An alignment strategy for SANDF Engineering Programmes

by

David Blyth

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Study leader: Prof P.G. Steyn

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 : STATEMENT OF PROBLEM

1.1 INTRODUCTION

At the battle of Hastings in 1066, William the Conqueror equipped his mounted soldiers with stirrups, a new technology to enable them to remain stable in their saddles. Using this technology they were able to conduct their assault from a commanding height, leaving their enemy at a disadvantage. This competitive advantage offered by a new technology contributed to William the Conqueror to winning the battle.

The South African National Defence Force (SANDF) owns and operates a large inventory needed to execute its task. This inventory is both complex and costly because of its engineering content and requires a significant management effort to ensure that the SANDF sustains its capabilities.

The SANDF Products System life cycle starts with the acquisition process up to commissioning. It then progresses to the operational phase where it is used in service and ends with the phase during which the Products System is removed from service and disposed of.

Each phase has its own requirements for appropriately skilled personnel to ensure optimal utilisation of the resources at the disposal of the SANDF.

As engineers are concerned with the properties of matter and sources of power made useful in machines, structures and processes, this study concerns itself with the roles that they may play and the functions that they may have during the life cycles of Products Systems used by the SANDF.

1.2 SOUTH AFRICAN DEFENCE

1.2.1 SOUTH AFRICAN DEFENCE VISION AND MISSION

A. THE VISION OF THE DEPARTMENT OF DEFENCE (DOD):

To ensure the provision in accordance with the Constitution, of an effective defence system for maintaining democracy in South Africa and to enhance national, regional and global security, through balanced, modern, affordable and technologically advanced defence capabilities.

B. THE MISSION OF THE DOD:

To provide defence capabilities that are commensurate with the needs of South Africa, and to manage, prepare and employ these capabilities in accordance with the regulations of the constitution, national legislation, and parliamentary and executive direction.

1.2.2 CONSTITUTIONAL ASPECTS

The SANDF is charged with the duties defined as follows in paragraph 200 (b) of the Constitution of the Republic of South Africa "The primary object of the defence force is to defend and protect the Republic, its territorial integrity and its people in accordance with the Constitution and the principles of international law regulating the use of force."

1.2.3 DEFENCE WHITE PAPER

Chapter 5 of the draft memorandum entitled "Defence in a Democracy White Paper on National Defence for the Republic of South Africa", of May 1996, states that in terms of the Constitutional provisions that the SANDF may be employed in the following roles and for the following functions:

- Service in the defence of the Republic, and the protection of its sovereignty and territorial integrity;
- Service in compliance with the international obligations of the Republic towards international bodies and other states;
- Service with the view to the preservation of life, health or property;
- Service with the view to the provision or maintenance of essential services;

- Service in upholding of law and order in the Republic in co-operation with the South African Police Service under circumstances, as defined in law where the Police Service is unable to maintain law and order on its own;
- Service in support of any department of state with the view to socio-economic upliftment.

These functions do not carry equal weight. The primary function of the SANDF is to defend South Africa against external military aggression. The other functions are secondary.

The size, design, structure and budget of the SANDF will mainly be determined by its primary function. Provision will, however, be made for the special requirements associated with internal deployment and international peace support operations.

1.2.4 STRUCTURE OF DEPARTMENT OF DEFENCE

The Department of Defence includes the Defence Secretariat, the SANDF and ARMSCOR. The DoD has at its highest level the Chief of the SANDF (C SANDF), the Secretary for Defence and the chairman of ARMSCOR who report to and receive instructions and guidelines from the Minister of Defence. The Ministry of Defence (MoD) is located in an integrated head office. The MoD reporting responsibilities are shown in Figure 1. Parliament has a Joint Standing Committee on Defence (JSCD) advising the Minister.

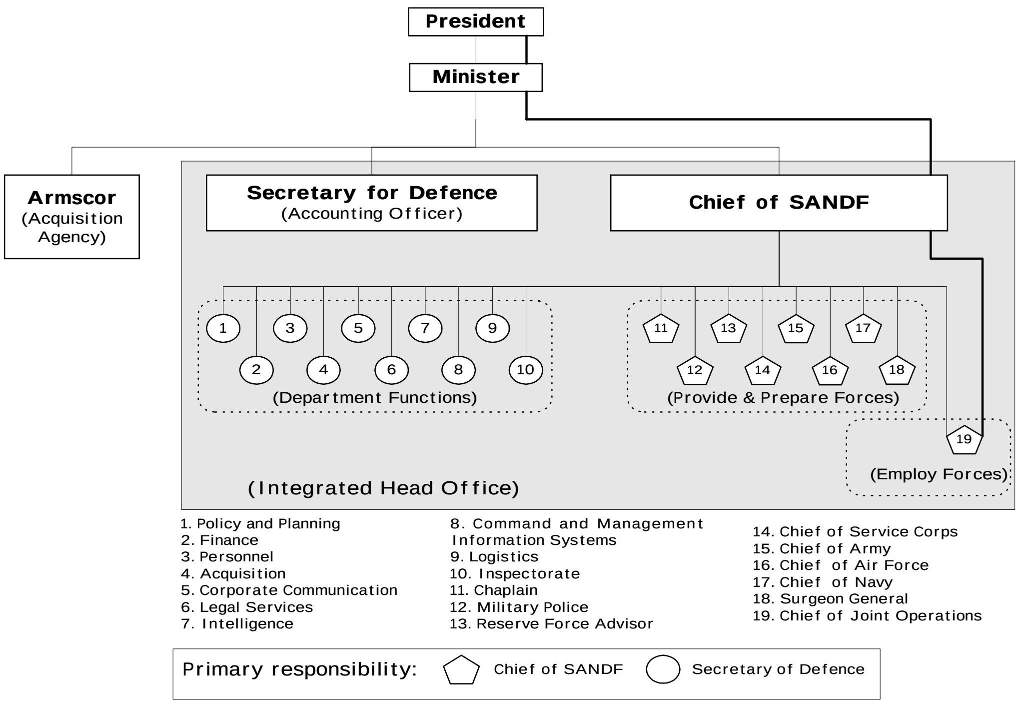

Figure 1: MoD Head Office Reporting Responsibilities.

The DoD is an organisation consisting of five levels in three tiers as illustrated in Figure 2 and as described in the following lines:

- The Minister is on level 0 and the DoD headquarters (DoD HQ) are on levels 1 and 2.
- The intermediate tier on level 3, houses task forces, type formations and support formations.
- The units are housed level on level 4.

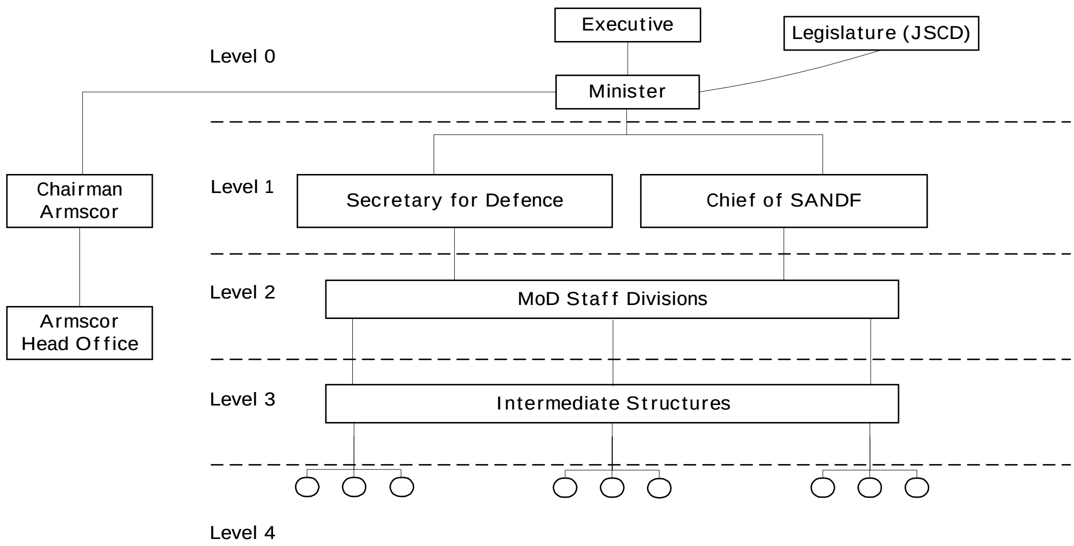

Figure 2: DoD Organisational Structure.

The systems approach to defence uses the four processes called, strategic direction, support forces, provide forces and employ forces.

The three processes known as support forces, provide forces and employ forces are executive processes. The DoD practices "jointness" in the conduct of its business (Defence Review 1996, paragraph 22.1 & 30). This approach is based on the decision to structure the organisation in such a way that common capabilities and functions may be shared by the Arms of Service (AoS). The business processes known as support, provide and employ forces may be defined as follows:

- Support Forces: The support forces process provides the combat forces with personnel and material for operational employment.
- Provide Forces: The provide forces process consists of the following three sub-processes:

- Integration and conversion of various force components into combat-ready units, or User Systems, such as battalions, squadrons and ships.
- Integration and conversion of combat-ready units into combat-ready AoS forces such as brigades and flotillas, known as higher order User Systems (HOUSs). Examples of this process include the SAAF's GOLDEN EAGLE exercise and the Army's SWEEPSLAG exercise.
- Integration and conversion of combat-ready forces from more than one AoS into combat-ready joint task forces or a Joint HOUS (JHOUS). An example of this process is the SOUTHERN CROSS exercise. This sub-process is also used to prepare a joint task force for missions.

- Employ Forces: The Employ Forces process consists of the operational deployment of combat-ready forces by the Chief of Joint Operations (C J Ops), who is responsible for force employment during missions. C JOps also is also responsible for mission preparation.

1.2.5 STRUCTURE OF THE SANDF

The SANDF consists of four AoSs, namely the Army, the SA Navy (SAN), the SA Air Force (SAAF) and the SA Military Health Services (SAMHS). The new term used in the DoD in lieu of "AoS" is "Service", but to avoid confusion with the normal meaning of the word service, the original term and its abbreviation AoS will be used in this document.

A User System consists of the personnel, Products Systems and methods doctrines as shown in Figure 3. The User System operates the Products Systems acquired by the Chief of Acquisitions, and is supported by the Chief of Logistics. The personnel supplied by Chief of Personnel are trained as part of force preparation and thus acquire the ability to perform operations from within the User System. A Naval User System could typically be a corvette; an Air Force User System could be a Cheetah squadron.

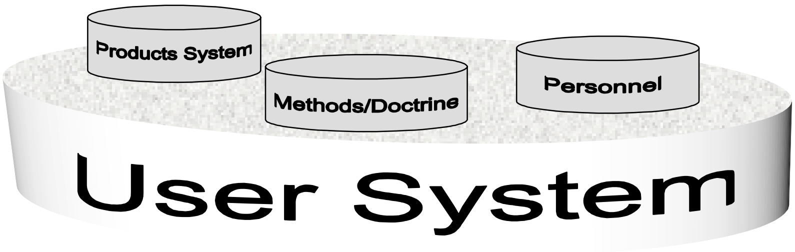

Figure 3: A Model of a User System.

Intermediate structures at Level 3 within the DoD include task forces, system groups or type formations (TyFs) and support formations. System groups are made up of User Systems with similar characteristics.

Combat-ready User Systems from more than one system group form a defence capability also referred to as a higher order User System (HOUS). C J Ops may use any appropriate mixture of combat-ready User System(s) or HOUSs for force application.

Combat-ready User Systems supplied by more than one AoS to C JOps form a joint combat force with defence capabilities.

When more than one AoS supplies HOUSs to C JOps they form a joint higher order User System (JHOUS). C J Ops will then perform force employment with a JHOUS task force.

1.2.6 SYSTEM HIERARCHY

South African defence systems are categorised in a hierarchical fashion for conceptual clarity that has proven to be useful in structuring thought processes in management. This approach is similar to that presented by Molas *et al* (1992: 16). These descriptions are intended as an aid to management and may change to suit requirements of the various AoS's environments. Table 1 presents the South African defence system hierarchy and a description of is given further down. Figure 4 illustrates the structure of the systems groups/TyFs, User Systems and units in the SANDF.

System Name	Level
Joint higher order User System	8
Higher order User System	7
User System	6
Products System	5
Product	4
Product subsystem	3

Component	2
Material/process	1

Table 1: South African Defence Systems Hierarchy.

The configuration of an item defines it by recording its form, fit, function and performance. Knowledge of the item's configuration makes it possible to predict its behaviour during development or to replace it with an exact equivalent when it fails during use. The management of systems is made possible by knowledge of their configuration.

A configuration item (CI) is a piece of equipment that is managed in terms of its status or configuration. An example of a CI is a radio, which is managed by the modification level of all its elements. If its power supply is upgraded in efficiency to provide a longer period of operation, this fact must be indicated by its configuration status. The user will then also know its capability and be able to plan operations and support accordingly. Failure to remain within the bounds of the baselines could result in the failure of a military operation, damage to or loss of equipment, injury or even loss of life.

- Level 6 is the User System. It is defined as all the elements of a combat-ready User System including the Products System(s), operational and support personnel, doctrine etc. which are permanently allocated to that User System. A model of a User System is shown in Figure 3. It also has interfaces to items shared between User Systems. A User System is the highest level of permanently assigned Products within the SANDF and cannot be acquired as a single entity. In the Air Force an example of this is the aircraft squadron, support systems, facilities, doctrine and flight and ground crew.
- Level 5 is the Products System, which is identified as a complete collection of Products forming its own configuration. In the Air Force an example of this is an aircraft with its weapons or a simulator with all the logistic support needed to sustain combat readiness.

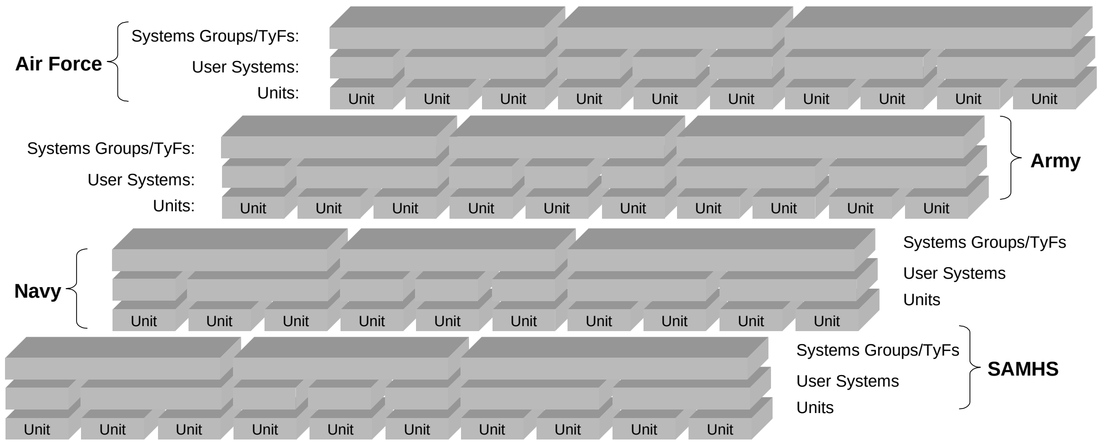

Figure 4: An example of the Application of the SANDF Systems Hierarchy.

- Level 4 is the Product, which is a single high-level configuration-managed item. In the Air Force an example of Products are a Cheetah airframe, a ground support unit, a piece of test equipment, or mission optional equipment such as a pylon or an external fuel tank. Products can be obtained by the acquisition process.
- Level 3 represents the Product Sub-systems, which constitute the Product. Typical Product Sub-systems are an electronic warfare subsystem or a weapon delivery subsystem of an aircraft or ship.
- Level 2 consists of components that make up the Product Sub-systems. A chaff dispenser and a radar warning receiver are components of an electronic warfare Product subsystem.
- Level 1 consists of the materials or piece-parts that constitute components.

1.3 PROBLEM DEFINITION

The Products Systems typically used by defence forces are highly complex, requiring high-level personnel to ensure their combat-readiness. This presents the following challenges:

- The acquisition, development, application and maintenance of knowledge of technology, Products, Products Systems and User Systems must be managed efficiently and effectively.
- Doctrines, procedures, Product capabilities and technology opportunities must be aligned to optimise defence capabilities.
- The ability of User Systems' to counter real or potential threats at the minimum life cycle cost must be optimised.
- Products System safety as required by the Occupational Health and Safety Act 85 of 93 and the Defence White Paper, chapter 3 paragraph 43.6 must be ensured.

1.4 GOALS AND OBJECTIVES

The aim of this study is to develop a strategy to optimise the value added to the SANDF by the services of the Engineering Technical Family (ETF).

1.5 SCOPE

This study is concerned with those ETF activities that contribute to sustaining the SANDF's capability to conduct military and other operations successfully and competitively.

1.6 CONSTRAINTS

1.6.1 SAFETY

Chapter 3, paragraph 43.6 of the Defence White Paper reads that "The government will not endanger the lives of military personnel through improper deployment or the provision of inadequate or inferior weapons and equipment." The government therefore undertakes to ensure that the Products Systems it provides are safe for deployment by members of the SANDF.

1.6.2 BUDGET

The Defence Review suggests that the DoD will be allocated 1,5% of gross domestic product (GDP) for the foreseeable future. The small size of the proposed defence budget is due to the greater socio-economic demands on the government. Efficient financial and asset management by the DoD is therefore a pressing issue if the SANDF is to carry out its duties.

1.6.3 SKILLS RETENTION IN THE SANDF

Chapter 9 paragraph 46 of the Defence Review states that it was foreseen that ARMSCOR would remain the State corporation responsible for the acquisition of defence equipment on account of the shortage of engineering specialists in the public service. The latter is due to inadequate public service salary scales offered to its engineering specialists.

The Republic of South Africa (RSA) is experiencing a flight of high-level skills by emigration. Experienced engineering personnel have become a scarce resource sought after by both local and international organisations.

The SANDF has a formidable challenge in the areas of recruitment, development and retention of suitable human resources for the engineering function.

1.7 METHODOLOGY OF STUDY

In the remainder of this study, the author proceeds with an environmental analysis, a literature survey, an overview of the SANDF's value chain/system, a strategic analysis, a discussion of strategy, an analysis of the ETF application. The study starts with an analysis to demonstrate the context of the SANDF and its engineering capabilities within its environment.

The paragraphs below briefly outline this study.

- <u>Environmental Analysis:</u> This study will start with a broad assessment of the environment in which the SANDF is required to operate, and identify real or potential threats to the RSA. A literature survey will follow, to set the theoretical basis for this study. The environmental assessment uses the following analyses:
  - An environmental dynamics assessment in terms of volatility and predictability.
  - An analysis of political/legal, economic, socio-cultural and technological (PEST) factors.
  - A market growth analysis.
  - A key success factor analysis.
  - A competitive industry analysis using: The five forces analysis and the four links analysis.
  - A competitor and product portfolio analysis.
  - Client analysis and market segmentation.
- <u>Literature survey:</u> The theoretical basis for this study, as extracted from literature, is discussed here. The topics used are as follows:
  - Theory of strategy.
  - Strategic management of technology and innovation.
  - Management of knowledge, expertise, skills and culture.
  - Value chain management.
  - Management of projects and programmes.
- <u>Value Chain and Value System:</u> The SANDF's value chain and value system are examined.

- A Strategic Analysis: Under strategic analysis the SANDF's environment and resources are compared.
- Strategy development: The basis of the strategy is developed.
- Acquisition Process: The acquisition life cycle phase of Products and Products Systems is analysed.
- Operational, Support and Disposal Process: Under this heading the life cycle phases of Products and Products Systems are analysed.
- ETF Application Analysis: The application of the ETF is analysed and an approach to its use is proposed.
- Alignment of Engineering Programmes: Under this heading the alignment of ETF activities and functions into programmes is discussed.
- Conclusions: This chapter presents the findings of this study.
- Recommendations: This chapter presents recommendations based on the findings of this study.

CHAPTER 2 ENVIRONMENTAL ANALYSIS

2.1 OVERVIEW OF THE ENVIRONMENTAL ANALYSIS PROCESS

Any strategy should take cognisance of the situation in the environmental situation intended for use. The analysis employed in this study includes an assessment of environmental dynamics, a PEST analysis, a market growth analysis, a key success factors analysis and a competitive industry environment analysis. The volatility and the novelty of situations in which the organisation finds itself, are a measure of the dynamics of the environment.

2.2 ASSESSMENT OF ENVIRONMENTAL DYNAMICS

2.2.1 CHANGEABILITY

Changeability is a measurement of the extent to which the environment may change. This section assesses changeability in relation to complexity and novelty.

A. COMPLEXITY

Definition: This is the extent of the number of factors in the environment and the extent to which they interact, influence the environment.

National security concerns political, economic, social and environmental factors (White Paper of Defence 1996: Chapter 2, paragraph 1). Political decisions are the basis for military actions. In terms of security, a broad spectrum of factors influences these political considerations. Economic instability or collapse could, for example trigger a chain of events that could lead to conflict. These factors and their interaction are complex.

Co-ordinating activities related to anything as sensitive as security between several sovereign independent states adds to the complexity.

Since the end of the cold war, alliances and associations have changed making their future direction more difficult to predict.

The White Paper on Defence of 1996 outlines the most predominant international trends since the cold war. These trends include the tendency for conflicts to occur within, rather than between, states, the increased interdependence of states, the discrepancy between the developed northern and the developing southern states and the willingness of the United Nations to actively contribute towards improving peace and security.

The defence industry has also undergone significant transformation. Owing to the reduction in spending on armaments, the industry has had to rationalise by means of alliances and acquisitions in line with the trend towards globalisation. Nations have had to prioritise the development of their domestic capabilities strategically. Some defence companies in the RSA now have a responsibility and loyalty to their shareholders in foreign corporations instead of ARMSCOR and the SANDF as in the past.

B. NOVELTY OR UNFAMILIARITY

Definition: This is the extent to which the environment tends to present the organisation with unfamiliar situations.

The fall of the Berlin wall and the fall of communism could hardly have been predicted to have taken place as soon as they did. Many other political and other manifestations have also defied prediction since then.

In the information and communications technology industries, the growth of innovation, capabilities and markets has exceeded all expectations. It has had an effect on all but the most remote communities.

The RSA is now a member of the Non-Aligned Movement. This, presents to investors, potential investors and nations dealing with or planning to deal with the RSA, with a new perspective.

2.2.2 PREDICTABILITY

Definition: Predictability is a measure of the probability that the changes in the environment can be accurately predicted. Predictability in this context is defined as a combination of environmental change and the visibility of future conditions within the environment.

A. RATE OF CHANGE

Definition: This parameter may be defined as the speed at which the change in the environment occurs.

Since the end of the cold war, many alliances and associations have changed rapidly, this often resulting in post-Cold War conflicts such as those in Bosnia and the Democratic Republic of the Congo (DRC).

The quantum leap that the world has experienced in the merging of communication and computers appears to have accelerated the pace of change. In addition to this, announcing occurrences through the news media, for example, can rapidly and strongly influence public opinion. Thus, for example images from Yugoslavia galvanised the world against the abuses of civilians in the conflict.

In 1975, the RSA public was denied knowledge of the first incursion by the SADF into Angola. With the current coverage of world news, an operation of such import would be difficult to hide. National and international reaction would be proportionately quicker and more severe. It is debatable whether the RSA government would have risked attracting the adverse publicity of the Angolan incursion under today's circumstances, given the visibility accorded to such actions by the international news media since the early 1990s.

The situations in Lesotho and Zimbabwe, which have both degraded more rapidly than was expected, are just two examples of the accelerating pace of change.

In the area of technology, items such as personal computers, enjoy a life of only two to four years before becoming obsolete.

Knowledge and information are more freely available than ever before, but the challenge is to harness them fully before one's competitors do.

B. VISIBILITY OF FUTURE

Definition: This concept relates to the availability of information, that is useful for estimating future trends within the environment.

Today knowledge and information are more freely available than ever before, allowing anyone interested to extrapolate data to possible future situations. In spite of this, important events such as the collapse of the economies of the Far Eastern countries in the late 1990s were unexpected.

2.3 POLITICAL, ECONOMIC, SOCIO-CULTURAL AND TECHNOLOGICAL (PEST) ANALYSIS

2.3.1 OVERVIEW OF THE PEST ANALYSIS

The PEST analysis scrutinises and assesses the political, economic, socio-cultural and technological (PEST) environments for their influence on the environment as a whole, and vice-versa. This analysis supports strategic thinking about the organisation.

2.3.2 THE POLITICAL ENVIRONMENT

National defence is also an international matter because the prime function of the SANDF is to protect the RSA against any external military aggression (Defence White Paper 1996: Ch 5, paragraph 1.1). International political opinion can also be influenced by the manner in which a defence force is employed domestically or in support of international forces. This also applies to the SANDF when it acts in terms of its secondary roles as defined in the Defence White Paper (1996: Ch 5, paragraphs 1.2 to 1.6).

There are two main factors influencing this role: the RSA national political arena and the politics of foreign national or international role-players.

Two further subsets of these aspects are concerned with the employment and the support of forces. The support of forces includes the acquisition and support of Products Systems. The employment of forces concerns those military operations conducted domestically, against external military aggression and with operations supporting the United Nations.

A. THE NATIONAL POLITICAL ARENA OF THE RSA

The RSA has a multiparty democratic political system that is based on a democratic constitution.

Political Parties: The government of the RSA is controlled by the African National Congress (ANC) alliance, which at the time of this study, holds the majority of seats in parliament of 66%. The ANC alliance consists of a broad spectrum of political groupings, that range from the SA Communist Party (SACP) and the Congress of South African Trade Unions (COSATU), on the left, to groupings that support free enterprise. The support base of the ANC alliance appears to consist almost totally of blacks. The next most significant parties in parliament include the Democratic Party and the New National Party, which have recently merged to form the Democratic Alliance. The Democratic Alliance is a centrist group that supports free enterprise.

Legislation: Since its ascent to power in 1994, the ANC alliance has enacted a plethora of laws, some of which have been surrounded by controversy. Labour legislation has been seen to be detrimental to job creation and changes are being considered amid strong objections by COSATU and the SACP. Other forms of legislation have exacerbated the shortage of skills and entrepreneurs in the RSA by placing hindrances in the path, eg. of immigrants. The SANDF on the other hand, has been legislated into existence in the Constitution of the Republic of South Africa (1996: Chapter 11, paragraph 198 to 204).

The military personnel of the SANDF are subject to the Defence Act of 1957. This act is in the process of being rewritten to comply with the constitution, but it is not expected that it will change the way in which the SANDF operates or have any significant effect on the personnel. The Labour Relations Act of 1995 does not apply to military personnel.

The Public Service Act personnel are however subject to the Labour Relations Act of 1995. Both the Public Service Act and Defence Act personnel are required to remain apolitical.

Relations between Government and Organisation: The SANDF is intended to be an apolitical state organ. The constitution and the Defence Act of 1957 define the nature of this relationship.

Retention of the SANDF's skilled members remains a serious problem on account of poor remuneration. Responsibility for remuneration, which was previously centrally regulated by the Public Service Commission, has been delegated to the Public Service departments in terms of the Code of Remuneration (CORE). The DoD uses the Personnel Management Code (PMC) for uniform members. In spite of this change, skilled members have seen little incentive to remain in the Services. Members who once studied engineering through the SAAF have been inclined to leave within two years of graduating. For similar reasons few engineers are attracted to employment in the SANDF. The organisation's ability to retain a core body of expertise as required by the Defence Review (1998: Chapter 3, paragraph 9.2), has, as may be expected been severely weakened.

Recruitment is also fraught with difficulties. The Equity in Employment Act as applied by the DoD requires that the recruits be appointed in the following ratios: 64% black persons, 11% coloured persons, 1% persons of an Asian ancestry and 20% whites persons (Fullard 2001:1).

In 2000, only 3 000 black school-leavers have passed higher-grade maths and 5 000 passed higher-grade science each year (Bisseker 2001: 1). These subjects are prerequisites for engineering degree studies. Few black candidates are consequently eligible for enrolling as students as engineers or pilots.

The SANDF must, furthermore, compete with the generous bursaries offered by corporations such as Anglo-American and Vodacom for their portion of an annual national pool of about 3000 eligible black matriculants. Very few black candidates accept the offer to study through the SANDF. The result is that a smaller number of non-blacks than that needed to maintain the proportions between the races are then recruited.

