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TITLE : AN EVALUATION OF THE PLANNING AND CONTROL SYSTEM REQUIRED FOR TECHNOLOGY MANAGEMENT IN AN ENGINEERING BUSINESS

STUDENT : R.D. PENTZ

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STUDY LEADER : PROF. H. PREKEL

EXTERNAL/SECOND EXAMINER : PROF. G. PELSER

DATE : 1989/12/17

SIGNATURE : ____________________

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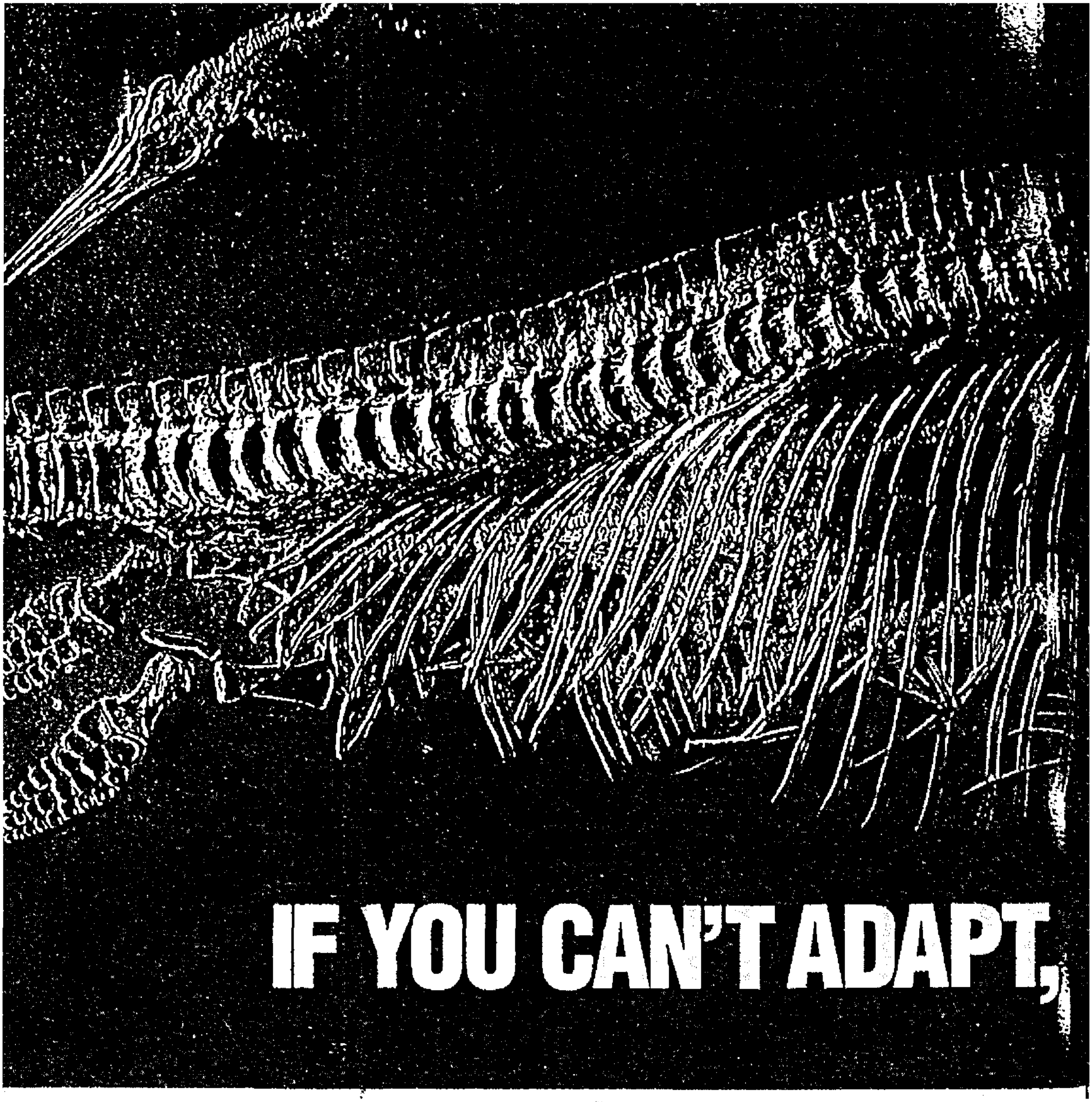

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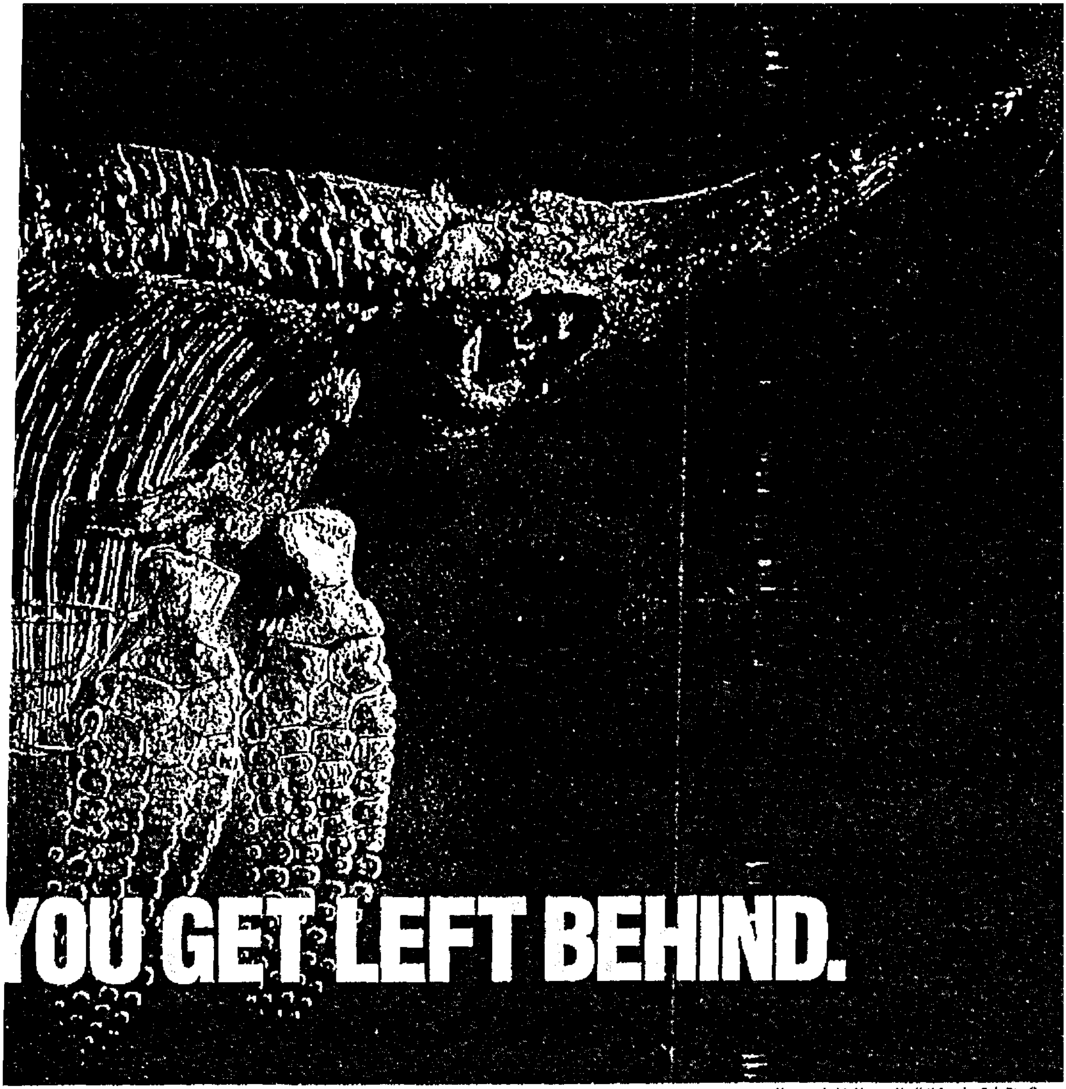

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S Y N O P S I S

Opportunities abound in the armaments industry is South Africa and abroad. This is probably one of the main reasons why it has grown to almost astronomical amounts in value. Simultaneously, the vast figures in turnover and profits have attracted numerous competitors into the business.

The next factor which has contributed most significantly to the increase in development and manufacture of armaments is of course the need of countries to defend themselves against aggressors. Political unrest, terrorism, border conflicts, war and invasions are the order of the day. All of these events require a show of arms, if not retaliation.

In order to satisfy a need for strategic independence, even to a limited extent, countries have insisted on development and establishment of various categories of technologies. During the past fifty years there has been an explosion in the amount of information published in the technology sector. Some highly sophisticated technologies have become commonplace in most technical fields, including the armaments industry.

As might be expected, the armaments industry is also greatly influenced by trends and change in the sector of economics, by social and cultural factors, and new legislation. It may rightfully be regarded as a highly volatile, complex and dynamic part of any economy.

Under these circumstances the role of technology management in a country and in a business enterprise becomes more important, more difficult, and more essential. To ensure that a large organisation stays competitive, or becomes more competitive, the system of planning and control must be well integrated, kept up to date, and well managed to fulfil its purpose.

For the purpose of this script an investigation was undertaken into the corporate and business systems for technology management in a firm in the local engineering industry.

The description covers planning and control theory, system models, innovation and technology management principles, and the theory of forecasting methods usually adapted for technology predictions,

Evaluation of the practical systems which are in place and are being utilised, led to a few significant observations and conslusions. The investigation was by no means exhaustive, but was aimed at getting an overview of the corporate and business systems as they operate within the stated strategic frameworks.

It is conluded that technology planning and control systems are well-developed, highly integrated and applied in a top-down fashion. Not all aspects are conducted as efficiently as should be possible. Also, due to the dynamic nature of the industry, effectiveness can still improve for the company.

Moves are afoot to meet new challenges and requirements and there is no doubt that the future will see great achievements.

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SECTION 1

I N T R O D U C T I O N

THE REAL PROBLEM

There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things, because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new.

Machiavelli,
The Prince

SECTION 1 - INTRODUCTION

1.1 BACKGROUND

Technology management has become of high importance worldwide, and especially so in South Africa. The impact of the technology sector on the economy, on growth and prosperity has become important in any developing country which aspires to achieve developed status.

In the RSA, the attainment of this goal has been thwarted by factors such as major disinvestments when there should be investments in the country, economic and other sanctions when there should be technology transfer and sharing of resources and knowledge, and the low rand-dollar exchange rates when capital equipment has to be bought and imported, (HUM RES MAN: 1989: 11)

1.2 PURPOSE OF THE STUDY

In the business which was the subject of this study, technology in all its facets is of particularly high importance. (SALVO: No.2; 1989) It discusses, amongst others, the introduction in 1989 of a White Paper in Parliament, entitled: "Industrial Development Strategy for the Republic of South Africa". The focus of the paper was on the greater role of the manufacturing industry in the promotion of economic growth.

South Africa wishes to achieve:

- economic growth through industrial development
- productivity improvement
- international competitiveness
- breaking of international isolation.

To do this, the RSA will have to determine:

a) a good blend of high and low technology
b) balance between incremental and quantum innovation
c) the optimum of high and low risk research and development (R & D) programmes.

For a business to make a worthwhile contribution towards achievement of these goals in its industry, will require a careful scrutiny of its technology planning and control systems. The impact of technology on the RSA economy is also described by CLARKE (1988: 13).

He emphasizes the role of a few factors in the international technological environment on scenario planning for future development in this country. These factors are:

- the globalization of markets
- the high rate of technological change
- the generation of wealth through creation of opportunities.

It follows that technology is one of the key elements in the Governments strategy to promote industrial development.

1.3 SCOPE OF THE INVESTIGATION

The evaluation will revolve around the stated missions and strategies of a major local armaments corporation and one of its subsidiaries in the high-technology engineering industry. However, these statements will only provide the basic framework within which the planning and control systems will be assessed. Scope will be kept as wide as possible to describe the whole field of endeavour in the applicable technologies. Some of the main constraints of the study are:

- the sensitive nature of the business in general
- the diverse nature of the products and technologies
- diverging approaches to technology management
- the lack of detailed information in all respects of the field of interest.

As a result, the study will be more a wholistic view into the planning and control systems, rather than an intensive analysis to identify the detailed planning and control procedures and execution of prescriptions.

1.4 METHODOLOGY

The study has as its main purpose to investigate some aspects of technology management in the South African armaments industry. It will take the form of an empirical evaluation of the current situation in a local compeny, a comparison with the relevant theory, and some recommendations about future requirements. The emphasis will be placed on the planning and control systems required in an engineering business to ensure that technology development is accorded adequate attention.

1.5 OBJECTIVES TO BE ACHIEVED IN THIS STUDY

The main objectives may be described as follows:

a) To achieve a reasonable understanding of the technology planning system as it is used at present
b) To identify recent models that could be adapted to the planning, forecasting and controlling of technology development needed in the industry applicable
c) To evaluate and comment on the existing status quo
d) To appraise the present and future technology management systems.

1.6 STRUCTURE OF THE SCRIPT

Section 1 - Introduction

Provides a general overview of the problem statement, an introduction into the situation and nature of the investigation, and the methodology to be adopted to execute the study. In addition, the scope and limitations are indicated and the objectives stated.

Section 2 - Theoretical Framework

In this part of the report, a brief description of the relevant and applicable theoretical principles will be given. The emphasis will be on a discussion of planning and control systems and models, methods used for technology forecasting, application of such models, and factors that affect the systems chosen for technology management.

This section will also describe the integration of a specific planning and control system into the overall company business strategy.

Section 3 - Empirical Study and Analysis

In this section the actual situation found in a particular industry and company is described.

This section will comprise a description of business and industry background, the importance and role of technology to the business activities, and planning models followed.

A discussion of organisation structures is included, as well as the current business strategy followed. Lastly, it is deemed appropriate that brief notes be given about the integration of the Research and Development (R & D) functions, and the role of Project Management be given.

Section 4 - Comparison of Empirical Information and Theory

Critique will be expressed about theories, models, and systems. Then, the existing actual system will be discussed.

Section 5 - Summary

The summary to provide an overview of the complete report, the conclusions drawn, and recommendations made. Further, comments will be included on the value of the study, existing advantages and disadvantages, and outstanding matters.

SECTION 2

THEORETICAL FRAMEWORK

PROPOSALS TO START NEW DEVELOPMENT PROGRAMS SHOULD RECEIVE INTENSE SCRUTINY, INCLUDING VERIFICATION THAT THE NEED IS VALID AND THAT THE COST OF THE PROPOSED SOLUTION IS COMMENSURATE WITH THE BENEFITS IT OFFERS. WITHOUT CLEAR EVIDENCE OF SIGNIFICANT PAYOFF, THE PROGRAM SHOULD NOT BE STARTED. THE OBEJCTIVE IS TO SEE HOW MANY GOOD PROGRAMS CAN BE COMPLETED, NOT HOW MANY PROGRAMS CAN BE STARTED.

SECTION 2 - THEORETICAL FRAMEWORK

2.1 INTRODUCTION

In most (profit-seeking) organisations the corporate, business, functional and operational plans are ultimately converted into financial plans, or budgets, (SCHUTTE: 1981: 83 and VAN DEN BERG: 1989). The main reason for this practice is that all business operations can be converted to, or described in, financial terms. It is therefore more convenient to all managers to compare different aspects of the business in terms of a common denominator. However, this practice has its limitations as is often found in budget control discussions. When budget deviations are analysed, it is essential that the underlying calculations are done in the proper applicable units, and then only expressed in monetary values.

As an example, one may expect that the planning of the development and establishment of some new technology, say a new type of steel, cannot be done adequately in terms of Rand values alone. The success of the technology transfer will have to be measured in terms of technical performance. Such a standard or yardstick will be decided upon beforehand (SCHUTTE: 1981: p118-121).

The subject of this section is to define and describe the theoretical framework for the planning and control system; as

- firstly: it may apply to an engineering business, and

- secondly: adapted for technology management in particular.

2.2 INTEGRATED PLANNING AND CONTROL SYSTEMS

2.2.1 Planning Systems

VAN DEN BERG: (1989) has the following to say about integrated planning systems.

"The dynamic and rapidly changing environment in which firms are presently managed, necessitates a well-integrated corporate planning and control system. Although today most firms do apply strategic as well as operations planning, the practical problem is to combine these different types of planning in an integrated system .... The most important practical problem, however, is to have a reference framework according to which integrated systems may be developed and each unique situation may be dealt with."

Planning may be described as an analytical process which involves an assessment of the future, and the determination of desired objectives in the context of that future. It is also the development of alternative courses of action to achieve such objectives, and the selection of one course of action among alternatives. (ANTHONY: 1965: p24). It is important to distinguish between the various levels and phases usually found in the planning process in an enterprise. ALLEN (1982: 59) observed that: "From experience of companies that have developed effective planning structures, it is clear that an orderly, logical framework offers many advantages."

An interactive planning cycle according to ACKOFF (1981:74) is divisible into five phases:

- formulating the mess
- ends planning
- means planning
- resource planning
- design of implementation and control.

He describes an intricate planning cycle which incorporates various levels of planning activities and contingencies.

In this regard (SCHUTTE: 1989: p54) describes the planning process as shown in this block diagram:

PURPOSE OBJECTIVES: - mission - profits - growth	Guides strategic planning
↓	
STRATEGIC PLANNING: - purpose objectives - critical assumptions - strategic guidelines - targets	Guides business planning
↓	
BUSINESS PLANNING : - reflects a series of operational objectives - strategic guidelines - targets	Guides operations (i.e. management control and operations control)

The items listed in the blocks are the components of a strategic plan. As indicated in the diagram, there are essentially two planning processes, viz. strategic planning (SP) and business planning (BP).

There are three outputs from these processes, namely:

- a strategic plan (from SP)
- a long-range plan (from both SP and BP)
- a short term plan and budget (from both SP and BP)

2.2.2 Planning System Models

The first model to be discussed is presented by SCHUTTE (1981:p58). It describes the strategic planning process as comprising SIX steps:

- formulate purpose objectives
- identify the organisation's strategic profile (which specifies the critical external success variables)
- list the assumptions about the critical variables
- identify issues (opportunities and threats) and appropriate strategies
- synthesize the strategic guidelines ("what to be done") and targets that flow from the analysis of issues and the development of alternative strategies
- compile action plans ("how to be done") to implement strategic plans.

