas E. 1990. Six keys to commercialisation. The Journal of Business Strategy, vol. 11, no. 6, p. 43 - 47.

Perrino, Albert C. & Tipping James W. 1989. Global Management of technology. Research technology management, vol. 32, p. 12 - 19.

Perrino, Albert C. & Tipping, James W. 1991. Global management of technology : A study of 16 multinationals in the USA, Europe and Japan. Technology Analysis & Strategic Management, vol. 3, no. 1, p. 87 - 98.

Petrani, G. 1985. Who should plan technological innovation? Long Range Planning, vol. 18, no. 5, p. 108 - 115.

Porter, M. 1990. The competitive advantage of nations. Harvard Business Review, Mar - Apr, p. 73 - 93.

Quinn, J. 1985. How companies keep abreast of technological change. Long Range Planning, vol. 18, no. 2, p. 69 - 76.

Replogle, Douglas L. 1988. Guidelines for a product technology strategy. Planning Review, vol. 16, p. 12 - 18.

Rubenstein, Albert H. 1989. Managing Technology in the decentralised firm. New York : John Wiley & Sons.

Stacey, Gary S. & Ashton, W. Bradford. 1990. A structural approach to corporate technology strategy. International Journal of Technology Management (Switzerland), vol. 5, no. 4, p. 389 - 407.

Staley, Jeffrey L. 1990. Getting more from investments in technology trough technology asset planning. International Journal of Technology Management, vol. 5, no. 6, p. 627 - 638.

Szakanyi, Robert. 1990. Coordinating R & D and business planning. Technology Analysis & Strategic Management, vol. 2, no. 4, p. 391 - 411.

Twiss, Brian C. & Jones, H. 1978. Forecasting technology for planning decisions. London : Macmillan.

Twiss, Brian C. & Jones, H. 1978. Managing technology for competitive advantage. London : Pitman.

University of South Africa, Department of Library and Information Science, [s.a.]. Library Science : study guide for BIB302-G. Pretoria.

Van Gunsteren, L. 1987. Planning for technology as a corporate resource: a strategic classification. Long Range Planning, vol. 20, no. 2, p. 51 - 60.

Van Wyk, Rias J. 1988. Management of Technology : New Frameworks. Technovation, vol. 7, no. 4, p. 341 - 351.

Blind spot in strategic planning? 1984. Management review, vol. 73, p. 26 - 28.

APPENDICES

Appendix A.1

Covering letter (1st mailing)

P.O. Box 914-744
WINGATE PARK
0153
11 September 1992

Dear Sir

Technology is considered by many as potentially the single most important source for successful long-term competitiveness in business today.

I am presently researching the field of technology management within the industrial sectors of the South African economy as part of my Masters Degree in Business Leadership. My promoter is Mr A. Ferreira of the School of Business Leadership at UNISA (see attached letter).

It will be highly appreciated if you would be so kind as to complete the questionnaire which should not take more than 20 to 30 minutes of your time, and return it in the enclosed envelope.

Absolute confidentiality is guaranteed. All reported findings emanating from this research will refer to the industrial sectors as a whole, with no specific reference being made to individual companies. A summary of my research findings will be forwarded to all respondents who desire a copy.

If necessary, I may be contacted at the following telephone numbers:

- (012) 3453015 after hours
- (012) 8425842 during office hours.

Thank you for your co-operation.

Yours sincerely

BRYAN BALLANTYNE

Appendix A.2

Covering letter (2nd mailing)

P.O. Box 914-744
WINGATE PARK
0153
15 October 1992

Dear Sir

All of us are busier these days than we should be, and most of us have a hard time keeping abreast of those obligations which are essential and required. We know how the little extras sometimes receive our best intentions, but we also know that in reality none of us have the time which we would desire to fulfill those intentions.

From the questionnaire which reached you -- I hope -- about four weeks ago, I have had no reply. Perhaps you mislaid the questionnaire, or it may have miscarried in the mail -- any one of dozens of contingencies could have happened.

In any event, I am enclosing another copy of the questionnaire. I am sure you will try to find 20 to 30 minutes somewhere in your busy schedule to complete the questionnaire and drop it in the nearest postal box. A good deal of the questionnaires have been returned. I'd like to get them all back. Will you please help?

Thanks, I shall appreciate your assistance.

Yours sincerely,

BRYAN BALLANTYNE

(the above reminder letter that went out with the 2nd mailing was adapted from an example that appeared in Leedy, 1989 : 147)

Appendix A.3

Covering letter (SBL)

SBL
GRADUATE SCHOOL OF BUSINESS LEADERSHIP
NAGRAADSE SKOOL VIR BEDRYFSLEIDING

UNIVERSITY OF SOUTH AFRICA
UNIVERSITEIT VAN SUID-AFRIKA

Graduate School of
Business Leadership
Cor. Visagie & Prinsloo Street
P.O. Box 392 Pretoria 0001
South Africa
Tel. (012) 322 6777
TTX. 35 0068
Fax. (012) 320 0421

Nagraadse Skool vir
Bedryfsleiding
H/v Visagie- & Prinsloostraat
Posbus 392 Pretoria 0001
Suid-Afrika
Tel. (012) 322 6777
TTX. 35 0068
Faks. (012) 320 0421

1992-09-09

TO WHOM IT MAY CONCERN

Mr BJ Ballantyne (student number 419-079-3) is a fourth year student of the Master of Business Leadership degree with the Graduate School of Business Leadership, Unisa. As part of the study programme he has to do independent research on an approved topic and submit a research report.

We would appreciate your assistance in this regard.

Yours sincerely

MA FERREIRA
for DIRECTOR: SBL

Appendix A.4

Questionnaire

QUESTIONNAIRE ON TECHNOLOGY MANAGEMENT

Please answer the following questions by ticking the appropriate boxes and by writing in the space provided, or by following the instructions. Where a question has multiple answers, please tick wherever relevant.

1. HOW IS YOUR COMPANY STRUCTURED? (TICK BOX)

- Holding company ☐
- Independent company ☐
- Subsidiary company ☐

If you operate as a holding company, please answer the questionaire at this level.

2. WHAT ARE THE PRIMARY OPERATIONS OF YOUR COMPANY? (TICK BOXES)

- Manufacturing ☐
- Refurbishing/Maintenance ☐
- Contracting ☐
- Consulting ☐
- Wholesaling/Retailing ☐
- Research/Development ☐
- Other, please specify _____

3. WHICH ARE YOUR MAJOR CUSTOMER GROUPS? (TICK BOXES)

- Private consumers (householder) ☐
- Manufacturers ☐
- Wholesalers & Retailers ☐
- Construction ☐
- Mining ☐
- Electricity ☐
- Transportation ☐
- Government, Provincial & Municipal ☐
- Military ☐
- Other, please specify _____

4. IN WHICH INDUSTRIAL SECTORS OF THE SOUTH AFRICAN ECONOMY DOES YOUR COMPANY OPERATE? (TICK BOXES)

- Chemical..... ☐
- Engineering..... ☐
- Industrial Holding..... ☐
- Pharmaceutical & Medical..... ☐
- Steel..... ☐
- Other, please specify_____

5. WHAT IS THE APPROXIMATE SIZE OF YOUR COMPANY IN TERMS OF:

- Approx. total number of employees..... ☐☐☐☐☐☐☐
- Approx. total annual turnover (Rands)..... ☐☐☐☐☐☐☐☐☐☐☐

6. DOES YOUR COMPANY HAVE A MISSION STATEMENT?

(TICK BOX)

Yes	No

If yes, please write it below, or attach a copy.