B. The International Political Arena

All hope for development, good governance, and the alleviation of human suffering is dependent on a secure and stable environment. Peace is therefore the foundation for Africa’s future. Sub-Saharan Africa is trapped in a vicious cycle consisting of poverty which gives rise to criminal and political violence which in turn, investment and weakens economic development. When a state is no longer able to offer its citizens safety and security, its primary reason for existing is lost. Thanks to the visibility that the news media give to wealthier developed economies, risk-takers, in their abject poverty, are becoming increasingly more willing to take up arms to claim their piece of the depleted economic pie in their regions (Thom 2000: 3).

Africa has enjoyed little growth since colonial times. A large proportion of African countries suffer from chronic infrastructural underdevelopment, poverty, unemployment, disease, debt and instability. The outcome of this situation is the displacement of people, the proliferation of weapons, illegal immigration, trafficking in contraband and the propagation of disease. Some countries such as Angola and the Democratic Republic of the Congo (DRC) are currently engulfed in civil wars.

Zimbabwe has recently deteriorated to the point where the rule of law has been eroded to virtual non-existence. The flight of skills has further weakened the country’s ability to grow its economy to maintain the well-being of its population.

African states do not have the coercive capacity, individually or collectively, to enforce stability on the continent in more than the most localised spots. At present an arc of crisis stretches from Eritrea, through Sudan, Rwanda and the Democratic Republic of the Congo to Angola, affecting almost a score of states. (Cilliers 2000: 1)

There is a strong link between regional and domestic security. Arguably the greater, more important challenge, considering the extent of state collapse in much of Africa, is that basic stability, law and order to be maintained in each state. The more secure states will then be in a position to assist those collapsed states. Encouraging undemocratic weak states to assist other undemocratic weak states in the provision of security without the unequivocal and significant involvement of the international community may, over time, have unintended consequences. One such consequence could be to further strengthen external involvement in the affairs of others, while continuing to allow poor countries to expend significant scarce resources on the maintenance of military forces with an essentially non-domestic security orientation (Cilliers 2000: 1).

The Drug Enforcement Agency (DEA) of the United States of America (USA) considers drug trafficking to be a global threat to stability. Today's major international drug syndicates are far more powerful and violent than any organised criminal groups ever encountered by American law enforcement agencies (Ledwith 2000: 1).

> *"Members of international groups headquartered in Colombia and Mexico today have at their disposal the most sophisticated communications technology as well as faxes, internet, and other communications equipment. Additionally, they have in their arsenal: aircraft, radar-equipped aircraft, weapons, and an army of workers who oversee the drug business from its raw beginnings in South American jungles to the urban areas and core city locations within the United States. All of this modern technology and these vast resources enable the leaders of international criminal groups to build organizations which – together with their surrogates operating within the United States – reach into the heartland of America. The leaders in Colombia and Mexico, by creating organizations that carry out the work of transporting drugs into the United States and franchising others to distribute drugs, themselves try to remain beyond the reach of American justice. The traffickers also have the financial resources necessary to corrupt law enforcement, military, and political officials in order to create a relatively safe haven for themselves in the countries in which they make their headquarters (Ledwith 2000: 1)."*

According to Ledwith (2000: 1), non-statutory paramilitary groups are also used by the drug traffickers:

> *"Since the 1970s, drug traffickers based in Colombia have made temporary alliances of convenience with leftist guerrillas, or with right wing groups. In each case, this has been done to secure protection for the drug interests. At other times, the drug traffickers have financed their own private armies to provide security services. Some insurgent and paramilitary groups have, in fact, become little more than bands of well-armed thugs selling their services to drug traffickers."*

Internationally, countries have tended to downsize their military forces since the end of the cold war.

Border Responsibilities: The RSA has a coastline of 2 798 km and land borders measuring 4 750 km. Along our maritime borders lie a 24 nautical mile contiguous zone and an exclusive economic zone of 200 nautical miles. The prospect of a border of such extent poses a considerable challenge to any defence force. The size of the RSA's borders makes them suitable as a transit route for illegal immigrants and criminal syndicates with contraband such as drugs or arms.

C. REGIONAL STABILITY

Botswana has a stable political environment, although nearly half of the electorate have not registered as voters because of disenchantment with opposition parties. The country sharply increased its defence spending during the latter part of the 1990s. Its neighbours are also upgrading their forces. Botswana sent 200 troops alongside the RSA contingent to restore order in Lesotho in 1999. The Tuli block in Zimbabwe is a potential source of conflict as Botswana locals feel that the area belongs to them. This matter has however not been raised with Zimbabwe. The satisfactory growth in Botswana has failed to generate adequate employment for young well-educated school-leavers and has resulted in riots. The electorate has become cynical of the political elite whose corruption has recently surfaced (Synge 2000: 59). Botswana has been inclined to be wary of its regional neighbours, preparing for a worst case scenario by maintaining relatively large military forces. Violent crime in that country is also a cause for concern (Synge 2000: 60).

The mountain kingdom of Lesotho, long marked by political turmoil and economic struggle suffered rejection of the results of the 1998 election by parties opposed to the Lesotho Congress of Democracy (LCD). The police and military were divided along political lines. The resulting violence led to intervention by a SADC/-RSA force. Further violence and arson ensued, destroying many businesses. Political tensions were reduced when the government announced that new elections were to be held in the second quarter of 2001 (Synge 2000: 107).

In Zimbabwe President Robert Mugabe suffered an unexpected defeat in a referendum to change the constitution. Perceiving the influence for this defeat to originate from the small group of Productive and influential farmers, the so-called “war veterans” terrorised the farmers, occupying white-owned farms and killing 20 people while injuring many others. Many farmers were forced to leave their farms. Further violence and intimidation marked the run up to the election in June 2000, which the ruling ZANU (PF) won albeit with a lower majority than before. Zimbabwe has been racked by a growing lack of respect for the law and dictatorial tendencies by President Robert Mugabe. His government amended the constitution to provide for the expropriation of farms without compensation. International confidence and the aid traditionally provided by the international community have dropped. The fuel shortage, which is due to non-payment of their accounts, has plunged the country into a crisis. Owing to involvement in the war in the DRC, conditions for the Zimbabwean military have been less than satisfactory (Synge 2000: 487).

For many years a peaceful kingdom, Swaziland is the only country in the Southern African region without a constitution or full democracy. Groups demanding the establishment of democracy are subjecting the monarchy to increasing pressure. A pro-democracy strike caused tremendous damage while enabling the population to gain a few concessions from King Mswati II. A political group called the “Black Tigers” emerged after the 1998 elections. This led to a government crackdown on opposition politicians. The Black Tigers claimed responsibility for a series of bomb blasts subsequent to the crackdown. Recent support of the people and intervention by South African unions in Swaziland’s internal affairs have the potential to cause increased instability in the workplace. The influx of crime syndicates and criminals from the RSA is distorting Swaziland’s economy. The understaffed police force is unable to control access through their borders, this resulting in the Southern and Eastern regions of Swaziland becoming transit points for criminals and contraband. Swaziland is also an area where dissidents from the RSA could easily take refuge from South African security forces (Synge 2000: 397).

Moçambique was afflicted by a civil war for many years under the FRELIMO government until the RENAMO movement was persuaded to join the democratic process. FRELIMO won the election in 1999 with an overall majority that was less than that of the previous election in

1994. Despite differences between the two opposing groups, it appears unlikely that RENAMO will revert to a campaign of violence. This group has threatened to form its own government in the central and Northern provinces, sparking fears of a possible secessionist war by its leader especially since the group has been excluded from provincial government. Lawlessness is the order of the day in large parts of the rural areas where the government has little presence. Crime networks controlled from other countries exploit this situation. Arms and ammunition are easily accessible, posing a threat to maintenance of law in the region. Moçambique suffered greatly under the devastation wreaked by major floods in the first quarter of 2000. Support from neighbouring countries was essential for survival and recovery. Unions have threatened a general strike if the government fails to increase the minimum wages for workers. The flood that ravaged Moçambique also devastated parts of Botswana, Zimbabwe, Swaziland and the RSA (Synge 2000: 185).

In spite of a lack of resources, some African states have shown a surprising and sobering ability to finance military operations (Thom 2000: 10).

In some African regions, generations have grown up knowing only war. It will be difficult stopping the conflicts in these areas (Thom 2000: 11).

By 2010, it is likely that Africa will consist of islands of stability around relatively strong, prosperous states such as the RSA, Kenya and possibly, Nigeria. Other states that are unstable will probably develop into secure city-states surrounded by local powers pursuing their own interests (Thom 2000: 11).

The predictive index of civil war has been determined to be greater in Sub-Saharan Africa than other regions. The probability of war in Sub-Saharan Africa, excluding the RSA, is also growing whereas in other regions it is on the decline. (Collier *et al* 2000: 15).

2.3.3 THE ECONOMIC ENVIRONMENT

A. THE DOMESTIC ECONOMIC ENVIRONMENT

The RSA's world competitiveness rating has increased to 25 and its growth competitiveness ranking is 33 (World Economic Forum 2000: 196).

A degree of friction and discomfort is being felt by the Southern African Development Community (SADC) countries on account of the RSA's economic dominance in the region.

Zambia and Zimbabwe have found it difficult to compete with imports from the RSA (Synge 2000: 287).

The issue of water security has led to tensions between Namibia, Botswana and Angola. In the future this may become a greater issue in the region (Synge 2000: xv).

<u>GDP:</u> The GDP for 1998 was US$ 116,730 million, which was the highest in Sub-Saharan Africa. Table 2 suggests that the RSA's economy has shifted towards a service economy with a decreased contribution from the agricultural sector (International Bank for Reconstruction and Development 2000: 253).

		Value added as percentage of GDP			
Year	**GDP [$M]**	**Agriculture**	**Industry**	**Manufacture**	**Services**
1998	116 730	4	38	24	57
1980	78 744	7	50	23	43

Table 2: Economic Sector Contribution to GDP (International Bank for Reconstruction and Development 2000: 253).

The RSA has shifted towards becoming a service-based economy.

The RSA has achieved a smaller growth in its Gross Domestic Product than was expected after 1994 when the then Government of National Unity was formed.

<u>Currency Fluctuation and Exchange Rates:</u> The value of the currency of the RSA has deteriorated since 1994 as shown in Figure 5. Since 1996 the RSA Rand has lost considerable value against other currencies. This holds advantages for the export trade, but weakens the RSA's ability to acquire resources required from foreign countries, to develop local industries for competition in the global market.

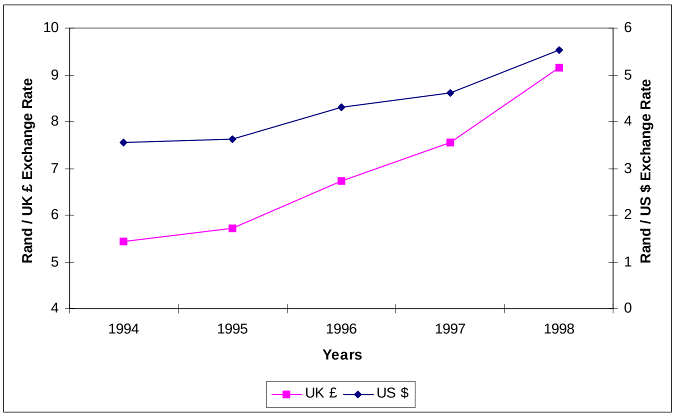

Figure 5: Currency Exchange Rates since 1994 (SARB 2000: x).

Industries: The RSA has an extensive mining industry and is the world's largest producer of platinum, gold and chromium. Other industries include the assembly of automobiles, metal-working, and the production of machinery, textiles, iron, steel, chemicals, fertiliser and foodstuffs.

Investment

- By the State: The State's capital expenditure for 1998 was 1,3% of GDP (International Bank for Reconstruction and Development 2000: 256).
- By the Private Sector: Investment by the private sector in 1998 was 72,9% of gross domestic fixed investment (International Bank for Reconstruction and Development 2000: 260).
- Foreign Investors: Foreign direct investment (FDI) was US$ 993 million and US$ 550 million in 1995 and 1998 respectively (World Bank South Africa Data Profile 2000: 1). This decline in FDI appears to be the result of an increase in conflicts and corruption in southern Africa.

Unemployment: The RSA's official unemployment level at the time of the 1996 census was 33,9 % of the 23,986 million people of the population aged between 15 and 65 years of age. The Global Competitiveness Report for 2000 (World Economic Forum 2001: 197), rated the RSA's unemployment very badly at 55 out of 59.

Globalisation: Globalisation has had a significant influence on the previously isolated RSA economy. Many firms closed when faced with competitively priced imported Products. Other firms that were well-managed found that new markets sought their services and goods.

Stability in monetary and fiscal issues: The RSA government has maintained fiscal discipline by resisting unrealistic public service wage demands and reducing the budget deficit. The Reserve Bank has generally adhered to strict monetary policies (Synge 2000: 291).

Labour movements: Between 1989 and 1997 the RSA lost more than a quarter of a million of people to emigration, a figure that is shocking compared with Statistics SA's count of 82 811. Since 1994, 56% more professionals have been emigrating annually than in 1989. Home Affairs on the other hand has not been able to cope with the processing of applications from skilled immigrants, but has been seen to improve recently. The inefficient processing of immigrants' applications serves as a discouraging signal to businesses entering the RSA (Berkowitz 2001: 1).

B. The International Economic Environment

Depending on its individual situations, each country has its own spending priorities. Generally expenditure on defence has dropped quite drastically throughout the world. Those opposed to funding of the military or in favour of disarmament, argue that a greater peace dividend would be earned if governments spent their money on social services rather than weapons. In the Sub-Saharan Africa some countries have spent a larger part of their Gross National Product (GNP) than have others. In some cases the larger spenders have poor national wealth as indicated by their GNP per capita. Figure 6 graphically shows the relationship between the GNP per capita and the degree of military spending by the countries listed in Table 3. The same parameters for the world are shown to place the sending of the various countries spending in context.

The average national military expenditure in the rest of the world is about 2,8 % of GNP (International Bank for Reconstruction and Development2000: 262).

Table 3 shows that the sub-Saharan African economies are relatively poor, each having a low GNP/capita.

Slowing economies in several countries have led to civil disorder as the populations protest particularly against urban unemployment (Synge 2000: xv).

Country	Military Spending [%GDP]	GNP per Capita [US$]
RSA	1.5	3400
Botswana	6.5	3260
Namibia	2.74	2200
Swaziland	2.5	1440
Zimbabwe	5.5	750
Lesotho	3.4	670
Zambia	1.76	380
Angola	6.9	340
Malawi	1.47	243
Moçambique	1.02	90

Table 3: The Correlation of Southern African Countries' GNP per Capita with their Military Spending during 1999/2000 (Synge 2000: xvii).

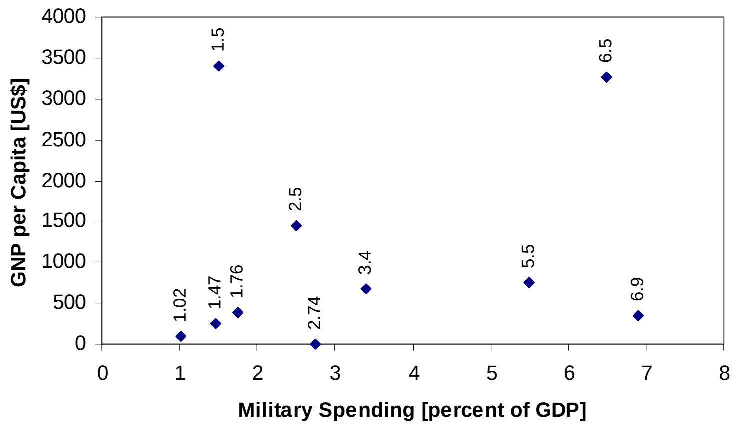

Figure 6: The Military Spending of Southern African Countries Listed in Table 3 during 1999/2000 (Synge 2000: xvii)

2.3.4 THE SOCIO-CULTURAL ENVIRONMENT

A. SHIFTS IN VALUES AND CULTURE

In South Africa there has been a shift away from the former authoritarian, hierarchical approach, which was the hallmark of the National Party's period of government. The ANC government generally tends to seek consultation during the development of new laws. They have however not hesitated to employ their majority in passing laws, sometimes to revisit certain legislation as in the case of the Labour Relations Act of 1995. Globally, the trend towards consensus-seeking is growing. However a few states, for example Zimbabwe under Mugabe and the DRC under Kabila have been less than accommodating towards those who disagree with them.

The youth in very poor communities are susceptible to active involvement in conflicts, wars and even banditry.

B. ATTITUDES TO WORK AND LEISURE

In terms of the competence of government officials, the RSA's competitiveness is very poor as it is ranked at 55 out of 59 countries (World Economic Forum 2000: 197).

Several incidents involving black members of the SANDF murdering their white counterparts have occurred. These include the incidents that have occurred at Tempe military base, Simon's Town and at 7 SA Infantry at Phalaborwa. The murder of two black SANDF members during the robbery of firearms by white members has also raised concern. The Tempe incident has been under investigation by the Setai committee.

Doctors employed at SAMHS are demilitarising to avoid serving in the DRC or in rural areas (JSCD 2001: 1).

The Chief of the SANDF (C SANDF) has stated that certain members of the SANDF have had a tendency to be absent without leave (AWOL). These cases are dealt with by the deduction of amounts from the salaries of the members concerned for the period absent. Because of the investment in them, these members are not being discharged (JSCD 2001: 1).

While the above cases are examples of offences caused by factors ranging from poor discipline to plain criminality, there are many members in the SANDF who are well-motivated and disciplined and who serve with distinction.

C. Natural Environment

Just as Africa comprises many countries, cultures, races and languages, it has many different ecological environments. These environments range from vast deserts, semi-deserts, dense forests, and savannah grasslands to swamps and lake areas. These environments each have their own unique ecologies and diseases. These diseases which include Malaria, Congo Fever and Sleeping Sickness pose a serious threat to any military force operating in these regions.

Moçambique and the Northern border areas of the RSA suffered floods during the first quarters of 2000 and 2001. Local and foreign military and civil organisations were required to assist with search and rescue operations in these areas and the SANDF played the leading role in the operation.

The SANDF is expected to conduct operations in any of these environments. Suitability and fitness for purpose in the environmental conditions encountered in these areas are important aspect of the design of the equipment used for these operations. The question has arisen whether the RSA's military equipment is suitable for deployment in these regions. If it is not, the efficacy of deploying the SANDF in these unsuitable regions, is questionable.

D. EDUCATION AND HEALTH

Education: The RSA's illiteracy rate declined from 15.8% to 14.3% in the case of male adults and 17.5% to 15.8% in the case of female adults between 1995 and 1999 (World Bank South Africa Data Profile 2000: 1).

Assessments have rated the quality of tertiary education in the RSA as poor, at 46 out of 59 economies. Maths and science education was rated as 58, the second worst of those 59 countries assessed. The difference in the quality of schools in the RSA also fared very poorly, being placed at 54 out of 59 countries. The quality of public-funded schools was rated as poor at 44 out of 59 countries (World Economic Forum 2000: 197).

Health: In 1995 the average life expectancy of South Africans was 62 for males and 68 for females (International Bank for Reconstruction and Development 2000: 232).

The RSA has a very large range in the quality of healthcare, is therefore considered to have an inadequate healthcare system nationally, being rated at 50 out of 59 countries (World Economic Forum 2000: 197).

Over the last six years, Zimbabwe has lost a million people to AIDS. It has been estimated that 25% of Zimbabweans are infected with HIV (Synge 2000: 488).

E. DEMOGRAPHIC CHANGES

Urbanisation: The ratio of the size of the urban population to that of the rural population increased from 49.3%, 52.1% to 51.7% in 1995, 1998 and 1999 (World Bank South Africa Data Profile 2000: 1).

Population growth rate: The population growth rate has been 2.2%, 1.8% and 1.7% for 1995, 1998 and 1999 respectively. There has been a steady net increase in the loss of people through emigration. In 1998 and 1999 the country lost 4843 and 5540 people, respectively. This reflects the difference between the number of immigrants to the South Africa from foreign countries and the number of emigrants leaving the RSA. The emigrant category comprises only those persons who have formally declared their intention to permanently leave the country. The emigrants category generally includes skilled professionals or businessmen or women. Of the 8 276 people that emigrated in 1998, 1 796 were from professional occupations, 736 were from managerial and administrative occupations and 306 were from artisan or related occupations (Lindeque 2000: 1.16).

Crime rate: The level of crime in the RSA is unacceptably high. In the second half of 2000, the Ministry of Safety and Security announced a moratorium on the publication of crime statistics. During the first sitting of parliament in 2001, the opposition parties strongly objected to this decision, exerting pressure on government to resume the release of crime statistics.

Police protection and organised crime in the RSA both score very badly, South Africa being placed 56th out of the 59 countries assessed (World Economic Forum 2000: 197).

As crime places a burden on the State, businesses and private individuals, it presents a risk to investors and hinders the development and growth of the economy.

F. INCOME DISTRIBUTION

The Gini coefficient is a measure of the income distribution in an economy. It is derived from statistics indicating the scales of income of different levels of population of the country. Figure 7 shows the income distribution profiles of the RSA compared with those of Zimbabwe, Egypt and Australia (International Bank for Reconstruction and Development 2000: 238). This graph shows the extent to which the RSA and Zimbabwe share the characteristics of a more uneven income distribution compared with Egypt and Australia.

If the wealth of a country were divided perfectly equally among all the citizens in the country, the Gini coefficient would be zero. If only one person out of the entire population were to hold a nation's wealth, the Gini coefficient will be unity. During the years of apartheid, the RSA registered one of the highest Gini coefficients in the world ranging from the high 0,50s to the low 0,60s. Countries such as Columbia, Chile, Brazil, Kenya and Jamaica where large degrees of inequality were prevalent had similar Gini coefficients. Studies by Statistics SA in 1995, 1996, 1997 and 1998 demonstrated how the Gini coefficient rose steadily from 0,73 in 1995 to 0,80 in 1998. Statistics SA has, however, always measured the Gini coefficient along racial lines each year. The trend is upwards for whites, coloureds, and blacks, but most dramatically among blacks, rising from 0,70 to a staggering 0,81 in three years. If the Gini coefficient is correct, this suggests that there has been a strong tendency in the RSA for wealth to concentrate in small groups within each racial group (Jack 2000: 1).

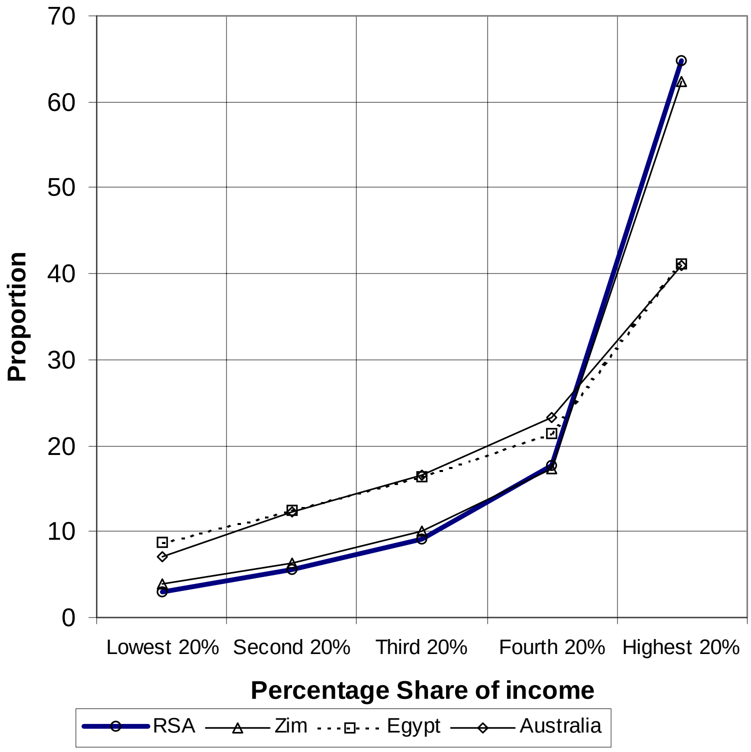

Figure 7: Profiles of the Income Distribution of several Economies (International Bank for Reconstruction and Development 2000: 238).

This is a cause for concern as great inequalities in wealth present a threat to the state's ability to maintain stability. Symptoms of popular discontent include corruption, high crime levels and even insurgency.

2.3.5 The Technological Environment

A. Government Policy

In 1996 the RSA government presented its approach to technology in the White Paper on Science and Technology. This appears to have been a deliberate attempt to approach and direct technology strategically.

It is crucial for government departments to retain A capability and capacity for intelligent buying of research and development and SET services (DACST 1996: Chapter 3, paragraph 3).

The approach for a national system of innovation is envisaged in the White Paper on Science and Technology of the Department of Arts, Culture, Science and Technology (DACST)

(1996: Chapter 3, paragraph 1) as an interacting system of functioning institutions, organisations and policies with a common set of social and economic goals.

The RSA government believes that the functions of DACST should include the following (DACST 1996: Chapter 5, paragraph 1):

- Promoting coherence and consistency in Government's approach to stimulating the national innovation system in general and in its effort to support the development of science, engineering and technology in particular.
- Promoting and co-ordinating interdepartmental and government-wide initiatives relating to the support of innovation and technology diffusion.
- Making available and controlling a government-wide science budget to enable ministers to assess and determine the multi-year spending priorities, thereby enhancing innovation effectiveness.

The defence sector is the repository of an extensive set of engineering and technological skills and holds potential for exploitation in civil applications (DACST 1996: Chapter 8 paragraph 5).

The DACST is carrying out a comprehensive audit of research and technology to identify and assess existing government interventions in science, engineering and technology (SET) and develop an inventory of research and technology projects in the economy (DACST 1996: Chapter 5, paragraph 2).

<u>Defence Technology Policy:</u> It is envisaged that a small, sophisticated force, by leveraging its technological advantage to increase its flexibility and responsiveness, could mobilise more rapidly. Investment in defence research is considered important for this reason (DACST 1996: Chapter 8, paragraph 5). The Directorate of Technology Development of the SANDF is one of the sources of expertise to be used to manage the innovation fund envisaged by Government (DACST 1996: Chapter 7, paragraph 2). A strong technology base for the SANDF is essential for the following purposes (DACST 1996: Chapter 7 paragraph 2):

- Maintaining the ability to detect threats.
- Creating an awareness of military technological trends and the implications thereof for the SANDF.
- Providing expert advice in the area of procurement.

- The provision of test and evaluation services.
- Supporting upgrading and maintenance efforts

Government Investment Policy: Government plans to support research and innovation by the co-ordinated funding of:

- Higher education institutions (DACST 1996: Chapter 7, paragraph 3).
- Science, engineering and technology institutes (SETIs) (DACST 1996: Chapter 8, paragraph 1).
- Patents: The RSA government plans to develop legislation and policy that will be in keeping with international norms, thereby affording protection to the innovator and encouraging economy-growing innovation (DACST 1996: Chapter 6, paragraph 1).

B. PRODUCTS

During the arms sanctions against the RSA, many indigenous Products of superior quality were developed, manufactured and employed in South Africa. Since the end of the Cold War, military spending has declined dramatically world-wide, making it difficult for South African weapons to be marketed in spite of the removal of sanctions. Several negotiations to obtain major sales of the Rooivalk combat helicopter system to the UK and Australia have been unsuccessful. Deals involving other defence Products such as the communications systems and the Health and Usage Monitoring Systems (HUMS) for the British Aerospace Hawk export contract to Australia have, on the other hand, been successful.

C. NEW TECHNOLOGIES

The RSA has initiated the acquisition of a set of new weapons systems to replace the existing inventory and to keep abreast of the current trends in arms technology.

In relation to other economies, the RSA has been rated 12th out of 59 for the licensing of technology, 19th for e-commerce and 12th for Internet use for general information (World Economic Forum 2000: 197).

The SANDF maintains research and development institutes to address those core areas that are strategically significant for ensuring a credible deterrent. The output of these R&D processes is used in defence Products. The lower level of investment in technology has, however, reduced the output of research.

D. TECHNOLOGICAL COMPETITIVENESS

The number of scientists and engineers per million people in the RSA compares favourably with that of other African countries, as shown in Figure 8. This is, however, not the case if we are compared with a first world country such as Canada.

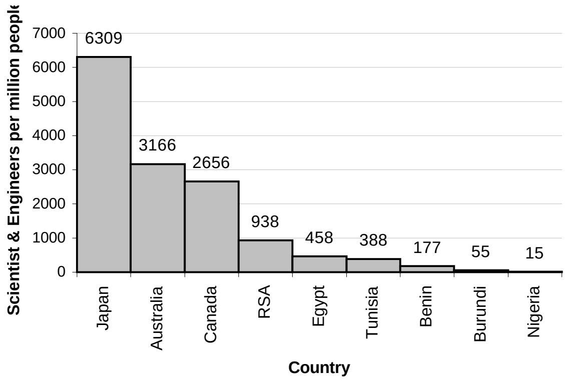

Figure 8: The Scientists and Engineers Population per Million People per Country (International Bank for Reconstruction and Development 2000: 266).