This process can be presented as follows:

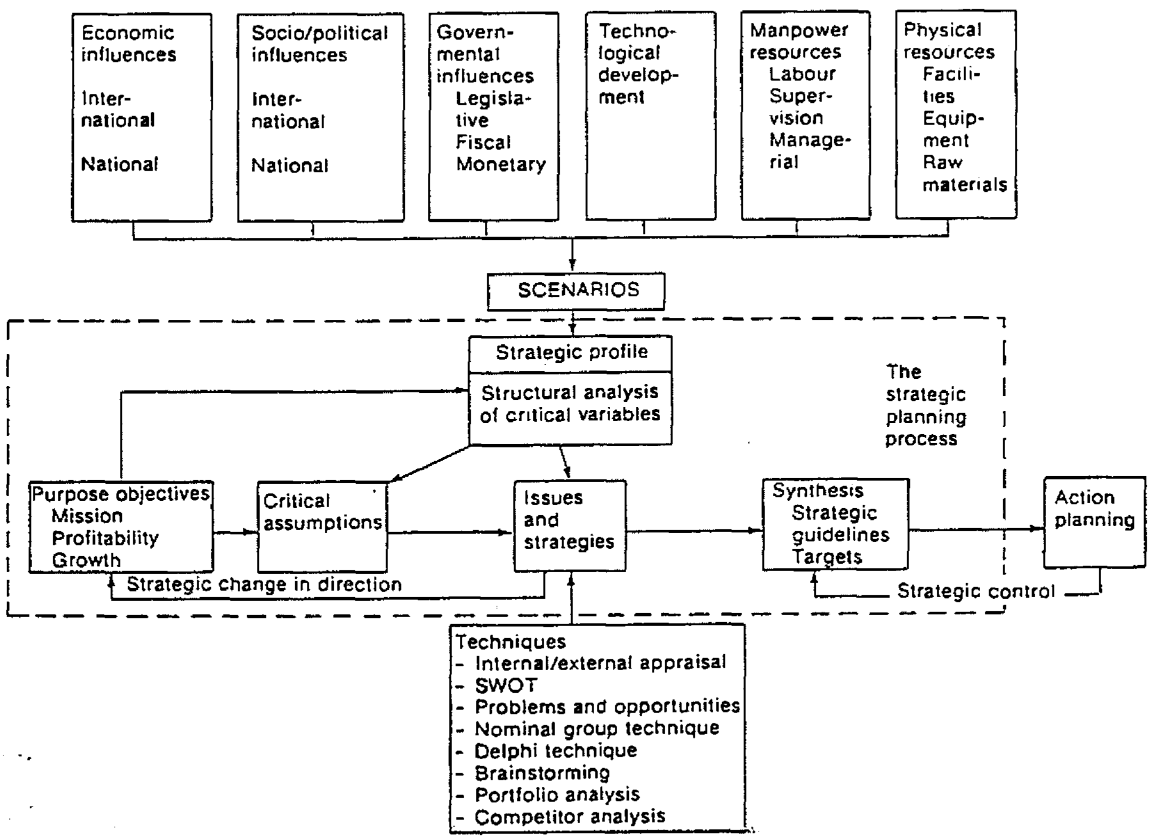


FIGURE 1 : THE STRATEGIC PLANNING PROCESS (SCHUTTE: 1989: 58)

The strategic plan, strategic guidelines, and targets are essential prerequisites to business planning. SCHUTTE (1981: p68) describes EIGHT steps of the business planning process:

- get inputs from the strategic planning
- compile specific assemptions
- do SWOT analyses
- do mechanistic forecasts (FOO)
- draw up an analytical forecast (FO)
- compile action plans (Fps)
- compile a bridge-of-gap performance statement
- generate the outputs of business planning: short term plans and budgets

The following model is proposed:

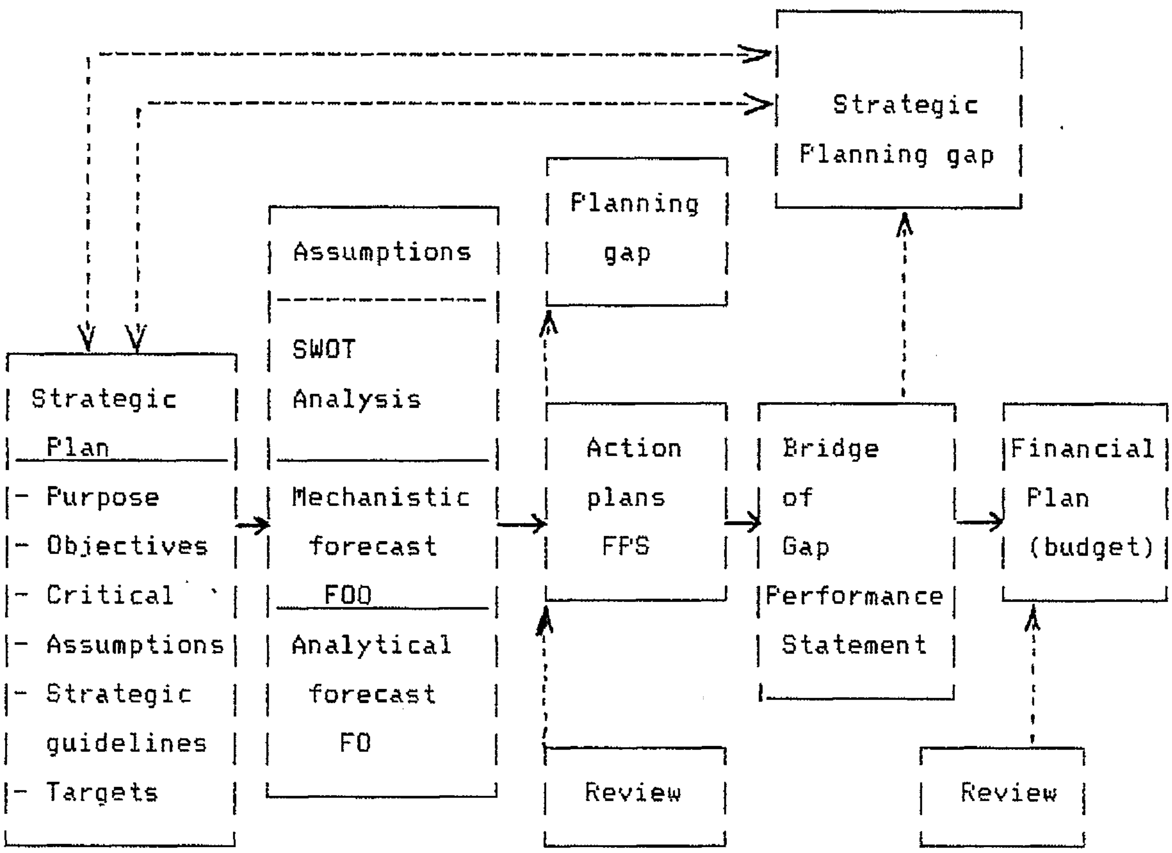


FIGURE 2 : THE BUSINESS PLANNING PROCESS (SCHUTTE: 1989: 85)

The ultimate goal of the above planning processes is to arrive at a planning gap and to conduct the concomitant gap analysis. Such a gap between the objective result and the planned result is determined in two positions of the model in Figure 2. A review is done and if a gap is found, the prerequisite action plans are compiled to close or reduce the gap. The second review takes place when the financial plan is put together. This gap is called the strategic planning gap and shows the deviation from corporate/strategic goals. Review sessions at any stage involve higher level managers than the level at which the planning is done.

2.2.3 Design of Planning Systems

The events in the planning process may be grouped into phases, which are in turn linked by a sequence of hierarchical review sessions. Each of these events implies actions which have to be undertaken by managers who are separated functionally, hierarchically, geographically and organisationally.

The design of a planning system is therefore (SCHUTTE: 1981: 91) dictated by:

- the extent of organisational decentralisation
- the functional, hierarchical and geographical spread of managers
- the manner in which the events are grouped into phases
- the manner in which the phases are linked by the sequencing of review sessions.

It is vitally important, however, to integrate strategy planning into the total business planning process, and to identify the interfaces required for gap analysis, the setting of priorities, recycling of planning processes at business unit levels, and for the review of all plans generated.

SCHUTTE (1981: p95) identifies three classes of organisations recognised in planning systems design. The most general model is the so-called: class three organisation - four level heterogeneous return-risk model. It can be simplified to one of the others. In this type of organisation the strategic planning deals with issues such as: product / market scope, expansion and diversification. Different divisions exhibit different return-risk characteristics, and thus require different purpose objectives. Each division develops its own strategic plans. The increase in interfaces leads to the incorporation of three levels of review sessions.

VAN DEN BERG (1989) emphasizes the difference between strategic planning and corporate planning. The latter term includes both strategic and operational planning.

Figure 3 illustrates the planning system model, according to SCHUTTE.

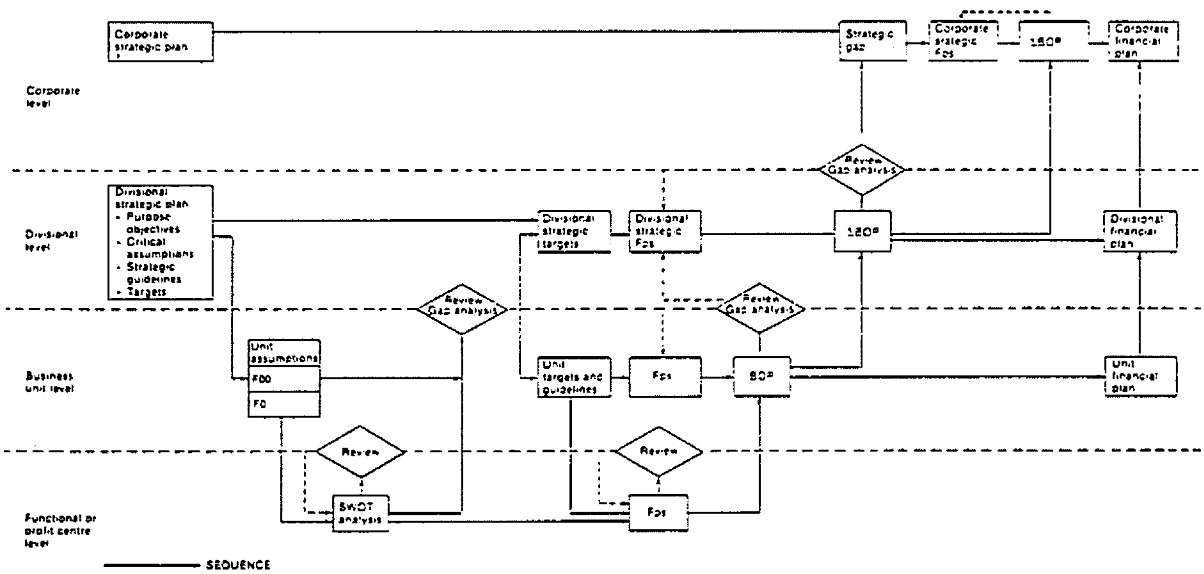


FIGURE 3 : FOUR-LEVEL PLANNING SYSTEM FLOW-CHART

(SCHUTTE: 1981: 99)

Strategic planning is described as that process from which any change in the domain of the firm initiates. It therefore involves the stream of decisions aimed at connecting the firm's inputs and outputs to the demands of the present and future environment. As a result, it includes changes to:

- mission, profitability and growth objectives
- products, market and technological scope
- policies regarding availability, allocation and application of resources.

Operational planning may be defined as the effective acquisition and utilisation of resources.

2.2.4 Framework for integrated planning systems

A framework has been proposed for the design of integrated corporate planning systems. This proposal includes the so-called five PLATO elements; (i.e. process, linkages, administration, time-related decisions, outputs), VAN DEN BERG (1989).

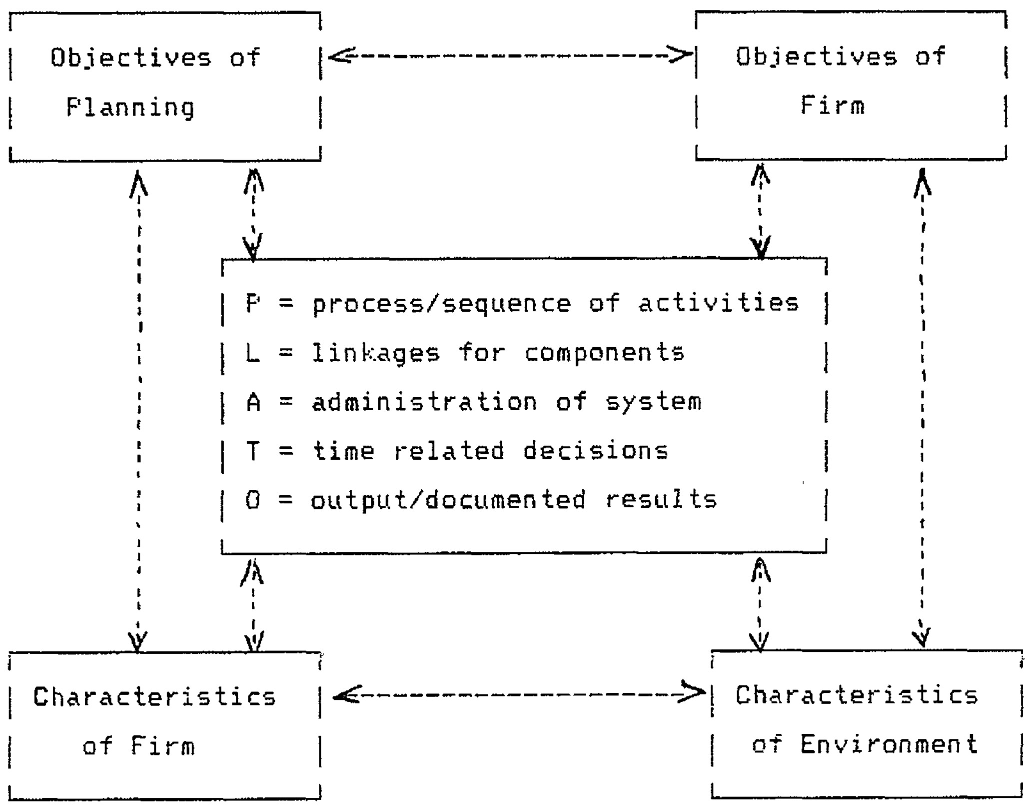


FIGURE 4 : DESIGN FRAMEWORK FOR INTEGRATED CORPORATE PLANNING SYSTEMS (VAN DEN BERG: 1989)

The development of integrated management systems consists of two phases (VAN DEN BERG: 1989):

a) Phase 1 : Analysis

- Training of all personnel
- Analysis of : job-descriptions
  : key performance areas (KPA's)
  : yardsticks
- Compile or revise the organisation structure, using the KPA organisation chart as a basis.

b) Phase 2 : Implementation

- Development of a performance improvement system:
  : performance reviews (appraisal procedures)
  : definition of input elements for appraisals

- Definition of the information systems model:
  : identification of information requirements for management and operating levels

- Development of a management planning framework:
  : reward system
  : management development
  : succession planning.

2.2.5 Control Systems

Control is the dynamic process of managing toward the achievement of an organisation's objectives.

2.2.5.1 Factors influencing the process of control

FIVE factors have a major effect on the strategic control process. They are:

- Environment : organisation is influenced by social, economical, political and technological change at national and international level.

- Uncertainty : is high due to instability in the environment, and competitive action around achievement of purpose objectives.

- Focus : management have to employ a broad focus at strategic level. To achieve operating standards requires narrow focus.

- Impact cycle : of decisions is very long to achieve purpose objectives. Very few of such decisions are not of a strategic nature. Results at that level are only visible in the long term.

- Organisational impact : impact of strategic decisions aimed at achieving purpose objectives is unavoidably high. A good decision will have favourable impact, whilst a poor decision could be disastrous.

2.2.5.2 Control process and system characteristics

It is vitally important that the structure of the control systems direct attention to those issues which are important from the organisation's point of view. They should take account of the type of universe in which a particular manager functions. The processes of control therefore relate to strategic control aimed at achieving purpose objectives of the organisation, management control aimed at achieving short-term organisational performance, and operational control aimed at performing to standards.

TABLE 1 : CHARACTERISTICS OF CONTROL PROCESSES AND RELATED SYSTEMS (SCHUTTE: 1981: 107)

Characteristic	Strategic and management control	Operational control
Common	* Supports individual, managerial positions * Supports key performance areas of thoss positions * Acts as one of the triggers for action	
Unique	- Uses predictive control - Uses updated forecasts - Has a broad focus - Triggers entrepreneurial plans - Ability to replan - Review of plans	- Uses feedback control - Uses variances from standard - Has a narrow focus - Triggers corrective action - Ability to meet standards - Exception reporting

2.2.5.3 Operational Control Systems

Operational control is the process of ensuing that specific tasks are carried out efficiently. A high degree of stability is created by buffering the physical operational system from the uncertainties of the environment, by any of a number of means.

2.2.5.4 Management Control Systems

Management control is the process of ensuring that the organisation's resources are acquired and utilised effectively. The process takes place within the strategic quidelines provided by top management. Management control is aimed at effectiveness. It is executed in an ever-changing environment characterised by a high degree of instability, and uncertainty, and risk. The process is predictive in the sense that plans are developed and decisions taken on the strength of a predicted future environment.

2.2.5.5 Financial Budgets

A financial budget is the end result of planning, which is a complicated statistical, analytical and intellectual process. It consists of three steps:

- mechanistic forecast;
- analytical forecast,
- action plans

which are carried out sequentially.

If financial budgets are to lead to innovative extrepreneurial decision making, a structure has to be developed which will change the management culture and eliminate problems. A financial budget is merely a forecast of the financial outcome of future operations based on certain assumptions and predictions.

The traditional budget variance reporting system can be transformed into a management control system, through the incorporation of a process of replanning on a monthly basis.

2.2.5.6 MANAGEMENT INFORMATION SYSTEMS

The design of management information systems (MIS) involves formalising and structuring of planning and control systems aimed at triggering managerial decisions. Such systems are aimed at either:

- operational control for efficient performance of tasks, or
- management planning and control for effective utilisation of resources.

A prerequisite to the development of both MIS and planning and control systems is the clear definition of the information requirements by each managerial position. So the importance and role of the key performance area (KPA) analysis is underlined. Most of the information required to support the philosophy is already available within the organisation.

MIS are in fact the end product of planning and control systems. Thus the reports generated in the planning and control systems must represent the management information systems within the organisation.

2.3 IMPLEMENTING STRATEGY

Control is in essence the monitoring and correcting of activities and results. As such it implies implementation of strategy and plans. It follows that implementation forms an essential element of the establishment of integrated management systems.

2.3.1 A Model for Strategy Implementation

Implementation of strategy tends to be placed secondly to formulation. Clearly, identifying attractive opportunities and setting the right strategic direction, do not, by themselves, guarantee success. It has been demonstrated repeatedly that successful performance occurs when an appropriate strategy is implemented through the effective rationalisation of the basic elements that make up and drive an organisation (STONICH: 1982: xvi). These elements are defined as:

* strategy formulation
* organisation structure
* human resources
* management processes, and
* corporate culture.

An organisation will move most effectively toward its declared objectives when all of its complex elements are synchromised. The following model is proposed by GTONICH: 1982: xvii) to:

"......(show) the concerted interactions and the interactive process that must occur for an organisation to succeed in today's business environment".

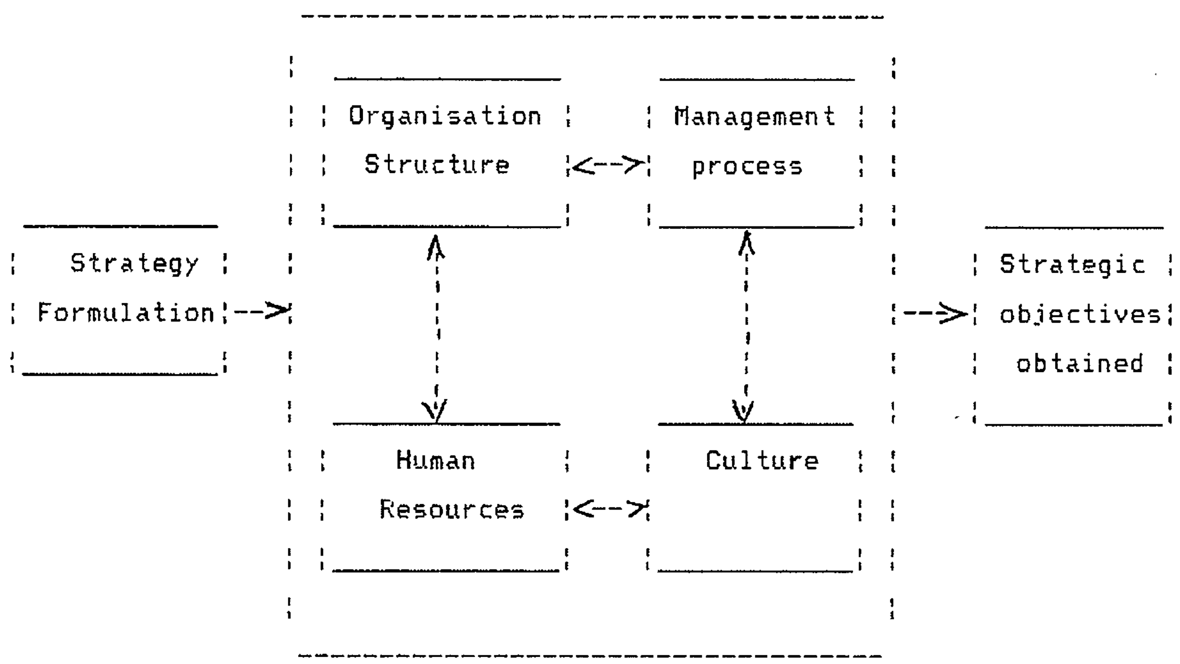


FIGURE 5 : MODEL FOR IMPLEMENTATION OF STRATEGY
(STONICH: 1982: 1)

Corporate management's task is not only to ensure that good business strategies are developed, but also to decide how all the business unit strategies fit together in a corporate strategy. A concept well worth considering at both corporate and company level is that of strategic alliance formation. High-technology businesses are increasingly entering into such agreements, because of:

".... the rapid pace of technological development and innovation and the increasingly high costs of the associated research and development...." (DEVLIN and BLEACKLY: 1988: 18).

The budget is the tool used to translate all strategic thinking and planning into action. It provides the link between programming and the performance of a company's tasks. Budgeting provides the data necessary for the measurement and control of functions and activities. Priorities can change as a result of a changed environment; hence the budget must be flexible enough to allow resultant changes in spending plans. In addition, the budget process provides a means to measure, reward, and control.

Effective systems also motivate the organisation's people to work toward the overall objectives established during strategy formulation and being articulated through the planning, programming, and budgeting processes.

2.4 INTEGRATION OF THE FUNCTIONAL SYSTEM WITH OVERALL STRATEGY

2.4.1 Introduction

In this section the intention is to give a reader some indication of the importance of innovation, research and development (R and D), and change in the technological sector. Also, to provide some indication of the role of various organisational functions in innovation, development and technological growth. Of course, all and any of the above can only be executed effectively within the framework created by the particular business strategy of the firm applicable.

TUSHMAN & MOORE (1982: p7) present convincing arguments why the USA economy has declined, as a result of a decline in technology innovations and development investments. During the past 10 - 20 years the other countries have taken the lead from the USA in various sectors and have closed the overall gaps significantly, especially West Germany and Japan. This is confirmed by SUNDARAM: 1989: 387 - EDITORIAL ARTICLE).