_____

_____

_____

_____

_____

_____

7 (a). DURING THE PLANNING PROCESS, DOES YOUR COMPANY SCAN TECHNOLOGIES BEING DEVELOPED OR APPLIED OUTSIDE YOUR COMPANY TO IDENTIFY THREATS AND/OR OPPORTUNITIES?

(TICK BOX)

Yes	No

7 (b). HOW EFFECTIVE DO YOU FEEL YOUR COMPANY IS IN CARRYING OUT THIS FUNCTION?

(TICK BOX)

- Extremely effective..... ☐
- Very effective..... ☐
- Somewhat effective..... ☐
- Not at all effective..... ☐

8 (a). DURING THE PLANNING PROCESS, DOES YOUR COMPANY MAKE LONG-RANGE FORECASTS OF THE POTENTIAL IMPACT OF EMERGING TECHNOLOGIES ON YOUR COMPANY?

(TICK BOX)

Yes	No

8 (b). HOW EFFECTIVE DO YOU FEEL YOUR COMPANY IS IN CARRYING OUT THIS FUNCTION?

(TICK BOX)

- Extremely effective..... ☐
- Very effective..... ☐
- Somewhat effective..... ☐
- Not at all effective..... ☐

9 (a). DURING THE PLANNING PROCESS, DOES YOUR COMPANY CONDUCT INTERNAL TECHNOLOGY AUDITS TO ESTABLISH THE COMPANY'S "BASELINE" TECHNOLOGY CAPABILITY?

(TICK BOX)

Yes	No

9 (b). HOW EFFECTIVE DO YOU FEEL YOUR COMPANY IS IN CARRYING OUT THIS FUNCTION?

(TICK BOX)

- Extremely effective..... ☐
- Very effective..... ☐
- Somewhat effective..... ☐
- Not at all effective..... ☐

10. HOW MUCH CONSIDERATION DOES YOUR COMPANY'S PLANNING PROCESS GIVE TO EXISTING AND EMERGING TECHNOLOGIES AVAILABLE BOTH INSIDE AND OUTSIDE YOUR COMPANY FOR THE APPLICATIONS LISTED BELOW?

4 = Extensive consideration
3 = Moderate consideration
2 = Minimal consideration
1 = No consideration

(Please indicate your answer by writing a number from "1" to "4" on each line under each column).

	EXISTING TECHNOLOGIES		**EMERGING** TECHNOLOGIES	
	Inside Company	Outside Company	Inside Company	Outside Company
Improving existing products.....	☐	☐	☐	☐
Reducing costs of existing products..	☐	☐	☐	☐
Developing new products.....	☐	☐	☐	☐
Improving existing processes.....	☐	☐	☐	☐
Reducing process costs.....	☐	☐	☐	☐
Developing new processes.....	☐	☐	☐	☐

11. A NUMBER OF FACTORS ARE CONSIDERED IN PLANNING CORPORATE STRATEGIES. HOW IMPORTANT ARE THE FACTORS LISTED BELOW TO YOUR STRATEGIES FOR THE FUTURE?

(Please indicate your response to each of the factors by making a tick in the box which best describes your choice).

	Very	Moder-ately	Mini-mally	Not at all
	Important			
- Your company's competitive position in the R.S.A.	☐	☐	☐	☐
- Your company's global competitive position	☐	☐	☐	☐
- Capital Requirements.....	☐	☐	☐	☐
- Market growth potential.....	☐	☐	☐	☐
- Product performance.....	☐	☐	☐	☐
- Manufacturing capacity and demand	☐	☐	☐	☐
- Manufacturing economics (costs).....	☐	☐	☐	☐
- Expected technology changes.	☐	☐	☐	☐
- New technologies in other industries	☐	☐	☐	☐
- New product development.....	☐	☐	☐	☐
- Availability of qualified technical people	☐	☐	☐	☐

12. HOW MUCH DO THE FACTORS LISTED BELOW SERVE AS BARRIERS TO INTEGRATING TECHNOLOGY INTO THE CORPORATE STRATEGIC PLANNING PROCESS?

(Please indicate your response to each of the factors by making a tick in the box which best describes your choice.)

	ACTS AS BARRIER			
	Very Much	Moder-ately	Mini-mally	Not at all
Separate unit business plans.....	☐	☐	☐	☐
Top management's discomfort with technology.....	☐	☐	☐	☐
Lack of formal analytic approaches to incorporate technology in business strategy formulation.....	☐	☐	☐	☐
Short-term, profit-orientated manage-ment perspective.....	☐	☐	☐	☐
Technology people are too little involved in the planning process....	☐	☐	☐	☐
Not enough top management involvement in technology decisions.....	☐	☐	☐	☐

13. WHICH OF THE FACTORS LISTED BELOW CHARACTERISE TOP MANAGEMENT'S ROLE IN YOUR COMPANY'S TECHNOLOGY PROCESS?

(TICK BOXES)

- Reviews major development programs above a stated financial threshold..... ☐
- Reviews all R & D programs early and periodically. ☐
- Focusses on projects "in trouble"..... ☐
- Singles out and follows strategically important projects..... ☐
- Actively participates in the firm's evaluation and the management of R & D programmes..... ☐
- Monitors short-term profits, not technology..... ☐

14. TO WHAT EXTENT HAVE THE FOLLOWING "APPROACHES" CONTRIBUTED TO YOUR COMPANY'S PERFORMANCE OR SUCCESS IN TECHNOLOGY MANAGEMENT?

(Please indicate your response to each of the factors by making a tick in the box which best describes your choice.)

	DEGREE OF ENHANCEMENT			
	Very Successful	Moder-ately	Mini-mally	Not at all
Involvement with universities.....	☐	☐	☐	☐
More recognition for technical people	☐	☐	☐	☐
Use of outside technical specialists	☐	☐	☐	☐
Technical career path equal to general management (dual path).....	☐	☐	☐	☐
Incentive compensation for technical people.....	☐	☐	☐	☐
Integrating technology with business strategy.....	☐	☐	☐	☐
Job security for technical people...	☐	☐	☐	☐
Top-management commitment to longer term results.....	☐	☐	☐	☐
Training of technical people.....	☐	☐	☐	☐
High levels of R & D expenditure....	☐	☐	☐	☐
Establishment of technical advisory board to serve Top Managers.....	☐	☐	☐	☐
Promotion of technologists to senior management levels.....	☐	☐	☐	☐
Better allocation of R & D resources amongst projects.....	☐	☐	☐	☐
Tighter coupling of technology and strategic planning.....	☐	☐	☐	☐
Long range planning for technology..	☐	☐	☐	☐

15. IS YOUR COMPANY'S STRATEGIC PLANNING PROCESS FORMAL OR INFORMAL?

(TICK BOX)

- Formal and structured..... ☐
- Informal and unstructured..... ☐

16. WHAT IS YOUR COMPANY'S STRATEGIC PLANNING HORIZON?

(TICK BOX)

- Less than 2 years..... ☐
- 2 to 5 years..... ☐
- 6 to 10 years..... ☐
- Greater than 10 years..... ☐

17. IS A FORMAL TECHNOLOGY PLAN PREPARED BY THE COMPANY?

(TICK BOX)

Yes	No

18 (a). IF YES, WHAT DOES THE TECHNOLOGY PLAN CONTAIN?

- Allocates project/program budgets..... ☐
- Supports new ventures/products for the future growth of company..... ☐
- Identifies gaps in existing resources (technologies, facilities, people, skills, etc).. ☐
- Helps integrate business strategy and plans..... ☐
- Performs competitive technology evaluations..... ☐
- Incorporates formalised technological forecasting..... ☐
- Other, please specify_____

18 (b). IF YES, IS TECHNOLOGY PLANNING INCLUDED AS PART OF THE STRATEGIC PLAN?