There are no records of scientists and engineers in Botswana, the DRC, Kenya, Lesotho, Malawi, Moçambique, Namibia, Tanzania, Zambia or Zimbabwe (International Bank for Reconstruction and Development 2000: 266). This suggests that the numbers of these resources in these countries are either insignificantly low or else the survey failed in these countries. These latter countries suffer from a distinct disadvantage in the areas of technological competitiveness or innovation. They are also dependent on foreign support and advice for technological acquisitions and support throughout their economy.

This apparent potential for technological advancement has two main requirements, namely a technologically more capable defence force and an economic engine to drive the creation of wealth by the development and production of commodities for the markets.

Most African countries need foreign assistance, as they are unable to maintain their weapons inventories effectively (Thom 2000: 3).

While the RSA may appear competitive compared with its neighbours, its technological also a source of concern, as wealth derived from technological innovations will not be distributed evenly in the sub-Saharan region. This may contribute to the potential for conflicts.

The brain drain or rate at which the RSA loses people with high levels of skills is the third worst in the world ranked 57th out of 59 countries, with the USA performing the best (World Economic Forum 2000: 197).

E. DEVELOPMENTS IN UNRELATED INDUSTRIES

Information warfare is an example of an area of the defence industry that has attracted attention from users of information technology (IT) such as banks. The civil use of IT is a defensive one focussed on avoiding and surviving the danger of threats from hackers and viruses.

Conversely, the military have begun adopting the cryptographic and communications technologies that have migrated to the civilian sector as effective, affordable Commercial off the Shelf Systems (COTS).

F. TRENDS

Global Trends in the Technological Environment: The distinction between communications and computers have become blurred beyond all expectations. The Internet, which operates on telecommunications networks, is challenging traditional telephone systems. Mobile telephony has more in common with a digital computer database than a radio communications system.

The role of the soldier has changed from one of being concerned only with all-out war to one of peacekeeping and police support. The conventional service or assault rifle has come under debate. The development and adoption of less-than-lethal and electronically controlled weapons is being proposed for the new roles of the soldier (Gander 2001: 1).

In general, many new Products have the following characteristics:

- They contain significant numbers of software components.
- They have a significant degree of embedded intelligence.
- They are physically compact.
- They are considerably more robust and reliable than older Products.
- They often have embedded functional redundancy to enhance dependability.

Because of these characteristics, the functions and performance capabilities of Products are tractable or adaptable. Often, the client or user can implement his changes to suit their range of applications. Modern Products are therefore flexible to the point where they can be considered to have deferred or virtual configurations.

Open systems have become an important and attractive trend. Hanratty *et al* (1999: 50) define open systems as systems that can be supported by the entire marketplace, rather than supportable by a single or small group of suppliers on account of the unique aspects of the design chosen. Open systems reduce risks and costs associated with developing new interfaces.

Communications: The RSA, rated 45th out of 59 countries, is one of the poorer performers internationally as regard its telephone density (World Economic Forum 2000: 197). The RSA had an average of 107 telephone main lines per 1000 people in 1997 compared with the world average of 144 and the lower middle income country average of 108 (International Bank for Reconstruction and Development 2000: 267).

Scenarios: In a peaceful environment, technological innovation capabilities can contribute to wealth creation for a country by means of exports and licensing agreements. When a country prospers while its neighbours experience poverty, a situation with a potential for instability develops. Unemployed people tend to migrate to the country where they can derive incomes but where the local populations resists the possible dilution of its employment opportunities and labour bargaining ability.

In an environment experiencing conflict, technological capabilities provide the military forces with innovation opportunities that leverage their capabilities and therefore their influences.

2.4 MARKET GROWTH ANALYSIS

A. THE MILITARY

The military as an "industry" also experiences life cycles. During peace-time the military should be reduced to a core size. Rebuilding a larger military capability is both expensive and a lengthy process. During times of impending conflict, nations increase the size of their defence forces. Restoring or increasing a defence capability is very expensive and takes considerable time. The end of the Cold War resulted in the drastic reduction in military spending internationally.

The major world powers and others have down-sized their defence forces and closed down many of their units and bases.

The ensuing conflicts such as those in Iraq and Yugoslavia have exerted pressure on those military organisations that were left.

More wars today rage within countries than between nations. This is true of Africa where many countries are embroiled in internal conflicts, often with interference from neighbouring states. Many of these conflicts involve light infantry often using the ubiquitous AK47.

Some states such as those involved in the Ethiopia-Eritrea border war and others operate sophisticated weapons. Examples include weapons such as Su 27 and MIG 29 fighter aircraft, Hind 24 attack helicopters; and tanks equipped with night vision equipment and fire control systems (Thom 2000: 8). Some of these advanced weapons could be used against the RSA.

B. THE DEFENCE INDUSTRY

The international defence industry had therefore also experienced a general decline after the end of the Cold War.

The influence of advanced technology during the war conducted by the Allied forces against Iraq and later the groups in Yugoslavia, has rekindled interest in military applications. Many of these applications such as the Global Positioning System (GPS), which was developed by the USA's DoD for military purposes, have been adopted for civil purposes.

The RSA defence industry has started experiencing growth in demand for its Products, from foreign countries. Large overseas companies have acquired several local firms. These firms are now manufacturing and designing Products on behalf of their principals for foreign clients.

Conflicts or wars could lead to embargoes or sanctions against the RSA. The RSA requires its own core capabilities for such contingencies.

2.5 KEY SUCCESS FACTOR ANALYSIS

2.5.1 INTRODUCTION TO KEY SUCCESS FACTOR ANALYSIS

The key success factors of success in the existence of a military organisation are those abilities required to win a conflict, since these abilities would discourage aggressors and ensure a peaceful existence for the nation. In the same way, the SANDF's factors of success are those that enable it to effectively and efficiently defend the RSA from aggression, preferably by deterrence. Deterrence is that capability that ensures that a potential aggressor hesitates to attack for fear of losing the conflict. The uncertainty generated in a potential aggressor by a country's flexibility and capability, can be a deterrent. Effective deterrence is therefore the key success factor.

2.5.2 KEY SUCCESS FACTORS

A defence force must be capable of executing operations and the quality of the operations is determined by whether the defence force in question wins any conflict in which it may become involved. Meiring (2001: 1) stated that the core function of the SANDF is to execute successful operations in which the aggressor is defeated (*wenoperasies*).

The principles of war are the elements that a defence force uses as a basis to win conflicts. The principles of war can therefore be regarded as key factors of success for the SANDF. These factors do, however, require certain resources to develop and sustain them. The table in Appendix C: shows those areas in which the resources may contribute towards the SANDF's successes. The ETF is concerned with the conceptualisation, development, acceptance, support, upgrading and disposal of Products, Products Systems and the associated processes, and is therefore well- placed to contribute towards the SANDF's key factors of success. The table in Appendix C: shows those areas in which the ETF can contribute to the success of a defence force. As part of a larger system, resources may contribute to more than one key success factor by design or by accident. The key success factors desired for one, or a series of operations are an issue of operations to be determined by research and force design.

Table 4 presents a summary derived from Appendix C: , of the areas in which the ETF may contribute to the SANDF's success factors.

Focus	ETF Contribution Areas to Support SANDF Success	
	Engineering	**Technical Services**
Products Systems and Products	Systems Engineering/Systems design for: • Capability • Compatibility • Dependability • Supportability • Ease of operation • Cost-effectiveness • Flexibility Verification of compliance of designs with specifications. Validation of compliance of designs with user requirements. Configuration management. Project management.	Availability at required rate and location. Configuration management. Project management.
Command, Control, Communications, Computers, Intelligence, Information, Surveillance, Reconnaissance and Electronic Warfare (C4I2 SR EW)	Same as in the case of Products Systems and Products Systems Engineering/Systems design for: • Penetration denial capabilities for Information and Communications Technology (ICT) Products. • Deception capabilities for Products	Availability at required rate and location. Configuration management. Project management.
Technology	Ability to identify new technologies suited to SANDF applications. Management of technology	Application of technology in support process.

Table 4: Areas in which ETF contribute to the SANDF's Factors for Success.

Resources and ETF contributions often affect more than one of the key success factors. An example of this, is an airborne refuelling capability, which results in “Mass of force”, “Manœuvre” and “Surprise”. User Systems employ resources such as mission planning tools and weapons effectiveness planning to achieve “Economy of Force” and the “Selection and Maintenance of the Objective”. Information and planning tools are force multipliers that should be at the disposal of commanders. As the availability of information to commanders and staff officers grows, the more its integrity becomes a factor. Denial, leakage and corruption of information pose a real threat to a successful command function. The protection of the information and the infrastructure used to disseminate it is a highly important task (Pretorius: 2001: 1).

The resources that support the principles of war and the ETF contribution to them, is made to them are strategic issues that depend on the approval of the executive. The strategic requirement need these resources has been recognised and defined by the RSA Government. The resources in question appear to match those identified in Appendix C: (Defence Review 1998: Chapter 13). The contribution of the ETF is a significant key to the success of the SANDF as a credible deterrent.

Certain resources are required to achieve success in certain areas. These are typically, personnel, training, technology, experience, finances and an organisational climate. The Strategic Management of Technology and Innovation is described in section 3.2 and the Management of Knowledge, Expertise, Skills and Culture is described in section 3.3.

2.5.3 COST-EFFECTIVENESS

Achievement of all the key performance objectives presented above is possible with unlimited resources. The chief resource preventing this achievement of success is finances. Consequently, a balance between cost and effectiveness is required. Figure 9 shows this relationship. The sloped line in the graph shows a trend towards constant cost-effectiveness. The dashed horizontal line presents the minimum required level of effectiveness for a given situation.

The cost may be derived from the net present value (NPV) of the financial or cash flows over the life of the User System. Effectiveness, being dependent on subjective judgement, is a more difficult parameter to quantify. The NPV method is a more accurate technique of assessing the feasibility of a programme.

The User System labelled as “A” Figure 9, has a low cost and a low effectiveness; as it is below the minimum required level of effectiveness and it is therefore unacceptable. The User System labelled as “B”, has the same cost-effectiveness as “A”, but a higher cost and effectiveness. Because it is above the minimum required level of effectiveness, it is an acceptable option. The User System labelled as “C” in Figure 9, has a lower cost-effectiveness than “A” or “B”, but a higher cost and lower effectiveness. Because the poor cost-effectiveness, and because it is below the minimum required level of effectiveness it is unacceptable. The User System labelled as "D" in Figure 9, has the same effectiveness as "B", but a lower cost. It is therefore more cost-effective. The User System labelled as "E", has a greater effectiveness than "B" or "D", but a much higher cost, and therefore appears to be less cost- effective. The most desirable solution will be that User System whose performance is such that it will be capable of successfully dealing with all the plausible threats, at the lowest cost. In this case it appears to be "D".

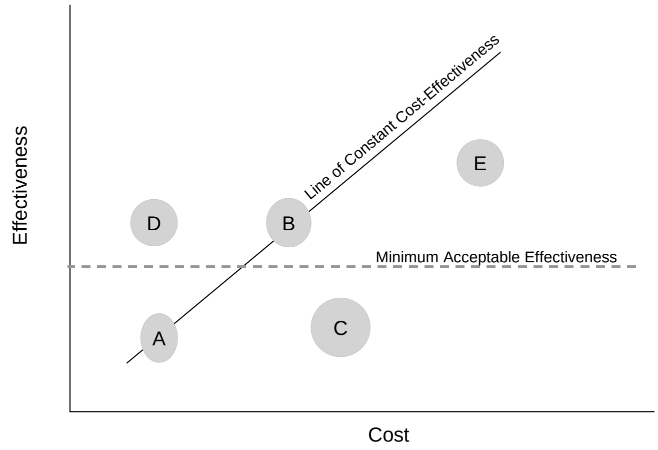

Figure 9: The Relationship between Cost and Effectiveness.

When cost-effectiveness is studied, consideration should be given to the total life cycle of the User System. The acquisition of a Products System precedes the establishment of a User System. The total cost of the User System includes the operation and support costs.

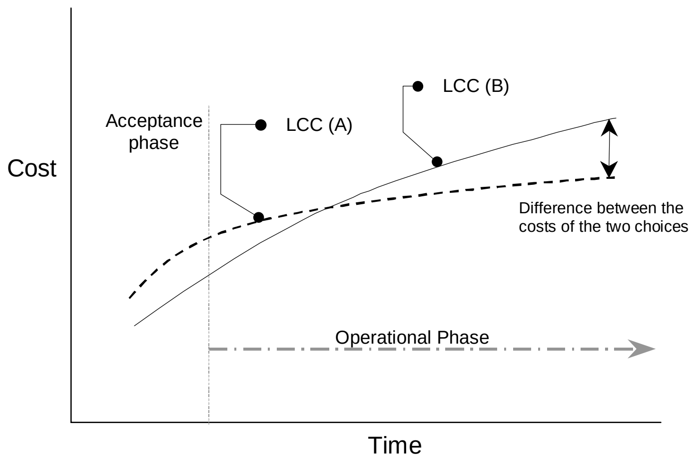

Figure 10: Comparative Cases of the Cost of Acquisition, Operating and Support.

Figure 10 presents a seductively low acquisition price accompanied by a curve ("B") depicting escalating operating and support costs. Curve "A" in Figure 10, is an example of a Products System with a relatively higher acquisition cost, but lower operating and support costs. The curves represent the cumulative costs of the two. In the longer run, the acquisition of Products System “A” is more cost-effective, if it is assumed that they are equally effective. The calculation of the NPV for each option is essential for sound judgement and decision-making.

2.6 AN ANALYSIS OF THE INDUSTRY ENVIRONMENT IN WHICH ORGANISATIONS COMPETE

2.6.1 FIVE FORCES ANALYSIS

Porter (1985: 4) developed a model of the competitive forces affecting an organisation. The purpose of studying these forces is to enable the organisation to develop a strategy that will give it a competitive advantage and thus enable it to outperform rivals.

According to Porter (1985: 5) industry competitiveness is based on the influence that the five basic forces shown in Figure 11 exert on the organisation. These forces are the following:

- The bargaining power of suppliers.
- The bargaining power of buyers.
- The threat of substitutes.
- The threat of new entrants.
- The extent of competitive rivalry.

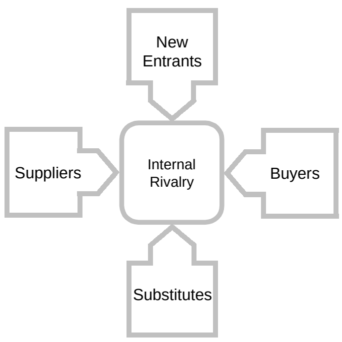

Figure 11: Porter's (1985: 5) Five Forces Model.

Although non-profit organisations generally do not compete for resources, the general rules of this model can still be applied to them (Lynch 2000: 125). Defence forces, which are non-profit government organisations, however do compete. The competitors of a defence force are the defence forces of other countries. During periods of conflict, their means of competition is the conduct of war, and during peace-time, the task of preparing for contingencies. Their competitiveness is determined by their ability to successfully conduct their operations and the quality of the resources they use. A measure of the quality of their resources could be the competitive advantages offered the by technology they use or the dependability and availability of their weapon systems, all of which are functions of the ETF roles.

A. THE BARGAINING POWER OF SUPPLIERS

The sources of Products and technology and the sources of personnel are the two main categories of supplier. Within these two categories there are two further classes, the new and the upgraded.

Since the end of the Cold War, the demand for defence Products has diminished considerably, leaving a shrinking market to a large number of suppliers. The supply has been greater than the demand, presenting the buyers with greater leverage when considering the acquisition of defence Products. This situation of buyer advantage is visible in the current acquisition process to re-equip the SANDF.

The phases that follow acquisition require training, spares, support and various other services. Once the buyer has bought a Product, it may be unable to use the support services from any source but that particular supplier. This situation could result from a contractual agreement or the uniqueness of the Product, its spares and the training required. The supplier will then gain bargaining power.

Once in the owner's inventory for a period, the Products will require upgrading of the capability, dependability or availability to remain militarily competitive.

The suppliers will enjoy an advantage if the SANDF has purchased, and is committed to operating their Products and therefore, supporting them. The suppliers will also have the leverage associated with being the design authority for the Products. Changes or modifications will require approval by the design authority. However, the choice of developing a local design authority can be prohibitively expensive.

The SANDF has a broadly based local military industry at its disposal to perform many of the services required to limit dependence on one supplier.

The SANDF finances the Defence Evaluation and Research Institutes (DERI), which supply technological support through evaluation and research services. This is a source that provides the SANDF with a technological competitive advantage.

Politics normally influences arms acquisitions and the RSA has presumably chosen the most well-disposed countries with which to do business.

Certain aspects of Products and Products Systems are significantly complex and therefore necessitate substantial investment for the establishment of local capabilities. Reliance on the supplier could be more feasible than the local capability option. The RSA has counter-trade agreements with suppliers involved in the arms acquisition programme. This significantly alleviates the buyer's vulnerability to developing a weak position.

The RSA has an advantage as a buyer on account of its position as a potential gateway to Africa. This is an attractive incentive for foreign non-African industries to do business with Africa.

The SANDF's major area of weakness lies in its inability to attract and retain competent and skilled personnel. Attempts to remedy this situation by the establishment of ARMSCOR have been partially successful, but this has drawn engineering skills away from the operational and support area of the SANDF.

Both industry and the SANDF have a need for ETF personnel. The need of industry and the SANDF for ETF personnel are represented by the line labelled Demand (SANDF) in Figure 12. The supply of ETF personnel is represented by the curve labelled Supply (ETF) in the same figure. The intersection of these demand and supply curves, represents the point of equilibrium where ETF personnel will be equally attracted to industry and the SANDF, assuming that remuneration is the only factor that plays a role. This point which is marked Equilibrium (SANDF), represents the average level of remuneration of ETF personnel.

Industry will attempt to attract these scarce resources by increasing the remuneration or reward it offers. This will raise the demand curve to the level of Demand (Industry) in Figure 12. This will cause the point of equilibrium to move to the point labelled Equilibrium (Industry). Figure 12 shows how the equilibrium between the supply of ETF personnel and SANDF demand differs from that of industry. The horizontal axis shows that the quantity of ETF personnel attracted to industry will be greater than attracted to the SANDF.

The further loss of ETF personnel to emigration, reduces their numbers, so that the ETF supply curve will move to the left as Supply' (ETF) in Figure 12. Industry will then have to increase the remuneration it offers to attract or retain personnel. This increase is represented by the intersection of the Supply' (ETF) and Demand (Industry) curves at Equilibrium' (Industry). If the SANDF fails to adequately adjust the remuneration it offers, its ability to attract ETF personnel will be represented indicated by the value at Equilibrium' (SANDF).

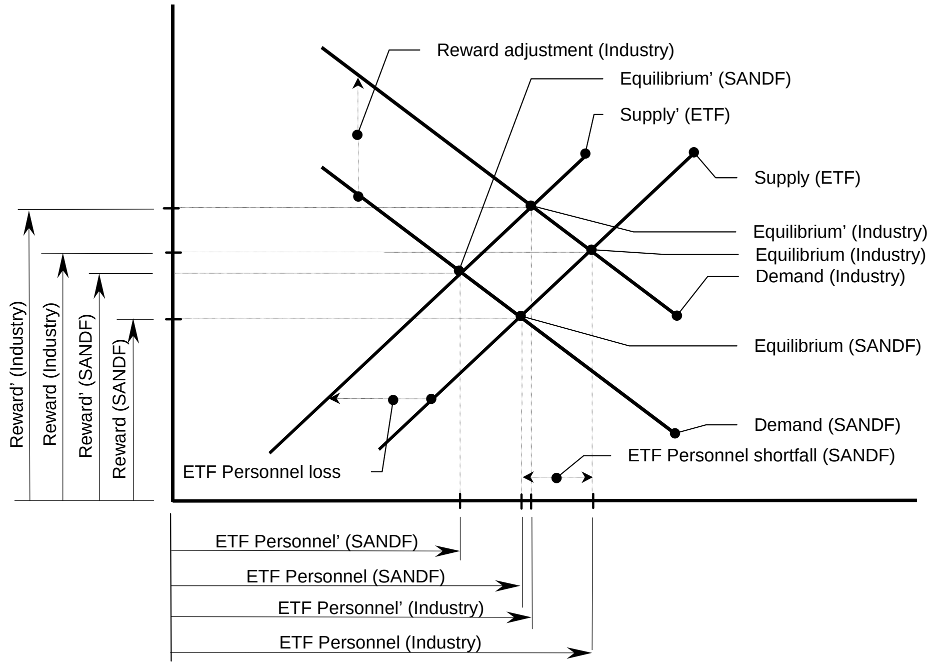

Figure 12: ETF Personnel Supply and Demand.

Bothma (1999: 1) has cited the cost of outsourcing technical services during the 1997/1998 financial year as, being R470 million after the loss of 63 sergeants and 24 flight sergeants from the technical branches, during the preceding years. If the salaries of the members had been tripled, cost would have would have amounted to than less than 10% of the price of the outsourcing contract. Of the SAAF's trained transport pilots, 169 resigned from 1989 to 1996. Considering that the training of one transport pilot costs about R1,8 million, there would appear to be a fundamental flaw in the personnel retention strategies of the SANDF.

Sustaining its capabilities with a diminishing defence budget, challenges the SANDF's ability to set priorities in the allocation of finances. Further factors contributing to the loss of personnel appears to be the uncertainty of career prospects and declining service benefits in the SANDF. As a buyer, the SANDF falls short in terms of the supply of high-level personnel, but appears to hold a strong position in the area of acquisition of Products.

B. THE BARGAINING POWER OF BUYERS

The bargaining power of suppliers and buyers are inter-linked. The suppliers in the arms procurement chain are in a market with low demand. A procurement process favourable to the RSA as the buyer is more likely under the current market conditions.

The major client of the SANDF is the RSA government. As the owner of the budget the government controls it.

As the client, the government uses the SANDF in several roles. These roles include supporting the SA Police Services (SAPS) and provincial and local authorities in disaster management, United Nations operations, co-operation with foreign countries and diverse diplomatic tasks.

The defence budget has diminished to the point where the SANDF has difficulty in maintaining its capabilities. The intention was to reduce the SANDF to consist of a small care force, but the government has failed to provide the mechanisms required to retain critical skills and shed superfluous members. The DoD therefore has difficulty achieving the desired expenditure ratio between personnel and equipment (JSCD 2000: 1).

C. THE THREAT OF SUBSTITUTES

UN forces have replaced several national military forces in operations throughout the world. UN forces could, therefore, be used as a substitute for a national defence force. The government would, however, have little control over its operation and loyalty. Nations generally prefer to have their own defence forces, which they can control and use as an instrument of state.

Engineering services originate from military organisations. However, today there is a tendency to outsource these services to a lesser or greater degree. Total control and ownership of engineering services can provide considerable advantage but at considerable cost. The SANDF is required to be a small, technologically advanced core force. To achieve this goal, it is necessary to develop a balance between outsourcing and operating core competencies internally.

The Department of Foreign Affairs is the government instrument that is used to resolve potential conflicts with diplomacy.

The UN has employed private armed services to perform military tasks and has found them to be more cost-effective than conventional military forces of counties. The RSA government has, however, decided to eliminate the operation of private military services by means of legislation. This form of substitute does, therefore, not appear to be a threat to the SANDF.

D. THE THREAT OF NEW ENTRANTS

Defence against aggression by foreign military forces is the main reason for the SANDF's existence. There is no indication of any conventional military threat against the RSA in the foreseeable future.

Organised criminal syndicates have replaced the military as the dominant forces in several regions word-wide. Although this is essentially the domain of the police, they have often been unable to deal with the superior resources of the crime syndicates. National governments have effectively lost control over areas controlled by the syndicates and this has enabled the syndicates to operate with impunity in these areas.

E. THE EXTENT OF COMPETITIVE RIVALRY

In attempting to deal with this competitive rivalry, the SANDF is at a disadvantage on account of its poor retention of trained personnel and the low level of expertise embodied in its personnel.

The SANDF has lost so many key combat and professional members to the private sector that it has a dire shortage in its core business areas namely those of the fighter pilots and in the support areas, the engineers. The SANDF has been forced to contract support for Products Systems to external contractors at a premium. Many former SANDF personnel perform this work on behalf of the contractors.

The SANDF has lost most of its ability to act as an intelligent client, relying instead on external contractors such as ARMSCOR and private sector firms to supply it with engineering, technical and logistics expertise.

2.6.2 FOUR LINKS ANALYSIS

In some areas organisations compete with rival organisations and in others they co-operate with other organisations. Co-operation can take place through informal relationships or through formal, contractually defined and binding joint ventures. A graphic model of the four links model is presented in Figure 13.

Co-operation with the role-players within its environment may contribute to the success of the organisation by (Lynch 2000: 133):

- Reducing costs.
- Supporting the achievement of a possible sustainable competitive advantage.
- Establishing more sustainable relationships outside the organisation.

This type of beneficial co-operation should therefore be actively sought. The analysis of the nature and strengths of the relationships between the organisation and the external role-players is performed by means of the Four Links model (Lynch 2000: 132).

The following paragraphs describe the links between the SANDF and the organisations in its environment:

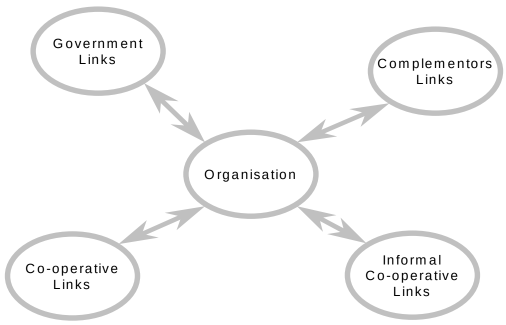

Figure 13: The Four Links Model (Lynch 2000: 133).

A. INFORMAL CO-OPERATIVE LINKS

Informal co-operative links and networks develop when organisations co-operate in striving towards a common goal, without a binding contractual relationship.

<u>Product Suppliers and DERIs</u>

The informal co-operative links and networks between Product suppliers and DERIs develop both prior to and during a formal contract. They continue to exist for a period after the closure of a contract and are based on personal relationships.

Even after they have left to new areas of responsibility, SANDF members are inclined to refer related queries to their acquaintances at DERIs or Product suppliers. Conversely, DERI or Product supplier personnel also tend to retain contact with SANDF members. Informal discussion of work activities contributes to a higher level of shared knowledge and may initiate new areas of technological or Product innovation and development.

There are however, factors that pose a threat to the informal links between SANDF members and their DERI or Product supplier acquaintances. These factors include the danger of the recruitment of personnel from the SANDF, this weakening the latter's skills base, the possibility of "insider trading" by the divulgence of plans or other sensitive information, and less-than-strict acceptance of deliverables, and bribery.

Inter AoS Links

Members of the AoSs may share expertise with their counterparts in other AoSs on a voluntary, informal basis. This free flow of knowledge can enhance the capabilities of the SANDF as a whole, as described in paragraph 2.6.2B.

Combined Operations with Foreign Military Organisations

Military forces from two or more countries sometimes combine to take part in activities such as operations or exercises at the User System level to broaden their experience and improve their doctrines. Enduring relationships can develop between the members of those forces involved in combined operations or training. The sharing of ideas and knowledge enhances in-house skills.

The threats that accompany this type of informal co-operation, however, include potential security breaches and loss of uniqueness in methods.

B. FORMAL CO-OPERATIVE LINKS

These comprehensively defined contractual links are the Product of much consideration and mutual understanding over a significant period. To be established, the linkage must be considered beneficial to all the organisations involved. These links are subject to a higher degree of formality and permanence than the informal links and depend on the harmony between the strategies of the participating organisations.

Formal links allow a structured approach to co-operation.

Product Suppliers and DERIs

The SANDF enjoys formal co-operative links with the DERIs, parastatals, private industry and foreign defence forces.

Educational institutions such as universities, technicons and technical colleges provide formal training to SANDF members, enhancing their competencies. The SANDF also uses foreign institutions for advanced training. Universities can often support the efforts of DERIs by means of co-operative agreements such as that between the CSIR and the University of Pretoria.

Product suppliers and DERIs are contracted to perform services or supply Products as deliverables that comply with certain quality, quantity, schedule and cost-related requirements. These projects generally have a long duration, and consequently foster links between the organisations. DERIs support operational methods by research, development and simulation and contribute towards the enhancement of the SANDF's capabilities by the development of new doctrines and Products.