HAYES & ABERNATHY (In Tushman & Moore: 1982: 11) describe in similar vein how the American management philosophy of:

- short term: using existing assets as efficiently as possible
- medium term: replacing labour and other scarce resources with capital equipment
- long term: developing new products and processes that open new markets or re-structure old ones;

has been allowed to deteriorate. They state:

"In our judgement, the assumptions underlying these questions are prime evidence of a broad managerial failure - a failure of both vision and leadership - that over time has eroded both the inclination and the capacity of US companies to innovate."

These statements illustrate the importance of technological developments and continual investment in this sphere.

2.4.2 The role of different organisational functions in innovation

The problem in developing and commercialising new products and processes does not typically arise from a lack of usable technology, but more commonly is due to marketing and organisational pathologies. Further, if one considers the entire stream of innovations that is required for longer term success, strategic and organisational issues play a dominant role in the success or failure of a business unit.

The development of an innovation from the idea - generation phase through to introduction and commercialisation is inherently an interfunctional process. Successful new products or processes require close cooperation between the functional areas of marketing, manufacturing, and R & D, under the guidance of senior management.

A market is not limited to those people who are interested only in technological innovation and high technology products. Instead, the principles apply to a wide range of situations including industrial and consumer products, high and low technology, short and long product life cycles, and major corporations and small firms.

FORD (1988: 85) describes Technology Strategy as that aspect of strategy which is concerned with exploiting, developing, and maintaining the sum total of the company's knowledge and abilities.

HAYES & ABERNATHY (In TUSHMAN & MOORE: 1982: 16) ascribe the change in U.S.A. management approach to three major categories:

1. financial control: tendency to create profit centers.

2. corporate portfolio management: creation of a cluster of companies and products under the guise of diversification.

3. <u>market-driven behaviour</u>: situation develops where consumer analyses and market surveys dominate other considerations when allocating resources to product development.

Until about twenty years ago most firms were production-driven. This orientation was largely replaced by firms that became product-driven or market-driven. Most recently, in some sectors the tendency is to become technology-driven (ANSOFF: 1987: 28).

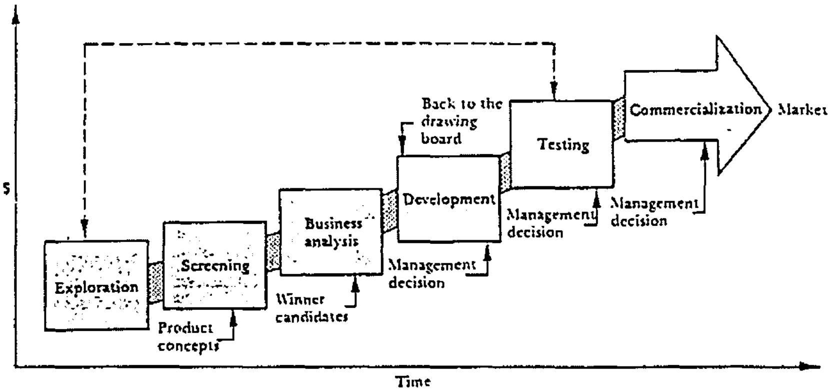
SOMMERS (In: TUSHMAN & MOORE: 1982: 51) describes new approaches for product development in the 1980's. He says about change in product development over the previous 10 years:

Change becomes apparent when we look at what is new in product development in these terms:

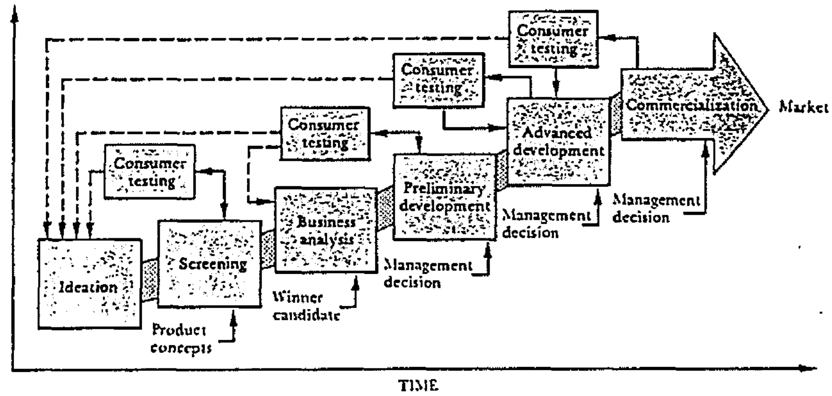
- the environment: economy, demographic factors, markets, and regulations
- management's outlook for product development
- the difference between product development 10 years ago and in the next decade
- significant trends in technologies affecting new products."

SOMMERS also describes THREE models to show the evolution of the product development process.

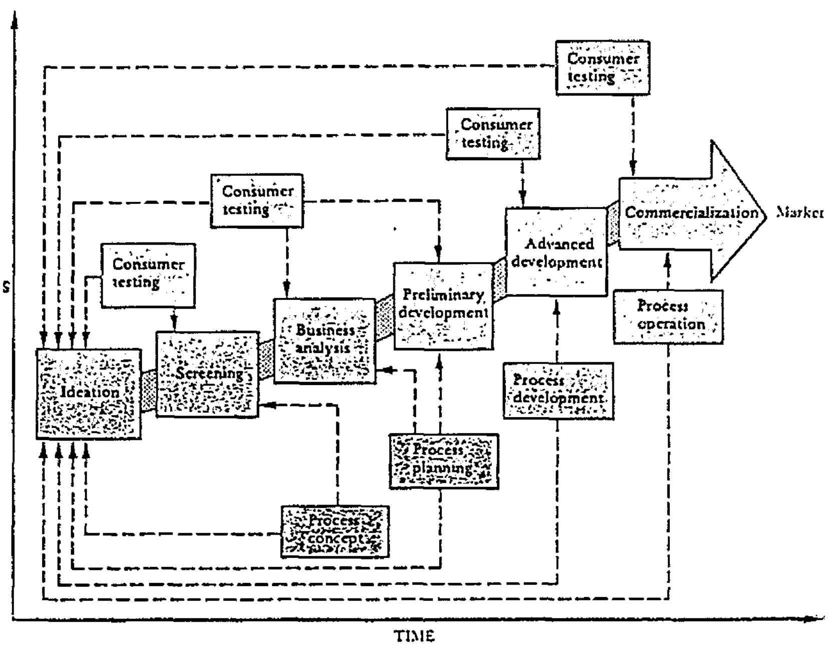
The <u>six</u> basic stages remained the same from the 1970's to the 1980's: exploration, screening, ..., commercialisation. One difference (improvement) was that there was a consumer test of the product at every stage of the development cycle. The second difference that took place was that process planning was also done during every stage of development to ensure that manufacturing capabilities were upgraded.



New Product Development Circa 1970



New Product Management Circa 1980



New Product Management Circa 1980—With Concurrent Process Development

FIGURE 6 : PRODUCT DEVELOPMENT MODEL (TUSHMAN & MOORE, 1982, 55)

The following trends were listed as the most likely occurrences for the future (SOMMERS: In TUSHMAN & MOORE: 1982: 57):

1. product development more costly
2. earlier testing for safety & reliability
3. consumer more involved in defining product concepts
4. marginal products screened out
5. market-evaluation techniques more widely used
6. tighter product specifications prior to commitments
7. more emphasis on manufacturing process
8. greater success in commercialisation if early phases done well
9. creativity directed more toward market needs
10. focus more on greater profits from development.

In order to improve the success rates of product and process developments, QUINN and MEULLER (In: TUSHMAN & MOORE: 1982: 60) state that a variety of organisations have been used to ensure that technology transfer takes place successfully. Examples are:

- task-force groups
- corporate development units
- outside companies
- staff groups at corporate level
- multi-functional research group with special budget
- individual researchers who entrepreneur their ideas through pilot facilities into the market
- multi-level committee responsibility
- entrepreneurial group at corporate level.

2.4.3 New Product Planning

During the past decade there has been growing recognition that the product planning function within diversified companies involves trade-offs among competing opportunities and strategies. Management cannot afford to avoid all opportunities for change and attempt to survive simply by doing a better job with the established products and services. Eventually all product categories become saturated or threatened by substitutes, and diversification becomes essential to survival.

DAY (In: TUSHMAN & MOORE: 1982: 255) describes the process of strategic product planning along the lines of the theories expounded in earlier sections. He summarises the list of activities in the form of a model, which is reproduced here.

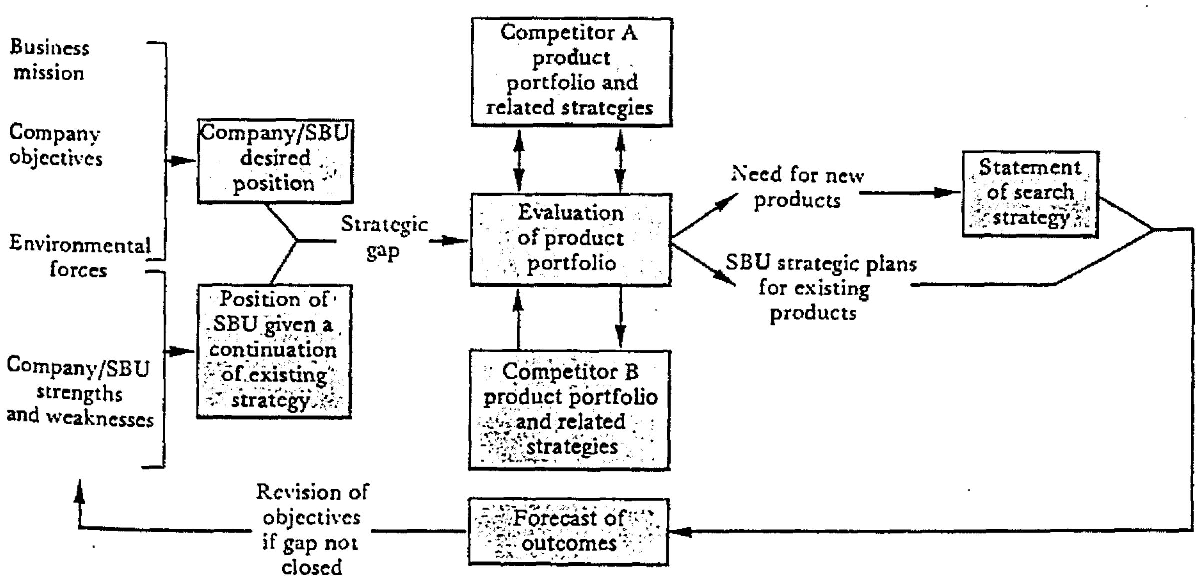


FIGURE 7 : PRODUCT PLANNING ACTIVITIES IN THE STRATEGIC PLANNING OF PRODUCTS (TUSHMAN & MOORE: 1982: 255)

He states that: "(what is) lacking in the planning process (just described) is a systematic procedure for generating and choosing strategic alternatives .... Too frequently top management sees only one strategy which the SBU has decided is best ......". To overcome this deficiency, he includes an analysis of the product portfolio in his model.

A product portfolio analysis identifies the need for new products or new markets and the probable level of available resources, but does not indicate where to look. Top management must decide how much growth is desired and feasible, the contribution of new versus established products and the broad direction as to how the growth will be achieved.

In figure 8 the possible new product strategies are illustrated.

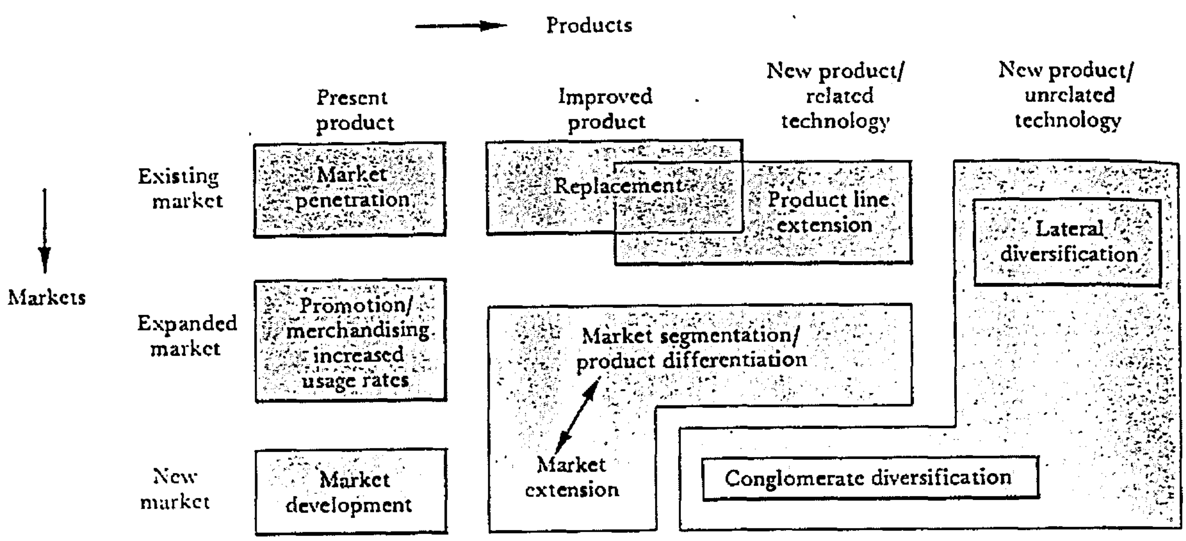


FIGURE 8 : GROWTH VECTOR ALTERNATIVES (TUSHMAN & MOORE (TUSHMAN & MOORE: 1982: 268)

The choice of growth vector will be influenced by all the factors that are part of the overall corporate planning process. Underlying any choice is an appraisal of risks compared with payoffs. Experience shows that growth into existing markets is much more likely to be successful than ventures into new markets. Therefore, diversification is the riskiest vector to follow - especially if it is attempted by means of internal development.

2.4.4 Corporate Strategy and Technology Policy

Technology is a vital force in the competitive environment of the modern firm. This is especially so in the technology intensive industries such as aerospace, computers, chemicals, electronics, and pharmaceuticals. What are needed are ways to eliminate the fundamental technological choices from the rest; i.e. the technological policy of the firm. Such a framework can aid firms to develop a well-defined, coherent posture toward technology and to facilitate and encourage execution by integrating technology with business planning MAIDIQUE and PATCH (In, TUSHMAN & MOORE: 1981: 274).
Such a framework is presented in the following diagram:

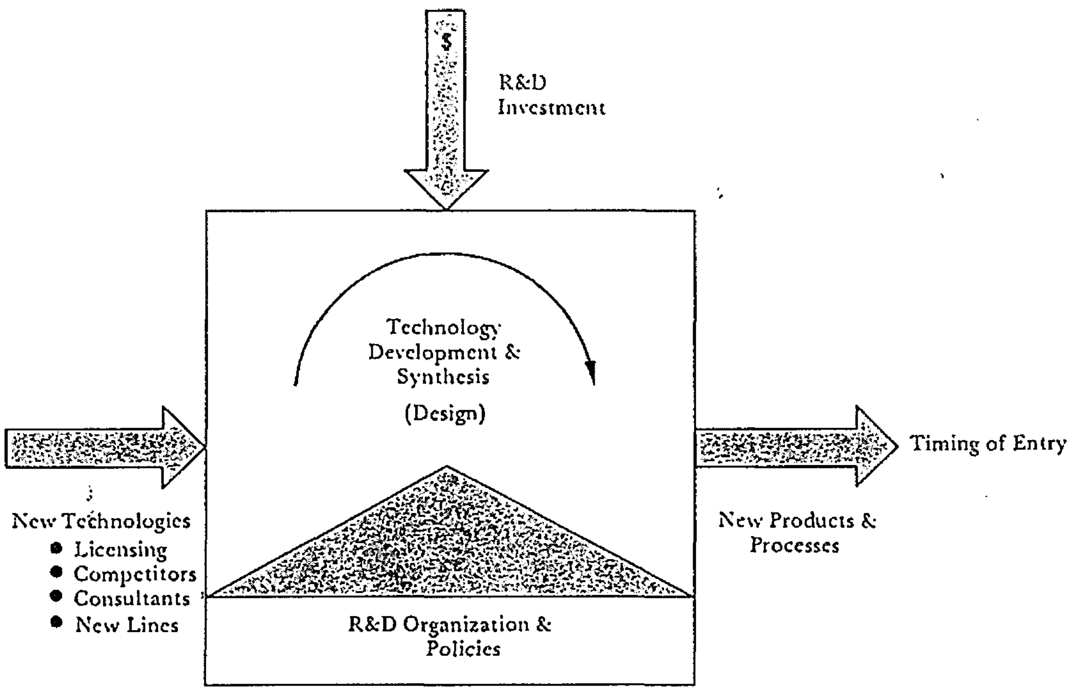


FIGURE 9 : FRAMEWORK FOR TECHNOLOGY POLICY
(TUSHMAN & MOORE: 1982: 275)

Functional requirements of alternative technological strategies are summarised in the following table:

Typical Functional Requirements of Alternative Technological Strategies

	R & D	Manufacturing	Marketing	Finance	Organization	Timing
t-to-Market	Requires state of the art R & D	Emphasis on pilot and medium-scale manufacturing	Emphasis on stimulating primary demand	Requires access to risk capital	Emphasis on flexibility over efficiency; encourage risk taking	Early-entry inaugurates the product life cycle
Second-Market	Requires flexible, responsive and advanced R & D capability	Requires agility in setting up manufacturing medium scale	Must differentiate the product; stimulate secondary demand	Requires rapid commitment of medium to large quantities of capital	Combine elements of flexibility and efficiency	Entry early in growth stage
Late-to-Market or Cost Minimization	Requires skill in process development and cost effective product	Requires efficiency and automation for large-scale production	Must minimize selling and distribution costs	Requires access to capital in large amounts	Emphasis on efficiency and hierarchical control; procedures rigidly enforced	Entry during late growth or early maturity
Market-Segmentation	Requires ability in applications, custom engineering, and advanced product design	Requires flexibility on short- to medium runs	Must identify and reach favorable segments	Requires access to capital in medium or large amounts	Flexibility and control required in serving different customers' requirements	Entry during growth stage

TABLE 2 : CORPORATE STRATEGY AND TECHNOLOGY STRATEGY

(TUSHMAN & MOORE: 1982: 279)

GLUCK and FOSTER (In: TUSHMAN & MOORE: 1982: 297) describes a model to demonstrate the way the top management would manage a technological project.

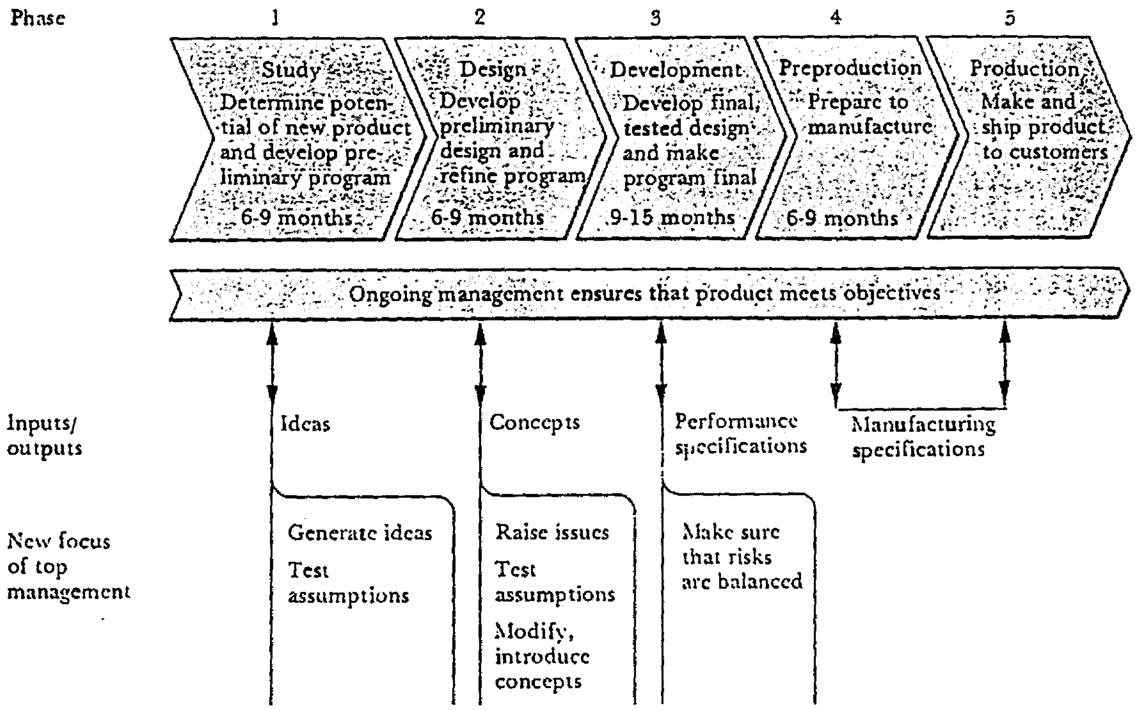


FIGURE 10 : TOP MANAGEMENT MONITORING OF PROJECT (TUSHMAN & MOORE: 1982: 297

2.4.5 Managing and Integrating Functional Areas

A continuing stream of successful innovations requires the coordinated efforts of effective research, development and engineering, marketing and manufacturing functions. New product productions are vital to the growth of corporate revenues in both the manufacturing and service industries PESSEMIER & ROOT (In: TUSHMAN & MOORE: 1982: 383). Managers must face the fact that new products are essential to the continued growth in revenues and profits, but that they are also expensive and very risky.