(TICK BOX)

Yes	No

19. WHO CONTRIBUTES TOWARDS THE PLANNING AND IMPLEMENTATION OF TECHNOLOGY IN THE COMPANY, WHETHER PART OF THE STRATEGIC PLAN OR OTHERWISE?

(TICK BOXES)

	PLANNING	IMPLEMENTATION
- Managing Director/CEO.....		
- Top Management.....		
- Managers of separate business units..		
- Technical Managers.....		
- Planning Department.....		
- Outside Consultants.....		
- Technical Experts.....		
- Marketing Staff.....		
- Engineering Staff.....		

20. PLEASE TICK ANY OF THE FOLLOWING TECHNIQUES WHICH YOUR COMPANY USES IN THE TECHNOLOGY PLANNING PROCESS.

(TICK BOXES)

- Environment scanning..... ☐
- Technology audits..... ☐
- Gap analysis..... ☐
- Technology portfolio analysis..... ☐
- Brain storming..... ☐
- Delphi technique..... ☐
- SWOT analysis..... ☐
- Scenario planning..... ☐
- Consultation with experts..... ☐
- Sales forecast..... ☐
- Value chain analysis..... ☐
- Technology forecasting..... ☐
- Technology product life cycle analysis..... ☐
- Technology management matrices..... ☐
- Competitive product profiling..... ☐
- Portfolio of technologies..... ☐
- Morphological analysis..... ☐
- Benchmarking..... ☐
- Other, please specify_____

_____

_____

_____

_____

_____

_____

21. HOW IS TECHNOLOGY ACQUIRED BY YOUR COMPANY?

(TICK BOXES)

- In-house research & development..... ☐
- Reverse engineering..... ☐
- Collaborative research & development..... ☐
- Intellectual property (internal experts, proprietary information, etc.)..... ☐
- Acquisition of intellectual property (consultants, seminars, etc.)..... ☐
- Technology purchasing (contract R&D, licensing, etc.)..... ☐
- Non-acquisition (buy-in parts, services, etc).. ☐
- Joint venture..... ☐
- Acquisition of innovative companies..... ☐
- Technology scanning..... ☐

Please could you furnish me with the following particulars which will assist me with recording. Full confidentiality will be maintained, and this information will not be included in any research publications.

Name of respondent:_____

Name of Company:_____

Position held by respondent:_____

Would you like me to forward a summary of my research findings upon completion. (TICK BOX)

Yes	No

THANK YOU FOR YOUR HELP.

Appendix B

Sample Frame

APPENDIX B

INDUSTRIAL SECTOR COMPANIES TO WHICH QUESTIONNAIRES WERE SENT

COMPANY NAME	TURNOVER (1991/latest) (Amounts in R'000)	
B.1 CHEMICAL		
AECI Ltd	5 031 000	
Chemical Services Ltd	445 768	
Engen Ltd	3 168 000	
Manro Chemical Holdings Ltd	86 315	
Omnia Holdings Ltd	380 787	
Roychem Ltd	169 200	
Sasol Ltd	7 561 834	
Sentrachem Ltd	2 991 422	
Wayne Manufacturing Ltd	129 779	
	19 964 105	(A)
B.2 ELECTRONICS		
Abacus Industrial Holdings Ltd	225 388	
Aberdare Cables Africa Ltd	432 409	
ABS Holdings Ltd	42 372	
Advanced Technical Systems Ltd	23 941	
African Cables Ltd	171 682	
Allied Technologies Ltd	925 484	
Allied Electronics Corporation Ltd	2 655 030	
Anbeeco Investment Holdings Ltd	114 063	
Audiodek Holdings Ltd	60 676	
Autopage Holdings Ltd	30 108	
Central African Cables Ltd	93 042	
Computermatic Holdings Ltd	17 270	
Control Instruments Group Ltd	65 144	
Corporate Management Services Ltd	58 101	
Darmag Ltd	26 221	
Datakor Ltd	498 595	
Delta Electrical Industries Ltd	-	
Dimension Data Holdings Ltd	-	
Elcentre Corporation Ltd	112 309	
Femco Technology Holdings Ltd	107 245	
Fintech Ltd	524 024	
Grintek Ltd	1 075 867	
Jasco Electronics Holdings Ltd	64 188	
Kopp Electronics Ltd	26 888	
Multisource Holdings Ltd	15 797	
Nu-World Holdings Ltd	35 098	
Ohio Group Ltd	14 324	
Power Technologies Ltd	1 204 157	
Q Data Ltd	124 501	
Reunert Ltd	1 414 933	

APPENDIX B (CONTINUED):

COMPANY NAME	TURNOVER (1991/latest) (Amounts in R'000)	
B.2 ELECTRONICS (Continued)		
Siltek Ltd	822 459	
Spescom Electronics Ltd	32 899	
SPL Ltd	70 750	
Supalek Holdings Ltd	73 147	
Technology Systems International Ltd	1 184 985	
Tedelex Ltd	429 796	
Voltex Holdings Ltd	1 075 020	
	13 847 913	(B)
B.3 ENGINEERING		
African Oxygen Ltd	903 878	
Berzack Brothers (Holdings) Ltd	108 129	
Buffalo Corporation Ltd	20 044	
Cementation Co (Africa) Ltd	356 105	
Chubb Holdings Ltd	172 827	
Clyde Industrial Corporation Ltd	68 747	
Chubb Electrical (Pty) Ltd*	-	
Chubb Fire Security (Pty) Ltd*	-	
Chubb Lock & Safe (Ppty) Ltd*	-	
Dorbyl Ltd	2 843 558	
Edward L Bateman Ltd	786 107	
Fenner Group SA Ltd	209 284	
Fraser Alexander Ltd	233 950	
Genrec Holdings Ltd	592 786	
Goldfields Industrial Corporation Ltd	74 052	
Haggie Ltd	1 254 149	
Hudaco Industries Ltd	403 119	
Inmins Ltd	193 220	
Josiah Parkes & Sons (SA) Ltd*	-	
Metkor Group Ltd	3 164 239	
Northern Eng. Indust. Africa Ltd	713 625	
Safety Technologies Ltd	18 562	
Scharrighuisen Holdings Ltd	90 424	
Sondor Industries Ltd	19 230	
Standard Engineering Ltd	690 541	
Titaco Consolidated Investments Ltd	73 244	
TPN Investments Ltd	-	
Unihold Ltd	196 854	
Winhold Ltd	255 087	
Valard Ltd	118 435	
Winhold Ltd	255 087	
Woodrow Holdings Ltd	40 506	
	13 855 789	(C)

* Subsidaries of Chubb Holdings Ltd

APPENDIX B (CONTINUED):