Informal links are also Products of this process. Co-operating organisations develop and strengthen their commitment to the high-level goals of the programme. Mutual respect and understanding is also developed. Future co-operation in dealing with new contracts can be enhanced by the success of the co-operation during the preceding contract. Ideas and concepts are shared, affecting the direction new technology, methods and growth take. Contractors can become more aligned to these new directions.

Poor fulfilment of contractual obligations may sour the relationship, reducing future co-operation and destroying the potential synergy. Firms may fail to delivery on account of bankruptcy, loss of skills and capabilities or unforeseen damages. Furthermore, the organisation may supply key technology to less than well-disposed forces.

The fact that some Product suppliers are located in distant countries makes regular contact difficult. The availability of the Internet has however, reduced this difficulty, to some extent.

ARMSCOR is the mandatory procurement agency through which the SANDF's Products Systems and Products are acquired. The organisation also provides support not available within the SANDF.

<u>Inter AoS Links</u>

Air Force pilots would view ships as either targets or threats, whereas to the naval combat officer, an aircraft would constitute a threat. Pilots and combat officers who exchange their experiences could gain deeper insight into the activities each party practises, and this could enhance operational expertise. Similarly, the ETF members of the AoSs will benefit from sharing their experiences and expertise.

During formal activities, members of the AoSs can share their expertise with their counterparts in other AoSs. This formal exchange and development of knowledge can enhance the joint capabilities of the whole SANDF. Doctrines may be changed, adapted or fine-tuned after assessment of the way they interact in joint operations or other activities. These formal links inevitably lead to informal co-operative links.

Combined Operations with Foreign Military Forces

In common with contractual links, combined training and operations have a formal basis. Forces share their expertise and doctrines, often upgrading both during and after the process. Future combined activities should have improved efficiency and effectiveness, benefits having been derived from earlier combined operations. New concepts, technologies and processes can be derived from the co-operation process.

Divulging information on a force's physical, and other assets to another force can diminish the force's potential to surprise an adversary. Inadvertent disclosure of such information by personnel of the other force, could benefit organisations less well-disposed to the RSA.

C. COMPLEMENTOR LINKS

Many of the formal co-operating parties include services that complement the SANDF's role and provide supporting activities. Examples of complementors include the following:

- The Department of Foreign Affairs which employs diplomacy in resolving conflicts
- The Department of Health, which provides medical services in places where there are no SAMHS facilities serving SANDF members, and which joins the SANDF's SAMHS whenever disaster support is required.
- Local authorities which use the disaster support the Army's Engineering Corps .

These complementors allow the SANDF to concentrate on its core business. With the help of the Department of Foreign Affairs, the SANDF can contribute positively to the stability, security and peace in the region. There is, however, always the danger that the role-players could confuse their roles and overstep their functional boundaries without the knowledge of the others.

Each AoS within the SANDF is meant to complement the others. An example of this complementing of functions is the SAAF, which operates helicopters from SA Navy ships at sea, or transports SA Army troops to areas in which they have to execute operations.

The Department of Arts, Culture, Science and Technology (DACST) complements the SANDF's work in the area of technology as described in section 2.3.5 above.

D. GOVERNMENT LINKS

As a state organ, the DoD and therefore the SANDF has strong links with government. The government mandates the DoD to execute its function and authorises the scope of its activities. Many of the government links have already been discussed in the previous paragraphs.

The Directorate of Technology of the SANDF also functions as an advisor to the DACST in technology issues.

The government on the other hand allocates a financial budget to the DoD by means of a parliamentary vote. In return, the government expects the SANDF to fulfil its expectations. Thus the Government may require the SANDF to comply with the policies of other State departments. By, for example, adhering to the personnel remuneration policies prescribed by the State, the SANDF has failed dismally in its efforts to retain personnel. This is especially the case in key occupations such as those of pilots, naval combat officers, engineers, artisans and other senior experienced personnel.

There is also a danger that the government of the day could interfere in the SANDF to the detriment of the national interest.

2.6.3 COMPETITOR AND PRODUCT PORTFOLIO ANALYSIS

A. COMPETITORS' OBJECTIVES

An external aggressor would typically intend to occupy RSA territory and impose a new political system on the country. The RSA has no external threat presently (Synge 2000: 287).

A military aggressor would typically follow the principles of war presented in paragraph 3.1.3.

Neighbouring states of the RSA such as Botswana, Zambia and Zimbabwe are re-equipping, modernising or reorganising their forces (Synge 2000: 59). Presumably these countries are ensuring that they will be able to defend their own sovereignty.

The RSA's main risk remains its ability to control the high levels of crime in the country. Sophisticated criminal syndicates in the country have a vested interest in ensuring that they are able to continue their business without disruption by law enforcement agencies. The syndicates include illegal narcotics traders.

Vigilantes spurred on by government inaction, are acting against the criminal groups, often relying on illegal means.

Technological capabilities are often assets useful to competitors. Competitors may, for example, strive to improve their probability of succeeding against the RSA's forces by making use of competitive technology.

B. RESOURCES

In terms of military resources the SANDF has few competitors in Africa.

Many African countries have ageing military equipment and, having inadequate expertise, they are generally unable to maintain these resources. Other countries despite their poor economies, have re-equipped themselves. Some countries such as Angola, Ethiopia and Eritrea have acquired advanced fighter aircraft such as the MiG 23, the MiG 29 and the Su 27. Many weapons such as surface to air missiles (SAM), are commonly available in Africa, are suitable for insurgents and pose a significant threat to conventional forces.

The SANDF would however require a significantly large inventory to contend with guerrilla warfare based on light infantry weapons. The RSA would also require considerable resources for securing its extensive borders against insurgents.

Illegal immigrants entering the country have few resources except stealth. Criminal syndicates also require few resources to blend in with the local population and avoid detection. These syndicates can however afford land, air and sea transport whenever required.

C. PRODUCTS

The Products of the SANDF's military competitors include the domination by a foreign military force, subversion by guerrilla groups, intimidation of the local population by terrorists and, the spread of anarchy and lawlessness by criminal syndicates.

The Products of the SANDF's technological competitors include greater threats and superior or competitive logistics.

2.6.4 CLIENT ANALYSIS AND MARKET SEGMENTATION

There are several levels of clients in the national defence process.

The primary client of the SANDF is the nation. Through its democratic representatives, the nation demands the delivery of those services for which the SANDF is mandated. The expectation exists that the SANDF should be small and technologically advanced. The "Markets" for the SANDF's services are presented in Table 5 below.

The SANDF's client may also be a foreign country requesting support, or international organisations such as the United Nations or the OAU, requesting support in peace operations. Such operations may require the SANDF to comply with a diverse set of requirements such as having specific operational capabilities or the ability to integrate logistically with other systems.

Top Level	Engineering Technical Family Contribution
RSA Government	
National Defence	Technological competitiveness Dependability, capability & availability
Support of SAPS	Dependability, capability & availability
Support of other Government Departments	Dependability, capability & availability
Defence technology	Technological expertise
International	
Support operations	Dependability, capability & availability
Regional co-operation	Dependability, capability & availability

Table 5 : Markets for the SANDF's and the ETF's Services.

The second level of client of the SANDF is within the SANDF itself. The SANDF's main internal client is the C JOps who is responsible for force application as required by the Government. The Air Force provides air power in the form of fighter, ground attack, transport and EW aircraft. The Army provides land-based forces such as infantry, artillery, an engineering corps, support functions and logistics. The Navy provides maritime combat and support forces. The SAMHS provides military health support to the forces. Table 5 presents the "markets" for the services of the SANDF's ETF.

Each of the AoS have its own infrastructures, but they also share common resources such as transport and stores. Each AoS has its own ETF which provides it with services.

2.7 ENVIRONMENTAL ANALYSIS FINDINGS

2.7.1 ENVIRONMENTAL DYNAMICS FINDINGS

Since the end of the cold war, thanks to the growing dominance of regional and domestic interests, the complexity of political, defence and associated industries has increased significantly.

The probability of a nation encountering a novel scenario has increased considerably since recent political and technological changes took place.

There is great pressure on organisations to conceive and execute their plans before others. The rates of change in many political, scientific and technological dispensations have exceeded expectations, making prediction more difficult. It is probable that the rates of change of these factors will remain high in the foreseeable future.

The increased availability and quality of information has enhanced the probability of our correctly predicting future events.

Although the availability of information has enhanced the predictability of the future, the increased rate of changes in some areas makes it difficult to predict some of the likely changes in the political, economic, social and technological environments.

2.7.2 FINDINGS RESULTING FROM THE POLITICAL, ECONOMIC, SOCIO-CULTURAL AND TECHNOLOGICAL ANALYSIS

A. FINDINGS: POLITICAL ANALYSIS

The RSA is governed by the majority ANC alliance. This government has introduced a host of new laws, some of which have adversely affected the creation of employment and the availability of skills. Steps have, however, been taken to correct this situation.

The SANDF has difficulty attracting and retaining skilled key personnel on account of its poor salary structures. Attempts at promoting representivity appear to have exacerbated the situation.

Several sub-Saharan African states suffer both inter-state and intra-state conflicts as well as political instability. Weaker African states are often unable to maintain the rule of law throughout their territories, thus affording criminal syndicates a free rein.

The SANDF has a challenging security task, given the threat of organised crime with considerable resources, the inability of many neighbouring governments to enforce law in their countries and the extent of the RSA's land and maritime borders.

The RSA appears to have no external military threats for the foreseeable future. The prevalence of wars and conflict is expected to increase in Africa. This threat of instability could require intervention in the form of peacekeeping or military operations by the RSA. Newer, more capable weapons that have begun to proliferate in Africa could pose a threat to the success of these operations and to SANDF personnel. Criminal syndicates have demonstrated their ability to acquire and deploy sophisticated communications equipment, aircraft and weapons.

In addition to this, labour movements now enjoy significant influence in government.

B. FINDINGS: ECONOMIC ANALYSIS

While some examples of high standards may be found in the education system, the RSA's education on the average has serious deficiencies specifically in the area of science and maths teaching. These deficiencies contribute to the country's poor performance at tertiary level.

The RSA has a strong economy based mostly on the provision of services, agriculture beingin the process of losing its significance. The value of the RSA's currency has dropped considerably, frustrating attempts at building infrastructure for the local industry with key foreign Products.

Globalisation has caused many firms to close down, whereas the competitive firms have found new global markets.

The RSA has a high level of unemployment, which has even increased during recent years. The trend among skilled professionals and entrepreneurs to emigrate is weakening any capacity of the local industry to grow.

While the RSA has a higher GNP per capita than any other African countries, its military expenditure as a percentage of GNP is lower than that of these countries. The RSA's military expenditure as a percentage of GNP is in fact lower than the world average. The sub-Saharan African region has poor countries with low GNP/capita that are unable to satisfy the economic needs of their populations.

C. FINDINGS: SOCIO-CULTURAL ANALYSIS

In all but a few African countries where dissidents are not tolerated, the trend is towards consensus-seeking.

The poor communities in Africa are a source of youth seeking their wealth through their participation in conflicts or even banditry.

Global competitiveness reviews present RSA government officials as incompetent. The SANDF has suffered several serious incidents, this casting a shadow over the standard of discipline in the organisation. The unacceptably high crime rate in the RSA is attributed to police incompetence. With police protection the 56th worst out of 59 countries, he risk of crime scares off many potential investors.

The RSA has a growing problem in that the shortage of skilled people is being aggravated by an inability to educate and train people adequately, and by the steady emigration of professionals and businessmen.

While life expectancy as a measure of health is high, there are great differences in the quality of health care offered in different areas and at different levels in the RSA. AIDS seems set to continue with its trend of the past, which is one that has claimed many lives in Africa. Population growth in the RSA has declined with the majority of the people urbanising.

Income is unevenly distributed in the RSA, wealth being concentrated in small groups within small patches of both the black and white communities.

D. FINDINGS: TECHNOLOGY ANALYSIS

The RSA government has developed what appears to be a coherent science, engineering, technology and innovation policy.

The defence sector is an important repository of skills and knowledge. While the RSA government regards a strong technology base as essential for defence, most African countries need foreign assistance, because they are unable to maintain their weapons inventories effectively.

There is a great shortage of scientists and engineers in the RSA, but this situation is considerably worse in the rest of Africa. The RSA's situation in this respect is aggravated by emigration.

Technology has had a significant impact on Africa, changing the way things are done, sometimes reducing employment, and at other times generating jobs.

The RSA has demonstrated a significant ability to harness and exploit technology to develop industries in the face of strong globalisation efforts.

2.7.3 MARKET GROWTH ANALYSIS FINDINGS

Although military forces world wide are decreasing in size, some African countries are spending more on sophisticated weapons to cope with regional and internal conflicts. These could pose a threat to the RSA or the SANDF when they operate in these regions.

The defence industry and its technology have become considerably more competitive. In addition to this, the defence industry, still produces innovative weapons and many other Products. The RSA defence industry has also become a significant role-player in exports, thus ensuring its own survival and growth.

2.7.4 FINDINGS: ANALYSIS OF KEY SUCCESS FACTORS

The RSA's greatest return from the SANDF, is the prevention of war through deterrence, and its second greatest return would be winning an unavoidable war.

If the key success factors of a defence force were the principles of war, such a defence force would require:

- the availability and efficacy of Command, Control, Communications, Computers, Intelligence, Information, Surveillance, Reconnaissance and Electronic Warfare (C4I2 SR EW) and other capabilities embodied in Products Systems;
- technological innovation capabilities;
- improved or changed capabilities, availability and dependability in Products Systems;
- "stealth" capabilities; and
- Products Systems that are simple, robust and easy to operate.

2.7.5 FINDINGS: ANALYSIS OF THE ENVIRONMENT OF A COMPETITIVE INDUSTRY ENVIRONMENT

A. FINDINGS: ANALYSIS OF THE FIVE FORCES AFFECTING THE ORGANISATION

In the rivalry encountered in this competitive environment, the SANDF suffers a disadvantage on account of its poor retention of trained personnel and the expertise embodied in these personnel.

The SANDF has lost so many key combat and professional personnel to the private sector that it has a dire shortage in its core business areas namely those of fighter pilots and engineers in the support areas. The SANDF is now forced to contract the support of Products Systems to external contractors at a premium. Many former SANDF personnel perform this work on behalf of the contractors.

The SANDF has lost most of its ability to act as an intelligent client, and now relies on external contractors such as Armscor and private sector firms to supply it with engineering, technical and logistical expertise.

B. FINDINGS: ANALYSIS OF THE FOUR LINKS BETWEEN THE ORGANISATION AND ITS ENVIRONMENT

The links the SANDF has with local authorities, the Department of Health, foreign military forces and DERIs positively support the SANDF's military capabilities. The Department of Foreign Affairs complements the SANDF in the area of relations with foreign nations.

The SANDF's informal links with DERIs, industry and foreign military organisations, are very valuable and should be nurtured. Caution should, however, be exercised in areas where security breaches or unethical behaviour could develop.

Through ARMSCOR, the DERIs and Product and service suppliers provide the SANDF with certain items. The quality of the links between the organisations enhances the quality of the services rendered. Improvement to the links is desirable.

Inter-AoS co-operative links in the spirit of jointness are very valuable and require further strengthening to enhance the knowledge and capabilities of the AoSs.

C. Findings: Competitor and Product Portfolio Analysis

The SANDF's competitors either intend to impose a new political system on the RSA or, to create anarchy so that they can advance the interests of criminal syndicates, by creating a suitable environment for them in which to pursue their illicit activities.

The SANDF's competitors have relatively limited resources, although the potential is there for some of the competitors to serious threaten own forces with sophisticated weapons, some of which some may be man-portable. Another serious threat is the potential for the formation of lightly-armed guerrilla bands that would be difficult to control or detect in the poorly policed Southern African region.

The RSA's extensive borders are difficult to protect against criminal syndicates and the large numbers of illegal immigrants that penetrate them, some with contraband and illegal arms.

D. Findings: Client Analysis and Market Segmentation

The SANDF provides the RSA government, and through it to international bodies, with defence capabilities. C JOps is the client of each of the AoSs, each which contribute their unique services towards the national defence capability. Each AoS is a client of the ETF.

CHAPTER 3 LITERATURE SURVEY

3.1 STRATEGIC APPROACHES

3.1.1 OVERVIEW

The earliest strategy formulation processes were closely linked to corporate planning. Corporate planning began as a simple extrapolation of budgets and was based on the assumption of a stable environment. More sophisticated methods considered the economic growth expectation of the firm concerned, the development of markets and the organisation's plans and intentions. The scope of corporate planning evolved to become corporate strategy when cases with many outcomes were considered. Various approaches to corporate strategy were developed and used during this period of evolution. Porter proposed the competitive approach to strategy (Kay 1993: 340).

According to Wolf *et al* (1998: 11) top executives are in for a rude awakening if they short-sightedly judge the organisation's performance only in terms of financial results and market share while ignoring internal and external clients and the culture needed to support their success. A sound, practical and achievable vision can resonate through an organisation to move people to come together in an extraordinary alignment of purpose and common goal.

The vision is the conceptual picture of how the organisation should operate at some point in the future.

3.1.2 ORGANISATIONAL SENSE OF PURPOSE

Lynch (2000: 7).describes corporate strategy as the organisation's sense of purpose and adds that plans or actions need to be developed and implemented to pursue the purpose

Irrespective of whether the organisation is a private or public body, Lynch (2000: 436) claims that all organisations need to develop their purpose and common understanding of the main elements of their activities. By identifying the organisation's essential elements, one can simplify them. This shaping of the organisation's purpose is a slow process that encompasses the following considerations as proposed by Lynch (2000: 436):

- <u>Area of Activity:</u> What is the organisation's area of activity and what should it be? The purpose of the organisation is related as much to its future direction as to that of the present. This is particularly important if the organisation's existence is threatened or if unique, attractive opportunities suggestion a redefinition of purpose.

- Kind of Organisation preferred: Organisations have some choice in deciding whether or not to develop in any of the following areas:
- The nature of the internal environment to be created is generally determined by the existing culture and style within the organisation and is also dictated to some extent by the external environment. However, the organisation still has some choice as regards power, roles, tasks, and the personal types of culture described by Lynch (2000: 317).
- The challenges to be presented to the personnel. The type of challenge presented will influence the organisation's working style. Lynch (2000: 438) refers to Drucker (1961: Chapter 13) who described this as follows:

> *"No organisation can depend on genius; the supply is scarce and always unpredictable. But it is a test of an organisation that it can make ordinary human beings perform better than they are capable of, that it brings out whatever strength there is in its members and uses it to make all the other members perform better."*

- Relative Importance of Shareholders and Stakeholders: Typically, the purpose of a business is to increase the shareholders' wealth in the form of larger dividends and share price growth in the short term and profit growth in the longer-term. Stakeholders are those that have a stake in the purpose of the organisation. An example of stakeholders includes employees, clients and suppliers. There is potential for conflict between shareholders and stakeholders (Lynch 2000: 438).
- Growth Intentions: Some organisations wish to grow whereas others do not. This depends on the organisation and its environment (Lynch 2000: 438).
- Relationship to Environment: The immediate environment determines whether the organisation can compete or should concentrate on survival. Wider societal pressures, which could include pressure exerted by pressure groups, also dictate the nature of this relationship and influence the organisation's purpose. Government policy may dictate an adjustment in the organisation's purpose (Lynch 2000: 439).

3.1.3 MILITARY ASPECTS OF STRATEGY

As the SANDF is a military organisation, it is necessary to consider aspects of military strategy.

The professional soldier must pay attention to the future and the opportunities that it brings. However it is as important to consider the past with the lessons it has taught us and its and inherent inertia. Finding a balance between the perspectives offered by the past and those offered by the future is one of the greatest challenges the soldier must face (Irwin 1997: 229).

Modern information-age forces are equipped with the latest high technology combat and communications systems. Industrial-age forces tend to be larger and are often equipped with the kind of second-hand fighting systems that have been cast- off by the information-age forces. Somewhere between these two forces are those “minimalist” forces whose fighting methods include terrorism. Minimalist forces, which have many advantages over conventional forces, are difficult to counter especially for a democracy (Irwin 1997: 229).

Military policy is the art of the application of a nation’s forces in war to enable its government to achieve its political goal, whereas tactics involve the deployment of individual military units to win a battle (Payne 1998: 153).

The inventory of a modern military force relies heavily on a variety of electronic devices for communicating with its own forces, predicting the movements of the enemy and then attacking the enemy (Payne 1998: 151).

According to Payne (1998: 153), there are widely recognised rules for the successful conduct of military operations. Of these rules, which are also known as principles of war, the United States Army recognises nine. These nine principles of war are described in Appendix A which also presents the 14 principles of war used by the SANDF.

The commander has a choice between the attrition and the manoeuvre styles of war-making (Payne 1998: 154):

- The Attrition Style: The attrition style of war-making is in most situations best able to achieve mass, economy of force, unity of command, security and simplicity. The attrition-oriented commander approaches the enemy as an inanimate object to be destroyed piece by piece and relies heavily on firepower rather than manoeuvre. This is a comparatively simple and predictable approach to waging war and requires little initiative from lower-ranking officers. This approach is however very costly as was experienced in the trenches during World War 1.

- The manoeuvre style: The manoeuvre or indirect style of war-making attempts to approach the enemy as a living organism with a brain and nervous system. This approach wins by confusing the organism demoralising and paralysing it, ultimately killing the brain or high command and, preventing it from maintaining control over its combat units. This style of commander, when least expected, strikes the enemy in its weakest spot. Manoeuvre tactics create a fluid, volatile battlefield. Lower-ranking officers can exploit the advantage they have in terms of flexibility and unpredictability. The lower-ranking officers therefore have to be very competent at mission tactics (what the Germans call *Auftragstaktik*).

Wilson (1996: 5) classifies conflicts in the following broadly similar categories:

- Conventional Warfare: This is the primitive approach to the achievement of a victory by means of the brute conquest, attrition or overwhelming. This approach forces the collapse of the opposition's political economy.

- Manoeuvre Warfare: This consists of opportunistic attacks on the military, and, sometimes, the political infrastructure and dependencies of the opposition. The aim of this approach is to impair the operation of the opponent's forces thereby making them too costly to operate. The desired outcome of this approach is the cessation of hostilities by the opponent.

- Terrorism: In this mode of warfare, the aggressor attacks the social fabric and dependency infrastructure of the opponent with propaganda efforts that focus media attention on areas dictated by the terrorists. This form of warfare is considered to be particularly heinous, as the targeted elements are civilian.

Romm (1991: 1) compared the attrition style employed by the US forces previously with the approach they took in conjunction with the coalition forces in the Gulf war. He claimed that the Gulf war was won in the same way as the Japanese are winning the high-technology trade and manufacturing war against the US: by means of a fast cycle time-based, competitive strategy.

The coalition forces refused to meet Saddam Hussein on his terms, in the head-on conflict such as he had with the Iranians. Instead the coalition forces aimed all efforts at increasing the "fog" of war for Hussein by pre-empting his plans and adopting coalition forces' tactics in a flexible, manoeuvre type of warfare with a faster cycle-time. In principle it was the investment in a highly trained force with advanced technology that won the Gulf war. This principle is equally valid for competition by nations in world markets (Romm 1991: 2).

3.1.4 STRATEGIC ANALYSIS

Some organisations cannot continue to survive with their current strategies and therefore should change. Three main aspects should be assessed before proceeding with a new strategy. A framework is presented in Figure 14 to aid the process of analysis of organisations' strategic change (Lynch 2000: 324).

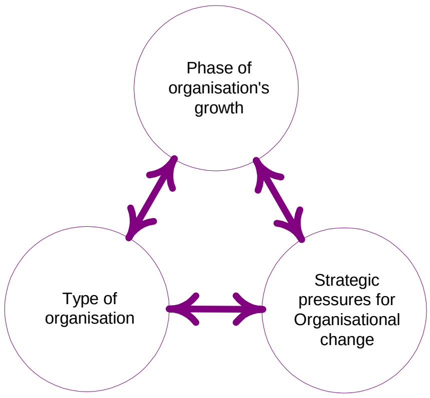

Figure 14: Framework for analysis of Strategic Change (Lynch 2000: 324).

According to Porter (1980: xvi) the development of competitive strategy is the development of a broad approach for the business' competitive stance, the nature of its goals and the policies needed to achieve those goals. Competitive strategy combines its ends (goals) and its means (policies) by which it intends to achieve. The wheel of competitive strategy presented in Figure 15 shows the "hub" as the set of the organisation's goals and the "spokes" as the key operating policies with which the firm wishes to achieve these goals. In Figure 17 the competitive strategy formulation context shows how the organisation's strengths and weaknesses in terms of its assets and skills relative to its competitors relate to the broader external environment (Porter 1980: xviii). Porter (1980: xix) presented a set of tests for consistency of the strategy in Table 6.

Figure 15: The Wheel of Competitive Strategy (Porter 1980: xvi).

Internal Consistency Are goals mutually achievable? Do the key operating policies address the goals? Do the key operating policies reinforce each other?	**Environmental Fit** Do the goals and policies exploit industry opportunities? Do the goals and policies deal with industry threats to the degree possible with available resources? Does the timing of the goals and policies reflect the ability of the environment to absorb the actions? Do the goals and policies responsive to broader societal concerns?
Resource Fit Do the goals and policies match the resources available to the organisation relative to competitors? Does the timing of the goals and policies reflect the ability of the organisation to change?	**Communication and Implementation** Are the goals well understood by the key implementers? Is there enough congruency between the goals and policies and the values of the key implementers to ensure commitment? Is there sufficient managerial capability to allow for effective implementation?

Table 6: Tests of Consistency (Porter 1980: xix)

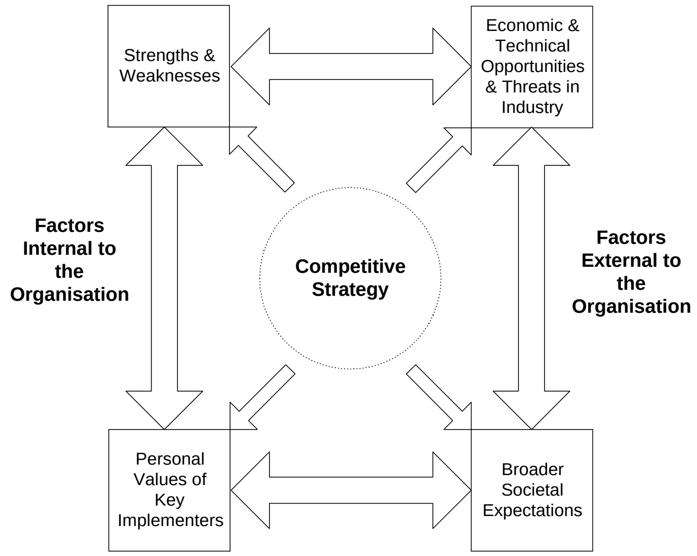

Figure 17: The Context of Competitive Strategy (Porter 1980: xiii)

A. ORGANISATION TYPE AND ABILITY FOR STRATEGIC GROWTH

Strategic change usually brings uncertainties. Analysis of organisations in advance allows them to be better prepared for the potential changes. No standard procedure exists for handling, analysing the relationship between the organisation and the proposed strategic change (Lynch 2000: 324).

Lynch (2000: 324) referred to the four main types of organisation that Miles and Snow proposed for analysis for their ability to cope with change:

Defender Organisations: These organisations aim for market leadership, possibly by concentrating on a niche and are more comfortable with steady strategic change although they are able to cope with sudden change.

Prospector Organisations: These organisations that are typically flexible, seek out new opportunities in growing markets. They respond quickly to change and are able to cope comfortably in this environment.

Analyser Organisations: These organisations follow the trends of innovation but wait while others prove the market potential. They tend to be cautious, protecting their interests while analysing the environment through marketing and responding accordingly.

Reactor Organisations: These organisations reluctantly take the initiative, being more reactive in approach. They often respond inappropriately to competitors and the environment and have difficulty in responding to change.

This classification may oversimplify the actual situation and should be treated with caution. It is essential to analyse the ability of the parts of the organisation to cope with change (Lynch 2000: 325).

B. PHASES OF ORGANISATIONAL GROWTH

As the organisation's willingness and ability to change changes with its phase of growth, it is appropriate to examine the type of change that may be expected (Lynch 2000: 325). Lynch (2000: 325) used Greiner's two major determinants to clarify the process:

- Organisation's age: Younger organisations are more receptive to change and often actively seek it. Older organisations that have achieved success can be more reluctant to change as they have more to defend and co-ordinate.
- Organisation's size: Smaller businesses may be have simpler administration and be closer to the market place. Older organisations may be larger with more personnel and have developed systems and infrastructure to cope with its environment.