It is clear that the interaction between the Marketing and R and D functions is very important. Because of vastly different priorities and approaches to market and product development, the managing of relations between these two functional areas is highly important (SOUDER: 1988: 6).

Probably the most frequently mentioned aspect of the innovation process is the tremendous risk involved, as reflected by the high rate of market failures and the cost of a debacle.
TAUBER: (In: TUSHMAN & MOORE: 1982: 432)

The role of the manufacturing sector is explained by SKINNER (In: TUSHMAN & MOORE: 1982: 439), in his description of the focused factory concept. The focused factory has FIVE key characteristics:

1) process technologies - a new unproven technology is limited to one at a time per factory
2) market demands - aspects like quality, price, lead times, and reliability are applicable
3) product volumes - are at comparable levels
4) quality levels - these employ a common attitude and set of approaches
5) manufacturing tools - limited to only one at a time.

A new management approach is needed in industries where diverse products and markets require companies to manufacture a broad mix of items, volumes, specifications, and customer demand patterns. One way to compete is to focus the entire manufacturing system on a limited task defined by the competitive strategy.

2.5 TECHNOLOGY FORECASTING

2.5.1 Introduction

Technology forecasting (TF), is done by various techniques to predict in quantifiable terms the direction, character, rate, implication, and impact of technical advance. TF techniques are based on the logical treatment of credible data and should produce results that are both informative and independent of the analyst performing the forecast. They are primarily concerned with providing information to managers for better decision making, (VANSTON: 1984: 1). The monetary value of technological innovation is useful in determining appropriate support levels, in formulating licensing strategies, in identifying special technical opportunities and to determine the effectiveness of research and development.

Three of the most-asked questions may be:

- How soon and at what cost can the technology be commercialized or made operational?
- What is the size of the market for the technology and what is the schedule of market take-over?
- How will the profitability of the technology be affected by competing new technologies or by non-technical factors?

2.5.2 Identification and Evaluation of new opportunities

Continued success requires keeping abreast of new products and processes. In this way an organisation may identify new business opportunities, new competitive advantages, or new threats to its markets. VISSER (1989: 4) describes some of the challenges facing South Africa in the export market, due to European common market change in 1992.

Sometimes an organisation is interested in new technologies that might change/improve the internal operations of the organisation itself. In most cases of this type, the organisation may find that suppliers are prepared to provide it with a great deal of information about technical developments which they are marketing. In such situations, TF may be useful in evaluating present and potential capability of the product offered, assessing probable displacement by a more advanced product, determining the most effective use of the new technology, identifying support equipment and personnel requirements, and in timing technology purchases and licensing.

A very important aspect of the whole forecasting-planning process is described by HOLT (1988: 249). This is the close interaction with users in product innovation and identification of user needs. It has been stated (WHEELER and SHELLY: 1988: 36) that forecasts of high-technology products have exceeded actual sales by up to 50%, with often disastrous results to the business. They describe methods to prevent this from happening. BRIGHT (1972: 1-4) discussed the merits of formal forecasting methods. He made the following comment about expert opinion per se:

"The use of an expert's opinion may be very logical, but is becoming an increasingly dubious procedure. One reason is that the former ability of a competent technical man to assess progress in his special field is disappearing, because of the growing interaction of technologies."

2.5.3 TECHNOLOGY FORECASTING TECHNIQUES

2.5.3.1 Introduction

About 150 techniques are available to forecast technical development (VANSTON: 1984: 13). Of these about 10 to 20 are mostly used. They are usually categorised into four groups, namely: surveillance, projective, normative and integrative techniques. Each of these groups is based on different forecasting principles and involves a different approach to the forecasting task.

2.5.3.2 Surveillance techniques (Three)

These techniques are all essentially passive or observational techniques. They differ in the degree of focus and intensity of the information search effort. Surveillance techniques are founded on two assumptions:

- that most successful innovations follow similar development patterns
- that the time duration from idea initiation to production stage is quite long (a number of years).

For a surveillance system to be successful, it requires a responsive data management system to provide data storage, and to permit simple information input and retrieval.

(a) Scanning

Identify development in technical, economic, social, political, and ecological environments that may materially affect the organisation. It is often desirable to involve the entire organisation in the scanning effort. When this is done an effective system of reporting, evaluation, follow-up, and feedback is necessary to ensure data is efficiently processed.

(b) Monitoring:

More focussed and disciplined type of surveillance effort than scanning. The organisation must have a plan for selecting those developments of most probable impact and for employing resources efficiently. An effective monitoring plan should include five basic elements: select areas to monitor, assign specific monitoring responsibilities, assess where new technologies become significant, define the action required when that happens, review the monitoring program and data basis.

(c) Tracking:

It involves a concentrated effort to follow developments of major significance to the organisation; for example - competitive response to a new product or process, near-term introduction of new products/processes that will threaten present markets, major technical breakthroughs in which the organisation needs to establish position.

2.5.3.3 Projective Techniques (Six)

The projective techniques are based on the theory that, for some period of time, the future will be very much like the past. It assumes that events, trends, and development patterns in the past were shaped by various fundamental driving forces which will not change much or suddenly, and will take cognisance of the expected results of predicted changes.

(a) Technical Trend Extrapolation

Empirical data indicate that when the values of key parameters of technical progress are plotted against time, a regular development pattern can be discerned. Such patterns can be logically extended for some period into the future using key characteristics to the performance of the particular technology. Examples are: cost, life-cycle, supportability, maintenance requirements, and accuracy. Next, appropriate measurement parameters are found, curve-fitting done on past data, and forecasts made regarding R and D goals, progress outside the organisation, and the need for new technical approaches.

(b) Precursor Development

Technical development in one area follows development in other areas in a predictable manner. When such oead-lag relationships exist, it is often possible to forecast developments in the lagging technical area by observing the state of development in the leading one. For such forecasts to be credible, however, a casual relationship must be established between the two technical developments.

(c) Substitution Analysis

When a given technology begins to mature, a new technology will often emerge that can accomplish the required function in a more effective and economic manner. The new technology will often have certain properties that give it special advantages in a small segment of the market. Profits and experience from this market segment will lead to progressive development of the new technology and a greater market share.

Projections can be based on as little as 1% substitution rates. At 20% substitution, projections are normally quite accurate. It is possible to predict substitution that has not yet begun, based on patterns in the industry. By using substitution analysis, one can forecast the market share the new technology will capture over time.

(d) Delphi Surveys

In any ongoing, technically-oriented company, there resides an imposing reservoir of technical talent, experience, and training, e.g. scientists, engineers, and technicians. Contributions from single experts are usually biased and limited by personal experience. Therefore, it is best to gather input from a group. To gain advantage of the capabilities available in a collection of experts, while minimising the limitations imposed by committee dymanics, other methods have been developed; example: DELPHI.

Any predictive Delphi technique should have the following characteristics:

- original input of opinion by expoets
- idea feedback procedures
- a standard display of results, and
- anonimity of participants.

(e) Structured Interviews

The person conducting the survey personally collects data and acts as an intermediary of ideas. All subject introduction techniques, sequence and nature of questions, and discussions procedures, are standardised. The interviewer goes from one participant to the next adding each interview's results to the database for the next interview. This method requires knowledgeable interviewers, and is time-consuming.

(f) Nominal Group Conferencing

Technique designed to improve use of expert opinion. It is most effective when a small group used (5 to 7).

The conference requires five stages:

- moderator explains how it will be conducted, sets the objectives, and presents panel with a problem
- panel members individually list all possible solutions
- each panlist writes one solution on board. Then another cycle, etc. until all solutions listed
- all solutions are discussed and re combined, modified, or sub-divided
- scoring/rating of solutions is done by individual panel members.

2.5.3.4 Normative (Goal-oriented) Forecasting (Four)

It is based on the assumption that future technology development will be driven by future needs. It assumes that, as needs are perceived; funds, facilities, and people will be made available to develop means to satisfy those needs and the value system prevailing at that future time. Other problems may be that:

- there may be many means of satisfying needs
- the needs will outnumber the technical development programms possible

The technique requires three tasks: identify societal needs, identify technologies to satisfy the needs, and select new technologies that will best suit organisational goals, capabilities and competitive status.

(a) Impact Wheel

This technique uses a panel of experts to identify higher order, perhaps non-obvious, impacts and implications of selected decisions or developments. Use of the technique starts with the specification of an event, trend, technical advance, or societal development which one wishes to analyse. The direct consequences of the occurence of this original item are listed and linked to it in the form of the spokes of a wheel around the hub (use ± 7). Next the consequences/implications of the first-order consequences are listed.

(b) Morphological Analysis

In most modern equipment and systems, many subordinate functions are involved in the accomplishment of the overall function. In morphological analysis, the forecaster determines what the major-subordinate functions are, identifies methods currently used to accomplish those functions, identifies alternate means of doing so, and examines different ways of combining the subordinate technologies. In so doing innovation approaches to accomplish the basic functions of the overall system are suggested. They are normally done using a structured format.

(c) Relevance Trees

The organisation must select those technologies which coincide with its objectives and capabilities. The basic principle of this technique is the division of the relevant elements of a decision into increasingly smaller components. Next step is to establish formal criteria to specify the relative importance of each component. Then a numerical rating step is used for each step and combined for the higher level elements/decisions. A breakdown is only practical to three or four levels.

2.5.3.5 Integrative Techniques (Three)

New technologies are often triggered or accelerated by advances in an entirely different technology. Technical advance is also often advanced or deterred by non-technical factors.

Thus, forecasts about future developments of technology must take other technical and non-technical developments into account, and it must specify and evaluate these interrelationships.

(a) Cross Impact Analysis (CI)

Identify all those factors which will significantly affect the technical development being considered, or which will be most affected by the development. These effects might be a change in the probability of an occurrence, the time of its occurence, or the significance of the development. Once all such factors are known, they are arranged in any sequence along the horizontal and vertical axis of a matrix. Each factor on one axis is evaluated against each one on the other axis. Note the nature and extent of the effect/impact in the particular block.

(b) Scenarios

Another method to examine and present the interactions between p[rojections of a number of technical and non-technical factors is to combine them into an integrated description of the future. Such descriptions are called scenarios and present multi-faceted portraits of the future. It allows consideration of numerous, different futures for the organisation. Usually, at least an "optimistic", a "pessimistic", and a "most-likely" scenario are sketched and evaluated.

(c) Mathematical Models

It is beneficial to utilize the power of modern computers to integrate a number of technical and non-technical projections and to take into account the interactions between them. Major models used are in two categories: feedback models and progression models.

Feedback models: they take into account that successor events often result in changes to precursor events. It starts with a network of events and significant interreleationships.

In progression models: feedback causalities are not normally specified; occurence of an event in the model affects only subseuent events.

In both cases starting values are allocated to the various important parameters. When the model is new, the change to the values is monitored. Important factors to consider in the use of models:

- it is expensive and time-consuming to develop
- it is a representation of the system
- updating of data is expensive
- there is a tendency to associate better models with improved precision - this is a false association.

2.6 SUMMARY

In this chapter a summary was given of the most relevant theoretical aspects that are applicable and underlie planning and control systems for technology management in an engineering business. The three broad categories discussed were:

1) principles of planning and control systems
2) innovation and technology development processes, and
3) technology forecasting programs and techniques.

On planning and control systems many models exist, most of which can, to a greater or lesser extent, be tailored to suit the requirements of a situation. The models selected to derive an integrated planning and control system, will be based on those of SCHUTTE and VAN DEN BERG. In essence, control must follow planning, and planning must be adequate to ensure a task or function can be executed properly.

The importance of innovation, and technology development was described. There is general consensus that innovation must be fostered in any business that is reliant upon, or who wishes to follow a strong technology growth strategy. Technology forecasting can be done by any one or more of about twenty quantitative and qualitative forecasting techniques. To implement and execute a Technology Forecasting Program, entails gathering a host of information from all sectors of the business and the environment. Through a selective group of suitable techniques, probably 3 to 5, an integrated planning system can then be provided of processed data on which to base strategic (and other) decision making.

SECTION 3

EMPIRICAL STUDY AND ANALYSIS

3. EMPIRICAL STUDY AND ANALYSIS

3.1 BACKGROUND OF INDUSTRY AND COMPANY

3.1.1 Introduction

The armaments industry worldwide is enormous, and growing. Technologies are developed at a high rate and are implemented as fast as they get established. Arms trade is by nature a highly political issue, but has also become economically essential to many of the participants.

Companies and countries make and use systems which date back to the Second World War, and even earlier. On the other hand it is common to see space age technology being adopted and utilized increasingly in defensive and offensive roles.

South Africa entered the industry rather late. Self-sufficiency was spurred on by the sanctions and embargoes against the Republic of South Africa (RSA), which were instituted at the insistence of the United Nations. Internal unrest, and a war situation on the northern borders served to enforce the perceived need for an own arms industry in this country, some fifteen years ago. During this period, the scope of the business activity has escalated to such an extent that a major export contract a few years ago constituted the biggest ever export contract of manufactured goods for this country.

The company involved in this investigation is a major local participant in the development and manufacture of armaments. The business mission and strategy have changed significantly over the past 10-15 years. Initially, the business comprised manufacturing of large volumes of products to bought out designs. A wide product range existed of mainly reasonably old products: aged 10 to 40 years. Industrial development was a major exercise during all this time, because production and delivery had to take place under great political, economic, technological and social pressures.

Although the products were comparatively old-fashioned and well-established overseas, it was found that the manufacturing and materials technologies available locally, just were not at the required level. It may rightly be stated that the technological and political impacts of the establishment of an arms industry in South Africa were of equal importance.

Recently, the products and systems developed and manufactured have been technologically much advanced and much more modern. This trend may be expected to persist in years to come.

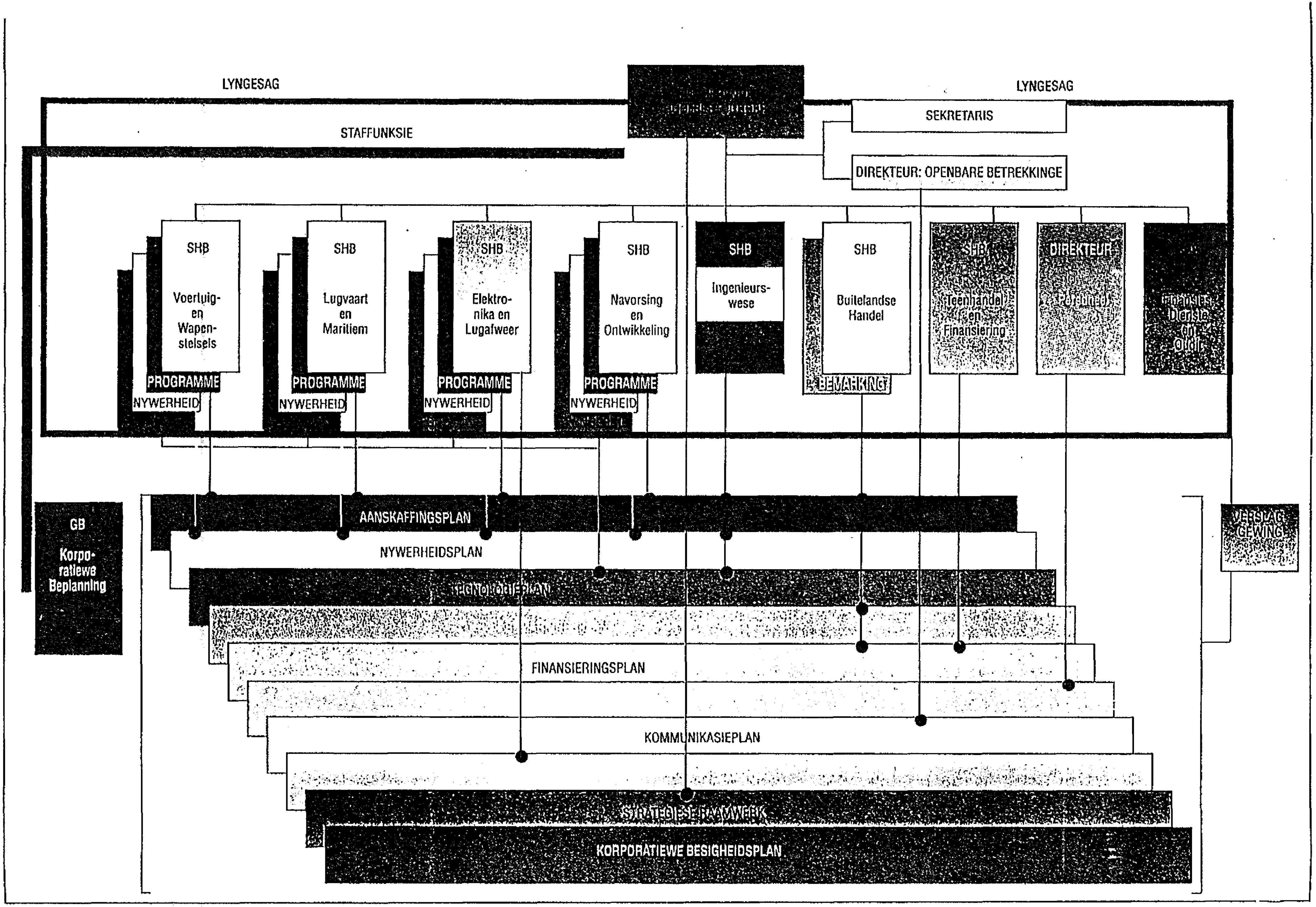
3.1.2 Organisation Structures

3.1.2.1 Corporate Organisation Structure

The corporate structure is shown in Figure 11. This diagram outlines the functional composition of the mother company. Another important feature of this figure is the interaction of the various corporate plans, which are compiled to execute the strategy.