COMPANY NAME	TURNOVER (1991/latest) (Amounts in R'000)
B.4 INDUSTRIAL HOLDING	
Afex Corporation Societe Anonyme	31 099
Anglo American Industrial Corp Ltd	6 123 000
Anglovaal Industries Ltd	7 386 400
Barlow Rand Ltd	29 119 000
Bidvest Group Ltd	115 129
Bolton Industrial Holdings Ltd	370 179
BTR Dunlop Ltd	700 803
CG Smith Ltd	14 158 000
Consolidated Afex Corporation SA	35 322
Cullinan Holdings Ltd	667 754
Currie Finance Corp Ltd	926 184
Eureka Industrial Ltd	135 729
Farm-AG Ltd	205 813
FSI Corporation Ltd	3 246 507
Grindrod Unicorn Group Ltd	497 463
Huntcor Ltd	587 146
Hunt Leuchards & Hepburn Holdings Ltd	587 146
Imphold Ltd	597 540
Klipton Ltd	106 776
KNJ Group Ltd	289 760
Macphail Holdings Ltd	211 835
Malbak Ltd	8 374 000
Micor Holdings Ltd	492 284
Murray & Roberts Holdings Ltd	4 603 960
Nictus Finansiële Instelling Bpk	-
Ozz Ltd	113 999
Picardi Holdings Ltd	526 307
Plate Glass & Shatterprufe Ind Ltd	2 298 877
Rale Holdings Ltd	205 813
Rentmeester Beleggings Ltd	170 076
Royal Corporation Ltd	170 551
Rubenstein Holdings Ltd	-
Sabvest Ltd	-
Saficon Investments Ltd	1 463 499
Sakers Finance and Investment Corp Ltd	1 463 499
S.A. Bias Holdings Ltd	-
SA Freight Corp Ltd	918 185
Technihire Ltd	6 632
Toco Holdings Ltd	131 291
Tollgate Holdings Ltd	598 515
T & N Holdings Ltd	413 429
Unidev Ltd	-
United Service Technologies Ltd	17 181
W & A Investment Corp Ltd	3 036 537
Waicor Ltd	-
	91 103 220 (D)

APPENDIX B (CONTINUED):

COMPANY NAME	TURNOVER (1991/latest) (Amounts in R'000)	
B.5 PHARMACEUTICAL & MEDICAL		
Adcock Ingram Ltd	615 730	
Crest Holdings Ltd	15 195	
Macmed Health Care Ltd	9 645	
Medhold Ltd	-	
Noristan Holdings Ltd	97 095	
PDC Holdings Ltd	522 313	
SA Druggists Ltd	1 061 880	
Twins Pharmaceuticals Ltd	493 399	
	2 815 257	(E)
B.6 STEEL		
Consolidated Metal Industries Ltd	118 435	
Highveld Steel & Vanadium Corp Ltd	1 431 711	
Iscor Ltd	7 364 800	
Usko Ltd	612 601	
	9 527 547	(F)
(A) + (B) + (C) + (D) + (E) + (F) :	R151 113 831	

Appendix C

Questionnaire return information (summary)

APPENDII C : Questionnaire return information (summary).

QUESTIONNAIRE QUESTIONS	CHEMICAL (5)	ELECTRONICS (9)	ENGINEER-ING (10)	INDUSTRIAL HOLDING (10)	PHARMACEU-TICAL & MEDICAL (3)	STEEL (1)	INDUSTRIAL SECTOR SEGMENTS
1. HOW IS YOUR COMPANY STRUCTURED?							
- Holding company	1 (20%)	8 (89%)	8 (80%)	7 (70%)	2 (67%)		26 (69%)
- Independent company	3 (60%)	0 (0%)	1 (10%)	0 (0%)	0 (0%)	1 (100%)	5 (13%)
- Subsidiary company	1 (20%)	1 (11%)	1 (10%)	3 (30%)	1 (33%)		7 (18%)
2. WHAT ARE THE PRIMARY OPERATIONS OF YOUR COMPANY?							
- Manufacturing	5 (100%)	6 (67%)	6 (60%)	5 (50%)	3 (100%)	1 (100%)	26 (68%)
- Refurbishing/Maintenance	0 (0%)	2 (22%)	4 (40%)	1 (10%)	1 (33%)		8 (21%)
- Contracting	0 (0%)	2 (22%)	6 (60%)	2 (20%)	0 (0%)		10 (26%)
- Consulting	0 (0%)	2 (22%)	4 (40%)	1 (10%)	0 (0%)		7 (18%)
- Wholesaling/Retailing	1 (20%)	5 (56%)	2 (20%)	1 (10%)	1 (33%)		10 (26%)
- Research & Development	0 (0%)	1 (11%)	0 (0%)	0 (0%)	0 (0%)		1 (3%)
3. WHICH ARE YOUR MAJOR CUSTOMER GROUPS?							
- Private consumers (householder)	3 (60%)	2 (22%)	2 (20%)	3 (30%)	2 (66%)		12 (32%)
- Manufacturers	5 (100%)	6 (67%)	8 (80%)	5 (50%)	0 (0%)	1 (100%)	25 (66%)
- Wholesalers & Retailers	2 (40%)	8 (89%)	4 (40%)	6 (60%)	1 (33%)		21 (55%)
- Construction	1 (20%)	5 (56%)	7 (70%)	4 (40%)	0 (0%)		17 (45%)
- Mining	3 (60%)	7 (78%)	8 (80%)	4 (40%)	0 (0%)		22 (58%)
- Electricity	0 (0%)	7 (78%)	4 (40%)	2 (20%)	0 (0%)		13 (34%)
- Transportation	1 (20%)	5 (56%)	5 (50%)	3 (30%)	0 (0%)		14 (37%)
- Government, Provincial & Municipal	2 (40%)	7 (78%)	6 (60%)	2 (20%)	3 (100%)		20 (53%)
- Military	0 (0%)	6 (67%)	5 (50%)	3 (30%)	2 (66%)		16 (42%)
4. IN WHICH INDUSTRIAL SECTORS OF THE SOUTH AFRICAN ECONOMY DOES YOUR COMPANY OPERATE?							
- Chemical	5 (100%)	1 (11%)	2 (20%)	1 (10%)	1 (33%)		10 (26%)
- Electronic	0 (0%)	9 (100%)	0 (0%)	0 (0%)	0 (0%)		9 (24%)
- Engineering	0 (0%)	1 (11%)	7 (70%)	1 (10%)	0 (0%)		9 (24%)
- Industrial Holding	0 (0%)	0 (0%)	4 (40%)	9 (90%)	0 (0%)		13 (34%)
- Pharaaceutical & Medical	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (100%)		3 (8%)
- Steel	0 (0%)	2 (22%)	1 (10%)	0 (0%)	0 (0%)	1 (100%)	4 (11%)

APPENDIX C (CONTINUED) : Questionnaire return information (summary).