According to Lynch (2000: 326), Greiner (1972: 265) postulated five phases of growth of organisations. This model is useful in identifying the main issues that could be encountered and the types of strategic changes that could be needed. In this model he describes the types of growth and crises that may occur in the organisations. He identified four types of organisations that would experience particular pressures for change. These are:

- Small Businesses.
- Large organisations previously owned by government.
- Not-for-Profit Organisations.
- Medium-sized Businesses.

C. STRATEGIC PRESSURES DRIVING ORGANISATION CHANGE

According to Lynch (2000: 327) there are two main sources of pressure that may drive organisational change:

- Internal pressure: This is due to the requirement for change in the internal organisational environment, for example greater profitability, growth, quality or innovation.
- External pressure: The influences of the external environment force the organisation to respond, or to pre-empt these changes. The organisation could be

forced to compete against new or existing competitors. The strategic environment may have changed and the organisation may have to compete differently due to political, economic, social or technological influences.

D. ANALYSIS OF THE STRATEGIC ENVIRONMENT

The SANDF operates in an environment that tends to be turbulent and not static. The prediction of the future state of the environment with any degree of accuracy is therefore difficult. This prediction can be improved by identifying those key elements that could influence the organisation's strategy (Lynch 2000: 105).

It is important to study and assess the environment for the following reasons (Lynch 2000: 105):

- It is necessary to determine the nature of competition in order to achieve sustainable competitive advantage.
- Identify the opportunities and threats.
- Identify the opportunities for networks and linkages.

The outcomes of an environmental study are either proactive or reactive. Proactive outcomes include those positive opportunities and negative threats for which strategies and actions can be developed to exploit or cope with the situation. Reactive outcomes are those important strategic occurrences over which the organisation has no control, but must be able to react to when they occur (Lynch 2000: 105).

3.1.5 STRATEGIC MODELS

The three core areas of corporate strategy defined by Lynch (1996: 18) are as follows:

- Strategic Analysis: In this core area of activity, the organisation, its mission and its objectives are assessed and analysed. Senior management develops a vision based on the organisation's objectives. They also assess the relationship between the organisation's objectives and the environment. Senior management analyses the organisation's resources.
- Strategy Development: In this area of activity strategic options are developed and the most suitable one selected for implementation. Factors considered during the selection of options include the organisation's skill resources and its relationships with clients, suppliers, government and other bodies that have an influence on the organisation or are influenced by the organisation.
- Strategy Implementation: In this area of activity the strategic option is implemented. If the strategy is non-viable and cannot be implemented, it must be reconsidered and a new strategy developed.

The influence of values and judgement and the high level of speculation involved in major predictions are significant factors in all three of the core areas of corporate strategy. Strategic decisions involve context, content and process, which must be considered both separately and together (Lynch 1996: 20).

Lynch (1996: 23) states, until recently, corporate strategy was presented as a single cohesive subject. Recent differing views have, however, merged to form two main approaches to the development of corporate strategy. The prescriptive and the emergent approaches to the development of corporate strategy differ, as shown in Figure 18, in the way they link the three core areas.

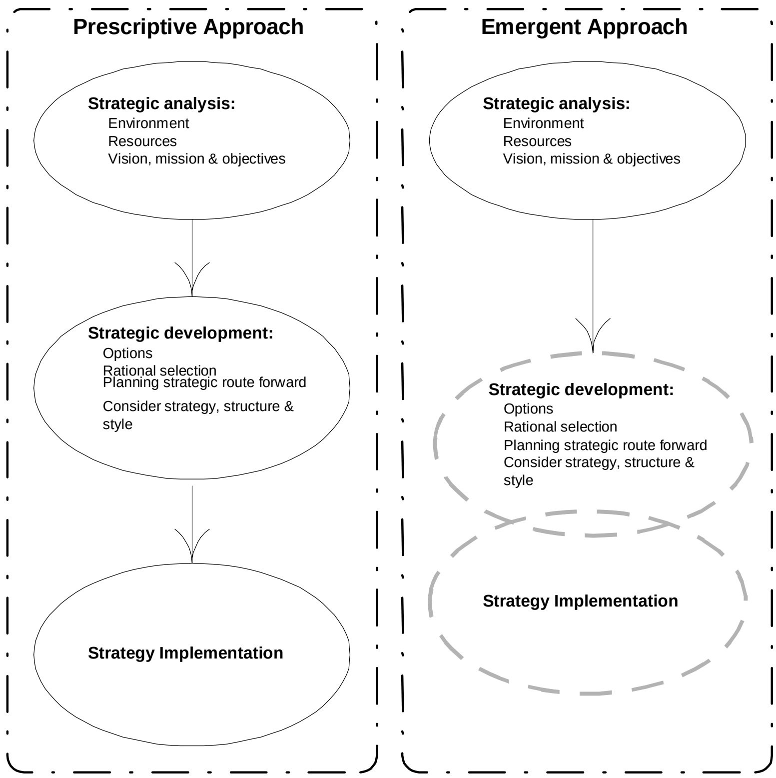

Figure 18: The Prescriptive and Emergent Approaches to the Three Core Elements of Strategy Development (Lynch 2000: 25)

The two models have been expanded further by Lynch (1996: 25) in Figure in which he illustrates the main activities in each of the three core areas of the prescriptive approach, and in Figure 20 in which he illustrates the emergent approach.

A. THE PRESCRIPTIVE APPROACH

According to Lynch (2000: 25), the prescriptive strategic processes take place in the following order as illustrated in Figure :

- Initially the organisation's environment and resources are analysed.
- This is followed by identification of the vision, mission and objectives.
- Next the strategic options available to the organisation are developed.
- Next the strategic options most suitable to the organisation in its efforts to achieve its goals are selected. This selection process is subject to the following two considerations:
    - Finding the strategic route forward.
    - Considering the structure and style suitable for the organisation.
- Finally, the strategic choice is implemented.

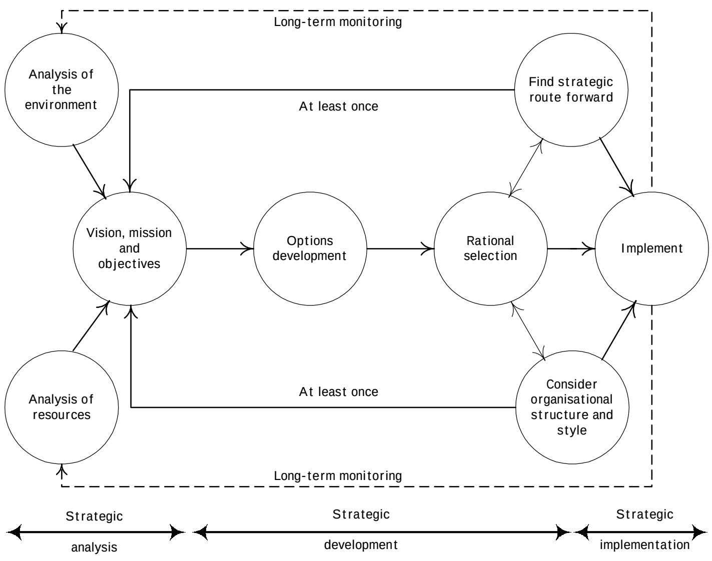

Figure 19: The Prescriptive Strategic Processes (Lynch 2000: 27).

Lynch (2000: 54) proposes that the prescriptive strategic process has the following advantages:

- The process presents a comprehensive overview of the organisation.

- It offers the possibility of comparing the defined objectives.
- It permits quantification of the resources required.
- The choices the organisation may have to make are more easily assessed when the resources are limited.
- The progress of the strategy is more easily measured.

Concerns about the use of the prescriptive strategic process include (Lynch 2000: 56):

- The fact that the whole process may be invalidated if an unforeseen occurrence takes place
- The fact that it is not easy to see long term benefits and that it is difficult to motivate people to sacrifice jobs or invest in an intangible benefit
- The fact that it is often difficult for the strategy to survive the organisation's politics.
- The fact that, although the chief executive officer may have the knowledge and authority to proceed and does not need to persuade anyone else to do so, he often does not proceed himself
- The fact that it is not always true that strategy is fully defined and requires no further development after analysis
- The fact that most situations are complex and that implementation of strategy is not easily separated from the rest of the process.

B. THE EMERGENT APPROACH

Lynch (2000: 25) describes the emerging strategic processes illustrated in Figure 20 as an experimental approach to the choice of strategy.

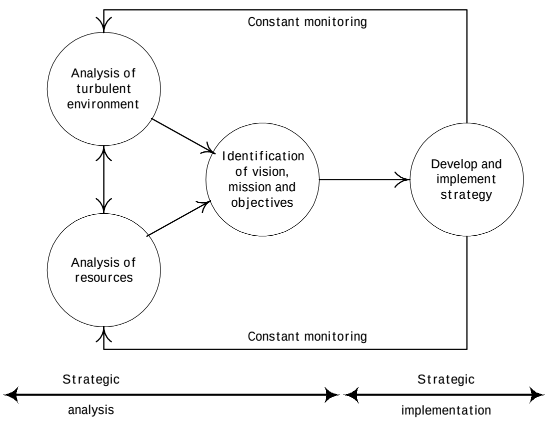

Figure 20: The Emergent Strategic Processes (Lynch 2000: 27)

This approach seems to be based on learning by trial and error as strategies are developed. There is no clear boundary between the strategy's development and its implementation. Furthermore, there is a strong feedback link from the implementation phase to the analytical phase.

Advantages of the emergent strategic process include (Lynch 2000: 63):

- the fact that many organisations use this approach, because it is practical
- the fact that the motivation of human resources is taken into account
- the fact that strategy is developed while the organisation learns about the strategic situation
- the fact that implementation becomes integral to the strategy development process and is redefined appropriately
- the fact that the organisation's culture and politics can become integral to the process
- the fact that the strategy process possesses the flexibility to respond in fast, chaotic markets.

Concerns about the use of the emergent strategic process include (Lynch 2000: 63):

- the fact that management may tend to muddle along instead of making visible progress towards realising the organisation's vision
- the fact that a strong strategic overview over the allocation of resources to the competing divisions within the organisation is required
- the fact that the thread of the strategic process may be lost if it is pursued over an extended period (Experimentation may be acceptable during the initial period, but strategy should be fixed for longer periods.)
- the fact that, during certain periods, evidence and logic may not drive the process
- the fact that managing this process is more complex, as the basis for actions is not planned in advance.

Wolf *et al* (1998: 13) proposed the following basic elements for a good strategy-developing programme:

<u>Vision - a picture of the future:</u> A vision must be crystallised based on what the organisation and market are expected to look like in several years time. Consideration must also be given to what the organisation may need to do to meet its people's needs.

- Leading by example: The tone for the new strategies must be set by leadership in thought, word and deed. Demonstrations of management's willingness to change old beliefs and ways of achieving goals must be constantly repeated.
- Communication: People are inclined to avoid discussion when faced with changes that could appear to be a threat. Effective and honest communication must be used to ensure that the necessary channels are kept open.
- Selflessness: The old paradigm of a company career is no longer valid. To keep their jobs secure, employees must spread selflessness by considering the organisation's well-being and relinquishing the 'every man for himself' tendency.
- Empowerment: People need more than to be delegated power - they need to be able to let others excel. An organisational culture encouraging teamwork with the common goal of superior service produces rewards for the organisation.

C. THE QUALITY OF THE STRATEGY

Lynch (2000: 28) describes the following tests for determining the quality of strategy:

- Value-adding: A good strategy will increase the value delivered or derived. This value may be in the form of profit or in the form of longer-term benefits such as innovative capabilities, employee satisfaction or market share.
- Consistency: A good strategy will be sufficiently robust to withstand the influences of both the internal organisational environment and the external environment. This relates to both the organisation's resources and external circumstances.
- Competitive Advantage: A good strategy will increase the organisation's sustainable competitive advantage.

3.1.6 LINKING CORPORATE AND OPERATIONAL STRATEGY

The success of industrial nations is generally ascribed to their management of production (Hill 1991: 16).

According to Hill (1991: 21) executives must recognise in the formulation of strategy that their business areas each have individual characteristics. It is necessary to perceive the organisation's markets in terms of segments, clients and generic Products. The production and /operations functions should be split accordingly. Errors of judgement in this area are very costly. Decisions based on sound judgement require that two issues be addressed, namely:

- Finding ways of extracting relevant information from production and operations to contribute to the strategy debate.
- The degree to which employees at operational level are aware of the various approaches as this will determine whether appropriate consideration is given to suitable alternatives.

Companies that developed marketing orientations earlier in their existences enjoy a higher survival and success rate than those that do not (Solomon 1992: 2).

Markets often change in a gradual, incremental manner, this resulting in an increasingly greater mismatch between the demands made on the operation and manufacturing functions and their ability to respond. Matching operation and manufacturing with marketing is therefore essential (Hill 1991: 22).

Hill (1991: 24) cites examples of businesses that to their own detriment failed to incorporate production and operations perspectives in their strategies and failed to differentiate their production and operations tasks. He proposes that these functions be distinguished as follows:

- The organisation must realise that it sells Products and services and not the markets or market segments.
- The organisation must find ways of wining orders in the various markets both now and in the future.

Hill (1991: 25) recommends the following analytical and objective steps for developing a link between marketing and production and operations:

- <u>Definition of corporate objectives</u>. The input made to the corporate strategy must be linked to the objectives of the business. This presents a clear strategic direction for the business and an intent to achieve corporate success. It also defines the boundaries and performance criteria for the organisation (Hill 1991: 27).
- <u>Developing marketing strategies</u>. The following marketing strategies must be developed to achieve these objectives (Hill 1991: 27):
  - Those Products that share closely related markets and marketing programmes must be "clustered" within common market planning and control units.
  - The situation in the Product and service markets must be assessed in terms of current and future volumes, end-user characteristics, industry

practices and trends, the major competitors and the relative position of the business.

- Winning orders. An assessment must be made of how the various Products and services can win orders over competitors. Typically, the ability of the organisation's Products and services to win orders is based on price, quality, delivery, technical support and reliability. This may change over time (Hill 1991: 28).
- Making available a process choice. The most suitable method of manufacturing these Product classes or of providing a process choice must be established. Each market has its own characteristics in terms of quantity and quality and forces the organisation to make trade-offs. This influences the choice of process.
- Creating an Infrastructure The necessary infrastructure for supporting the production or operating process must be created. The organisation's infrastructure is that part of production or operations that excludes processing.

The tendency is to treat the first three steps as interactive, with feedback loops, and the last two as linear and deterministic this leading to the above-mentioned mismatches between production and operations and marketing. The inherent complexity of production and operations and failure to take into consideration the mutual dependency between production and operations and marketing can be devastating. An approach that takes these factors into consideration is shown in Table (Hill 1991: 25).

It is clearly understood by all that there is a need for marketing to be differentiated. The production or operations function is perceived as a matter to be avoided for convenience while not to require differentiation is seen as a strategic asset. The reality of the matter is that not being able to accommodate all the demands of marketing effectively or efficiently and failure to take cognisance of production and operations in strategy could cost the organisation dearly (Hill 1991: 31).

An important distinction made by Hill (1991: 29) is the difference between being market led, and being marketing led. Substitution of the business or market perspective with the functional marketing perspective will invariably lead to the distortion of strategies and to corporate disadvantage.

Corporate Objectives	Marketing Strategy	How do Products Win Orders in the Marketplace?	Production/Operations Strategy	
			Process Choice	Infrastructure

• Growth
• Survival
• Profits
• Return on investment
• Other financial measures
	• Product/service markets and segments
	• Range
	• Mix
	• Volumes
	• Standardisation
	• Customisation
	• Level of innovation
	• Leader or follower alternatives
		• Price
		• Quality
		• Delivery
		  • Speed
		  • Reliability
		• Demand changes
		• Colour range
		• Product/service range
		• Design leadership
		• Technical support supplied
			• Choice of various processes
			• Trade-offs embodied in the process choice
			• Process positioning
			• Capacity
			  • Size
			  • Timing
			  • Location
			• Demand changes
			• Role of inventory in the process confirmation.
				• Function supports operations' planning and control systems
				• Quality assurance and control
				• Systems Engineering
				• Clerical procedures
				• Payment systems
				• Work structuring
				• Organisational structure

Table 7: Framework for Reflecting Production/Operations Strategy issues in Corporate Decisions (Hill 1991: 26).

3.1.7 STRATEGY IN NOT-FOR-PROFIT ORGANISATIONS

The two main categories of organisations that operate without a profit goal are governmental organisations and non-governmental organisations (NGOs). Governmental organisations include national, provincial and local government organisations. NGOs include religious denominations, charities, pressure groups and professional societies. Government is the most dominant institution in society being able to legislate and administer a country into ruin or success (Steiner *et al* 1986: 285).

In government, decisions are essentially forged on the political anvil in contrast with businesses which are more concerned with economics when attempting to satisfy their customers and to survive and grow (Steiner *et al* 1986: 289).

Private organisations are not legally bound to respond to the demands of interest groups, although they may do so. They are primarily concerned with the opinion of their market segment. Public institutions listen to demands and the weight they have on the public scale determines public policy. They are concerned with the opinion of their constituency (Steiner *et al* 1986: 288).

In the governmental sector the formulation of policy is often tentative and incremental because the democratic process is a learning process and the state of knowledge is inadequate (Steiner *et al* 1986: 289).

Compared with the private sector, which tends to make decisions based on quantifiable issues, the government sector relies more on judgmental, non-quantifiable factors (Steiner *et al* 1986: 291). Even though the test of a "good" policy is conceptually the public interest, analysts often differ in opinion on the "goodness" of the policy in question (Steiner *et al* 1986: 294).

As decisions in government are often left to committees, there is a danger in the potential of "groupthink" in government. This has been linked to a number of major government policy fiascos in the United States (Steiner *et al* 1986: 290).

A highly experienced and successful businessman, commented on his experience when asked to join President Eisenhower's cabinet to restore order in certain government processes. He found the complexity of the many organisations in the government service to be overwhelming, since there was little co-ordination or integration even when work was being carried out on different facets of the same activity. Executive management operated under divided authority, members had to verify that their course of action did not conflict with the activities of others, laws, directives or policy. This would lead to numerous meetings with their associated delays (Steiner *et al* 1986: 291).

The implementation of policy in the government sector is very difficult as there are many, often conflicting and hard-to-measure goals to achieve. The interpretation of strategy can be problematic as this is done by various people who all have an influence on the process (Steiner *et al* 1986: 294).

As regards rewards for good employee performance, it is difficult for a centrally administered control system such as those encountered in governmental administrations, to function effectively if salary and promotions are tied rigidly to seniority (Steiner *et al* 1986: 294)

The three basic incentive mechanisms that can be applied to address the deeper problems to improve capability shown in Figure 21, are (International Bank for Reconstruction and Development 1997: 7):

- Effective rules and restraints to guide the state institutions.
- Increased competitive pressure to provide a benchmark for efficacy.
- Greater civil voice and partnership.

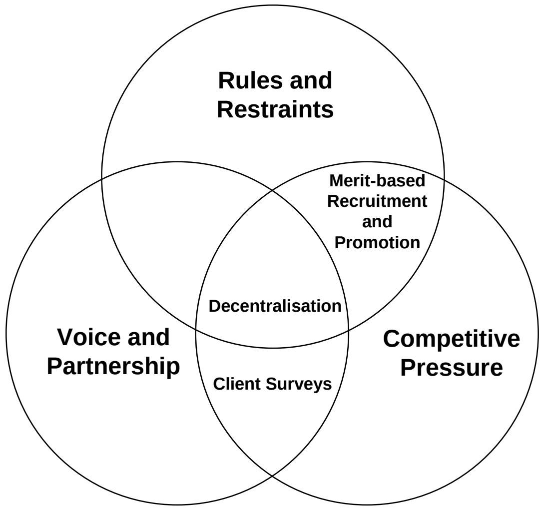

Figure 21: Mechanisms to Enhance State Capability (International Bank for Reconstruction and Development 1997: 7).

Further key mechanisms to ensure a capable state function include (International Bank for Reconstruction and Development 1997: 7):

- Merit-based recruitment and promotion to ensure the most suitable personnel are appointed.
- Decentralisation of functions.
- Client surveys to measure the degree of satisfaction and to take appropriate actions to strive towards the desired level of service.

Competent personnel are essential to achieve the desired level of service. Civil servants can be motivated to perform when they are adequately compensated, and enjoy merit-based recruitment and promotion. Evidence shows that bureaucracies employing competitive merit-based appointment and promotion are more capable (International Bank for Reconstruction and Development 1997: 9).

3.1.8 CORE COMPETENCE

The competitiveness problem facing companies today has more to do with "non-traditional" competition. The players in this arena are the laggards versus the challengers, incumbents versus innovators and the inertial and imitative versus the imaginative. The challengers typically develop more efficient solutions to satisfy clients' requirements. New solutions emerge because the challengers are substantially more imaginative, not because they are more efficient. The challengers discover innovative new solutions because they look far beyond the old (Hamel *et al* 1994: 17).

Some organisations seem to have over-the-horizon radar when it comes to predicting the future of their particular industry. According to Hamel *et al* (1994: 22) this ability requires:

- an understanding of how competition in the future will be different
- a process for finding and developing insight into future opportunities
- an ability to energise the organisation from top to bottom for what may be a hazardous journey toward the future
- the capacity to outrun competitors, and, while avoiding risks, to reach that desired future first

Many exciting new opportunities are not the result of innovation around a stand-alone Product, but rather the integration of complex systems across business unit lines (Hamel *et al* 1994: 33).

Prahalad *et al* (1989: 91) believe that the application of concepts such as strategic fit, generic strategies and strategy hierarchy have abetted the processes of competitive decline.

An organisation's capacity to improve existing skills and learn new ones is the most defensible competitive advantage of all (Prahalad *et al* 1989: 91).

In the long run, competitiveness is derived from the ability to build at lower cost and at a faster than one's competitors those core competencies that spawn unanticipated Products (Prahalad *et al* 1990: 81).

A. The Definition of Core Competence

Core competence is the communication and involvement required for, and deep commitment to, working across organisational boundaries (Prahalad *et al* 1990: 82).

The collective learning enabling the co-ordination of diverse production skills and the integration of multiple technology streams, is the core competency of the organisation (Prahalad *et al* 1990: 82).

Prahalad et al (1990: 83) postulated the following test for verifying the core competence of an organisation:

- It must provide potential access to a wide variety of markets.
- It must make a significant contribution to the perceived benefits derived by the customer from the Product.
- It must be difficult for competitors to imitate the Product.

According to Javidan (1998: 61), Prahalad and Hamel seem to consider the concepts of competence, core competence and capability as synonymous. He believes that their definition is too narrow, focusing only on a limited sector of the organisation's value chain and that it has generated some confusion between competencies and capabilities.

Javidan (1998: 62) divided the company's core competencies, competencies, capabilities and resources in terms of their difficulty and value into the hierarchy shown in Figure 22.

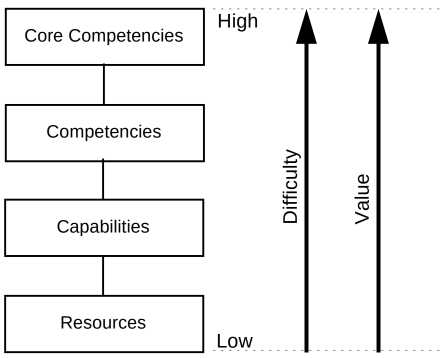

Figure 22: The Competencies Hierarchy (Javidan 1998: 62).

The hierarchy is described in more detail below (Javidan 1998: 62):

- <u>Resources:</u> These are the source of inputs to the organisation's value chain. Javidan postulates resources to include the following:
  - o <u>Physical assets</u> such as plant, equipment and location.
  - o <u>Human resources</u> such as manpower, management, experience and training.
  - o <u>Organisational resources</u> such as culture and reputation.

- Capabilities refer to the organisation's functionally-based ability to exploit its resources by means of its business processes and routines and to guide the interaction that takes place between the resources (Javidan 1998: 62).
- Competency: A competency is the cross-functional integration and co-ordination of capabilities (Javidan 1998: 62).
- Core competencies: Core competencies cross boundaries when competencies interact and are shared by the strategic business units. Core competencies are in other words, the shared, harmonised competencies within the organisation (Javidan 1998: 62).

The higher the levels reached in the hierarchy, the broader the organisational scope becomes and the more difficult these levels become to accomplish, this increasing their value (Javidan 1998: 63).

B. THE PRINCIPLES AND BENEFITS OF CORE COMPETENCE IN STRATEGY

Intellectual capital depreciates steadily. Investment in creating new intellectual capital is essential to guard against this danger (Hamel *et al* 1994: 55). It is only by humbly considering the merits of other management frames that one can one enlarge and enrich one's own (Hamel *et al* 1994: 59). Industry foresight is forged on a deep understanding of lifestyles, technology, demographics and geopolitics. It also depends on imagination as much as it does on prediction (Hamel *et al* 1994: 82). To be able to compete for the future, an organisation must be able to expand its opportunity horizon by viewing itself as a portfolio of core competencies rather than a portfolio of business areas (Hamel *et al* 1994: 83).

Organisations run great risks if they don't have a vision of needs as yet unarticulated by the clients. Irrespective of how content the organisation's current clients are, it could find its growth stymied if it cannot appeal to new client groups (Hamel *et al* 1994: 101).

A graphic model of the relationship between client needs and types is presented in Figure 23.

Clients tend to seek the existing proposition because it is offered faster and at a lower price. They generally fail to conceive of creative solutions. Creative solutions that enhance value must be designed by the supplier and proposed to the user (Young 1997: 12).

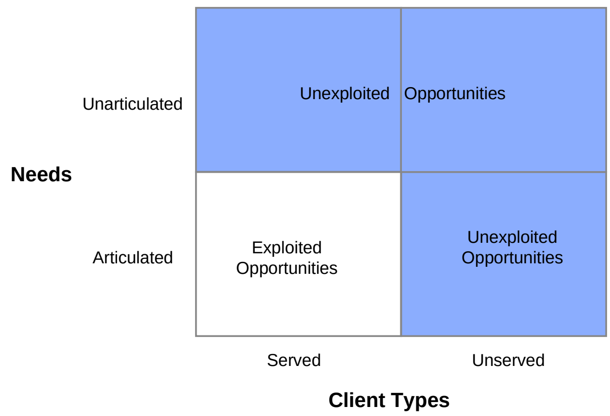

Figure 23: Relationship Between Client Types and Needs (Hamel *et al* 1994: 102).

To embed the perspective of core competence in an organisation, the entire management team must fully understand and participate in the five key competence management tasks (Hamel *et al* 1994: 224) namely:

- Identifying existing core competencies. A substantial effort is required to distinguish between competencies and the Products and services in which they are embedded. The shared core competencies must therefore be untangled from non-core activities. The task of developing this shared understanding is significant (Hamel *et al* 1994: 224).

- Establishing a core competence acquisition agenda. An organisation's competence-building agenda is generally determined by its strategic architecture. A competence-Product matrix is an excellent tool for developing competence acquisition and deployment goals. An example of such a matrix is presented in Figure 24 (Hamel *et al* 1994: 226).

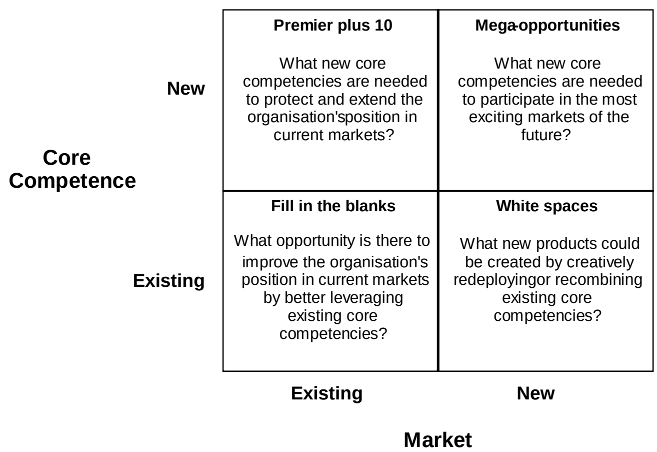

Figure 24: Matrix for the Development of a Core Competence Agenda (Hamel *et al* 1994: 227)

- Building core competencies. Core competencies take many years to develop. Consistency of effort throughout this period is essential but success, depends on a deep consensus about which competencies to build and support and the stability of management teams charged with the task of competence development (Hamel *et al* 1994: 231).
- Deploying core competencies. Capital is normally judiciously allocated within an organisation. In the same way, competencies should be allocated to leverage the organisation's total assets. The difference between asset value and book value is competence. Competence is embodied in people. Competence carriers should be shared between business units and not be jealously held by one when a demand exists throughout the organisation (Hamel *et al* 1994: 232). The benefits of competencies like those of money supply depend on the velocity of circulation as well as the size of the stockholding (Prahalad *et al* 1990: 87).
- Protecting and defending the organisation's core competencies. Leadership in core competence may be lost as a result of a lack of funding, fragmentation through decentralisation, loss of management's sponsorship, inadvertent surrender to alliance partners or divestment. Protecting the organisation's core competencies requires continuous vigilance by top management. Top management should develop the perspective of the organisation's personnel as follows (Hamel *et al* 1994: 235):
  - A deeply involving process for identifying core competencies should be established.
  - Strategic business units should be involved in a cross-corporate process for developing a strategic architecture and determining competence acquisition goals.
  - Clear corporate new business growth and business development priorities should be defined.
  - Establish explicit "stewardship" roles should be established for core competencies.
  - A structure for the allocation of critical core competence resources should be established .
  - Competence-building efforts against should be benchmarked against those of competitors.