3.1.2.2 Company Organisation Structure

The company or business is in effect a division or business unit of the holding company. As indicted in Figure 12 the company has a typical functional or departmentalised organisation structure. Each subsidiary business has a particular mission and business mandate, which is defined by the company's top management, and negotiated with the Head Office and the other affiliates. In fact, the total business of the corporation is sub-divided into the purpose-made business units, which have distinct core businesses, albeit very much interrelated and interdependant. The organisation is described in Appendix 2.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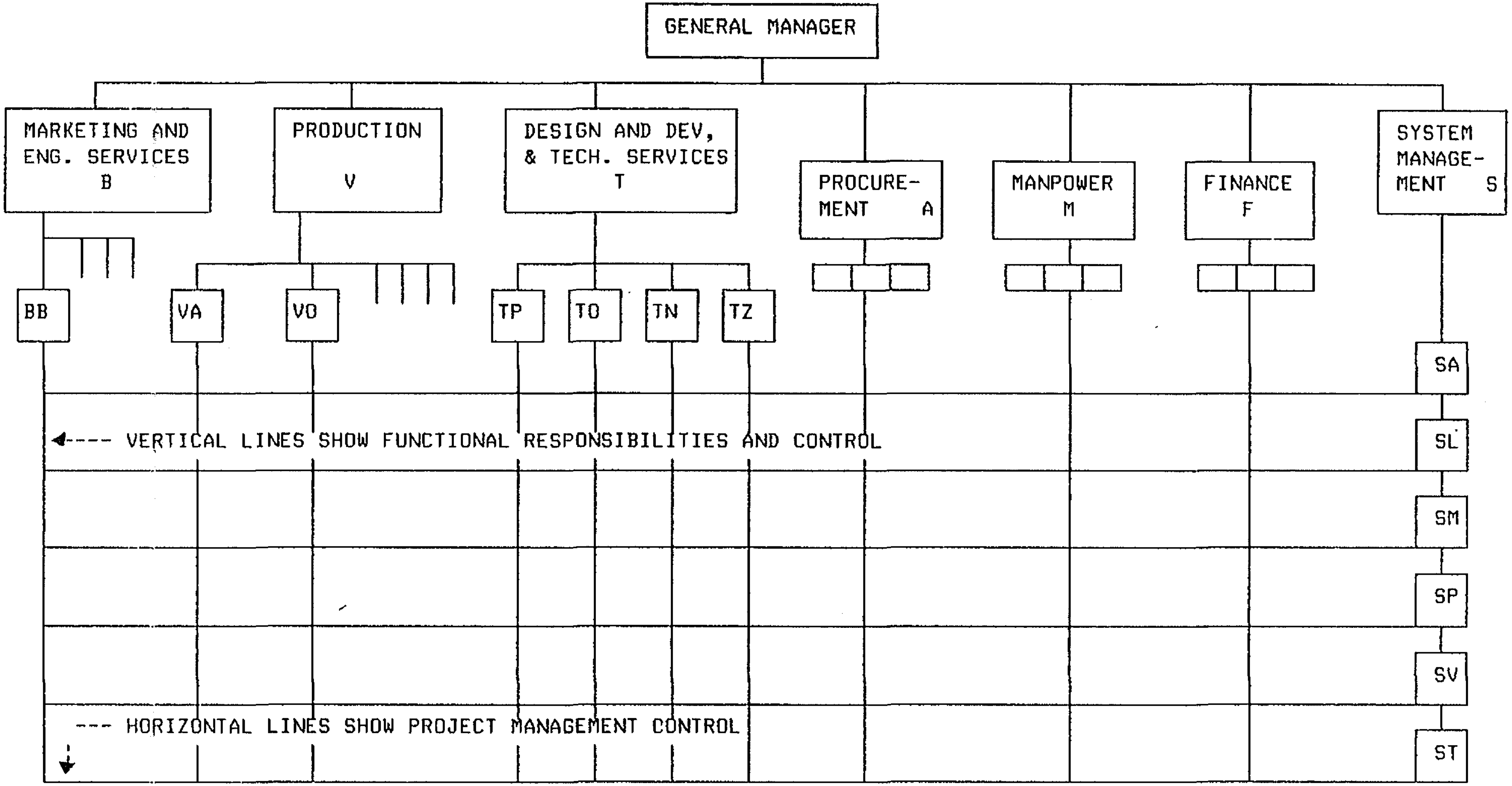


FIGURE 12 : COMPANY ORGANISATION STRUCTURE AND PROGRAMME MANAGEMENT MATRIX

3.1.3 Environmental Factors

The company and its environment is depicted in Figure 13. As may be expected, a business in the armaments industry, especially when situated in the RSA, is susceptible to certain factors from all the sectors of its business environment. Of particular interest are the following list of items:

3.1.3.1 Political Sector

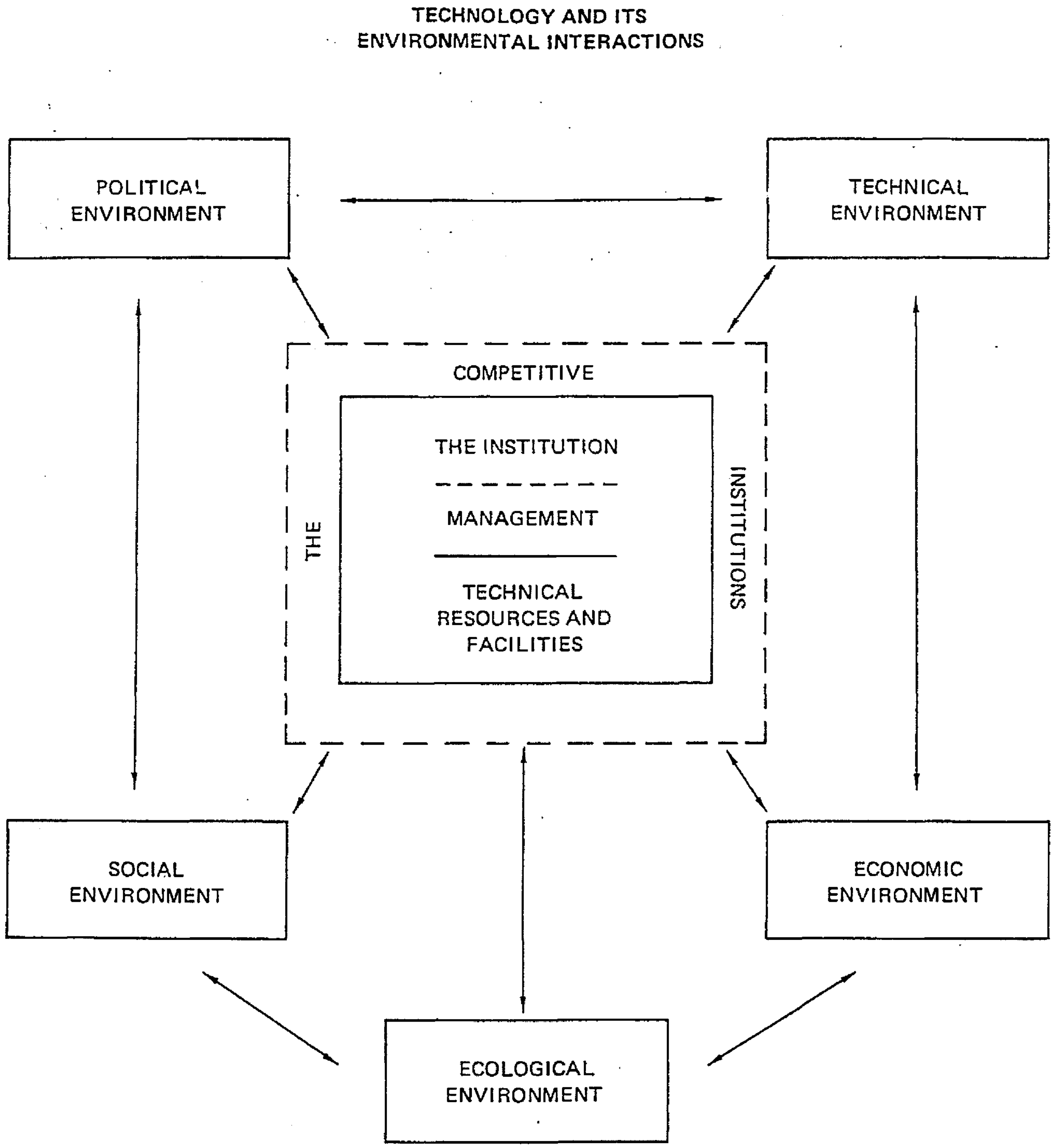
- peace negotiations in the RSA, SWA, Southern Africa, and elsewhere
- sanctions, embargoes with respect to arms deals
- changes of government in the RSA's trading partners
- internal political change and legislation
- East-West strategic arms negotiations.

3.1.3.2 Economical Sector

- import substitution policies implemented/encouraged
- exchange and interest rates locally and overseas
- sanctions against capital investment in RSA
- bargaining/bartering position of the RSA with strategic raw materials
- labour productivity.

3.1.3.3 Social Sector

- political rights and unrest conditions
- education of the population
- living standards and expectations of the people
- quality of life offered to the working population
- geographic and other separations and barriers.



NOTE: Within each *environment* are *individuals* and *organizations,* whose *value systems* may be changing at the time and perhaps in a vastly different manner than in other parts of the system.

FIGURE: 13 - COMPANY IN ITS ENVIRONMENT
(BRIGHT: 1972: 1-6)

3.1.3.4 Technological Sector

- international participation in conferences
- technology transfer agreements
- capital investment in the manufacturing industry
- infrastructure to develop and assimilate sophisticated technologies
- opportunities to export products and technology.

3.1.4 Followership in High-technology

South Africa is reliant on the First World to do technology development, to provide the means for technology transfer, and to supply the necessary capital equipment. The armaments industry is no exception in this regard.

It is reasonable, therefore, to expect that the industry should concentrate its efforts on those technologies and aspects of technology that comprise the optimal approach for a business in the market follower position. This situation will have a significant effect on technology management strategies and systems.

3.2 MISSION AND STRATEGY

3.2.1 Corporate Strategic Framework

This framework is illustrated in Figure 14, and described in Appendix 1.

The corporative statement reads as follows:

"A strategic framework is developed with a view to building singlemindedness and unambiguousness into the day-to-day actions of an organisation."

OBJECTIVES / STANDARDS	CULTURE
- Expanded Export Market Share	- Client Orientation
- Develop Unique Technologies	- Performance Orientation
- Build Industry to Maturity	- Effective Communication
- Technical Integrity of System	- Spontaneous Teamwork
- High-level Manpower	- Security Mindedness
- Effective Planning	
- Effective Management	

CAPABILITIES	PRODUCTS MARKETS CLIENTS LIST	STRUCTURE
- Reach New Clients	- SADF	See Figure 11
- Update Products	- SAP and Prisons	
- Develop Technologies	- RSA Security	
- Flexible Manf. Base	- Commercial	
- High Level Manpower	- International	
- Technical Integrity		
- Optimise Costs		
- Communicate Well		
- Maintain Security		

DRIVING FORCE
- Operational Effctiveness
- User Friendliness
- Cost Effectiveness
- Max Local Content
- Life-Cycle Support

FIGURE 14 : CORPORATE STRATEGIC FRAMEWORK

3.2.2 Company Mission and Strategy

The company strategy as derived from the corporate strategy, and as formulated to suit its own purpose objective and business domain, is also described in Appendix 1.

According to Du Plessis (SALVO: 1989: 20,25): "It is a truism that - 'he who wants peace must prepare for war'. The question SA defence planners must ... find an answer to is ... 'what kind of enemy (can we) expect in years to come?' An analysis of the general trends in terms of society's capability from 1974 to 1989 indicates and unmistakable decline on all levels: economic performance, agricultural output, infrastructure and manpower." He comes to the conclusion about Southern Africa that capabilities of societies (infrastrcuture, production and manpower) to support their military capabilities, will make war far too expensive for the region.

In an editorial article (SALVO: 1989: 9) the highlights of the outgoing Chairman of the Board's tenure of office are described. It is evident that technological achievements in this field over the past decade have been formidable.

He (the retiring Chairman) stated:
"Daarom moet die land se benadering vorentoe een wees van doeltreffende bestuur, van vooruitgang sonder vrese, en om doelstellings vreesloos en met oorgawe na te streef." (SALVO: 1989: 10). The new Executive Chairman gave an indication of future strategy as follows:
"...daar-sal voortgegaan word met uitbouing van die plaaslike krygstuignywerheid ...... verdere sofistikasie en verhoging van tegnologiese vermoëns ... .. en dat tegnologiese ontwikkelings ook toepassing vind in produkte van kommersiële aard," (SALVO: 1989: 15).

From the above statements a few deductions regarding marketing and development efforts can be made, namely:

- higher level technologies will be developed
- a greater degree of technology transfer to the industrial section will take place
- budget reductions will occur
- the enemy and probable war arena will have to be re-defined
- the RSA may likely require different defence systems
- long drawn-out wars are likely to change
- arms suppliers to the neighbouring countries will be looking for new markets elsewhere
- competition in the sector of more sophisticated products will be stronger, because the suppliers are stronger, wealthier, and more developed
- new products and systems may be strategically more vulnerable, due to specialised materials and inputs.

3.2.6 Product and Technology Diversification

When it comes to selecting and setting up examples to follow in the spheres of economic and technological growth, the two outstanding ones at present are Japan and West Germany. STALK: 1989: 61) describes how Japan achieved a competitive advantage in respect of time over her major (Western) rivals. He states that:

"The ways that leading companies manage time: in production, in new product development and introduction, in sales and distribution - represent the most powerful new sources of competitive advantage." He describes how Japan has been changing strategies to attain the status of a technological leader and lists a number of areas that represent time-based advantages. The strategies were:

- low labour costs to enter markets
- economies of scale and work force productivity
- focussed factories, small variety in product lines
- just-in-time production, shop-floor decision making
- flexible factories for low cost and variety
- shortening the planning loop in product development
- trimming process cycle times for production.

It is probably not unreasonable to expect that the RSA will tend to adopt a similar approach where possible. An incremental approach to change, to development, and to education is more likely to succeed and bring lasting improvement in the economic growth pattern in the country.

Two other important criteria are going to be:

- <u>time-to market</u>: the underlying aspects here are responsiveness, flexibility, infrastructure, proficiency in development and marketing methods.

- <u>diversification</u>: the basis of this factor is variety, adaptability, marketing approach rather than production orientation, and system effectiveness.

3.3 ENGINEERING TECHNOLOGY IN THE INDUSTRY AND THE COMPANY

3.3.1 Integration of Marketing with R and D and Manufacturing

3.3.1.1 System hierarchy

The company operates in a highly complex industry and environment. On a macro-level, all new developments take place as, or have to be incorporated into, total weapons systems. Such system development can be very complex, have a long duration (from 5 to 15 years) and be expensive (costs are measured in millions and orders of magnitude higher). For the purpose of simplification, or ease of understanding, a so-called system hierarchy has been defined (SALVO, 1988, 34). It forms part of the so-called technology space which is obtained when three elements are plotted on each of three perpendicular axes. These three elements are: life-cycle stage, type of system, and level in system hierarchy. The concept is explained by ABEL and HAMMOND (1979: 392).

TABLE 3 : THE SYSTEM HIERARCHY

LEVEL	DESCRIPTION
8	Operational Force
7	Battle Grouping
6	User System
5	Product System
4	Product
3	Sub-assembly
2	Component
1	Material, process, characteristic

This principle is used throughout the corporation and all its subsidiaries. In fact, there are a multitude of manuals, procedures, standards and directives that govern, prescribe, enforce, or encourage specific ways of doing things. Owing to the highly visible nature of the business, the organisation and its culture are highly bureaucratic. Appendix 3 contains an article reproduced from SALVO (1988, 34-37).

3.3.1.2 Matrix organisation

Historically, the whole infrastructure had to be developed, established, implemented and expanded within 10 to 15 years. During this time there were demands for large quantities of a large variety of relatively sophisticated products. At the start many designs were bought out, but that changed rapidly as sanctions were imposed and embargoes enforced, the rand exchange fell dramatically and disinvestments started.

Another stereotyped management structure was imposed, namely the matrix form of ogranisation structure to do the necessary project management most efficiently. The current company project management structure is illustrated in Figure 12.

3.3.1.3 Project teams

A typical project team may consist of representatives from the following departments and external contributors:

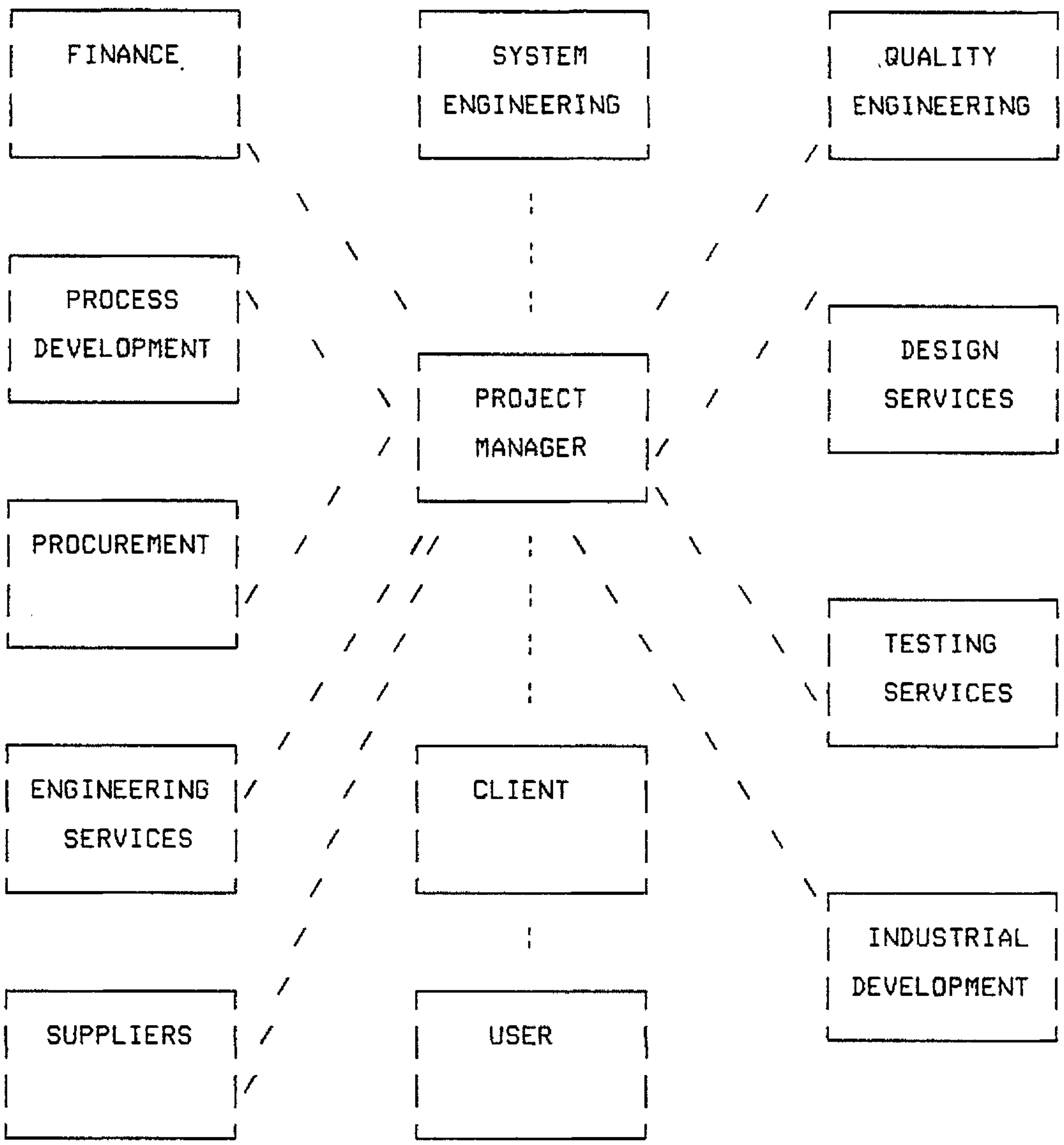


FIGURE 15 : TYPICAL PROJECT TEAM

These members are usually involved in more than one project or programme. The concepts of project management and a matrix organisation are particularly suited to encourage interaction between functions and exchange of information and viewpoints.

3.3.1.4 Committee management structure

Company business decisions are largely based on a committee-structure. Some of the most important committees are the following:

- Management Committee, consisting of the General Manager and the Divisional Managers, and who are responsible for the strategic management decisions.

- Procurement Committee, consisting of the Divisional Head Administration and all the Department Managers in the Design, Engineering and Systems Divisions, responsible for business contracts.

- Systems Department Committee, consisting of the Divisional Manager Systems and all the Department Managers of the systems business units.

- Development Management Committee, consisting of the Divisional Manager Design and Development Services and the Department managers of that division, rsponsible for the management of R and D affairs.

- Technology Steering Committee, consisting of all the Divisional department managers in Systems, Design and Development, and Process Development, as well as the senior technical specialists in R and D, responsible to establish the direction that technology development should take in the future.

- Production Committee, consisting of all department managers in manufacture, procurement, systems business units and quality control, under chairmanship of the Senior Manager Manufacturing, and responsible for the annual production programme.

- Marketing Committee, consisting of the Divisional Manager Marketing and the department managers of marketing, and the system business units. This committee is responsible for the setting of marketing policy, particularly with respect to new products, systems and markets.

3.3.1.5 Work Groups

Since about five years ago, there has been increasing emphasis on technology development, and development of products and systems which employ a higher level of technology. More recently, informal work groups (quality circles of a sort) have been formed with the main objective of concentrating on some technology field, or technical discipline. Examples are: explosives development, system engineering, and warhead development.

A few more of these technical work groups are being planned.

3.3.1.6 Marketing and Technology Surveys

In this sector there are three common categories of technology information gathering and dissemination.

Firstly, market surveys are done with the assistance of the corporate counterparts and local and overseas market research undertakings.

Secondly, technology trends and development status is determined by various means, including scans of publications, feasibility studies and attendance of symposia and seminars.

Thirdly, a very significant input comes from the industrial development department. It identifies potential suppliers of materials, components and services and evaluates their capabilities, capacities and know-how in the technical field.

There is a fourth method to collect and filter information. This is by doing a continuous literature scan. At present, this is done mainly by the systems units and development sections. Ideally, it should be done by, or under the auspices of the technical information services.

3.3.2 Technology Development and Establishment

Technology initiation, development and establishment takes place on various fronts, viz.:

- in the internal research and development facilities, for materials, products, methods, processes and testing.

- in the internal manufacturing facilities where new products and processes are developed and industrialised.

- by the systems business units through their efforts in project and programme management, "technical" marketing and through funding of development proposals;

- by the marketing function through demonstrations, participation in exhibitions, to potential users, and identifying market niches, and technology trends;

- externally at and by suppliers and potential suppliers of services and products over the whole spectrum of technology development;

- at corporate level, where a department has been created to coordinate all efforts in this field of endeavour, to allocate funds to deserving projects;

- in the domain of the local users to identify new trends in warfare applications, doctrines, available systems, and cost effectiveness.

In order to coordinate and integrate all these efforts, proposals and requirements, requires a highly complex system of planning and control at all levels of management.