QUESTIONNAIRE QUESTIONS	CHEMICAL (5)	ELECTRONICS (9)	ENGINEERING (10)	INDUSTRIAL HOLDING (10)	PHARMACEUTICAL & MEDICAL (3)	STEEL (1)	INDUSTRIAL SECTOR SEGMENTS
5. APPROX. SIZE OF COMPANY:							
- Approx. tot. no. of employees	66100	35300	39890	321553	3594	1000	467437
- Approx. tot. annual turnover	15980000	7634000	7480000	50429359	829150	300000	82652509
6. IS ANY REFERENCE MADE TO TECHNOLOGY IN THE MISSION STATEMENT?	0	0	2	0	0	0	2
7(a). DURING THE PLANNING PROCESS, DOES YOUR COMPANY SCAN TECHNOLOGIES BEING DEVELOPED OR APPLIED OUTSIDE YOUR YOUR COMPANY TO IDENTIFY THREATS AND/OR OPPORTUNITIES?	5 (100%)	8 (89%)	9 (90%)	9 (90%)	3 (100%)	1 (100%)	35 (92%)
7 (b). HOW EFFECTIVE DO YOU YOU FEEL YOUR COMPANY IS IN CARRYING OUT THIS FUNCTION?							
Extremely effective	1 (20%)	1 (11%)	0 (0%)	1 (10%)	0 (0%)	4 (100%)	4 (11%)
Very effective	1 (20%)	6 (67%)	4 (40%)	5 (50%)	0 (0%)		16 (42%)
Somewhat effective	3 (60%)	1 (11%)	5 (50%)	3 (30%)	3 (100%)		15 (39%)
Not at all effective	0 (0%)	1 (11%)	1 (10%)	1 (10%)	0 (0%)		3 (8%)
8 (a). DURING THE PLANNING PROCESS, DOES YOUR COMPANY MAKE LONG-RANGE FORECASTS OF THE POTENTIAL IMPACT OF EMERGING TECHNOLOGIES ON YOUR COMPANY?	5 (100%)	8 (89%)	8 (80%)	8 (80%)	2 (66%)	1 (100%)	32 (84%)
8(b). HOW EFFECTIVE DO YOU FEEL YOUR COMPANY IS IN CARRYING OUT THIS FUNCTION?							
Extremely effective	0 (0%)	1 (11%)	0 (0%)	1 (10%)	0 (0%)		2 (5%)
Very effective	1 (20%)	3 (33%)	2 (20%)	3 (30%)	0 (0%)	3 (100%)	10 (26%)
Somewhat effective	4 (80%)	4 (44%)	6 (60%)	4 (40%)	2 (66%)		20 (53%)
Not at all effective	0 (0%)	1 (11%)	2 (20%)	2 (20%)	1 (33%)		6 (16%)
9 (a). DURING THE PLANNING PROCESS, DOES YOUR COMPANY CONDUCT INTERNAL TECHNOLOGY AUDITS TO ESTABLISH THE COMPANY'S 'BASELINE' TECHNOLOGY CAPABILITY?	3 (60%)	5 (56%)	4 (40%)	4 (40%)	2 (66%)	1 (100%)	19 (50%)
9(b). HOW EFFECTIVE DO YOU FEEL YOUR COMPANY IS IN CARRYING OUT THIS FUNCTION?							
Extremely effective	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (100%)	1 (3%)
Very effective	1 (20%)	2 (22%)	4 (40%)	2 (20%)	0 (0%)		9 (24%)
Somewhat effective	2 (40%)	2 (22%)	0 (0%)	2 (20%)	2 (66%)		8 (20%)
Not at all effective	2 (40%)	4 (44%)	6 (60%)	6 (60%)	1 (33%)		19 (50%)
Unknown		1 (11%)					1 (3%)

APPENDIX C (CONTINUED) : Questionnaire return information (summary).

QUESTIONNAIRE QUESTIONS	CHEMICAL (5)	ELECTRONICS (9)	ENGINEERING (10)	INDUSTRIAL HOLDING (10)	PHARMACEUTICAL & MEDICAL (3)	STEEL (1)	INDUSTRIAL SECTOR SEGMENTS
10. HOW MUCH CONSIDERATION DOES YOUR COMPANY'S PLANNING PROCESS GIVE TO EXISTING AND EMERGING TECHNOLOGIES AVAILABLE BOTH INSIDE AND OUTSIDE YOUR COMPANY FOR THE APPLICATIONS LISTED BELOW?							
4 = Extensive consideration 3 = Moderate consideration 2 = Minimal consideration 1 = No consideration							
(a). EXISTING TECHNOLOGIES (Inside company)							
- Improving existing products	3.8	3.4	2.2	2.8	3.7	3	3.0
- Reducing costs of existing products	3.8	3.1	2.4	2.9	4.0	4	3.2
- Developing new products	3.4	3.2	2	2.8	3.7	3	2.9
- Improving existing processes	3.8	3.1	2.2	3	4.0	4	3.2
- Reducing process costs	3.6	3.1	2.2	2.6	4.0	4	3.1
- Developing new processes	3.2	2.8	1.9	2.4	3.3	4	2.8
(b). EXISTING TECHNOLOGIES (Outside company)							
- Improving existing products	3.6	2.8	1.8	2.5	2.7	3	2.5
- Reducing costs of existing products	3.4	2.8	1.7	2.5	2.0	4	2.4
- Developing new products	3	3.1	1.9	2.5	2.7	3	2.5
- Improving existing processes	3.2	2.7	1.6	2.6	2.3	4	2.5
- Reducing process costs	3.2	2.4	1.4	2.1	2.0	4	2.2
- Developing new processes	3.2	2.3	1.3	2.3	2.3	4	2.3
(c). EMERGING TECHNOLOGIES (Inside company)							
- Improving existing products	2.8	3.1	1.4	2.4	2.7	3	2.3
- Reducing costs of existing products	2.6	2.4	1.2	2.5	2.3	3	2.2
- Developing new products	2.8	3.0	1.4	2.3	2.7	2	2.2
- Improving existing processes	2.8	2.6	1.4	2.4	2.3	4	2.4
- Reducing process costs	2.6	2.3	1.4	2	2.3	4	2.2
- Developing new processes	3	2.1	1.5	2	2.3	4	2.2
(d). EMERGING TECHNOLOGIES (Outside company)							
- Improving existing products	3	3.1	1.5	2.2	2.0	3	2.2
- Reducing costs of existing products	2.8	2.2	1.4	2.3	1.7	3	2.0
- Developing new products	2.8	3.0	1.7	2.1	2.3	2	2.1
- Improving existing processes	3	2.6	1.3	2.2	1.7	4	2.1
- Reducing process costs	2.6	2.2	1.4	1.7	1.3	4	1.9
- Developing new processes	3	2.3	1.5	1.9	1.7	4	2.1

APPENDIX C (CONTINUED) : Questionnaire return information (summary).

QUESTIONNAIRE QUESTIONS	CHEMICAL (5)	ELECTRONICS (9)	ENGINEERING (10)	INDUSTRIAL HOLDING (10)	PHARMACEUTICAL & MEDICAL (3)	STEEL (1)	INDUSTRIAL SECTOR SEGMENTS
11. A NUMBER OF FACTORS ARE CONSIDERED IN PLANNING CORPORATE STRATEGIES. HOW IMPORTANT ARE THE FACTORS LISTED BELOW TO YOUR STRATEGIES FOR THE FUTURE? 4 = Very important 3 = Moderately important 2 = Minimally important 1 = Not at all							
- Your company's competitive position in the RSA	3.8	4.0	3	3.8	4.0	4	3.7
- Your company's global competitive position	3.6	2.3	2.1	3.3	2.0	4	2.7
- Capital requirements	3.6	3.7	3.1	3.5	3.7	4	3.5
- Market growth potential	3.8	4.0	3	3.7	3.7	4	3.6
- Product performance	3.8	3.8	2.8	4	3.7	3	3.5
- Manufacturing capacity and demand	3.4	2.8	1.9	3.1	3.3	4	2.9
- Manufacturing economics (costs)	3.6	3.2	2.5	3.6	3.3	4	3.3
- Expected technology changes	3	3.8	2.9	3.3	2.7	4	3.2
- New technologies in other industries	3	3.0	1.9	2.9	2.0	4	2.6
- New product development	3.4	3.6	2.4	3.5	3.7	3	3.2
- Availability of qualified technical people	3.4	3.6	2.5	3.6	3.0	3	3.1
12. HOW MUCH DO THE FACTORS LISTED BELOW SERVE AS BARRIERS TO INTEGRATING TECHNOLOGY INTO THE CORPORATE STRATEGIC PLANNING PROCESS? ACTS AS BARRIER 4 = Very much 3 = Moderately 2 = Minimally 1 = Not at all							
- Separate unit business plans	2.6	2.6	2	2.7	3.0	3	2.6
- Top management's discomfort with technology	1.8	2.0	1.9	2.2	3.7	3	2.5
- Lack of formal analytic approaches to incorporate technology in business strategy formulation	2.4	2.7	1.5	2.4	3.0	2	2.3
- Short-term, profit-orientated management perspective	2.8	2.8	2	2.3	3.3	2	2.5
- Technology people are too little involved in the planning process	2	2.1	1.8	2.3	2.3	3	2.2
- Not enough top management involvement in technology decisions	2	2.0	1.6	2.1	3.0	3	2.3

APPENDIX C (CONTINUED) : Questionnaire return information (summary).