- The status of existing and nascent core competencies should be regularly reviewed.
- A community of people who view themselves as "carriers" of the corporate core competencies within the organisation should be built.

Prahalad *et al* (1990: 88) illustrated the value of a strategic architecture in their case study of Vickers. The strategic architecture of that organisation represents a broad map of evolving linkages between client requirements, potential technologies and core competencies. This architecture assumes that the development of new Products cannot be predicted with certainty, but that to pre-empt competitors in the development of new markets requires an early start to core competencies.

Strategic architecture is a tool for communicating with clients and other role-players, this revealing the broad direction without exposing each step (Prahalad *et al* 1990: 89).

An organisation will only be fit to fight, if it is conceived of as a hierarchy of core competencies, core Products and market-focused business units (Prahalad *et al* 1990: 91).

Management's ability to consolidate corporation-wide technologies and production skills into skills empowering individual businesses to rapidly adapt to changing opportunities, is the real source of competitive advantage (Prahalad *et al* 1990: 81).

Top management must add value by means of the strategic architecture that guides the competence-building process (Prahalad *et al* 1990: 91).

Incremental planning in a volatile world is unlikely to add value to an organisation. Because the very foundations of the organisation are being shaken, assumptions about the industry and the broader environment, are not dependable. Strategic planning works well when the foundations for planning are stable. Strategic planning does not build new foundations on which to extend leadership (Hamel *et al* 1994: 282). The models for strategic the planning and crafting of strategic architecture are compared in Table 8.

	Strategic Planning	Crafting Strategic Architecture
Planning goal	• Incremental improvement in market share and position	• Rewriting industry rules and creating new competitive space.
Planning process	• Formulaic and ritualistic. • Existing industry and market structure as baseline. • Industry structure analysis (Segmentation, value chain, cost structure, competitor, benchmarking, etc.). • Test for fit between resources and plans. • Capital budgeting and allocation of resources among competing projects. • Using individual businesses as the unit of analysis.	• Exploratory and open-ended. • An understanding of discontinuities and competencies as the baseline. • A search for new functionalities or new ways to deliver traditional functionalities. • Enlarging opportunity horizons. • Tests for significance and timeliness of new opportunities. • Development of plans for competence acquisition and migration. • Development of opportunity approach plans. • The corporation as the unit of analysis.
Planning resources	• Business unit executives. • Few experts. • Staff driven.	• Many managers • The collective wisdom of the company. • Line and staff driven.

Table 8: Comparison of the Strategic Planning and Crafting Strategic Architecture Models (Hamel *et al* 1994: 283).

Hamel *et al* (1994: 47) proposed a model consisting of three phases for competition for the future. The model is shown in Figure 25.

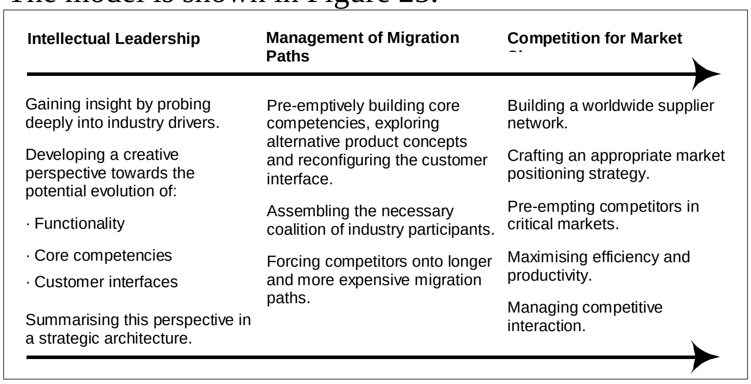

Figure 25: Three Phases of Competition for the Future (Hamel *et al* 1994: 47).

Successful firms that collaborated internally were found to have a culture in which managers and partners viewed partnering not as a threat or risk but as an opportunity. They perceived benefits in their participation in the outcomes of the decisions of other individuals or groups (Javidan 1998: 70). Basing their arguments on the principle of ore competencies in organisations, Hamel *et al* (1994: 24) proposed the new strategy paradigm shown in table 9.

Not only	But also
The Competitive Challenge	
Re-engineering processes	Regenerating strategies
Organisational transformation	Industry transformation
Competing for market share	Competing for opportunity share
Finding the Future	
Strategy as learning	Strategy as forgetting
Strategy as positioning	Strategy as foresight
Strategic plans	Strategic architecture
Mobilising the Future	
Strategy as fit	Strategy as stretch
Strategy as resource allocation	Strategy as resource accumulation and leverage
Getting to the Future First	
Competing within an existing industry structure	Competing to shape future industry structure
Competing for Product leadership	Competing for core competence leadership
Competing as a single entity	Competing as a coalition
Maximising the ratio of new Product "hits"	Maximising the rate of new market learning
Minimising time-to-market	Minimising time toachieve global pre-emption

Table 9: The New Strategy Paradigm (Hamel *et al* (1994: 24).

According to Hamel *et al* (1994: 222), an organisation that is unable to conceive of itself in terms of core competencies, exposes itself to the following dangers:

- It risks reduction of its opportunities for growth.
- If someone within the organisation does identify an opportunity, it will encounter difficulties deploying the core competencies across business unit boundaries. This is because unit managers are possessive of their personnel and are reluctant to relinquish control of them.
- Competencies are further fragmented among the business units as the organisation breaks into more discrete business elements. Leveraging these competencies is then even more difficult.
- The lack of a core competence perspective can desensitise an organisation to its growing dependence on outsourcing of its core competencies.
- Organisations focused only on end Products could neglect to invest adequately in core competencies that would drive future growth.
- New entrants who rely on core competencies developed in other markets could surprise organisations that do not understand the competitive basis of their own core competency.
- Organisations insensitive to the issue of core competencies may unwittingly discard some of these valuable skills when divesting under-performing parts of their businesses.

C. Implementing Core Competence in an Organisation's Strategy

- Javidan (1998: 64) proposes the following eight steps for organisations attempting to incorporate the core competence principle in their strategies:
- At ...(name of organisation).. we know how to ......very well. Identify those areas in which the organisation performs well. These areas of know-how can be listed in the first column of Table 11.
- Is this know-how present in one function, one business unit or across the organisation? Each of the organisation's areas of know-how is classified as a capability, competency, or a core competency. The results of these decisions are listed in the three right-hand columns of Table 11. The number of groups sharing the know-how are listed in the appropriate column of Table 11.
- <u>Is the organisation any better than its competitors?</u> Management compares the organisation's performance in the know-how areas, with those of its competitors. They thus link the core competencies to competitive advantage and reduce any tendency towards introspection by consideration of the external environment.

		The know-how is a:		
We know how to:	**No of groups:**	**Capability**	**Competency**	**Core competency**
Know-how 1				
Know-how 2				
Know-how 3				

Table 11: Table for identifying the Core Competencies of an Organisation (Javidan 1998: 65).

- Is it significant? Successful competitive advantage is built on an organisation's core competencies. Management needs to link the organisation's capabilities and competencies to those Product/delivery attributes that are considered to be key buying criteria by the different markets. This ensures that management analyse the value of the organisation's abilities to the market. The finding of the significance of the know-how is entered in the appropriate column in Table 12 (Javidan 1998: 66).

	Relative to competitors?			Significant?		Durable?	
Know-how:	**Better**	**Equal**	**Worse**	**Yes**	**No**	**Yes**	**No**
Know-how 1							
Know-how 2							
Know-how 3							

Table 12: Relating Core Competencies to Competitive Advantage (Javidan 1998: 66).

- How durable is the advantage? The durability of the organisation's competitive advantage, which is determined by the following parameters is noted in the appropriate column in Table 12 (Javidan 1998: 67):
- The organisation's ability and willingness to continuously invest in related competencies and capabilities to remain a leader in the field.
- The competitor's ability to emulate the organisation's competitive advantage. The more difficult the organisation makes this, the more durable the advantage is. Potential deterrents of imitation include the uniqueness of resources, path dependency, causal ambiguity and economic deterrence.
- The competitor's ability to develop advantages as substitutes for those of the organisation. If imitation is not attainable for a competitor, it may attack the market with a substitute Product.

- The degree to which the Product and delivery attributes remains the key criteria for the market.
- What key changes are taking place in the industry? The market is volatile and the organisation could find that the industry changes the nature of the market.
- Given the key changes occurring in the industry:
  - Which competencies or capabilities will become obsolete?
  - Which competencies or capabilities should be retained or grown further?
  - How can the competencies or capabilities be used to further advantage?
  - Which new competencies or capabilities should be developed?
- Where are we to go from here?
  - Dismantle or adjust those competencies or capabilities expected to depreciate.
  - Sustain or upgrade the identified resources, competencies and capabilities.
  - Increase the leverage from the identified resources, competencies and capabilities.
  - Acquire or develop the identified resources, competencies and capabilities.

3.1.9 STRATEGY AND STRUCTURE

The prescriptive approach has been that structure follows strategy. Emergent strategists believe that the relationship is more complex as the organisation itself may hinder or enhance the proposed strategy (Lynch 2000: 717).

The following are the main criticisms of the strategy-first, structure-later process (Lynch 2000: 727):

- The structures may be too rigid, hierarchical and bureaucratic to cope with newer social values and rapidly changing environments.
- The type of structure the organisation has, is just as important as the business area in the development of the organisation's strategy. The structure will restrict, guide and form the strategy options that the organisation can generate. Strategy and structure are interrelated and need to be developed concurrently.
- The type of organisational structure may be dictated by the value chain configurations for cost reduction or new market opportunities.
- The complexity of strategic change needs to be managed, requiring more complex organisational considerations.
- Strategy is no longer solely the domain of top management. The organisation's culture and structure may be important to middle management in the development of new innovative strategies.

Lynch (2000: 734) presented the principle that there are six ways to link and co-ordinate the six parts of every organisation. The six parts of the organisation include:

- The Operating Core: This is the part of the organisation where it generates the Products or services.
- The Strategic Apex: This is the source of the strategic direction of the organisation.
- The Middle Line: This part of the organisation contains those managers between the apex and the operating core.
- The Technostructure: This part of the organisation contains personnel such as engineers, accountants, IT specialists, that design the processes that monitor and control the operating processes.
- The Support Staff: This part of the organisation provides support services such as transport and administration to the organisation.
- The Ideology: This intangible part of the organisation holds the culture and beliefs of the organisation.

The six co-ordinating methods to link the parts of the organisation together, include (Lynch 2000: 735):

- Mutual Adjustment: This type of informal communication, typical of smaller organisations, involves direct discussion and is useful in exploring difficult issues in complex situations.
- Direct Supervision: This supervision may be executed from the strategic apex to the operating core.
- Standardisation of Work Processes: This defines the way in which work is to be executed within the organisation.
- Standardisation of Output: This aims to ensure that the organisation’s Product output is predictable.
- Standardisation of Skills: Skills, which in this case includes knowledge, can be more effectively managed if they are standardised and shared.
- Standardisation of Norms: This ensures the sharing of values and beliefs within the organisation.

3.1.10 THE DEVELOPMENT OF A STRATEGIC ROUTE

Lynch (2000: 671) presents the following four approaches to strategy:

- Survival-Based: This emergent approach emphasises survival and the seeking out of strategic opportunities in a highly competitive environment.
- Chaos-Based: Viewing the environment as uncertain, this emergent approach regards the strategic processes as opportunistic and transformational.
- Negotiation-Based: This route considers the following approaches:
  - The human resource aspect of strategic decision making.
  - The networks between the organisation and its external environment.
  - A competitive game involving negotiation between the organisation and the main role-players in the environment.
- Learning-Based: This approach emphasises context and the process derived from the organisation's knowledge and experience

A. SURVIVAL-BASED STRATEGY

This strategy is based on natural selection and the survival of the fittest. The mechanisms for survival are adaptation to the environment and selection for survival. Objectives are short-term and conservative. Analysis to assess whether survival is in fact achieved is very complex and predicting whether survival will b possible is very difficult. The choice is left to the market as long as the organisation leaves its choices open (Lynch 2000: 676).

B. UNCERTAINTY-BASED STRATEGY

According to this strategic approach, organisations survive by innovating and transforming themselves. According to chaos theory, a small change may later lead to a large consequential result. Actions should be based on the shorter term because of the difficulty of predicting the outcomes of actions and the future of the environment (Lynch 2000: 679).

C. NEGOTIATION-BASED STRATEGIC APPROACHES

Organisations developing their strategies when taking over outside organisations have to conduct considerable negotiation and persuasion within and outside the organisation to derive the full added value and to develop the sustainable competitive advantage of the enlarged entity. This approach has three conceptual areas: human resource, network-based and game theory strategies (Lynch 2000: 686).

I Human Resource-Based Strategy

Coalitions and groups in organisations are an important consideration in developing strategy. When the structure of the organisation changes, negotiation between the groups is essential to arrive at a compromise on important strategic issues. This is because it is difficult for senior management to define the combined strategy without any form of negotiation (Lynch 2000: 687).

II Network-Based Strategy

Network-based strategy is that set of relationships developed both inside and outside the organisation to add value. The two principles in the adding of value are the benefits of owning resources rather than outsourcing them and the value chain and its linkages (Lynch 2000: 688).
Table 13 presents a prescriptive approach to network-based strategy.

Internal Networks	**External Networks**
Economies of scale and scope	Cost-effective logistics
The development of superior, sometimes, unique knowledge and technologies	Superior purchasing from suppliers
Investment in client service, marketing and reputation	Skilled sourcing of new technical developments, licensing of new technologies and other technical advances
Skills, knowledge and expertise in financial matters.	Strong, stable relationships with government and other organisations with influence.

Table 13: Ways in which Networks can add Value to Organisations (Lynch 2000: 688).

III Game Theory-Based Strategy

Game theory uses mathematical models to deal with the structured approach of business decisions and is concerned with the strategy and not its implementation. It therefore clarifies the nature of the negotiation and can predict the optimal outcomes of some games. It is often difficult to model complex problems that are interdependent and interrelated (Lynch 2000: 690).

D. LEARNING-BASED STRATEGY

Including into strategy, mechanisms to transfer learning from the individual to the group, enhances survival in a turbulent business environment. Learning in this context means considerably more than memorising or coping with change but active creativity to generate new ideas and opportunities. Senge's (1990: 6-10) five learning disciplines are a useful model for use in a learning-based strategy (Lynch 2000: 696).
The learning process has the following advantages to the group and the organisation (Lynch 2000: 696):

- Through commitment to knowledge, learning presents new insights and ideas to the organisation.
- Organisations will tend to adapt through renewal and therefore not stifle.
- It will stimulate a greater openness to the external environment and the organisation will be more capable of appropriately responding to events.

3.2 STRATEGIC MANAGEMENT OF TECHNOLOGY AND INNOVATION

3.2.1 TECHNOLOGY

Technology influences many aspects of organisations. Changes due to technology influence the way organisations operate and therefore should also impact on strategy. Barker (2000: 49) demonstrated this principle by means of a comparison of the number of aircraft and bombs required to attack a target of 60 x 100 foot with 2000 pound bombs from a medium altitude of 1500 foot, in conflicts from the highly risky efforts of pilots in the Second World War to the recent operations using stand-off weapons in Yugoslavia during 1999 and is shown in Table 14. Stand-off or "smart" weapons allow the commander of the bomber to deliver the weapon at a distance without exposing the aircraft to air defence over the target.

Conflict	Bombs Required	Aircraft Required	Accuracy [ft]
WW2	9 070	3 024	3 300
Korean War	1 100	550	100
Vietnam War	176	44	400
Gulf War	30	8	200
Yugoslavia	1	1	6

Table 14: The Changes in Bombing Sorties due to Technological Advances (Barker 2000: 49).

A. DEFINITION OF TECHNOLOGY

Van Wyk (1988: 341) presented the following definition of technology:

> *Technology is created capability: it is manifested in the purpose of which is to augment human skill (Rapp 1981: 33-36).*

Van Wyk (1988: 342) described the following key concepts in the definition of technology:

- Created: It is the Product of deliberate action. Technology has to be cultivated and nurtured if it is to be harnessed as a resource.
- Capability: In this context it is the ability to manipulate aspects of the physical world.
- Artefacts: These are the repositories of capability and refer to devices, tools, instruments or machines.

- Augment: In this context augment is intended to refer to both the enhancement of human capability by means of adding artefacts to support human activities and the replacement of human ability by substitution with artefacts.

B. FRAMEWORK FOR ANALYSIS AND CLASSIFICATION OF ARTEFACTS

Van Wyk (1988: 343) proposed the following framework for the analysis and classification of artefacts:

- Function: This can be defined by the type or nature of the output as matter, energy, or information. The output is the result of the function, which can be categorised as processing from one form into another, transporting across a distance and storage of the input for later retrieval.
- Performance: This can refer to a variety of parameters including speed, power, and the number of instructions per second and so on. This allows a quantitative measurement and classification of the artefact.
- Principles employed: This refers to the principles employed in the use of the artefact. In the case of telephone switchboards, one may use electromechanical and another electronic principles.
- Material composition: The material used may be directly associated with the principle with which the artefact operates or it may be incidental only providing structure. The former is more difficult to substitute while the latter lend itself more easily to improvement by substitution.
- Size: This refers to the physical dimensions of the artefact.

C. TECHNOLOGICAL TRENDS

Van Wyk (1988: 345) proposed a set of standard technological trends listed in Table 15.

Feature	Trend
Function	Normally static
Performance	Increases in one or more of efficiency, capacity, compactness and accuracy.
Principles	Difficult to chart
Material	From natural to synthetic
Size	Extending range of size
Structure	Increasing complexity

Table 15: Technology Trends (van Wyk 1988: 346)

By the use of Table 15, managers can improve their ability to predict suitable configurations of their Products and develop suitable plans to exploit their technologies (van Wyk 1988: 346).

D. TECHNOLOGICAL LIMITS

Van Wyk (1988: 347) combined the functional categories with the technological trends in the format shown in Table 1 to relate each of the trends with the category of the artefact.

		Type of Limit					
Ouput Type	Transformation Type	Efficiency	Capacity	Compactness	Accuracy	Size	Complexity
Matter	Processing						
	Transport						
	Storage						
Energy	Processing						
	Transport						
	Storage						
Information	Processing						
	Transport						
	Storage						

Table 16: Technological Limits Chart (van Wyk 1985: 214).

According to Van Wyk (1988: 347), knowing and understanding the limits of technology, aids the manager in these ways:

- A large difference between the present technological characteristics and those ultimately achievable indicates the size of the opportunity that can be exploited.
- A forecaster of technology can gain insight into the steepness of the trend graph if the extent of the technological limit is evident.
- The direction and extent of the research and development effort can be determined with the knowledge when the areas of performance are more accurately defined.

E. SOCIO-TECHNICAL PREFERENCE PROFILE

Van Wyk (1988: 347) referred to the four categories of interaction between technology and society recognised by De Vulpain (1984: 32):

- Allergy: This is the rejection of a particular technology by society. An example is anti-personnel mines, which have been banned internationally.
- Deviation: Society partially rejects the particular technology. Some countries support nuclear weapons whereas others not.

- Enforced Penetration: A powerful force imposes a technology on society. France has endorsed the use of nuclear weapons in spite of the nation's rejection.
- Synergy: Society enthusiastically accepts the technology. The ubiquitous cellular telephone is an example of a synergistic acceptance.

3.2.2 INNOVATION

Two basic tasks required of general managers according to Burgelman *et al* (1996: 1) are:

- The acquisition, development and allocation of the organisation's resources. Technology is a key resource for many organisations.
- The development of the organisation's capacity for innovation. Assess the organisation's innovative capabilities and investigate methods for leveraging them.

A. DEFINITION OF INNOVATION

Burgelman *et al* (1996: 1) hold the following definitions in the innovation field:

  - Basic research generates new knowledge about physical, biological and social phenomena.
  - Applied research is concerned with solving technical problems. The success or failure in applied research is determined by technical rather than commercial criteria. Typically there is a significant period of time between the achievement of successes in applied research and the successful exploitation of the subject researched.
  - Technology is the theoretical and practical skills, knowledge and artefacts suitable for development of Products, services and their production and delivery systems. Technology can be embodied in people, materials, processes, plant equipment and tools. Technologies are usually the Products of development activities to find practical application of the innovations. Certain key elements of technology may be implicit in trade secrets based on experience or know-how. The success of technologies is based on technical criteria.

- Technological innovations are either technology-based or technology-facilitated. The former have technology embodied while the latter are created by a technology. The success or failure technological innovations is determined by commercial rather than technical criteria, producing more in returns than the cost of the investment to produce the innovation. Innovation processes lead to the new marketable Product, service or process.

The relationships between the technological innovation activities and their outcomes as described above are presented in Figure 26.

Porter (1990: 780) however describes innovation as the discovery of a new way of doing things, which can be commercialised.

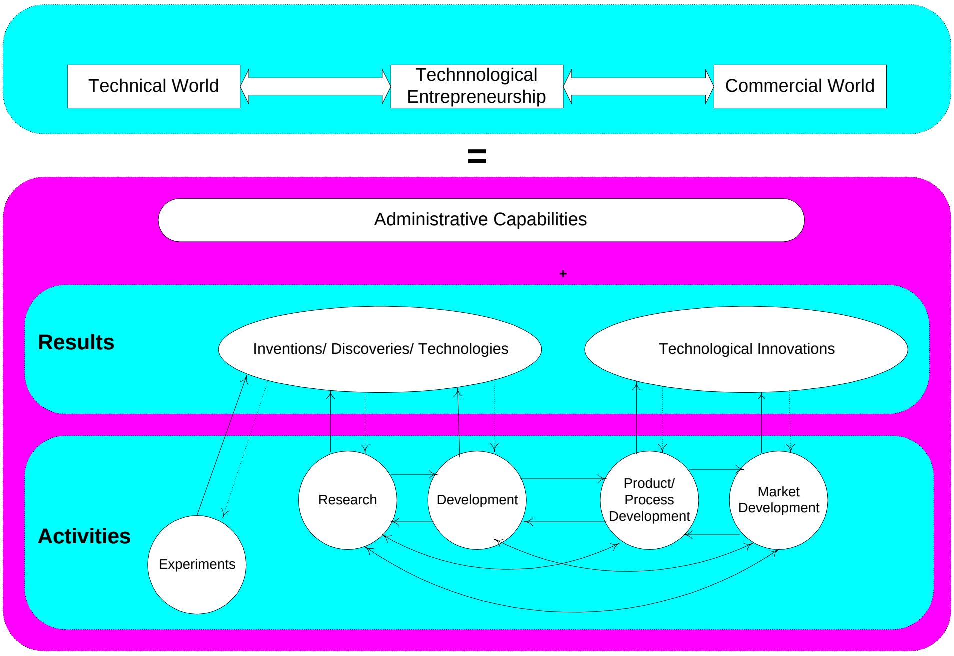

Figure 26: Relationships between Key Technological Concepts (Burgelman *et al* 1996: 5).

He also states that innovation is the result of unusual effort often in the face of obstacles or threats (Porter 1990: 49). Outsiders to the established social structure of an industry or organisation are often the catalysts for innovation (Porter 1990: 581).

Innovation pushes Products, markets and production beyond current capabilities and limits. It generates and exploits new data and ideas, allowing organisations the following advantages (Lynch 2000: 498):

- Substantial future growth.
- Competitive advantage.
- The capability to overtake even dominant competitors.

Innovation is an approach to limit the following three dangers associated with the analytical process in strategy development (Lynch 2000: 498):

- Strategy often is based on past experiences and historical data limiting the opportunities for breaking with the past.
- An overemphasis on analysis may stifle creativity.
- A reliance on past events for prediction of the future.

Successful innovation as a distinctive capability is often difficult to sustain as it often attracts imitation from imitators (Kay 1993: 14). To yield sustainable rewards from innovation, it must therefore sometimes be accompanied by other strategic tools such as architecture, etc…(Kay 1993: 106).

Project HINDSIGHT, an endeavour by the United States Department of Defence to assess the efficacy of their research and development efforts, produced findings that include the following:

- In the majority of cases it was found that the initial recognition for the need originated with the external group assigned to attend to the systems design. The technical initiative for the solution however came from the research-performing group. In another words the need-recognisers informed the researchers of the nature of the problems without prescribing the nature of the solution (Sherwin 1967: 93).
- The median for the time to application for science research results was nine years and that for technology research results five years. Project HINDSIGHT found that large changes in performance/cost were due to the synergistic effect of many innovations, of which many were modest (Sherwin 1967: 94).
- Investment in directed research effort produced returns many times over (Sherwin 1967: 95).
- The results of undirected research effort should be retained in an eternal archive to be available for future exploitation (Sherwin 1967: 96).

A Product requires two types of knowledge, firstly the core design concepts of the components and secondly, the architectural know-how of the ways in which the components are interrelated and integrated. The framework of the four basic types of innovation described below is shown in Figure 27 forms a useful guide to understand their nature and consequences (Henderson *et al* 1996: 402-403).

- Incremental Innovation: The individual components of the Product are improved or refined using current design concepts. The links in the new architecture remain therefore unchanged.
- Modular Innovation: This type of innovation retains the architecture with the relationships between the components while the core design concepts of one or more of the components are changed.

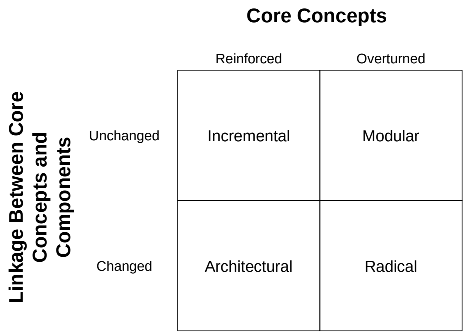

Figure 27: A Framework for Defining Innovation (Burgelman *et al* 1996: 403).

- Architectural Innovation: This is defined as those innovations that change the way in which the components of a Product are linked together but not altering the basic knowledge embedded in the design concepts. An example of this category would be the table fan, which could replace the ceiling fan. The difference is in the way in which the components are fitted together while some changes are made to the components to enable them to fit in the new configuration.
- Radical Innovation: This type of innovation establishes a new dominant design with a new set of core design concepts for the set of components that constitute the Product. This will of necessity require new sets of knowledge of the links in the new architecture.

B. DISCUSSION

The innovation process is integral to the organisation’s strategic and competitive context. Innovation by perceiving or discovering new and better ways to compete in an industry and presenting them to the market is the way organisations create competitive advantage. Innovation can be manifested in Product or process changes new approaches to marketing, distribution or a new concept of scope (Porter 1990: 44).

Merely by imitating competitors and basing advantage on cheap labour or raw materials is rarely sustainable as the basis for economic development beyond a certain level (Porter 1990: 780).

Due to large, established organisations' tendency to resist change, innovation is often suppressed in these organisations. Organisations that innovate are frequently not large established leaders in their respective fields as the larger organisations often tend to resist discontinuities (Porter 1990: 49).

Burgelman *et al* (1996: 3) describe the organisation's actual strategy and its creation as the positive view of strategy. This reflects the belief of top management through its experience of past and present success. These beliefs include core competencies, Product market areas, core values and people as well as their associations with the organisation's success gained as part of the organisational learning process. There is usually a difference between the organisation's statements of strategy and the actual execution thereof.

The way in which the organisation competes with its Products and services is referred to as the Product-market view of strategy. The resource-based view of strategy is mainly concerned with the acquisition of those factors needed to create the core competencies and capabilities for the establishment of sustainable competitive advantage. This is used to exploit opportunities, which may arise. This last approach to strategy falls into the category of Porter's "five forces of competition" and "generic strategies" whereby it is explained why some industries are more attractive than others (Burgelman *et al*, 1996: 3).