3.3.3 Forecasting

The war in Angola which directly involved the RSA Defence Force, was, amongst other things, a good testing ground of available armaments systems. Report back activities provided the post dated and predictive feedback which is required from Users and clients about product and service performance standards required and achieved. Some of the effects are, for instance:

- a greater emphasis on the Airforce and their requirements;
- greater interaction between users and system designers;
- a change towards more modern, sophisticated and complex systems;
- a resulting change towards the level of contracting for deliverables throughout the whole spectrum ;
- a greater application of modern technologies;
- a concomitant technology forecasting system which applies various other forecasting methods.

Such a system has been implemented in varying degrees of success at user, corporate, and supplier levels. The observation is that for weapon systems and lower system levels like: products, sub-assemblies, materials and processes, the planning system exists but is not fully efficient.

3.4 SUMMARY

In this section the discussion revolved around the observations made about actions and conditions in the company.

The main aspects described were:

- the methods whereby technology planning and control is executed,
- what the role of the various management and business functions in this proccess is,
- how research, development and pre-production technology establishment takes place,
- what forecasting methods are used and how they are applied,
- how the integration of activities is achieved to ensure successful management of technology in this company.

SECTION 4

COMPARISON AND INTEGRATION OF EMPIRICAL INFORMATION AND THEORY

4. COMPARISON AND INTEGRATION OF EMPIRICAL INFORMATION AND THEORY

4.1 INTRODUCTION

It is the purpose with this section to discuss the applicability and utilisation of the theory on planning and control systems in technology management. But, to do this specifically for the company being evaluated. Then, opinions will be given about the existing status of planning and control systems. An attempt will be made to indicate what areas for improvement have been identified and what could be done to rectify the situation. Where comments have been made in previous sections, the core ideas only will be repeated here.

4.2 APPLICATION OF THEORETICAL PLANNING AND CONTROL MODELS

From the information reproduced and described so far, it is evident that:

- on national level and corporate level the armaments industry is especially complex and of strategic nature to the country. As may be expected many changes in its environmental sector are likely to have a significant impact on trends that develop, or decisions that are taken and implemented. Models for planning and control systems such as those proposed by SCHUTTE (1981), VAN DEN BERG AND PELSER (1987), and ANTHONY (1965) seem appropriate, because they make provision for highly complex, multi-tier organisations which conduct business in a dynamic environment.

- When the organisation is one of high complexity, high structure and large size, then a formalised bureaucratic type structure is usually inevitable.

For this reason, it is to be expected that business activities will be influenced by a preponderance of instruction manuals, standards, specifications, rules and regulations and a hierarchical approval and decision making system. When the organisation is closely linked to the military system, a rigid adherence to procedure for its own sake is sometimes the result. The model(s) prescribed by SCHUTTE and the way that its use is advocated seems ideal under the circumstances, but once entrenched, may prove too inflexible for the dynamic environment and management style required.

- In recent years a common approach to project and programme management and system engineering has been adopted at corporate level, and is being applied throughout in all its subsidiary companies. Together with this, there is the higher level of contracting, (decentralisation of business units), and tailoring of system or product requirements, standards and procedures, and technical specifications. The reason is to introduce adaptability, dynamism, realism, cost savings, time savings, reduced control mechanisms into the planning, execution and control of projects.

- Technology management is a very important aspect of the corporate and company business. Some reasons being that the development and establishment of the requisite level of proficiency in a technology is very costly, may have very limited application elsewhere, and often takes very long to achieve.

In order to be competitive therefore, whether in the high technology or low technology fields, the company (as an element in the local industry) must be streamlined, flexible, adaptable, effective, efficient and dynamic. It can only succeed on all these criteria if the planning and control system is designed and applied to allow this to happen.

- The existing organisation, programme management and technology development structure are deemed to be in position. In addition, work procedures and standards are being revised within this context. Much training is taking place to publicise the "new" approach.

  However, the opinion is expressed that outputs should be defined more in terms of the effect that is produced, or solution that is provided, or level of technology established, rather than for the type of product manufactured.

- The system of management committees and work groups is the obvious way to pool knowledge, to provide a platform for critical analysis of development proposals and achievements, and to create a climate that is conducive to risk-taking.

4.3 COMPANY TECHNOLOGY MANAGEMENT

The strategy for technology development and establishment has been derived from the stated corporate and company mission, objectives and core value frameworks. As a result, certain organisation changes were made, a project priority list has been established, a planning and control structure is being implemented, and resource allocation is done in a pre-determined manner. It would seem, that there is a need to be able to decide when technology establishment must result in saleable hardware, and when it was worthwhile even if only as a step up the ladder.

Overall, the opinion is held that technology forecasting techniques are underutilised at present. Especially the normative and integrative techniques can be fruitfully employed on a formal basis. It needs to be stated that moves are in progress to establish the facility and capability to do the modelling of systems mission profiles and to translate these into technology requirements. The result will be to show a list of technology development requirements derived from user's needs.

4.4 TECHNOLOGY FORECASTING

Additional suggestions about techniques and approaches to adopt are contained in Appendix 2.

In the case of the company of this study, the forecasting methods include mainly the following list:

(a) surveillance techniques, with major effort in scanning and too little monitoring and tracking

(b) projective techniques, but with most effort applied in substitution analysis, Delphi surveys, structural interviews, and nominal group conferencing.

(c) normative (goal-oriented) forecasting techniques applied are mainly: morphological analysis, and the relevance tree method.

(d) integrative techniques, which are particularly important are applied.

Overall, the perception is that the importance of the techniques are in the reverse order in which they are listed above. A second comment is that the infrastructure and methodology existing in-house is inadequate at present to really achieve maximum benefit of the efforts put in already, and to satisfy identified information requirements.

4.5 SUMMARY

This section contains comments on the comparison of theoretical requirements for a system of planning and control with the real situation. It was proposed that the models proposed for highly complex, structured organisations can be usefully applied to this company, its corporate company and its industry.

Technology forecasting techniques are used, but probably not as efficiently and effectively as they might be. The basic infrastructure for planning and control of development projects is well established.

SECTION 5

S U M M A R Y

5. SUMMARY AND CONCLUSIONS

5.1 OVERALL DISCUSSION

An investigation was undertaken into the planning and control system used for technology management in a company in the armaments industry. A few models proposed for the presentation and explanation of complex integrated management systems were briefly analysed. Management of innovation was described by means of readings published on the subject. Brief descriptions of four general categories of technology forecasting techniques were included as background information. These four categories of TF methods are:

surveillance, projective, normative, integrated techniques.

It is observed that some of the techniques contained in each category are being applied. A description was given of the local armaments industry, as well as the corporate and company mission and proposed strategic frameworks. In addition, a discussion was given of the company organisation structure, and project management structure.

This theoretical and background analysis was followed by a discussion of the actual situations found in the company investigated. The emphasis was placed on technology management strategy and methods of implementation. It was indicated that the company utilizes a comprehensive structure of management committees and technical work groups to ensure effective planning and control of development projects. Such a structure or management mechanism has the potential to ensure that projects are executed efficiently.

Technology forecasting in the context of user systems is done in a global fashion. It appears that the translation of such requirements are not yet carried out to the extent that identification and definition of technology is complete. However, the major shortcoming still existing might be the integration of all technology development information at all levels of management, i.e. operational planning and control, management planning and control, and strategic management.

5.2 VALUE OF THE STUDY

The value of the study follows from the fact that the reader gets the opportunity to relate all activities that have a bearing on technology development. In so doing, an overall perspective is gained on the integration of these activities to achieve the desired end result.

Technology management has a high priority in this company and is likely to remain in the spotlight. Of particular importance is the realisation of the particular role which each of the company's functions plays in technology establishment and investigation. Usually, with the emphasis being on the specific product or process development programmes, this linkage is forgotten.

5.3 CONCLUSIONS

(a) The armaments industry worldwide is at the forefront of technology development and application. The RSA is no exception. On the local scene the company analysed here operates a very complex system of technology management to ensure that the locally established technological capabilities are exploited to the full.

Goal-oriented methods could be coordinated by marketing services, with major inputs from technical information services and the library.

Forecasts or reports can be reviewed periodically to determine what methods are found to be most effective.

(b) Greater emphasis could be placed on the functioning and interaction of work groups.

(c) Another recommendation is that development projects should be defined from the effect that is required to be produced. For instance, all products could be grouped into two categories, namely:

- directed (energy) effects

- spatial (energy) effects.

(d) Technology developed and established may be emphasised more. It is company and corporate policy that development should be product oriented. In the efforts to create and produce products, the importance of technology involved may be subordinated.

(b) A technology planning and control system requires the integration of apparently diverse activities to ensure that opportunities are exploited and user reuirements are fulfilled to the best possible degree.

(c) It is evident from the description of the system under investigation that the framework for the system, as well as the system itself exists. There are improvements to be made, and further aspects to be fully implemented to achieve maximum benefit.

(d) Environmental influences like the peace settlement with Angola, internal political trends, a need to counteract the disinvestment trend, will cause a great reduction in the scale of military activity and armaments requirements. However, a well developed technology planning system may be even more important than in the past.

5.4 RECOMMENDATIONS

(a) That all the forecasting methods listed in this report be evaluated using actual information. The results obtained, information requirements and implications with respect to resources required can be determined and compared. Based on this evaluation a selection of methods can be allocated for routine use to different functional areas. For example:

- Scenarios and modelling could be done by Research and Development, with main inputs being given by systems units and marketing.

SECTION 6

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SECTION 7

A P P E N D I C E S

<u>APPENDIX 1</u>

STRATEGIC FRAMEWORK

DESCRIPTIONS

- CORPORATE

- COMPANY

A1.1 CORPORATE STRATEGIC FRAMEWORK

Based on the above strategic framework it is believed that certain competitive advantages are achieved. They are:

- involvement in needs assessment
- comprehensive product range
- capability to manage complex projects
- flexible production capacity
- supply performance
- wide base of know-how
- use unique international trade instruments
- operational experience
- assurance of systems integrity

Performance is measured against a corporate plan comprising:

- a procurement plan
- an industrial plan
- a technology plan
- a marketing plan
- a financing plan
- a manpower plan
- a communication plan
- a security plan.

A1.2 Company Strategic Framework

The company strategic framework was derived from that of the corporation. Here follows a summarised version of the main aspects thereof.

(a) Framework

A strategic framework consists of the interaction of the following components: driving force, products, markets, objectives, capacilities, structure and organisation culture.

(b) Driving Force

It is primarily the satisfaction of market needs.

(c) Competitive advantages

- direct involvement of key personnel in needs analysis for identification of client requirements
- modern flexible production facilities
- unique products which present cost-effective solutions to real threats and problems

(d) Key capabilities

- a well managed development and technical function
- utilisation of modern technologies
- maintaining a procurement organisation
- industry experience and professional posture
- cost effective production facilities
- system engineering experience
- entry into overseas markets and key technologies

(e) Performance standards and criteria measures

Specific criteria have been set with regards to the following parameters:

- sales
- products
- product facilities
- development facilities
- overhead expenses, and
- procurement.

(f) Sales

Local sales must be the same as the previous year in real terms. Overseas sales must exceed 20 percent, and commercial sales 5 percent of the total turnover. Technology and development project income must be 30 percent by 1990.

(g) Products

A target has been set that 50 percent of product sales must be from products brought to production within the last five years, and 20 percent in the last two years. This approach supports the importance of innovation.

(h) Product facilities

20 percent of turnover must be realised on assets at replacement value.

(i) Development facilities

Development facilities must be funded from development contracts and must not exceed 20 percent of the development budget in cost.

(j) Overhead expenses

Indirect overheads must be less than 20 percent of total turnover. This is one of the most critical yardsticks of the strategic plan.

(k) Procurement

Successful performance will be judged against the following criteria:

- formation of "partnerships" with 50 percent of supplies of existing products, and
- with 70 percent of suppliers involved in development projects
- annual cost increases to be inside the rate of inflation.

(l) Planning and control

Execution of strategic plans will require continued establishment of detail plans, measuring progress against targets, and implementing corrective action. The following plans have been compiled and are being executed to achieve strategic objectives:
sales, procurement, marketing, technology, industrial, financial, manpower, and security.

A1.3 DESCRIPTION OF COMPANY ORGANISATION STRUCTURE

1. GENERAL MANAGER

The general manager position at the head of the company to integrate the various functions and act as the company spokesman.

2. DIVISIONS

The divisions and their main functions are as follows:

2.1 MARKETING & ENGINEERING SERVICES

This division executes marketing functions such as sales, market research, promotions, customer relations, and identification of user needs and export policies.

The other leg of the division is in charge of capital projects, maintenance, safety, and the enrironment.

2.2 PRODUCTION

In this division the activities concern all thos related to the internal manufacture of the product lines at the company's factory. Also included, are quality control and process development.

2.3 DESIGN AND DEVELOPMENT SERVICES

As the name indicates, this division is responsible for the product design and development services. It also contains a department responsible for external (process) technology development or industrial development.

2.4 SYSTEMS

In this division the systems business units (SBU's) are housed. The purpose is to have a generic grouping of products or sub-systems which may be regarded as belonging together by nature of their use/application by the Users. This division also does the project management and systems engineering.

2.5 FINANCE

The 'division' is responsible for salaries, the financial plan, budget control, creditors, financial reporting, financial statements, the computer data srvice centre, and stock control.

2.6 PROCUREMENT

This 'division' used to be combined with 'Finance' in the Administration division. It is responsible for legal services, procurement, vendor quality, and metrology services.

2.7 MANPOWER

The name is probably self-explanatory. Functions found here include personnel administration, training, selection and recruitment, housing, benefits, clinic services, security and the industrial commando.

APPENDIX 2 : PRELIMINARY MODELS FOR TECHNOLOGY FORECASTI

A2.1 INTRODUCTION

A few concepts are applied to the current situation with a view to achieve the following objectives:-

(a) arrangement and integration of all projects existing in the various system business units under one umbrella for technology management purposes;

(b) provision of an example of how the impact wheel technique may be applied;

(c) provision of an example of how the work breakdown structure may be used to identify and interrelate technologies;

(d) illustration of the technology system of the company and its environmental influences.

A2.2 TECHNOLOGY SYSTEM AND ENVIRONMENTAL SECTORS

The system diagram is illustrated in Figure A2-1.

OVERALL TECHNOLOGY PLANNING SYSTEM

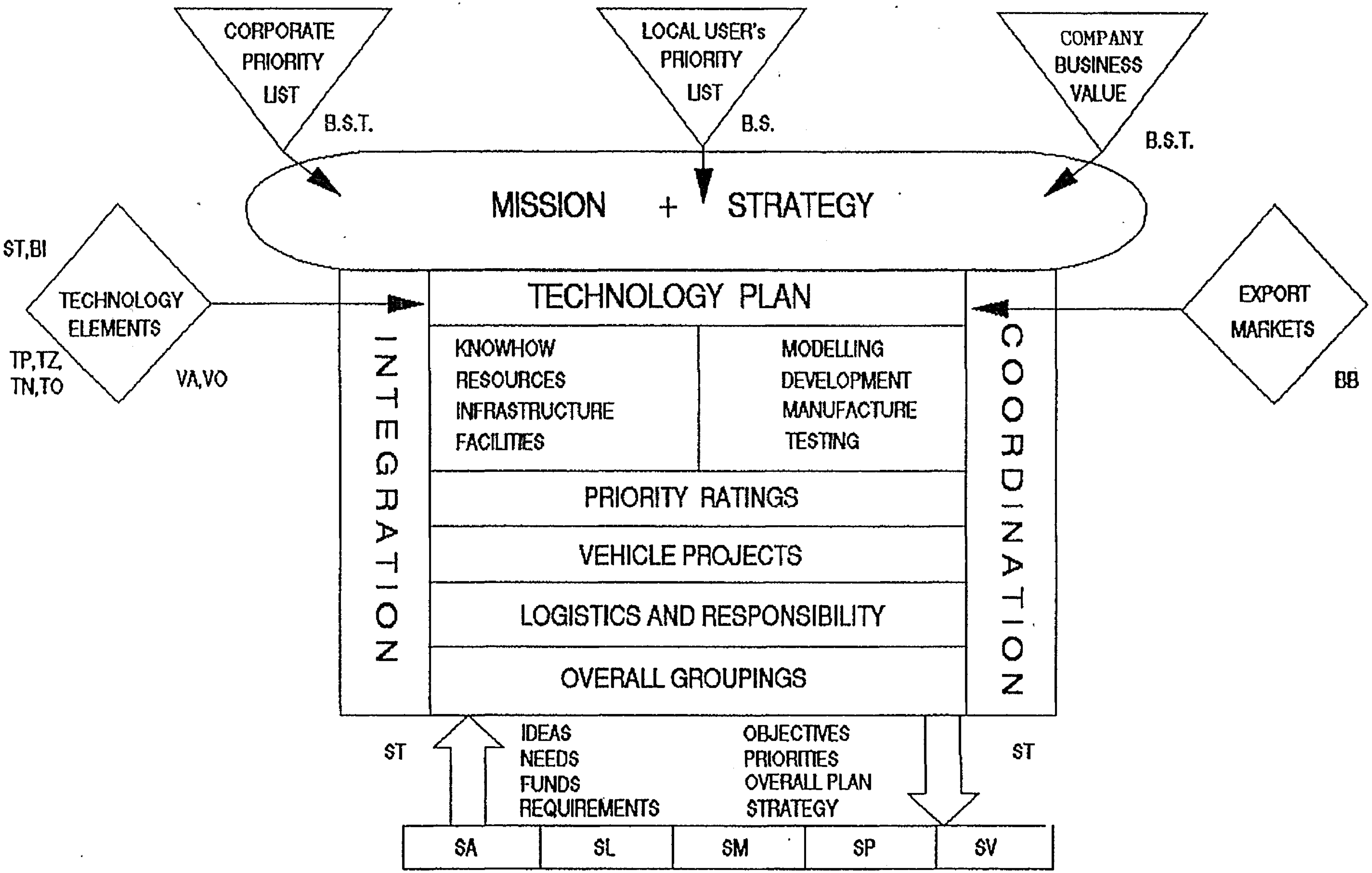


FIGURE : A2-1

A2.3 UMBRELLA PROJECTS FOR TECHNOLOGY MANAGEMENT

An illustration of how the various categories of technology may be interrelated is shown in Figure A2-2.

SCHEMATIC TECHNOLOGY BREAKDOWN

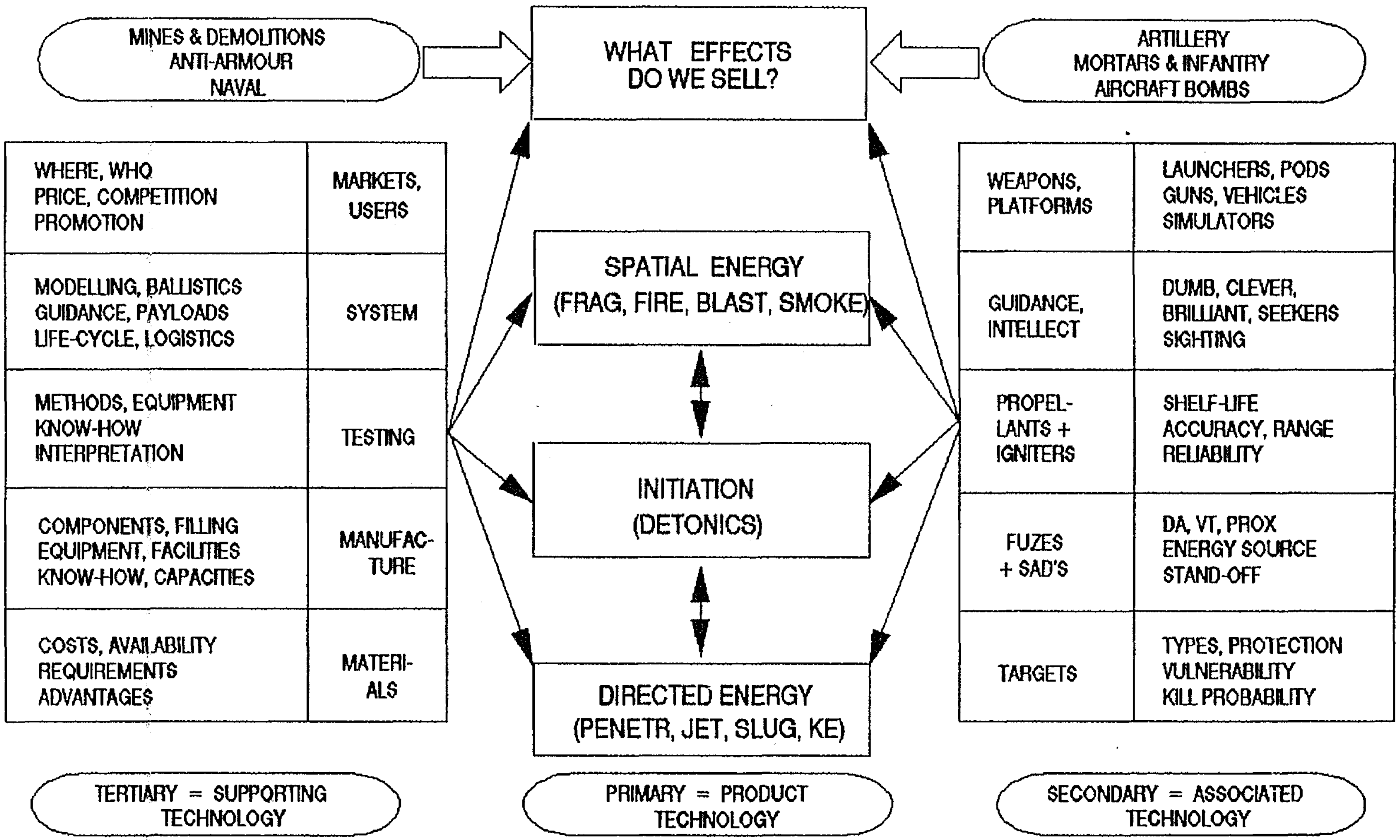


FIGURE : A2-2

This concept is further detailed in the Work Breakdown Structure approach shown in Figure A2-3 and A2-4.