QUESTIONNAIRE QUESTIONS	CHEMICAL (5)	ELECTRONICS (9)	ENGINEERING (10)	INDUSTRIAL HOLDING (10)	PHARMACEUTICAL & MEDICAL (3)	STEEL (1)	INDUSTRIAL SECTOR SEGMENTS
13. WHICH OF THE FACTORS LISTED BELOW CHARACTERISE TOP MANAGEMENT'S ROLE OF YOUR COMPANY'S TECHNOLOGY PROCESS?							
- Reviews major development programs above a stated financial threshold	4 (80%)	6 (67%)	6 (60%)	7 (70%)	1 (33%)	1 (100%)	25 (66%)
- Reviews all R & D programs early and periodically	2 (40%)	6 (67%)	3 (30%)	3 (30%)	0 (0%)		14 (37%)
- Focusses on projects "in trouble"	1 (20%)	4 (44%)	5 (50%)	4 (40%)	1 (33%)		15 (39%)
- Singles out and follows strategically important projects	5 (100%)	7 (78%)	5 (50%)	7 (70%)	2 (66%)	1 (100%)	27 (71%)
- Actively participates in the firm's evaluation and the management of R & D programmes	1 (20%)	6 (67%)	1 (10%)	4 (40%)	0 (0%)		12 (32%)
- Monitors short-term profits, not technology	1 (20%)	3 (33%)	3 (30%)	3 (30%)	2 (66%)		12 (32%)
14. TO WHAT EXTENT HAVE THE FOLLOWING "APPROACHES" CONTRIBUTED TO YOUR COMPANY'S PERFORMANCE OR SUCCESS IN TECHNOLOGY MANAGEMENT?							
DEGREE OF ENHANCEMENT							
4 = Very successful							
3 = Moderately							
2 = Minimally							
1 = Not at all							
- Involvement with universities	3.2	2.2	1.3	2.1	2.0	2	1.9
- More recognition for technical people	3.2	2.9	2.2	2.5	2.7	3	2.6
- Use of outside technical specialists	3	2.1	2.3	2.8	3.0	2	2.6
- Technical carreer path equal to general management (dual path)	3.4	3.1	1.6	2.1	1.3	3	2.0
- Incentive compensation for technical people	3	2.6	1.7	2.1	1.3	2	1.9
- Integrating technology with business strategy	3	3.1	2.1	2.7	2.0	3	2.5
- Job security for technical people	2.6	2.9	2	2	2.0	4	2.3
- Top-management commitment to longer term results	3	3.0	2.4	3	3.3	3	2.9
- Training of technical people	3	3.0	2	2.8	2.7	3	2.6
- High levels of R & D expenditure	2.6	2.6	1.2	2.1	2.3	2	2.0
- Establishment of technical advisory board to serve top managers	2	2.3	1.2	1.1	1.0	1	1.2
- Promotion of technologists to senior management positions	3	2.8	2	2	2.0	3	2.2
- Better allocation of R & D resources amongst projects	2.6	2.4	1.4	1.9	2.0	3	2.0
- Tighter coupling of technology and strategic planning	2.8	2.9	1.7	2.6	2.3	4	2.5
- Long range planning for technology	2.6	3.0	1.8	2.4	1.7	4	2.3
15. IS YOUR COMPANY'S STRATEGIC PLANNING PROCESS FORMAL OR INFORMAL?							
- Formal and structured	3 (60%)	8 (89%)	6 (60%)	7 (70%)	2 (66%)	1 (100%)	27 (71%)
- Informal and unstructured	2 (40%)	2 (22%)	4 (40%)	3 (30%)	1 (33%)		11 (29%)

APPENDIX C (CONTINUED) : Questionnaire return information (summary).

QUESTIONNAIRE QUESTIONS	CHEMICAL (5)	ELECTRONICS (9)	ENGINEERING (10)	INDUSTRIAL HOLDING (10)	PHARMACEUTICAL & MEDICAL (3)	STEEL (1)	INDUSTRIAL SECTOR SEGMENTS
16. WHAT IS YOUR COMPANY'S STRATEGIC PLANNING HORIZON?							
- Less than 2 years	0 (0%)	4 (44%)	2 (20%)	3 (30%)	1 (33%)		10 (26%)
- 2 to 5 years	2 (40%)	5 (56%)	8 (80%)	6 (60%)	2 (66%)		23 (61%)
- 6 to 10 years	2 (40%)	0 (0%)	0 (0%)	1 (10%)	0 (0%)	1 (100%)	4 (11%)
- Greater than 10 years	2 (40%)	0 (0%)	0 (0%)	1 (10%)	0 (0%)		3 (8%)
17. IS A FORMAL TECHNOLOGY PLAN PREPARED BY THE COMPANY?	2 (40%)	7 (78%)	2 (20%)	2 (20%)	0 (0%)	1 (100%)	14 (37%)
18 (a). IF YES, WHAT DOES THE TECHNOLOGY PLAN CONTAIN?							
- Allocates project/program budgets	1 (20%)	7 (78%)	2 (20%)	2 (20%)	0 (0%)	1 (100%)	13 (34%)
- Supports new ventures/products for the future growth of company	1 (20%)	6 (67%)	2 (20%)	2 (20%)	0 (0%)	1 (100%)	12 (32%)
- Identifies gaps in existing resources (technologies, facilities, people, skills, etc)	1 (20%)	7 (78%)	0 (0%)	2 (20%)	0 (0%)	1 (100%)	11 (29%)
- Helps integrate business strategy and plans	2 (40%)	7 (78%)	2 (20%)	2 (20%)	0 (0%)	1 (100%)	14 (37%)
- Performs competitive technology evaluations	1 (20%)	3 (33%)	1 (10%)	1 (10%)	0 (0%)	1 (100%)	7 (18%)
- Incorporates formalised technological forecasting	2 (40%)	2 (22%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	5 (13%)
- Other, please specify	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		0 (0%)
18 (b). IF YES, IS TECHNOLOGY PLANNING INCLUDED AS PART OF THE STRATEGIC PLAN?	2 (40%)	6 (67%)	2 (20%)	2 (20%)	0 (0%)	1 (100%)	13 (34%)
19 (a). WHO CONTRIBUTES TOWARDS THE PLANNING OF TECHNOLOGY IN THE COMPANY, WHETHER PART OF THE STRATEGIC PLAN OR OTHERWISE?							
- Managing Director/CEO	4 (80%)	7 (78%)	7 (70%)	5 (50%)	1 (33%)	1 (100%)	25 (66%)
- Top Management	4 (80%)	8 (89%)	7 (70%)	8 (80%)	0 (0%)	1 (100%)	28 (74%)
- Managers of separate business units	5 (100%)	7 (78%)	5 (50%)	8 (80%)	3 (100%)	1 (100%)	29 (76%)
- Technical Managers	5 (100%)	7 (78%)	4 (40%)	3 (30%)	1 (33%)	1 (100%)	21 (55%)
- Planning Department	2 (40%)	1 (11%)	0 (0%)	1 (10%)	0 (0%)		4 (11%)
- Outside Consultants	2 (40%)	0 (0%)	3 (30%)	4 (40%)	0 (0%)		9 (24%)
- Technical Experts	2 (40%)	5 (56%)	3 (30%)	3 (30%)	0 (0%)		13 (34%)
- Marketing Staff	4 (80%)	5 (56%)	5 (50%)	3 (30%)	0 (0%)	1 (100%)	18 (47%)
- Engineering Staff	3 (60%)	7 (78%)	4 (40%)	6 (60%)	0 (0%)	1 (100%)	21 (55%)

APPENDIX C (CONTINUED) : Questionnaire return information (summary).