Technological change can create new opportunities for the design of a Product, its marketing, production, delivery and the provision of ancillary services (Porter 1990: 45).

According to Lynch (2000: 474) knowledge, creation, technology development and innovation need to be related back to the ability of the organisation to add value to its Products and sustainable competitive advantage as illustrated in Figure 28.

3.2.3 TECHNOLOGY AND INNOVATION STRATEGY

When strategy is developed, the focus is on the present and future Product or market mix. Once a decision is arriving at, the way in which the organisation's resources are to be exploited must be decided. As one of the resources to be considered during this process, the technological solutions proposed for the development of new Products must be evaluated in terms of their feasibility (de Wet 1992: 2).

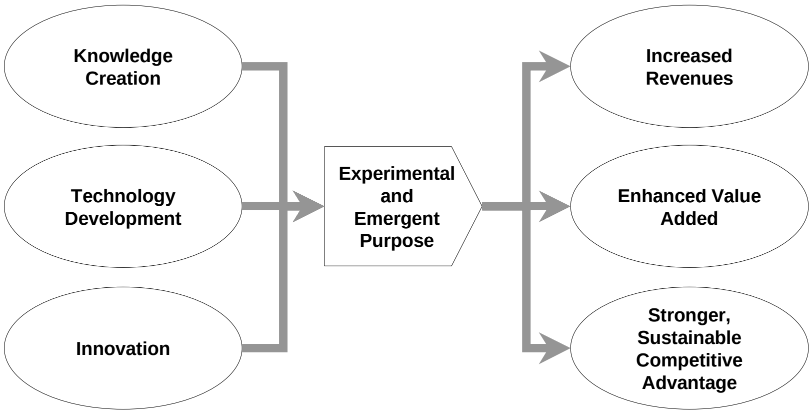

Figure 28: An Emergent Approach to Purpose (Lynch 2000: 474).

It is desirable that the managers of technology should be able to communicate with corporate management in a common language (de Wet 1992: 2).

De Wet (1992: 2) proposes the model shown in Table 17, which he terms the "Technology Balance Sheet", to depict the relationship between the various strategic factors in the management of technology. The relationship between the various Products and the market is shown in the upper right-hand corner of the table. The technologies for producing artefacts can be traced from the upper left-hand corner of the table through the processes that transform the artefacts into the end-Products.
Corporate management needs to know the financial implications of a technological strategy. For this purpose the lower right-hand corner of the table indicates the financial flows required for the research, development, production, logistic and sales activities (de Wet 1992: 5).

The lower left-hand corner of Table 17 shows the technological and Product life cycle phases applicable to the artefact technologies. They are shown separately as these life cycles do not necessarily coincide.
Technology has economic value only in its commercial manifestations (Solomon 1992: 2).

The most significant technological advances currently originate in the civil sector rather than the military sector of the economy. Reliability standards for civil sector Products are similar to those for military Products. In the civil sector there is enormous pressure on firms to advance technology Products in order to remain competitive in terms of capability, cost and reliability. With shrinking defence budgets, the trend in military organisations is, therefore, rather to rely on the acquisition of COTS Products than to be subjected to the risk of developing Products of their own. Development by military and defence organisations is now more focused on adding value by the integration of Products and lower-order items into more complex Products and Products Systems (Molas *et al* 1992: 15-16).

Artefact Technologies / **Products**

Markets	Product M	Product N	Product O	Product P	Future product X	Future product Y
Market A		x			x	x
Market B	x	x	x	x	x	x
Market C		x	x			x
Market D			x			x
Market E				x	x	x

Technology A	Technology B	Technology C	Technology D	Technology E	Technology F	Process Technologies	Product M	Product N	Product O	Product P	Future product X	Future product Y
x		x				Process 1	x	x		x		x
	x	x	x			Process 2	x		x	x	x	x
	x	x				Process 3				x	x	x
		x	x	x	x	Process 4						x
x		x			x	Process 5					x	x

Technology Life-cycle	Technology A	Technology B	Technology C	Technology D	Technology E	Technology F
Emerging				x		x
Growth			x			
Mature		x			x	
Declining	x					

Product Life-cycle	Technology A	Technology B	Technology C	Technology D	Technology E	Technology F
Emerging				x		x
Pacing		x			x	x
Key	x		x		x	
Basic	x				x	

Product Phase	Product M	Product N	Product O	Product P	Future product X	Future product Y	Technology Income Statement [R1000s] Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
Research		x			x	x	(200)	(600)	(900)	(400)	(600)	(500)
Development		x	x		x	x	(10)	(100)	(700)	(100)	(500)	(700)
Production	x	x	x	x			(800)	(810)	(850)	(750)	(700)	(650)
Logistic	x	x	x	x			(100)	(150)	(200)	(140)	(120)	(110)
Sales	x	x	x	x	x		2,000	2,100	2,000	3,000	2,900	3,100

[shaded] : Future products.

Table 17: Technology Balance Sheet (de Wet 1992: 10).

Accurate communication to corporate management, of the strategic aspects of an organisation's technology resources and position is essential to ensure that the correct decisions are taken. De Wet (1992: 3) developed a model, shown in Figure 29, to address this issue. This model correlates the life cycle phase and the systems hierarchy with the organisation's capabilities.

Figure 29 shows the two capabilities of a fictitious organisation. Capability A includes the ability to support, operate and dispose of assets at the User System, Products System, Product and subsystem levels. The abilities are however limited at the User System and subsystem levels. This capability cannot support the research, development and production of a new User System. Replacement will then have to take place by purchase or by expansion of the capabilities to produce a new User System by itself. The latter choice will demand high levels of investment, and protracted time scales.

Capability B in Figure 29 shows the research, design, development and production abilities at Product, subsystem and component levels. This capability is incomplete in the area of research and production abilities and generally low at the Product level. From this diagram it can be seen that this capability requires some resources to bring it to the point where it can be supported and operated.

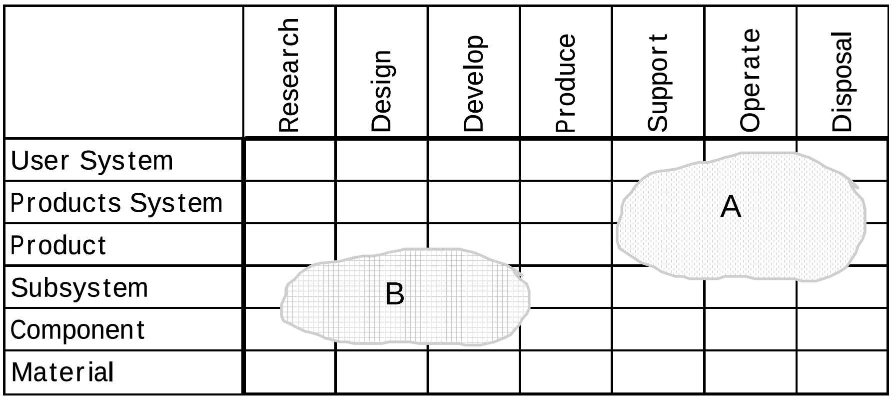

Figure 29: Technology Space Map (de Wet 1992: 6).

The block at the intersection of "Design" and "Subsystem" implies the capability to design a subsystem. This includes the following abilities, resources and infrastructure:

- Design theory, knowledge, codes and practice.
- Development and maintenance of specifications.
- Project, engineering and contract management.
- Systems and development engineering, including simulation, creating development models and testing.
- Testing and qualification of items.

The level of capability in the technology space map can vary between no knowledge of the subject to sufficient skill to function independently. By comparing the existing capability with the capability needed to pursue the strategy, one can determine what change is required (de Wet 1992: 9).

Technological forecasting is the process of estimating the importance and directions of present and emerging technologies. This type of forecast is used for strategy formulation. Twiss (1992: 260) offers the following reasons why technological forecasting would be beneficial to the business decisions of an organisation:

- A survey providing into developments in the greater environment to see what could potentially influence the industry's future and possibly the organisation's Products could form part of the forecasting process and provide very useful information.
- Estimating the time scales for the impending developments will make it possible to assess the urgency for action.
- Such a forecast may provide further information in an area where an incomplete initial analysis suggests a major threat or a major opportunity in the future or it may result in continued monitoring having to be done to ensure the availability of sufficient information for future use.
- Forecasting may expose a need for major reorientation of future organisational policy to cope with threats or opportunities.
- Forecasting could improve operational decision making.

Analysis of historical data on phenomena encountered when an organisation deals with a given technology has shown that such phenomena follow a regular pattern. When an attribute of value for example performance, is plotted with respect to time, the trend appears in the form of an S-Curve (Twiss 1992: 269).

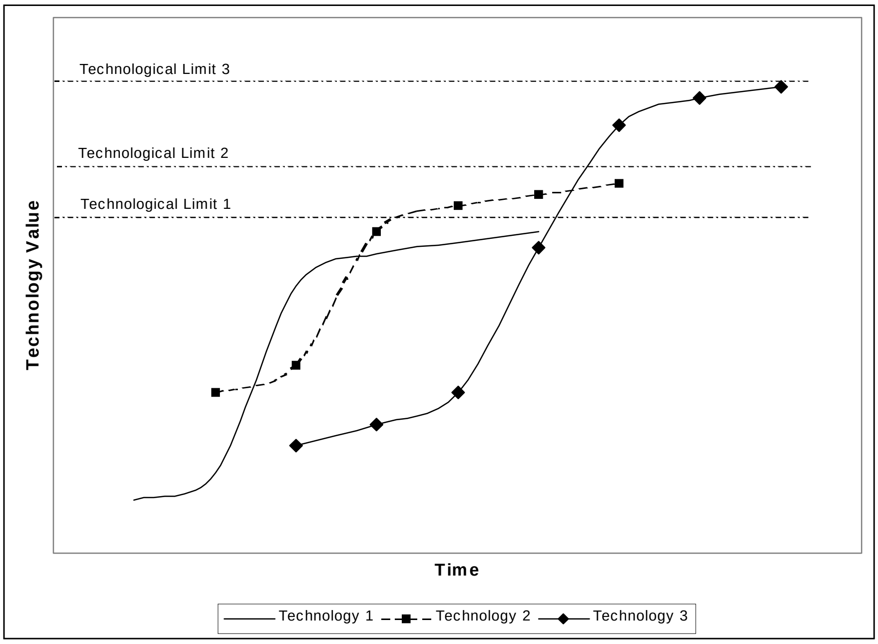

Figure 30: Examples of S-Curves for an Organisation's Technology Strategy Formulation.

The S-Curve is made up of the following main phases (Twiss 1992: 271-273):

- Initial Slow Growth: During this phase there is great uncertainty about the potential of the new technology. Examples of the slowness of this phase of growth include carbon fibre technology, which after being introduced in the 1960s only began gaining acceptance in aircraft construction in the 1990s.
- Rapid Growth: During this phase the uncertainty of the potential of the technology has diminished considerably and the technology may offer a value advantage to the client or user. The level of investment and infrastructure required will, however, affect the acceptance of the new technology.
- Reduced Growth: When the technology approaches its upper limit, it loses its attractiveness and is then ripe for replacement with a new technology with potential for further growth. In many cases there is reluctance to relinquish an understood technology, so there will still be further investment in small, incremental improvements.

By studying the S-Curve, can enable one to understand the technology phases, and enable forecasters to identify suitable new technologies to replace the old. In Figure 30 an example of three subsequent technologies is presented. Technology type 1 is initially exploited and adopted while Technology type 2, which has a higher potential, is investigated. When the former technology type reaches its limit, further investment in the latter increases its acceptance and growth. The cycle is repeated with Technology type 3, which has potential that is considerably greater than that of the previous technologies. By studying the trends in technologies, the manager can constructively contribute to the formulation of an organisation's strategy.

3.3 MANAGEMENT OF KNOWLEDGE, EXPERTISE, SKILLS AND CULTURE

3.3.1 INTRODUCTION TO THE MANAGEMENT OF KNOWLEDGE, EXPERTISE, SKILLS AND CULTURE

According to Lynch (2000: 479) knowledge is a resource and as such it should be treated as any other. Normally an organisation's knowledge concerns markets, brands, customers etc. The creation of future knowledge and opportunities, is an aspect that one should be considered when analysing an organisation's knowledge resources. The latter consideration could impact on the organisation's purpose. According to Davenport *et al* (1998: 2):

> *Knowledge is a fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices and norms.*

Lynch (2000: 479) claims that knowledge is more than just data or information. He states:

> *The most useful knowledge in many organisations is often the most difficult to understand, codify and replicate.*

Knowledge as a resource can contribute to sustainable competitive advantage. Knowledge, which has a tacit component so that it is of no use outside the organisation, is therefore difficult for a competitor to replicate (Lynch 2000: 487).

Nonaka *et al* (2000: 7) have adopted the traditional definition of knowledge as 'justified true belief'. Nonaka believes that the focus should be on the 'justified' rather than the 'true' aspect of knowledge. He criticised the traditional Western view for failing to acknowledge the relative, dynamic, and humanistic dimensions of knowledge. Knowledge is context-specific and depends on its space and time of existence.

Lynch (2000: 485) lists the six mechanisms that, according to Davenport *et al* (1998: Ch3), aid the creation of knowledge. The are as follows:

- <u>Acquisition:</u> Ideas can be acquired by observing other organisations.
- <u>Rental:</u> By sponsoring an academic institution or consultants, an organisation can acquire specialist knowledge.

- Dedicated resources: A task force within the organisation can create specialist knowledge.
- Fusion: By grouping together people with different skills and backgrounds to adopt a novel way of looking at a problem, an organisation can create new knowledge.
- Adaptation: Existing knowledge can be adapted to suit a new situation.
- Networks: Formal and informal networks may share knowledge thus increasing everyone's store of knowledge.

Lim *et al* (1999: 615) propose that knowledge is the ability to act on information.

I one case, a more radical approach to redesigning the organisation's research and development processes appeared to succeed where the classical re-engineering effort failed. This subtle approach entailed that a small group of scientists collected the organisation's entire knowledge base of the entire research and development process, regulatory approvals and international variations. This knowledge was embedded in a series of documents and in a weblike hypertext computer system. After much consideration and changes, a greater sense of cross-functional understanding seemed to prevail. This illustrates how the classical top-down re-engineering approach is often insufficiently participative or flexible for improving work by autonomous workers (Davenport *et al* 1996: 53).

Engineering Productivity is largely determined by the effectiveness of the knowledge worker rather than the efficiency of the factory worker. Knowledge workers are referred to as those highly skilled types of labour who need education, sophisticated training and sharp talents to perform highly specialised tasks in organisations. Managers have the significant challenge of motivating engineers. Engineering resources are generally poorly managed and applied. As much as 30% of a professional's time is spent performing work that is within the reach of a high school graduate. There is also inadequate understanding between management and these technical resources (Badawy 1978: 27).

Badawy (1978: 35) proposes several strategies to improve the Productivity of engineers and other knowledge workers:

- Management should communicate their visions and strategies to knowledge workers.
- Engineers should not be tied to an organisation, but be motivated to remain in its service out of job interest for the rewards they are given.

- Senior engineers should be encouraged to venture into new fields to broaden their scope and interests, this will constitute a new source of motivation.
- Implement continuing education and training should be implemented.
- Their jobs should be redesigned.

More of organisations' core competencies will depend on how knowledge and knowledge workers are managed. Industrial growth and Productivity gains will depend heavily on the improvement in knowledge work (Davenport *et al* 1996: 53). Davenport *et al* (1996: 54) referred to the work of Quinn *et al* (1996: 71-80) in which they equate knowledge with professional intellect. They propose that professional intellect in organisations centres on know-what, know-how, know-why and self-motivated creativity.

Davenport *et al* (1996: 54) define the primary activity of knowledge work as the acquisition, creation, and packaging or application of knowledge. Professional or technical workers perform knowledge work and this work is characterised by variety and exception rather than routine.

A process approach to knowledge work attempts to separate the work from the characteristics of the individual knowledge worker. The process approach allows the organisation an improved view of how to structure, sequence and measure activities to achieve the desired out comes. There are, however significant challenges to the application of the process approach. These are (Davenport *et al* 1996: 53) as follows:

- Variety and uncertainty of inputs and outputs.
- Unstructured and individualised work rules and routines.
- Little separation between process inputs and outputs.
- Insufficient measuring.
- Worker autonomy.
- High variability in performance between individuals and over time.
- Inadequate information technology support.

The task of managing of professionals differs from that of managing of administrative and operational workers in that it requires that the manager passes on day-to-day task control to the professional worker while retaining control and direction over strategic issues. Knowledge workers are distinct from administrative workers in their greater level of discretion and autonomy (Davenport *et al* 1996: 55).

Based on their arguments on the results of a survey of thirty projects in a broad spectrum of industries, Davenport *et al* (1996: 57) distinguishes the following five primary orientations to knowledge:

- Finding. This entails the collection of existing knowledge.
- Creating. This is the creative process of generating new knowledge.
- Packaging. This is the packaging or integration of externally-created knowledge.
- Application. This focuses on the process of applying existing knowledge.
- Reuse. Previously used knowledge is leveraged in new processes.
-

Davenport *et al* (1996: 59) identified the following ways for improving knowledge work:

- Making an implicit knowledge process explicit and consistent.
- Adding knowledge to a process in order to add value to the process customer.
- Involving the customer in the process in order to increase their satisfaction with the results.
- Sharing knowledge more effectively throughout the process.
- Improving the execution of programmes and initiatives.

As knowledge work frequently involves expertise fragmented among several individuals, it is necessary to obtain the participation of all to gain a full understanding of the process (Davenport *et al* 1996: 60).

The appropriate knowledge process improvement method depends on the primary orientation of the work, the organisation's culture and the time and level of the risk that the project can endure. The *laissez-faire* approach is most suitable for those organisations attempting to improve their knowledge creation processes. Organisations intending to reduce or eliminate the amount of administrative activity should apply these changes by means of the more classical re-engineering approach. The organisational culture also has an influence on the suitability of the choice of knowledge work process improvement. The project's time frame and risk also dictates the choice of approach (Davenport *et al* 1996: 61).

Because decisions on the flow of work should be left to the individual knowledge workers, Davenport *et al* (1996: 61) believe that the primary knowledge work strategies lie in the following three areas:

- Organisations can change knowledge itself by reducing or creating a knowledge unit that can be reused or accessed by improving knowledge capturing processes.
- Organisations can improve knowledge work by changing the location where, and determining with whom people work.
- Organisations can bolster knowledge work by the use of technology to create knowledge bases and telecommunications infrastructure and applications.

The simple act of putting people together in the same room greatly improves knowledge work. When workers form divergent business functions, often from the same physical locations, were combined into teams, they shared a common purpose, common measure and often cross-training in tasks and skills. The knowledge process became more co-ordinated (Davenport *et al* 1996:63).

According to Malhotra (1998:1) knowledge management addresses the critical issues of organisational adaptation, survival and competence in an environment that is undergoing increasing amounts of discontinuous change. Knowledge management seeks synergistic organisational processes that combine information, its technology and the creative, innovative capacity of humans. It is a framework within which an organisation views its processes as knowledge processes. These knowledge processes involves the creation, renewal, dissemination and application of knowledge to the benefit of the organisation.

Malhotra (1998: 2) claims that information technology is regarded as a key component of the information value-chain principle. Knowledge management, by contrast, treats humans engaging in the continuous assessment of information as the key players. ‘Best practices’ are therefore not accepted unconditionally. ‘Double-loop learning’ needs to be incorporated into the design of the processes to learn, unlearn, relearn or discard processes and thus ensure that ‘best practices’ are appropriate in the context that the organisation finds itself. Knowledge management is therefore important for organisations because that which worked yesterday, may not work today.

Human sensors continuously interact with, and develop a rich understanding of the phenomena in the external environment (Malhotra 1998: 2).

Knowledge workers also need an overall understanding of the business of their organisation as well as the context of their contribution to optimally contribute to the organisational learning and unlearning processes. Creativity and inquiry-driven learning may be difficult to achieve in a control-and-command paradigm (Malhotra 1998: 3).

To a lesser or greater extent, all organisations possess organisational knowledge in their respective fields. Organisational knowledge according to Kay's definition, is distinctive to the organisation and is more than the sum of the expertise of the employees. It is, furthermore, not available to other organisations. Organisational knowledge is distinctive if the organisation is able to take ownership of, and apply, this knowledge. Competitive advantage in the market is achieved through distinctiveness in organisational knowledge. Kay presented the concept of employees each knowing only one part of the code to open a safe as the purest form of an example of organisational knowledge. In firms providing professional services or those in high-technology industries, knowledge is their stock in trade. Their challenge is the integration of their employees' individual skills into a greater knowledge-base from which Products or services can be produced (Kay 1993: 73).

Lim *et al* (1999: 617) propose the following four steps to enable knowledge management to become an integrated component of the organisation's quality strategy:

- <u>Capturing or creating knowledge (Planning):</u> Knowledge may be captured from external and internal sources or it may be created internally. Both structured and unstructured sources may be considered.
- <u>Share knowledge (Do):</u> Use as many media possible to share knowledge.
- <u>Measuring effects (Checking):</u> Determine the outcomes of possession of the new knowledge.
- <u>Learning and improving (Acting):</u> Any knowledge gained must be applied according to the Total Quality Management philosophy of continuous improvement.

Lim *et al* (1999: 617) present the following four perspectives in their COST model to analyse the elements to be measured:

- <u>Customer:</u> Identify the known customer problems, solutions and other information that can be used for learning.

- Organisation: Identify the key skills that can provide the organisation with success.
- Suppliers: Determine whether the links with suppliers are able to provide the organisation with an optimal quality, cost and delivery service.
- Technology: Establish whether technological links are optimally exploited both inside and outside the organisation.

According to Lim *et al* (1999: 620) knowledge management as a quality strategy offers the following benefits:

- It reduces the loss of intellectual capital resulting from the departure of employees.
- It reduces the cost of developing new Products.
- It results in increased worker Productivity because it streamlines access to knowledge.
- It results in increased employee satisfaction.

Competence carriers should know that their careers are tracked and guided by corporate human resource professionals (Prahalad *et al* 1990: 91).

3.3.2 COMPETENCE

According to Österlund (1997: 135), the working substance in new Product development is competence. This is the ability to perform certain work with the help and support of the organisation. Competence is made up of knowledge, skill, experience, and the ability to communicate with peers, the upholding of values and the ability to use externally-sourced knowledge, experiences and tools. The output of individuals proves their competence.

According to Verkasalo (1998: 415), knowledge is the capability to link pieces of information together intelligently. The utilisation of knowledge occurs in decision-making and the selection of alternatives. Pure information cannot be used in decision-making, it must be converted into knowledge.

Knowledge exists either in tacit or explicit form (Verkasalo 1998: 415) (Nonaka *et al* 2000: 7).

Tacit knowledge is difficult to formalise as it is personal and context-specific and may be considered to be akin to craftsmanship. Explicit knowledge is factual codified knowledge that can be formally documented and transmitted [(Verkasalo 1998: 415), (Lim *et al* 1999: 616) and (Nonaka *et al* 2000: 7)].

The knowledge creation school model describes how knowledge changes from tacit to tacit, explicit to explicit and explicit to tacit by means of analogies and metaphors to form a shared mindset and a pool of understanding during organisational learning (Verkasalo 1998: 415).

Through each of the four modes of knowledge conversion referred to in the previous paragraph, the knowledge created, interacts in the spiral of knowledge creation. This is called the socialisation, externalisation, combination and internalisation (SECI) process, and is graphically presented in Figure 31 (Nonaka *et al* 2000: 12).

Socialisation converts new tacit knowledge into explicit knowledge. Externalisation articulates tacit knowledge into explicit knowledge. Combination converts explicit knowledge into more complex and systematic forms of explicit knowledge (Nonaka *et al* 2000: 9). Internalisation involves the embodying of tacit knowledge into explicit knowledge (Nonaka *et al* 2000: 10).

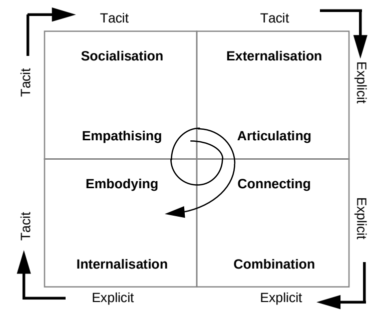

Figure 31: The SECI Process (Nonaka *et al* 2000: 12).

To facilitate the way in which knowledge assets are created, acquired and exploited, Nonaka *et al* (2000: 20) divided them into the four classes shown in Figure 32.

Experiential Knowledge Assets Tacit knowledge shared through common experiences: •Skills and know-how of individuals. •Care, love, trust and security. •Energy, passion and tension.	**Conceptual Knowledge Assets** Explicit knowledge articulated through images, symbols and language: •Product concepts. •Design. •Brand equity.
Routine Knowledge Assets Tacit knowledge embedded in routine actions and practices: •Know-how in daily operations. •Organisational routines. •Organisational culture.	**Systemic Knowledge Assets** Systemised and packaged tacit knowledge: •Documents, specifications and manuals. •Database. •Patents and licences.

Figure 32: Four Categories of Knowledge Assets (Nonaka *et al* **2000: 20).**

A monodisciplinary group can form a living system for generating creative solutions by learning from sharing knowledge and experience with other members of the group in a common professional language. This group can create high technology by the driving force of just being problem-solvers. The requirement is that they support each other in common face-to-face dialogue (Osterland 1997:135).

Marquardt (1999: 34) refers to the development of knowledge as "action learning". He states that both significantly more learning and a higher level of learning occur when action is based on the reflective recommendations of the group. The action learning group should have the expectation and responsibility of carrying out their ideas and recommendations. He presents the formula for action learning shown in Figure 33 and proposes that learning will only have taken place after programmed knowledge has accumulated, the ability to ask insightful questions has developed and, reflection and implementation of the learnt activity have all occurred.

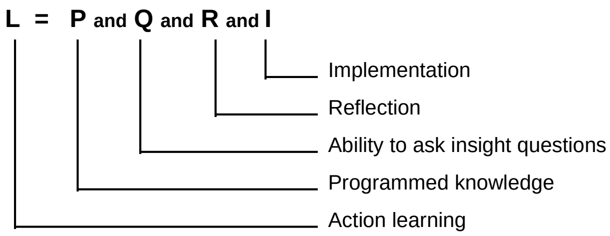

Figure 33: Action Learning Formula (Marquardt 1999: 34).

Programmed knowledge is knowledge that is in current use in books, for example in one's mind, in the organisation's memory, etc. The ability to ask insightful questions offers access to that which is not yet known. Reflection consists of recalling, considering, analysing and understanding. Implementation consists of taking action to apply the knowledge learning (Marquardt 1999: 29 – 34).

Hill (1991: 17) presents the levels of learning in Figure 34 below. The lower levels of learning involve things that are easier to perform, whereas the higher levels of learning, which include application, synthesis and evaluation, are more difficult but are essential for effectiveness (Hill 1991: 16).

Increasingly higher levels of learning

Levels Of Learning	Description
Evaluation	Appraise, Compare, Conclude, Contrast, Interpret, Explain
Synthesis	Classify, Compile, Design, Modify, Reorganise, Formulate, Reconstruct, Substitute
Analysis	Select, Discriminate, Illustrate, Separate, Distinguish
Application	Demonstrate, Relate, Use Compete, Prepare
Understanding	Explain, Extend, Generalise, Infer, Summarise, Estimate
Knowledge	Know, Identify, List, Name, Outline, State

Figure 34: Levels of Learning (Hill 1991: 17).

Figure 35 shows Österlund's (1997: 137) representation of the transfer of competence in new Product development work over time.

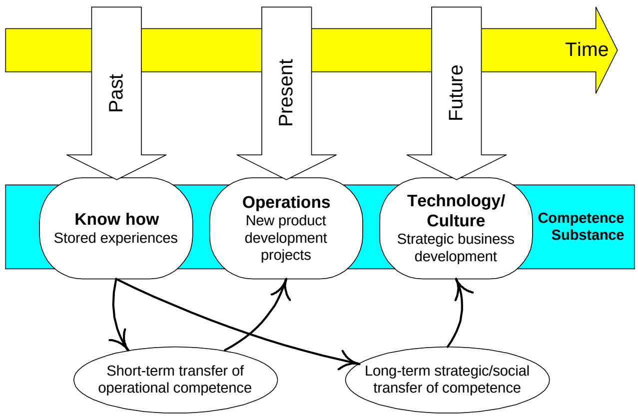

Figure 35: Competence Transfer over Time (Österlund 1997: 137)

Österlund (1997: 137) describes the resource box as a homogeneous group of individual specialists in a particular area of competence. The total competence of the resource box is greater than the sum of the individuals' competence. The size of the group is such that it will consist of sufficient members to form the critical mass for self-development of competence by internal dialogue on experience and theory. The group should be kept smaller than the size at which it becomes unwieldy so that all its members can engage each other in meaningful professional dialogue. The size of this group should consist of ten or fewer members. A diagram of a resource box with its three axes is shown in Figure 36.