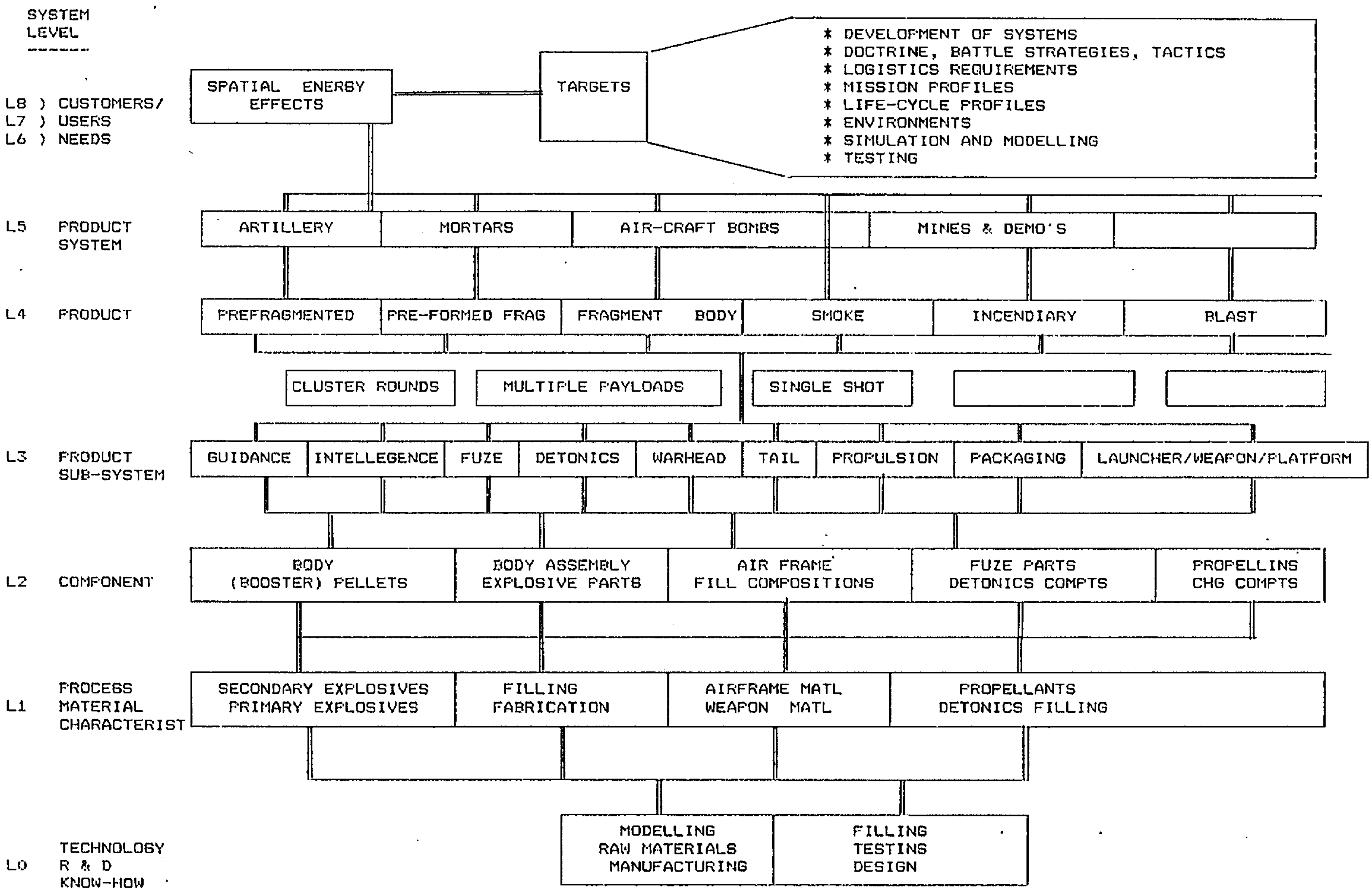


FIGURE : A2-3(a) SYSTEM LEVEL BREAKDOWN FOR SPATIAL (ENERGY) EFFECTS

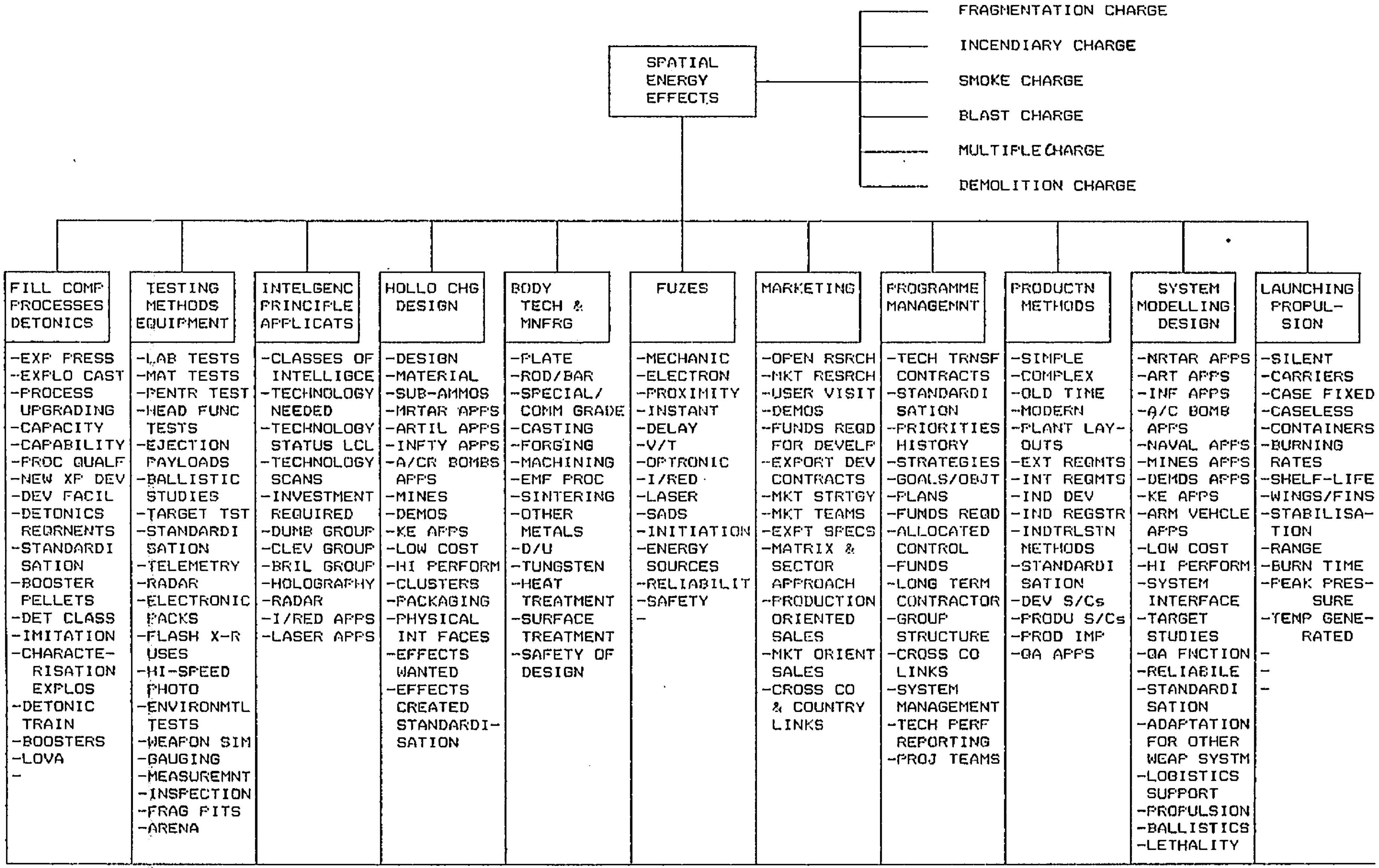


FIGURE : A2-3(b) : WORK BREAKDOWN STRUCTURE FOR SPATIAL (ENERGY) EFFECTS

A2.4 EXAMPLE OF AN IMPACT WHEEL ANALYSIS

This technique is demonstrated in Figures A2-5 (a) and (b)

In this approach the core of the impact wheel is the desired effect or result to be achieved. The first ring of spokes depict the various means to achieve this result. Next, identify the most important parameters in product design for each of the possible solutions.

IMPACT WHEEL : SPATIAL ENERGY EFFECTS

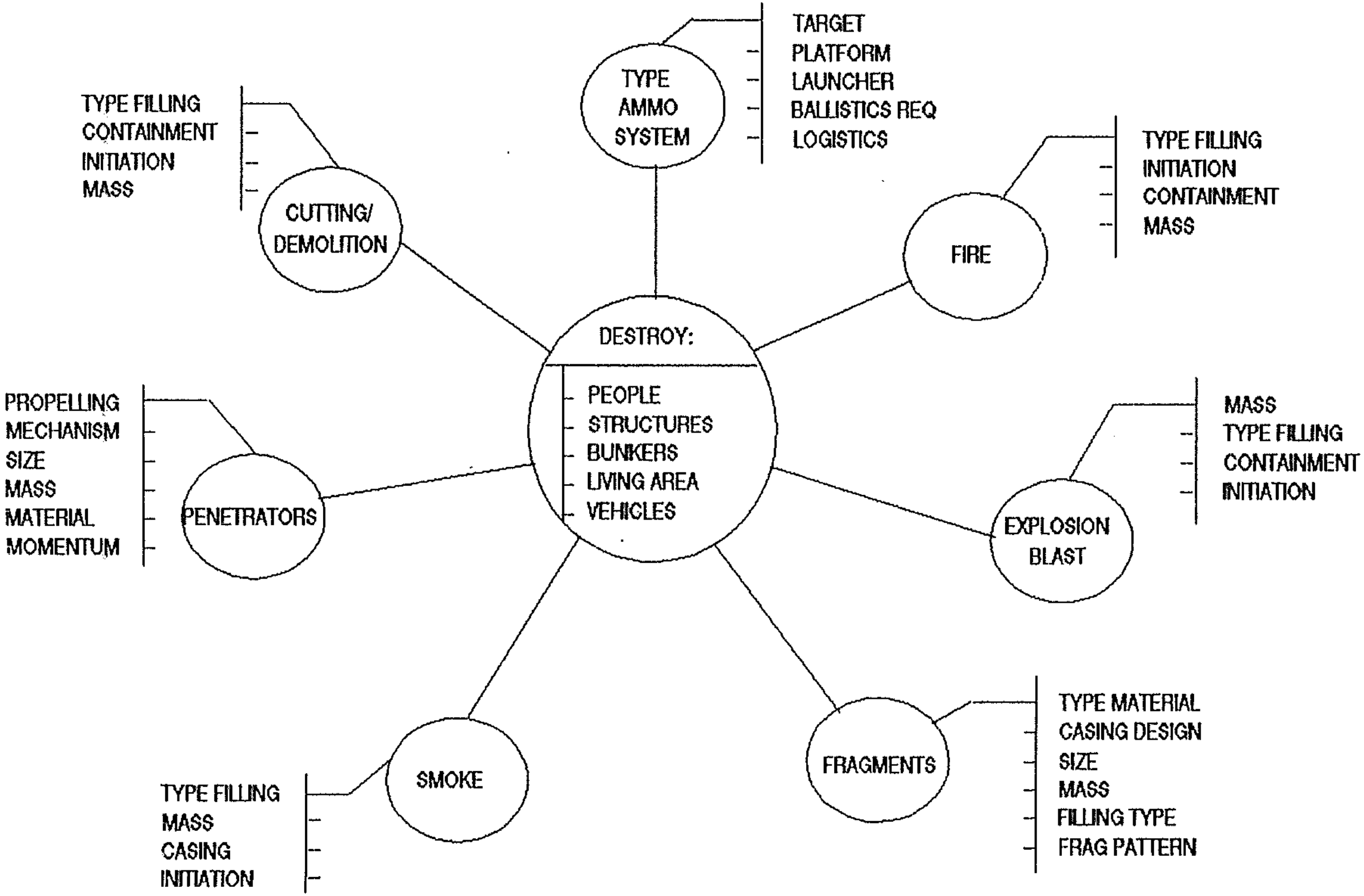


FIGURE : A2-5(a)

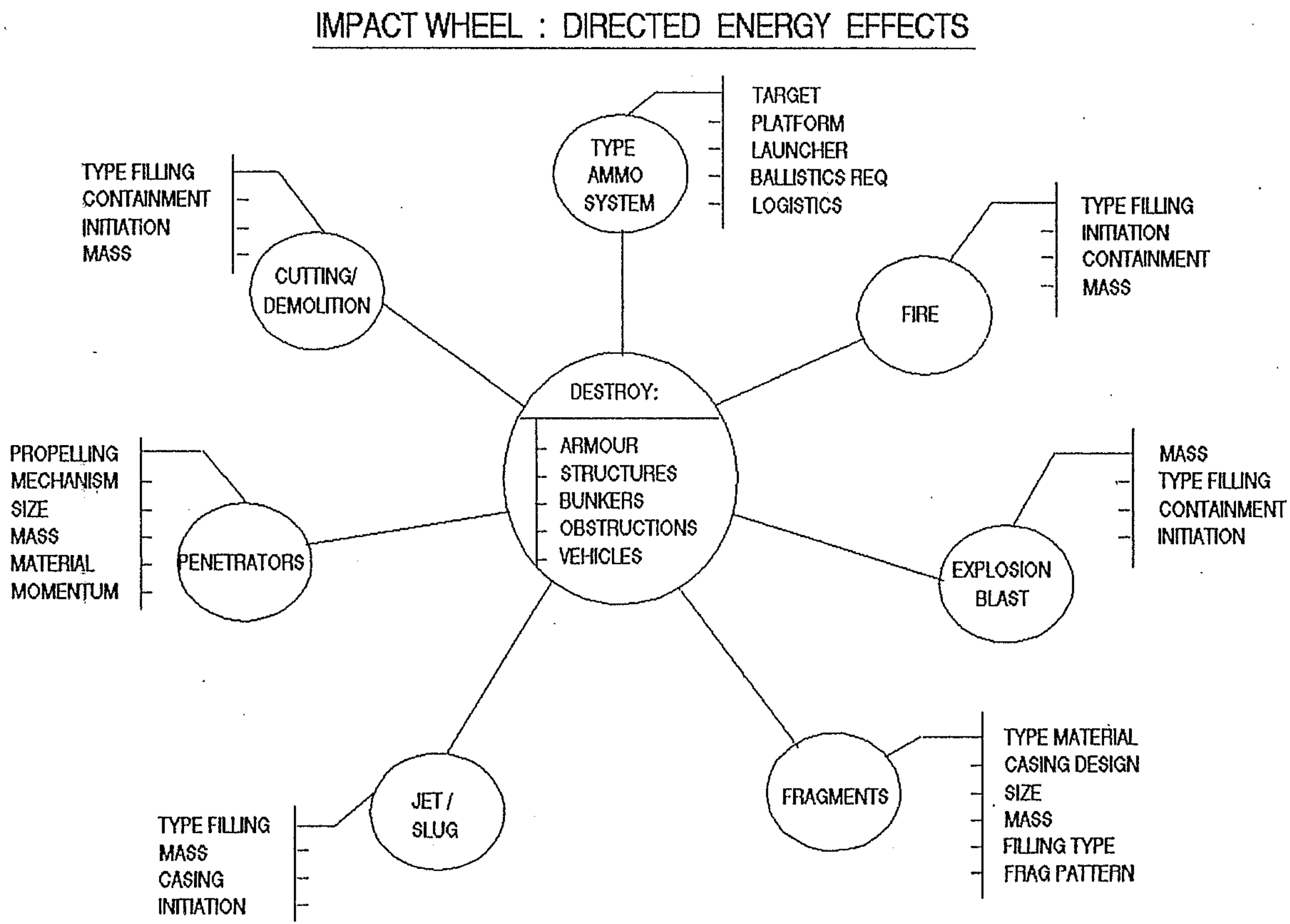

IMPACT WHEEL : DIRECTED ENERGY EFFECTS
TYPE AMMO SYSTEM
TARGET
PLATFORM
LAUNCHER
BALLISTICS REQ
LOGISTICS
CUTTING/ DEMOLITION
TYPE FILLING
CONTAINMENT
INITIATION
MASS
FIRE
TYPE FILLING
INITIATION
CONTAINMENT
MASS
DESTROY:
ARMOUR
STRUCTURES
BUNKERS
OBSTRUCTIONS
VEHICLES
PENETRATORS
PROPELLING MECHANISM
SIZE
MASS
MATERIAL
MOMENTUM
EXPLOSION BLAST
MASS
TYPE FILLING
CONTAINMENT
INITIATION
JET / SLUG
TYPE FILLING
MASS
CASING
INITIATION
FRAGMENTS
TYPE MATERIAL
CASING DESIGN
SIZE
MASS
FILLING TYPE
FRAG PATTERN

FIGURE : A2-5(b)

Die bestek van stelselbestuur

Om die bestek van stelselbestuur, soos afgelei uit die Krygkor-strategie te verduidelik, het dr Willem Barnard, Senior Hoofbestuurder: Ingenieurswese by Krygkor, onlangs dié direksievoorlegging gedoen. Aandag word in dié artikel gegee aan sake soos die tegnologieruimte vir die krygstuignywerheid, die aard van krygstuigtegnologie, bestuur van die ingenieurswesefunksie en die ontplooiing van die organisasie vir stelselbestuur.

KRYGKOR het 'n markgerigte stuurkrag. Soos die Uitvoerende Hoofbestuurder, mnr Johan van Vuuren, reeds voorheen verduidelik het, is die bevrediging van die ware behoefte van die gebruiker dus ons verbintenis.

Die aanspreeklikheid van die ingenieursfunksie, of dan die stelsel-ingenieursfunksie wat hieruit volg, is om 'n spesifieke optimum-verhouding van funksionaliteit, koste van eienaarskap en gebruikersvriendelikheid, afgestem op 'n spesifieke gebruiker, te spesifiseer vir die wapenstelsels wat Krygkor lewer.

Krygkor se ondervinding met stelsels soos die G5 en Motley in die Suid-Afrikaanse en oorsese markte het bewys dat die mark daarna streef om eerstens 'n objektiewe bepaling te maak van elkeen van hierdie elemente en daarna sy eie optimum-verhouding vasstel. 'n Stelselverskaffer moet dus in die eerste plek in staat wees om 'n globale, meetbare spesifikasie van die stelsel as geheel aan die gebruiker voor te hou. Die vlak van geloofwaardigheid waarmee dit gedoen kan word, is afhanklik van die ontwikkelingstatus van die stelsel en weerspieël regstreeks die verskaffer se stelselingenieurswesevermoë.

Tegnologieruimte vir die krygstuignywerheid

Die tegnologie-omgewing wat geskep word om die behoeftes van gebruikers van wapenstelsels te kan bevredig, het drie dimensies: vlak in die stelsel-hiërargie, tydstip in die lewensiklus en tipe stelsel – figuur 1.

Vlak van stelselhiërargie

Stelsels word hiërargies saamgestel deur elemente te integreer om logiese samestellings te vorm. Die logika van die samestellings word bepaal deur die spesifiseerbaarheid en die kontrakteerbaarheid daarvan. 'n Analise van die hiërargie in die krygstuignywerheid soos Topbestuur dit sien, word in figuur 2 gegee.