QUESTIONNAIRE QUESTIONS	CHEMICAL (5)	ELECTRONICS (9)	ENGINEERING (10)	INDUSTRIAL HOLDING (10)	PHARMACEUTICAL & MEDICAL (3)	STEEL (1)	INDUSTRIAL SECTOR SEGMENTS
19 (b). WHO CONTRIBUTES TOWARDS THE IMPLEMENTATION OF TECHNOLOGY IN THE COMPANY, WHETHER PART OF THE STRATEGIC PLAN OR OTHERWISE?							
- Managing Director/CEO	2 (40%)	6 (67%)	6 (60%)	3 (30%)	0 (0%)		17 (45%)
- Top Management	2 (40%)	6 (67%)	7 (70%)	7 (70%)	2 (66%)	1 (100%)	25 (66%)
- Managers of separate business units	4 (80%)	7 (78%)	6 (60%)	8 (80%)	1 (33%)	1 (100%)	27 (71%)
- Technical Managers	5 (100%)	8 (89%)	5 (50%)	5 (50%)	2 (66%)	1 (100%)	26 (68%)
- Planning Department	1 (20%)	1 (11%)	0 (0%)	1 (10%)	1 (33%)		4 (11%)
- Outside Consultants	2 (40%)	0 (0%)	1 (10%)	3 (30%)	1 (33%)		7 (18%)
- Technical Experts	3 (60%)	5 (56%)	4 (40%)	3 (30%)	1 (33%)	1 (100%)	17 (45%)
- Marketing Staff	3 (60%)	6 (67%)	5 (50%)	4 (40%)	0 (0%)	1 (100%)	19 (50%)
- Engineering Staff	4 (80%)	6 (67%)	7 (70%)	7 (70%)	1 (33%)		25 (66%)
						1 (100%)	
20. PLEASE TICK ANY OF THE FOLLOWING TECHNIQUES WHICH YOUR COMPANY USES IN THE TECHNOLOGY PLANNING PROCESS.							
- Environment scanning	4 (80%)	4 (44%)	3 (30%)	7 (70%)	2 (66%)	1 (100%)	21 (55%)
- Technology audits	4 (80%)	2 (22%)	3 (30%)	3 (30%)	0 (0%)	1 (100%)	13 (34%)
- Gap analysis	2 (40%)	0 (0%)	1 (10%)	2 (20%)	1 (33%)		6 (16%)
- Technology portfolio analysis	3 (60%)	1 (11%)	1 (10%)	1 (10%)	0 (0%)	1 (100%)	7 (18%)
- Brain storming	3 (60%)	7 (78%)	6 (60%)	5 (50%)	3 (100%)	1 (100%)	25 (66%)
- Delphi technique	0 (0%)	1 (11%)	0 (0%)	0 (0%)	0 (0%)		1 (3%)
- SWOT analysis	5 (100%)	7 (78%)	6 (60%)	5 (50%)	2 (66%)	1 (100%)	26 (68%)
- Scenario planning	3 (60%)	7 (78%)	2 (20%)	2 (20%)	0 (0%)	1 (100%)	15 (39%)
- Consultation with experts	4 (80%)	5 (56%)	5 (50%)	8 (80%)	2 (66%)	1 (100%)	25 (66%)
- Sales forecast	2 (40%)	8 (89%)	4 (40%)	4 (40%)	0 (0%)	1 (100%)	19 (50%)
- Value chain analysis	1 (20%)	2 (22%)	0 (0%)	2 (20%)	0 (0%)		5 (13%)
- Technolgy forecasting	3 (60%)	4 (44%)	4 (40%)	0 (0%)	1 (33%)	1 (100%)	13 (34%)
- Technology product life cycle analysis	1 (20%)	4 (44%)	2 (20%)	3 (30%)	0 (0%)	1 (100%)	11 (29%)
- Technology management matrices	1 (20%)	3 (33%)	0 (0%)	0 (0%)	0 (0%)		4 (11%)
- Competitive product profiling	2 (40%)	5 (56%)	2 (20%)	5 (50%)	1 (33%)	1 (100%)	16 (42%)
- Portfolio of technolgies	2 (40%)	4 (44%)	2 (20%)	0 (0%)	0 (0%)	1 (100%)	9 (24%)
- Morphological analysis	0 (0%)	1 (11%)	0 (0%)	0 (0%)	0 (0%)		1 (3%)
- Benchmarking	3 (60%)	4 (44%)	2 (20%)	3 (30%)	1 (33%)		13 (34%)
- Other, please specify	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		0 (0%)

APPENDIX C (CONTINUED) : Questionnaire return information (summary).

QUESTIONNAIRE QUESTIONS	CHEMICAL (5)	ELECTRONICS (9)	ENGINEERING (10)	INDUSTRIAL HOLDING (10)	PHARMACEUTICAL & MEDICAL (3)	STEEL (1)	INDUSTRIAL SECTOR SEGMENTS
21. HOW IS TECHNOLOGY ACQUIRED BY YOUR COMPANY?							
- In-house research & development	5 (100%)	7 (78%)	4 (40%)	9 (90%)	2 (66%)	1 (100%)	28 (74%)
- Reverse engineering	1 (20%)	3 (33%)	3 (30%)	3 (30%)	0 (0%)	1 (100%)	11 (29%)
- Collaborative research & development	4 (80%)	4 (44%)	2 (20%)	3 (30%)	3 (100%)	1 (100%)	17 (45%)
- Intellectual property (internal experts, proprietary information, etc.)	2 (40%)	4 (44%)	3 (30%)	6 (60%)	0 (0%)	1 (100%)	16 (42%)
- Acquisition of intellectual property (consultants, seminars, etc.)	3 (60%)	5 (56%)	3 (30%)	7 (70%)	2 (66%)	1 (100%)	21 (55%)
- Technology purchasing (contract R & D, licensing, etc.)	5 (100%)	6 (67%)	4 (40%)	6 (60%)	2 (66%)	1 (100%)	24 (63%)
- Non-acquisition (buy-in parts, services, etc.)	1 (20%)	4 (44%)	1 (10%)	5 (50%)	1 (33%)	1 (100%)	13 (34%)
- Joint venture	2 (40%)	5 (56%)	4 (40%)	4 (40%)	0 (0%)	1 (100%)	16 (42%)
- Acquisition of innovative companies	1 (20%)	5 (56%)	3 (30%)	3 (30%)	1 (33%)		13 (34%)
- Technology scanning	3 (60%)	2 (22%)	1 (10%)	2 (20%)	1 (33%)	1 (100%)	10 (26%)
COMPANY PARTICULARS							
- Name of respondent							
- Name of company							
- Position held by respondent							
WHETHER OR NOT A SUMMARY OF THE RESEARCH FINDINGS MUST BE FORWARDED TO THE RESPONDENT?	5	8	8	6	3	1	31

Appendix D

Tools used in the technology management process

APPENDIX D

D. TOOLS USED IN THE TECHNOLOGY MANAGEMENT PROCESS

Today's technology manager, or management for that matter, requires tools or techniques to enable them to perform the technology management function. There are numerous techniques available to assist with the process of technology management, with some being of a rudimentary nature (drawn from other management disciplines), whilst others are more sophisticated and have been developed exclusively for the purposes of managing technology. Some of these methods are:

- environment scanning
- technology audits
- brainstorming
- SWOT analysis
- scenario planning
- value chain analysis
- technology forecasting
- technology product life cycle analysis
- technology management matrices
- portfolio of technologies
- benchmarking.