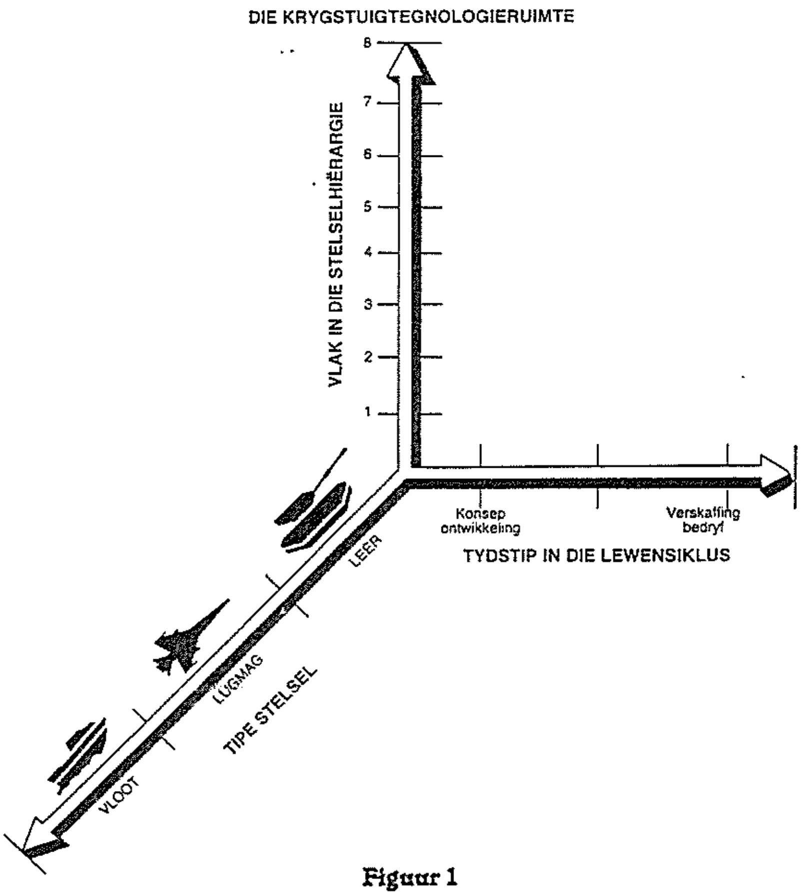
Tydstip van lewensiklus

Weens die kompleksiteit van wapenstelsels kan die ontwikkelings- en bedryfsvereistes daarvan nie op een tydstip hanteer word nie. Die lewensiklus van 'n wapenstelsel word daarom in fases verdeel waarin die verskaffer en gebruiker vooraf ooreenkom oor watter kwaliteitstandaarde aan die einde van elke fase gehaal sal word en dus voordat die volgende fase begin.

Hierdie kwaliteitstandaarde word die populêr basislyne genoem en elke fase in die lewensiklus gee dus aanleiding tot die totstandbrenging van die ooreengekome basislyn. Figuur 3 toon die lewensiklus van belangrike of "kardinale" wapenstelsels soos wat Topbestuur dit gedefinieer het.

Tipe stelsel

Dit is duidelik dat wapenstelsels van mekaar sal verskil wat hulle kompleksiteit (in die tegniese sin) betref. Die omvang van die tegniese werk wat op 'n sekere tydstip in die lewensiklus en op 'n sekere vlak in die stelselhiërargie gedoen moet word, sal verskil van een na die ander wapenstelsel. Hierdie derde dimensie van die tegnologieruimte moet dus tussen verskillende tipes stelsels onderskei. Met 'n markgerigte stuurkrag kan die tipes stelsels nou volgens gebruikers ingedeel word en ontstaan 'n tegnologieruimte soos in figuur 4 getoon. Die "tipe-stelsel"-dimensie is as 'n skalaar gegee, maar deur dit rangorde te gee (vektories saam te stel) soos die ander twee dimensies, kan nuttige bestuurs- en bemarkingsindekse verskaf word.



Figuur 1

Die aard van krygstuigtegnologie

Hoëtegnologie

Deur die wêreldgeskiedenis is dit bekend dat die krygstuignywerheid die tegnologieleier is. Die RSA is nie die uitsondering op hierdie reël nie. Die voorste vlak van tegnologie in die land hoort dus in die krygstuignywerheid. Vir ingenieurswese impliseer dit die tegnologiespits oor die totale spektrum van struktuurkundigheid, energiekundigheid en informatika-kundigheid.

Kort halfleeftyd

Die tegnologie waarmee wapenstelsels ontwerp kan word vir 'n wenvoorsprong in die mark, het 'n halfleeftyd van tussen twee en vyf jaar. Dit het dus prakties geen rakleeftyd nie.

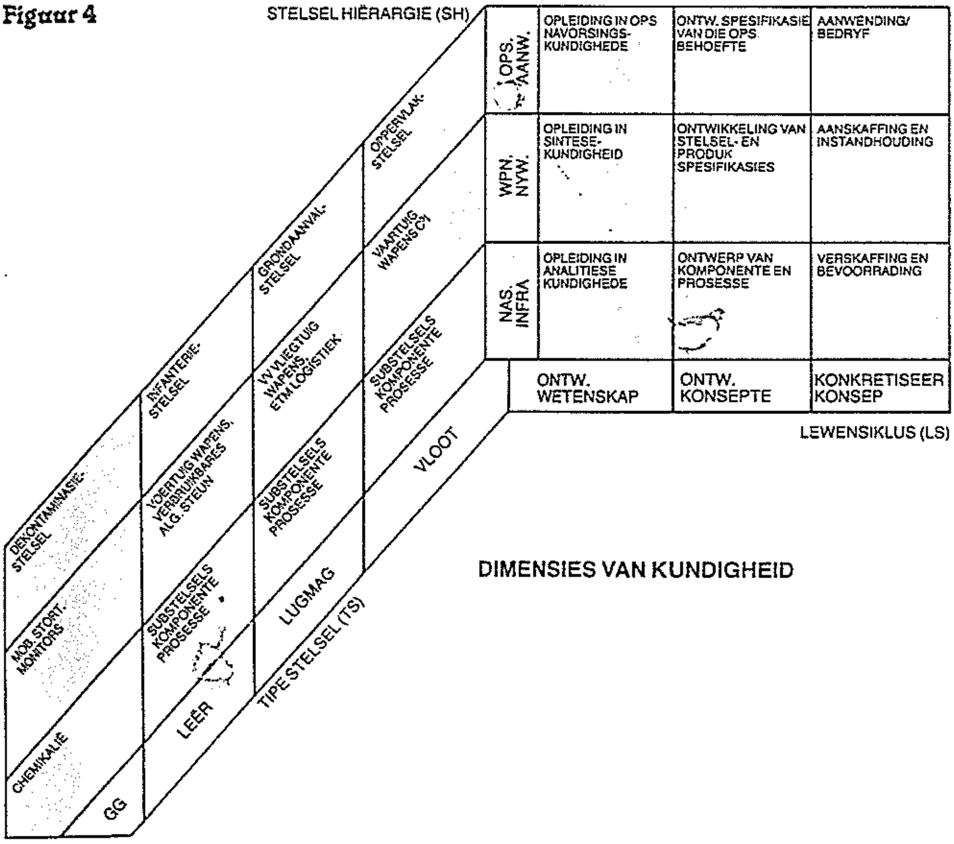
Spektrum

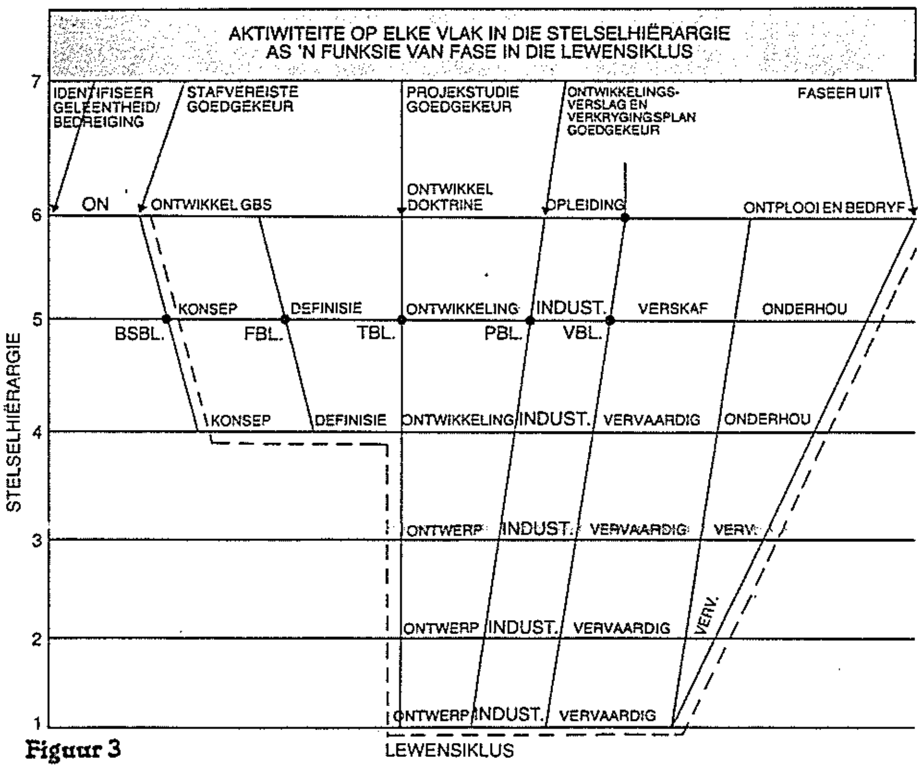
Die krygstuigbedryf in die RSA het om politieke redes nie die normale toegang tot internasionale kundigheid soos ander krygstuigverskaffers in die wêreld nie. Vir ons kan die poging dus verlore gaan by gebrek aan die kleinste besonderheid. Die krygstuignywerheid moet dus die totale veld op alle vlakke van spesialisasie dek vir 'n geloofwaardige selfstandigheid.

Die setel

Die kundigheid is hoofsaaklik in mense gesetel. Fasiliteite en toerusting maak 'n klein gedeelte uit van die vermoë om 'n gebruikersbehoefte te bevredig.

Figuur 4





Figuur 3

Bestuur van die ingenieurswesefunksie

Die scenario

Die aard van die tegnologie, tesame met die koste-van-eienaarskap, bepaal dat die nuttige leeftyd van wapenstelsels in die RSA tussen 20 en 40 jaar. In hierdie periode sal dit tot soveel as tien modifikasie-siklusse deurgaan. Hieruit volg dat wapenstelsels in 'n kontinue proses van ontwikkeling tydens vervaardiging en bedryf is. Dit is dus duidelik dat 'n wapenstelselverskaffer 'n totale leeftydsverbintenis met sy gebruikers aangaan. Hy verbind hom tot 'n spesifieke *indeks* of *niche* in die stelsel/tegnologieruimte en het geen kans om opportunisties buite hierdie spesifieke area in die mark te wees nie.

Die proses

Die bevrediging van die behoeftes van 'n gebruiker is ooglopend in die stelselhiërargie 'n bo-na-onder-proses. Die tegniese vereistes en standaarde wat op die laer vlak geld moet eerstens die waardestelsel van die hoër vlak volledig steun en moet tweedens die verkrygingsproses volledig steun. Die waardestelsel van die hoër vlak in die stelselhiërargie word verstaan deur te *simuleer*. Die stelselverskaffer wat aan die operasionele gebruiker verskaf, moet dus in staat wees om funksionaliteit, koste-van-eienaarskap en gebruikersvriendelikheid te simuleer, lank voordat die gebruiker met 'n aanskaffingsbesluit gekonfronteer word.

Met resultate van dié simulasies beskikbaar, word toedelings aan *spesifikasies* gemaak. Die spesifikasies wat ontwikkel word, is afgestem op die hiërargiese verdeling van die stelsel.

Vir elke vlak in die hiërargie word twee stelle spesifikasies ontwikkel. Die eerste is daardie waarmee na die hoër vlak gekontrakteer word (bemarking) en die tweede groep is daardie waarmee na die laer vlak gekontrakteer word (verkryging). Omdat spesifikasies die konfigurasie van die stelsel definieer, is dit kontraktueel bindend en moet spesifikasies oor die leeftyd van die stelsel in stand gehou word. Dit bevestig weer eens die verbintenis van die verskaffer gedurende die hele lewensiklus.

Bewys van voldoening aan spesifikasies is 'n *evaluasieproses*. By sekere kritieke besigheidsbesluite, byvoorbeeld dat ontwikkeling moet oorgaan na produksie, word die evaluasieproses geformaliseer en word dit *kwalifikasie* genoem. Evaluasie en kwalifikasies word eksperimenteel (in toetsprogramme) en deur ontwerphersienings gedoen. Dit is koste-effektief om vooraf en met 'n aanvaarbare vlak van vertroue te verseker dat daar wel voldoen sal word aan die spesifikasies wanneer die stelsel getoets word.

Die gereedskap

Soos reeds genoem, is die gereedskap ter sprake hoofsaaklik tegnieke en prosesse wat deur stelselingenieurs aangewend word. Fasiliteite wat wel noodsaaklik is, is rekenaars en toetsbane.

Van die belangrikste gereedskap is:

- Simulasiemodelle, tegnieke en rekenaars
- Beplanningstelsels
- Standaarde en tegniese inligtingstelsels
- Konfigurasiebestuur
  - Identifikasie
  - Beheer
  - Verifikasie
- Toetsfasiliteite
- Kwaliteitsversekering

Die bestuurstaak

Die bestuur van die stelselingenieurswesefunksies berus op kennis van die proses, die gereedskap en 'n vermoë om vir elke taak 'n risikobepaling te maak en dan te beplan om die risiko's te minimiseer.

Ontplooiing van die organisasie vir stelselbestuur

• Posisie in die tegnologieruimte

Dit sou moontlik wees om 'n indeks neer te skryf waarmee die piek van 'n stelselaanspreeklike organisasie in die tegnologieruimte geïdentifiseer kan word. Deur verskillende maatskappye en groepe eenduidig teen hierdie indekse aan te wend, word poging gefokus en skaars hoëvlakmannekrag optimaal benut. Dit skep struktuur en skryf intervlakke voor oor die hele krygstuignywerheid. Aanspreeklikheid vir 'n indeks vereis kundigheid en opleiding. Tegnologievestiging kan dus gerig word om sogenaamde *sentra* en *uitnemendheid*te vorm. Indien hierdie koördinasie nie bestaan nie, kan die nywerheidsvestiging en tegnologievestigingspogings verwarrend en negatief op mekaar inwerk.

• Eenheid van bestuur

Om aanspreeklikheid op 'n sekere vlak in die stelselhiërargie of op 'n spesifieke indeks in die tegnologieruimte te aanvaar, moet die maatskappy volledige beheer neem oor die totale besigheid binne die spesifieke area en moet die intervlakke met die omliggende nywerheid hanteer kan word. Dit moet dus die vermoë hê om te kan spesifiseer, te kontrakteer en om te kan bemark oor die intervlakke heen, terwyl hy binne sy eie beheervolume 'n optimale toegevoegde waarde bied. Hierdie funksies moet onder een eenheid van bestuur staan om balans in die besigheid te kan hê. Die begrip *"stelselverskaffer"*, wat die vermoë het om vir stelsels te kontrakteer en die spesifikasies te kan ontwikkel en onderhou, is deur Topbestuur aanvaar.

• Vlak van kontraktering

Die vlak (binne die stelselhiërargie) waarop gekontrakteer word, is afhanklik van die vermoë wat die opdraggewer het om te kan spesifiseer en die uitvoerder van die opdrag het om die kontrak te bevredig. In 'n onderontwikkelde nywerheid moet die opdraggewer normaalweg meer detail spesifiseer en dus op 'n laer vlak kontrakteer. Hoërvlakspesifikasies aan die ander kant is ook meer kompleks omdat die simulasie van die stelsel moeiliker is en daarom is die natuurlike neiging om op 'n laer vlak te spesifiseer.

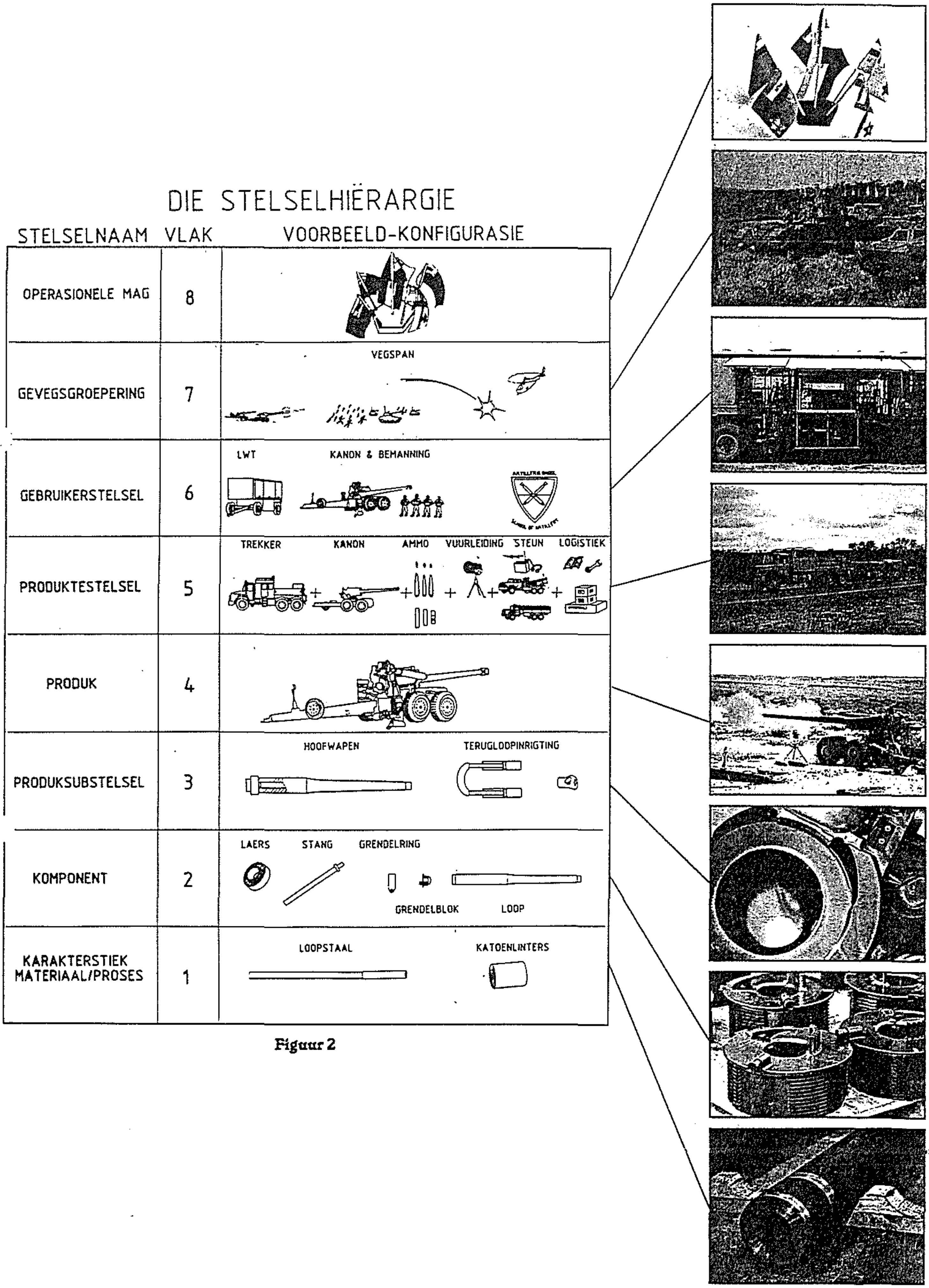
Hierdie neiging vertraag egter die tegnologiese groei in 'n nywerheid en maak dikwels daarby ook die behoeftestellers deel van die verskaffingsproses. Dit betrek byvoorbeeld dikwels die SAW-projekoffisier en die Krygkorprojekbestuurder op die komponentvlak.

Hoewel hierdie situasie noodwendig sal bestaan in 'n onontwikkelde nywerheid of gedeelte daarvan en die aanskaffingsproses dus daarvoor begrip moet hê, is die benadering dat dit nie *daar* moet stagneer nie, maar dat die kundigheid van die verskaffers voortdurend ontwikkel sal word sodat die vlak van kontraktering voortdurend verhoog kan word. □

Diagram regs: *Stelsels word hiërargies saamgestel deur elemente te integreer om logiese samestellings te vorm. Die logika van die samestellings word bepaal deur die spesifiseerbaarheid en die kontrakteerbaarheid daarvan. Hier is 'n analise van dié hiërargie in die krygstuignywerheid soos Topbestuur dit sien.*

APPENDIX 3

DESCRIPTION OF THE TECHNOLOGY SPACE


DIE STELSELHIËRARGIE
STELSELNAAM
VLAK
VOORBEELD-KONFIGURASIE
OPERASIONELE MAG
8
GEVEGSGROEPERING
7
VEGSPAN
GEBRUIKERSTELSEL
6
LWT
KANON & BEMANNING
PRODUKTESTELSEL
5
TREKKER
KANON
AMMO
VUURLEIDING
STEUN
LOGISTIEK
PRODUK
4
PRODUKSUBSTELSEL
3
HOOFWAPEN
TERUGLOOPINRIGTING
KOMPONENT
2
LAERS
STANG
GRENDELRING
GRENDELBLOK
LOOP
KARAKTERSTIEK MATERIAAL/PROSES
1
LOOPSTAAL
KATOENLINTERS

Figuur 2