Since the technology portfolio development technique plays a vital role in the technology function of many properly managed companies, it will be discussed in detail below. Reference is also made to this technique in the body of this report (see chapter 2).

D.1 Technology portfolio development technique

This is a technique which can be used to identify and analyse key corporate technology alternatives and to set technology priorities.

In chapter 2 (see section 2.6.1) it was stated that the planning of technology strategy can be viewed as a four step process (Manahan (1989 : 55-56); Pavitt (1990 : 24); Sethi & Hickey (1985 : 95) & Harris, Shaw & Sommers (1983 : 31)). These are:

- technology situation assessment
- technology portfolio development and evaluation
- technology and corporate strategy integration
- establishing technology investment priorities.

Technology situation assessment leads to the identification of technology alternatives. At this point of the technology strategy process, a "technology portfolio" is developed by creating a two-by-two matrix (similar to that used in strategic planning), as illustrated in Figure D.1. There are two dimensions associated

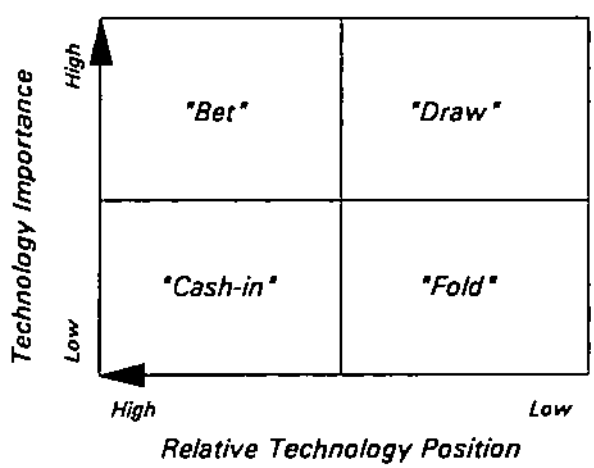
with the technology portfolio:

- **technology importance**, i.e. the relative importance that a specific technology plays in a given business segment

- **relative technology position**, i.e. a measure of the company's investment in a given technology relative to the market-place.

Technology "importance" is based on criteria that include value added, rate of change, and potential markets and their attractiveness. The "relative technology" position is determined by assessing the current and future position in a given technology, and its expected future development.

Figure D.1 : Developing the technology profile



If the company finds itself in the upper left or "bet" quadrant of the matrix, then it is in an excellent position technologically in a business segment where that technology is important. Company objectives should aim high to sustain and increase competitive advantage. This would include business where commitment to the newest equipment, to "high" risk R & D, and the like, should be made.

The upper right-hand or "draw" quadrant, represents a potentially serious problem and is inherently unstable. One needs to consider making one of two decisions:

- either bet against the competition and invest to attain a leadership position, or
- develop a plan to withdraw from that business and invest in more profitable areas.

In the lower left or "cash-in" quadrant, a company is in a strong position technologically, but the technology is not really important in terms of the market-place requirements.

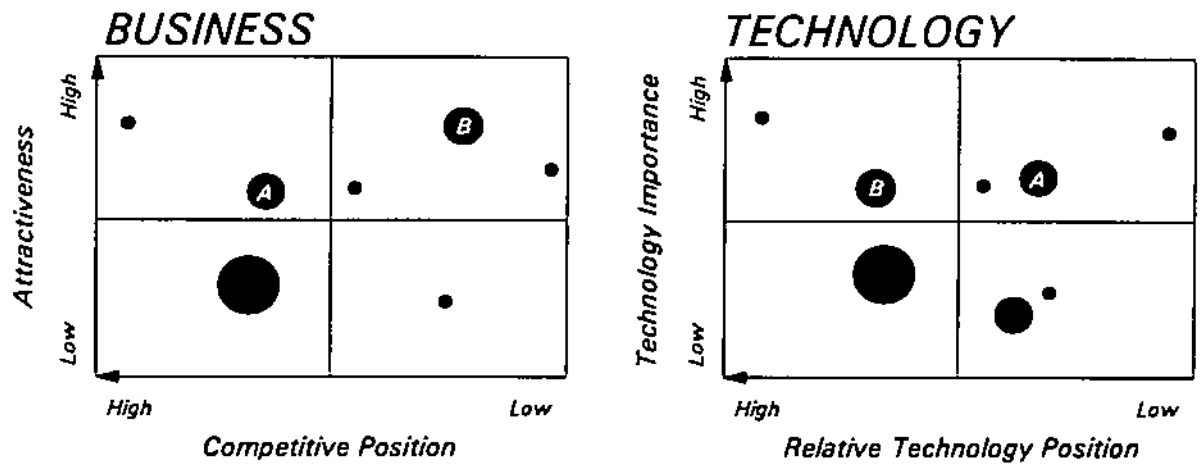
If a company is in the lower right-hand or "fold" quadrant, it is weak technologically but in a field where technology is unimportant. These technology investments should be viewed as sunk costs.

At this point the company must consider integrating technology with the corporate business strategy.

The business portfolio is product orientated and measures the company's product lines in terms of market position and importance. As discussed earlier and in contrast, the technology portfolio is technology based and defines the company's relative product and process technologies in terms of market-place position and their importance to the basic business of the company (see Figure D.2).

The business and technology portfolios must be compatible if a company wants to gain advantage from their technological investments. This means that a technology portfolio will be effective only if it is consistent with the company's business strategy implied by its business portfolio. Once this process is completed the technology alternatives being considered may then be referred to as technology investment options.

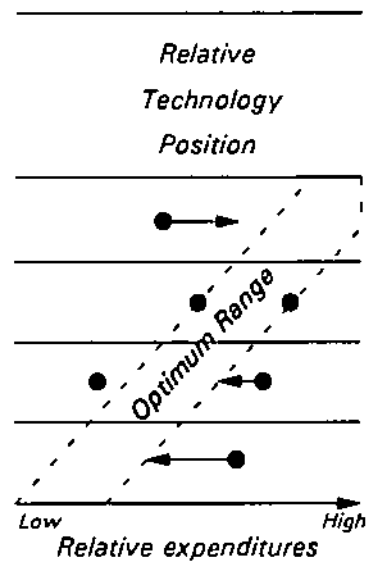
Figure D.2 : Matching business and technology portfolios



The final step in the process involves developing a specific technology strategy. A technology investment matrix (see Figure D.3) of strategic plays versus relative technology expenditures can now be developed from the technology portfolio analysis previously described.

Figure D.3 : Technology investment matrix

Category (Strategic plays)	*Technology Portfolio Quadrant*	*Technology Importance*	*Relative Technology Position*
"Bet"	*Upper left*	*High*	*High*
"Draw"	*Upper right*	*High*	*Low*
"Cash-in"	*Lower left*	*Low*	*High*
"Bet"	*Lower right*	*Low*	*Low*



The technology investment matrix is a useful technique for summarising a company's technology investment options. If technology is outside of the optimum range, the investment strategy should move it toward the optimum.

As illustrated by Figure D.3, spending should be high relative to the "leader" for any technology lying in the upper left or "bet" quadrant. In fact, a company should strive to become a leader. In

the upper right or "draw" category, with a weak position in technology of high importance, expenditures should be increased in order to move to the left (see Figure D.2) into a "bet" position, or perhaps wait until increased expenditures can be better justified. Finally, with technologies in the lower left ("cash-in") and lower right ("fold") positions, companies need to consider reducing or terminating their investments and begin concentrating its resources on technologies with higher leverage.