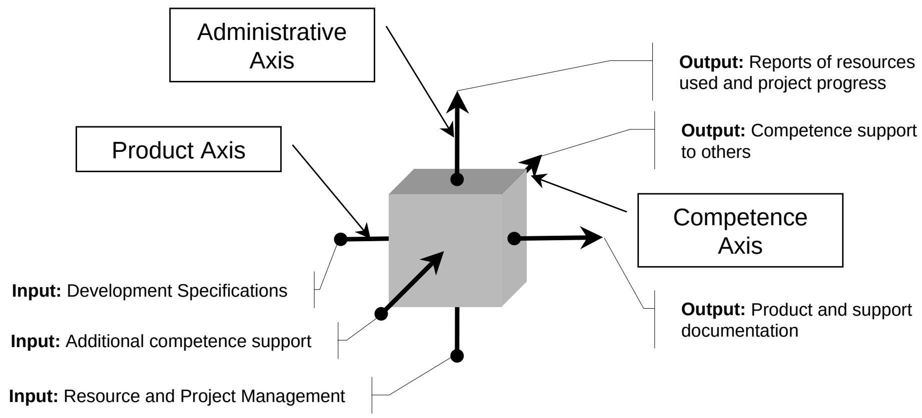

Figure 36: The Resource Box (Österlund 1997: 137)

The Product axis represents the task definition expressed in terms of requirements that have to be satisfied to meet the client's needs, including the method of verification of the appropriateness of the Product's quality. The competence axis represents the flow of competence from the external sources through the resource box where additional value is added and, back to the external sources. The administrative axis represents the requirements that have to be met in planning the assignment of resources to the resource box and in reporting project progress in terms of schedule, quality, reliability, resource consumption, economy and other resource criteria.

The advantage of these small teams is borne out by Federal Express experiencing a 13% reduction in service problems after it organised its 1000 clerical workers into teams of five to ten members each (Dess *et al* 1995: 15).

Österlund's model (1997: 139) of the processes on the three information axes of the competence resource boxes shown in Figure 37 are:

- Competence transfer axis: The competencies needed for the development of the new Product, are investigated, accessed, developed and disseminated on this axis.
- Product/task axis: The Product specification is taken to lower levels by means of a structured, functional breakdown of the Product and a work breakdown structure outlining the work expected of each resource box.
- Administrative axis: The project manager assembles a team of representatives from each resource box. A project plan is then devised on the basis of the work breakdown structure and the competencies required for completion of each work package. Thereafter the work packages are allocated to the resource boxes for execution.

The technology communicator, also known as the technology gatekeeper, tends to read far more literature relevant to the area of expertise, than his or her peers, and presents new knowledge to the group from the outside world (Allen 1971: 394). This role-player also presents competence goals that are aligned with the strategic competence goals (Österlund 1997: 137).

Technology gatekeepers also tend to maintain communication with each other and in this way sustain the flow of knowledge to the organisation (Allen 1971: 394).

The co-ordinator manages group co-operation, negotiates tasks with project managers, plans activities, distributes tasks, provides resources according to needs identified as a result of progress reporting and supervises the quality. In this way the co-ordinator acts as a buffer between the operators or specialists and management, allowing them to proceed with their work with minimum disturbance by bureaucracy. The group members rate the value of the co-ordinator on the influence he successfully exerts on the organisation (Österlund 1997: 137).

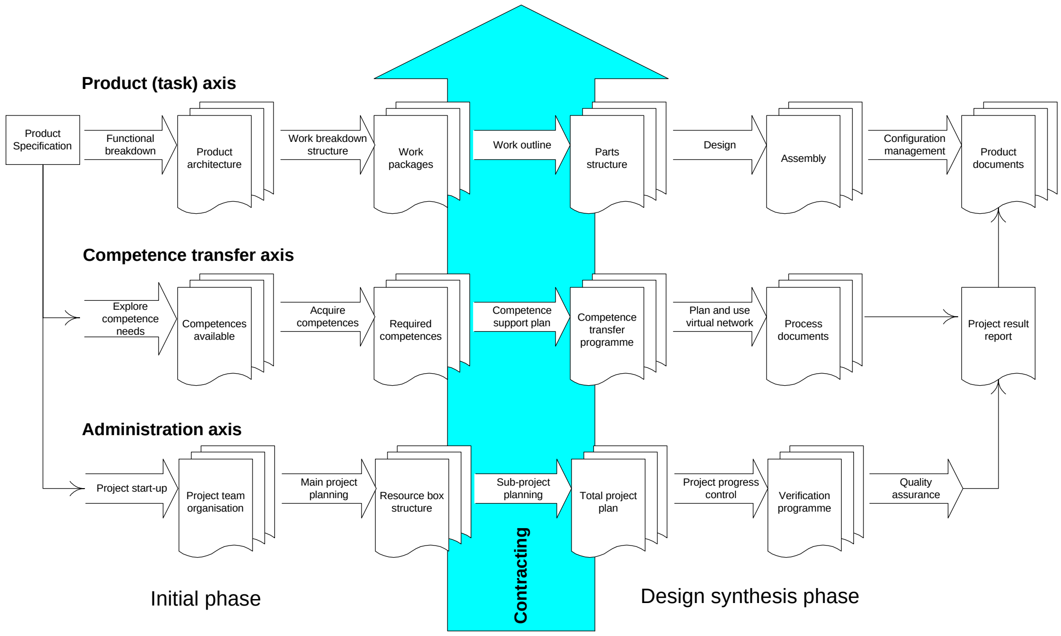

Figure 37: Österlund's Resource Box Information Process model (1997: 139)

The resource box operators play a cardinal role in creating solutions to development problems. These solutions are often based on innovations, which may originate from an unrelated discipline. Temporary virtual teams convened for problem solving can result in these beneficial learning contacts (Österlund 1997: 137).

Core competencies are not diminished but improved by the use of unlike physical assets, but can also be lost by a lack of use (Prahalad *et al* 1990: 85).

3.3.3 COMPETENCE PROCESS

Österlund (1997: 138) describes the new Product development process shown in Figure 37 as three phases namely:

- Definition Phase: This is a phase during which the client's requirements are translated into Product specifications.
- Initial Phase: This is a phase that includes the functional design of the Product's architecture by systems analysis. The Product sub-functions are then grouped into packages within a work breakdown structure in preparation for the design phase.
- Contracting Phase: Resources necessary for executing the work packages are identified. The work packages are then contracted to the various resources boxes.
- Synthesis Phase: The functional specifications are used to develop Products. Compliance by these Products with the specifications must be proven. The proof of compliance is known as verification. The resource box is responsible for the development and execution of the verification process.

Initial systems design is the most critical phase in the development of a new Product because of the need for an appropriate architecture based on functional requirements and the correct usage of competence (Österlund 1997: 138).

3.3.4 COMPETENCE INTEGRATION

Although teams allow more opportunity for creative contribution, they also open opportunities for conflict, which could result in the disintegration of the teams (Solomon 1992: 2).

The process of knowledge creation cannot be managed by simply controlling information, but requires managers to actively lead the process by creating conducive conditions (Nonaka *et al* 2000: 22).

On account of the boundless nature of knowledge, it is important for top management to articulate a knowledge vision that extends beyond the boundaries of existing Products, divisions and markets (Nonaka *et al* 2000: 23).

Organisations should stimulate their members' commitment by the formulation of an organisational intent. Commitment is the basis for human knowledge creation actions (Nonaka *et al* 2000: 24).

Competencies must be integrated to the advantage of the organisation. Österlund (1997: 140) proposes that the integrated competence structure should consist of operative resource boxes, supporting resource boxes and decider boxes. These form a three-layer communication network each with its own function and purpose as shown in Figure 42.

The operative resource boxes contain highly developed specialist competence and are responsible for all technical decisions. These resource boxes are self-organising while striving to become a core competence of significant value to the organisation (Österlund 1997: 140).

The supporting resource boxes, an example of which is shown in Figure 38, contain competence that are based on expertise gained from front-line technologies and users' field experience with similar Products and processes. The groups of supporting resource boxes are responsible for satisfying the competence requirements common to the other competence resource boxes (Österlund 1997: 140).

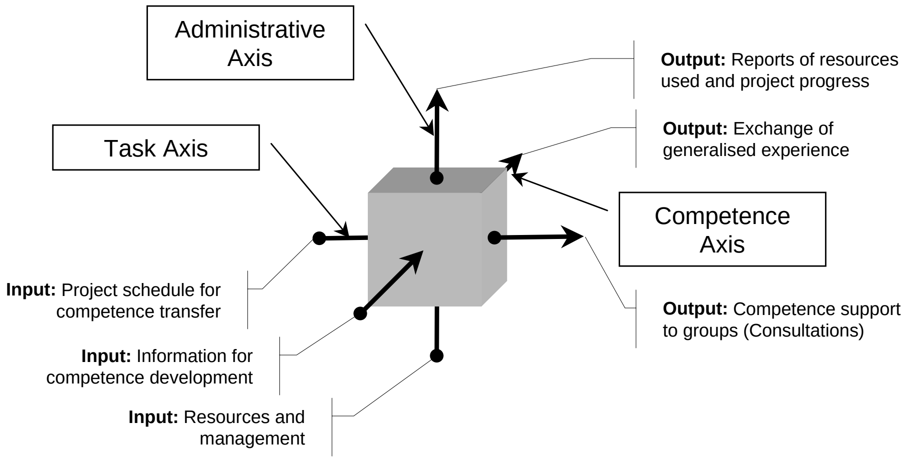

Figure 38: Supporting Resource Box (Österlund 1997: 140).

The decider box shown in Figure 39 is made up of interdisciplinary teams who analyse and monitor the progress of tasks that required co-operation between the disciplines to achieve optimal solutions. These teams also make decisions about the implementation of tasks. A temporary, virtual team is the more favourable option for the formation of this type of group. Management should establish a set of teams of this nature to address the profile of problems to be solved (Österlund 1997: 140).

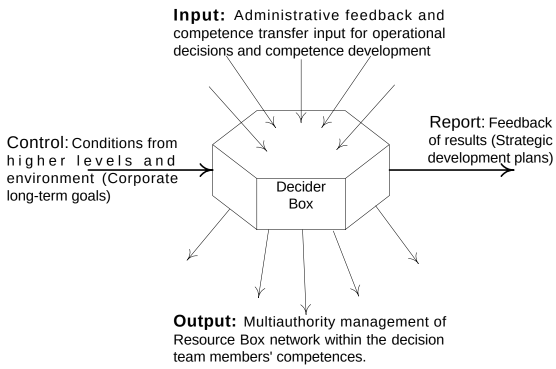

Figure 39: Decider Box (Österlund 1997: 143)

3.3.5 COMPETENCE COMMUNICATION

Allen (1988: 9) compared the communication orientations of scientists and engineers. He found an inherent incompatibility between the input and output of engineers' work as opposed to the inherent compatibility between the input and output of scientists' work. He attributed this inherent incompatibility in engineering work, to the difference between the natures of the input and output. The output in technology work by engineers has a physically encoded format.

For this reason the "backward engineering" of foreign weapons to establish the underlying principles, is difficult (Allen 1988: 9).

Figure 40 shows the extent to which scientific and technology projects differ in their use of communications channels in their work.

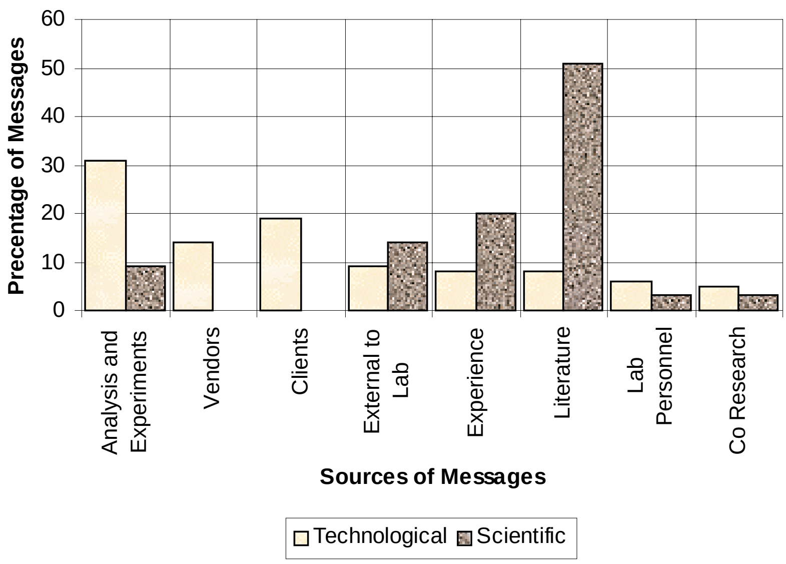

Figure 40: Sources of Messages in Technological and Scientific Projects (Allen 1988: 11)

The smaller the distance between the parties that are communicating, the greater the probability that they will be inclined to do so. Conversely, the benefits of higher performance are lost when distance or inconvenience is increased (Allen 1971: 399-400).

Wheelwright *et al* (1996: 862) discussed four modes of communication during interaction between upstream and downstream groups. The interaction described concerns the transfer of information between the designers of a Product and the group that is to design the production facilities. The modes of interaction shown in Figure 41 are as follows:

- <u>The Serial Mode:</u> In this relationship, the downstream group waits until the upstream group has completed its design before starting work. Design information is communicated in a single batch transaction. This transaction cannot include all the nuances nor can it include all the strengths and opportunities that the downstream group offer.
- <u>The "Early Start in the Dark" Mode:</u> The downstream group attempts to start earlier to ensure that it achieves its milestone. The upstream group, however, only transfers the design information after completion of its work in a single batch transaction. So, although the downstream has been preparing itself for the task, there will inevitably be some surprises on receipt of the design information. This effect could result in confusion and a slip in progress and possibly failure to achieve delivery of the completed project output on time.
- <u>The Early Improvement Mode:</u> This is also called the involvement mode. The two groups interact by bilateral communication of preliminary information during the initial design phase of the upstream group and before the downstream group starts its work. The downstream group then develops insight into the emerging design and is able to contribute through feedback to the design process. The downstream group only starts its work after the completion of the upstream group's work. The downstream group's work can then be completed more efficiently with fewer changes. In this case the downstream group relies on past practice and theoretical knowledge.

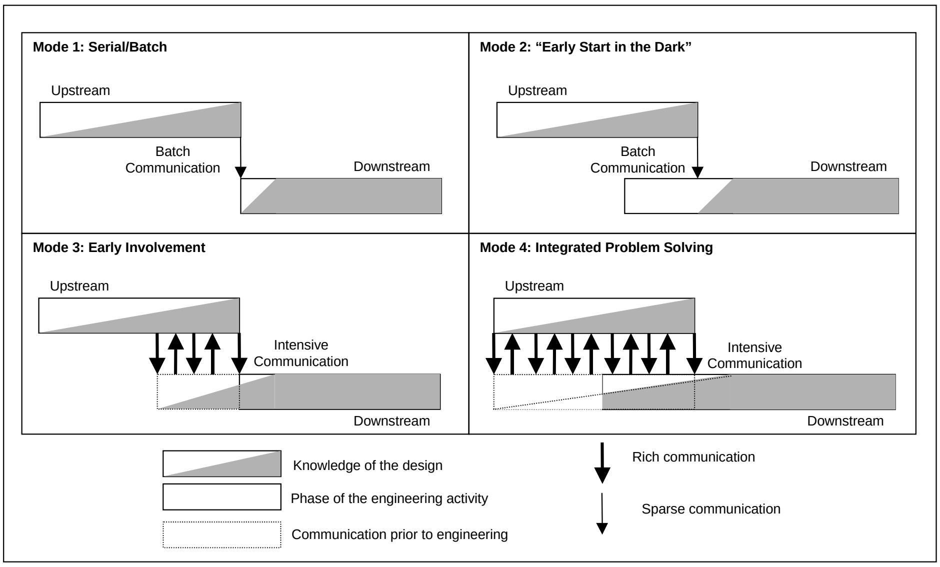

Figure 41: Modes of Upstream/Downstream Interaction (Wheelwright *et al* 1996: 863)

- <u>The Integrated Problem Solving Mode:</u> This mode links the two groups in time and by bilateral communication. The downstream group is able to start its work while the upstream group's design is still in progress. In this case the downstream group relies on practice and theoretical knowledge used to influence the upstream design. Communication in this mode is rich and intense.

According to Wheelwright *et al* (1996: 864), integrated problem solving during the design-build-test cycle relies on early inclusion of the downstream group, rich bilateral communication between the upstream and downstream groups and a broad, comprehensive style of problem-solving.

The task/product network in the diagram of the three layered competence network in Figure 42 carries information on product requirements breakdown and design parameters. This method of communication is intended for developing a product's architecture in relation to its use, suitable as tasks for distribution between the various operative resource boxes (Österlund 1997: 140).

The competence transfer network is capable of forming virtual decision teams with the appropriate competencies during the initial phase of new Product development. In this way the operative resource boxes are supported by a supply of competencies (Österlund 1997: 140).

The decision network reflects the structure of the problems requiring solving, the conditions laid down by the authorities and the business results, all of which are related to one another. A member of the organisation may then establish interfaces with several decision-making teams (Österlund 1997: 140).

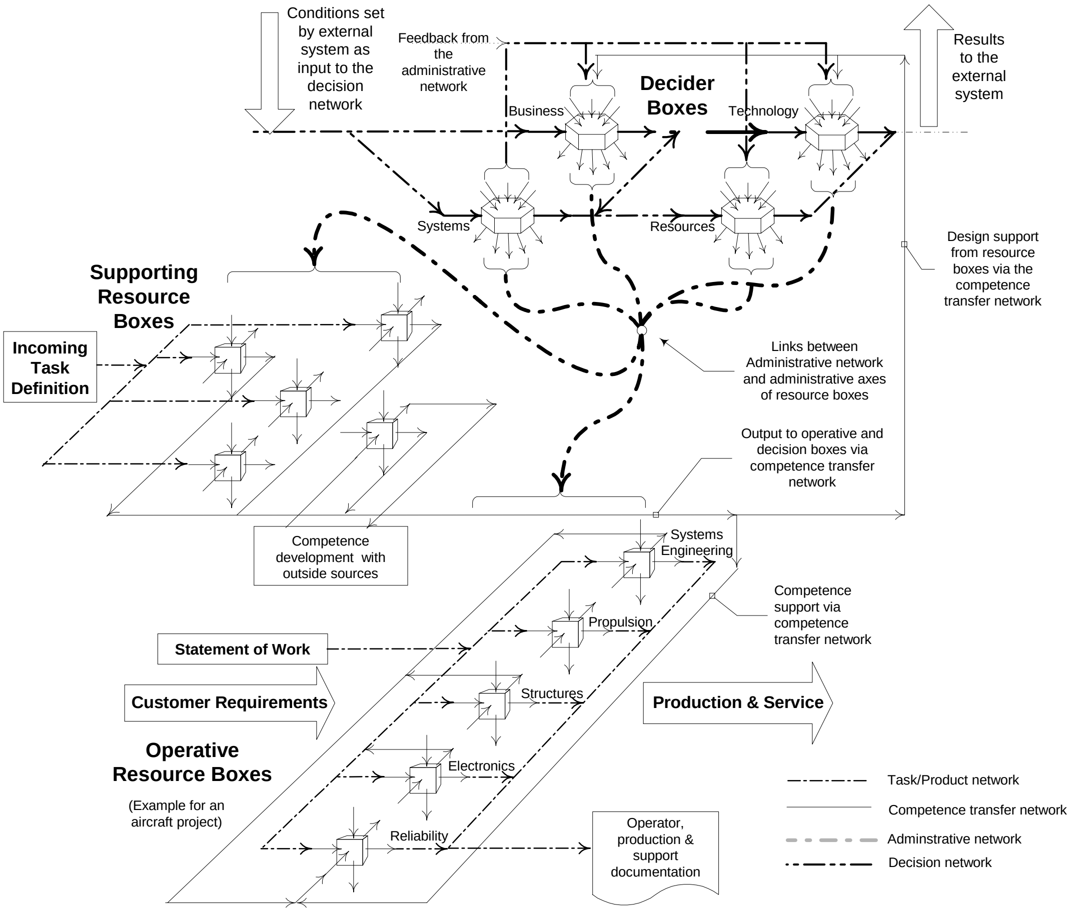

Figure 42: The Competence Network (Österlund 1997: 141)

The administrative network supplies co-ordination information as required, to all boxes and conveys feedback on project progress, resource consumption and needs. This network also carries verification information for project quality management (Österlund 1997: 140).

Allen (1971: 392) found that high performers have considerably more communication with colleagues including specialists in other fields and members of other project teams.

3.3.6 CULTURE

Marquardt (1999: 151) defines culture in terms of the following three elements:

- It is a way of life shared by the majority of the members of a group.
- Culture is characterised by the way that senior members of the group convey cultural information to the younger members.
- It is the way in which the individual member's perceptions and behaviour are shaped.

According to Österlund (1997: 142) it is important to initiate changes in the corporate culture while competencies are still being developed. The culture has to be in harmony with the strategic and market development. These cultural changes require time to become effective. The dynamics of development can be set in motion by exerting forces in a positive direction on the corporate members. Examples of these forces are:

- A reward policy.
- Human resource competence development.
- A career policy.
- Group resource competence development.
- Group development as a living system.
- Organisational development.
- Development of communication systems.

Although documentation of the organisation's knowledge, experience and skills is a way of retaining and preserving these resources, the competencies acquired must be embedded in the minds of those applying them. This form of learning is brought about by various forms of interactions within the monodisciplinary groups. Group competence is gained by sharing beliefs, values and understanding within the organisational culture. The communication by management of rules, symbols and statements to corporate members, contributes to the conversion of a cultural framework into a cognitive framework. This establishes a corporate "language" which facilitates the effective and efficient transfer and interpretation of information. This effect of achieving a common culture can be regarded as a competence of an administrative nature.

Lynch (2000: 317) uses Handy's (1993: 183) model to name the four main categories of culture:

- <u>Power Culture:</u> In this type of culture, an individual or a small group dominates the organisation.
- <u>Role Culture:</u> In this type of culture, the organisation relies on committees, structures, logic and analysis.
- <u>Task Culture:</u> In this case, the organisation is geared to tackle identified projects or tasks using flexible teams.

- Personal Culture: In this type of culture, the organisation is tolerant, but personnel may be difficult to manage.

Type of Culture	Prescriptive or Emergent Strategy	Delivery of Competitive Advantage	Ability to cope with Strategic Change
Power	Prescriptive	Enhanced but individuals may miss competitive moves	Depends on individual or group at centre
Role	Prescriptive	Solid, slow and substantive	Slow, will resist change
Task	Emergent	Good where flexibility is important	Accepted and welcomed
Personal	Possibly emergent	Depends on individual	Depends on individual

Table 18: Analysis of the Strategic Implications of Culture (Lynch 2000: 319)

The reactions of these cultures to strategies, the delivery of competitive advantage and their ability to cope with strategic change are shown in Table 18 above.
According to Marquardt (1999: 153), there are nine factors that create and influence culture. These factors are shown in Figure 43. The characteristics of the factors and their interaction determine the culture.

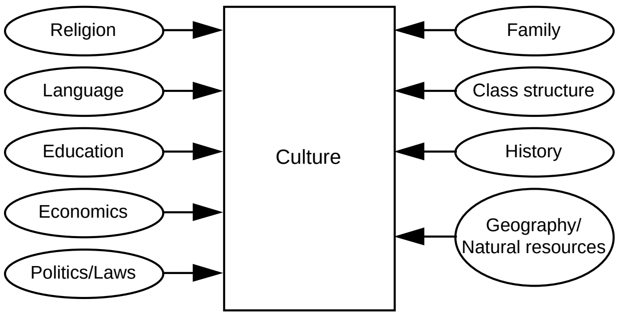

Figure 43: Factors Creating Culture (Marquardt 1999: 153).

Competence carriers should be loyal to the integrity of their competence areas more than the particular business (Prahalad *et al* 1990: 91).

3.3.7 ORGANISATIONAL LEARNING

Argyris *et al* (1978: 3) define organisational learning as a process of detection and correction of errors. The organisation therefore learns through the efforts of individuals acting as agents.

Senge (1990: 4) notes that adaptive learning is only the first stage of organisational learning. Double-loop learning, or generative learning, focuses on continuous experimentation and feedback while discovering the way problems are defined and solved by organisations (Argyris *et al* 1978: 3).

Lynch (2000: 696) refers to the five learning disciplines of Senge:

- <u>Personal Mastery:</u> This consists of both developing one's own goals and creating an organisational environment conducive to the development of new purposes by groups.
- <u>Mental Models:</u> The development of mental models consists of reflecting and speculating on the visions that others within the organisation have of the environment and assessing the influence of these on decisions and actions.
- <u>Shared Vision:</u> The group builds and shares a commitment to a vision and achievement while further exploring the aims.
- <u>Team Learning:</u> In team learning the members use their individual abilities to create a team ability that exceeds the sum of the abilities.
- <u>Systems Thinking:</u> Systems thinking is the type of thinking that enables one to visualise the sum of the elements of a system as a whole system.

When managers only raise the issue of effectiveness within an organisation, but cannot correct errors under existing norms using first-order learning, they can be driven to conflict. They must learn to accept that it may be the existing norm for predictable management that conflicts with their wish to achieve corporate growth through technological innovation (Argyris *et al* 1978: 22).

According to Malhotra (1996: 2) adaptive learning concentrates on solving present problems while failing to examine the appropriateness of the current learning behaviours. This approach also fails to question the underlying assumptions that lead to the present ways of doing work.

The type of collective learning approach that permits the co-ordination of diverse production skills and the integration of multiple technology streams, is what creates the core competency of the organisation (Prahalad *et al* 1990: 82).

3.4 VALUE CHAIN MANAGEMENT

According to Lynch (2000: 266) the value chain links the value of an organisation's activities with its main functional sections. He used the work of Porter (1985: Chapter 2) that presents the concept that the organisation can assess the contribution that each makes to the overall value of the business during strategic analysis. He links the following two areas:

- The value that each part contributes to the greater organisation (optimisation).
- The contribution that each of the parts make (co-ordination) to the organisation's competitive advantage.

Porter (1990: 40) proposes that competitive advantage originates in the way that firms organise and perform their various activities. The value chain of an organisation is the network of interdependent activities that are interconnected by linkages. In this context a linkage is the influence that one activity exercises on another activity. A linkage could exercise an influence on the cost or effectiveness of the other activities. To optimise the organisation's capabilities, it is necessary to make trade-offs in other activities. Thus, for example, when an organisation spends more on the Product design process, it could reduce after-sales service costs.

Linkages connect interdependencies both within an organisation and with the suppliers and channels (Porter 1990: 42).

Porter (1990: 40) divides the activities in which an organisation needs to engage, in order to compete, into primary and support activities. Primary activities are those concerned with the production of the organisation's Products or services and include marketing, logistics and operations. Support activities are those concerned with the provision of infrastructure, technology, human resources and procurement services to support the primary activities. Figure 44 presents a graphic model of Porter's value chain within an organisation. He uses the term "margin" in the diagram to represent the value added by the activities in the value chain. This value may be in the form of lower costs to the organisation or tasks performed in a unique way and that differentiates the organisation from others. According to Porter (1990: 42) strategy drives the way in which the organisation organises the individual parts of its value chain to achieve its competitive advantage. By reconfiguring its activities as a system, the organisation can discover its optimal value chain as a low-cost or a differentiated producer. Competitive advantage is increasingly becoming a function of how the organisation manages its entire system.

The use of the value chain approach allows a more comprehensive look at the types of competitive advantage that can be achieved and the role that competitive scope can play in enhancing competitive advantage. The scope shapes the organisation's activities, the ways in which they are performed and the configuration of the value chain. When selecting a narrow segment, an organisation can tailor each activity's scope to suit the segment's requirements, thereby achieving the cost leadership or differentiation desired. When aiming at a broad scope across several market segments, the organisation gain competitive advantage by sharing the activities associated with the industry segments (Porter 1990: 44).

Wilson (1996: 2) describes two types of value chain, the material and the informational, each interlaced with the other, as follows:

- The material value chain consists of links each converting the Product from one state to another. Each step increases its value or utility in some meaningful way.
- The informational value chain converts data into information, information into knowledge and knowledge into wisdom.

This approach however neglects other aspects of value adding such as for example the physical location of the Product.

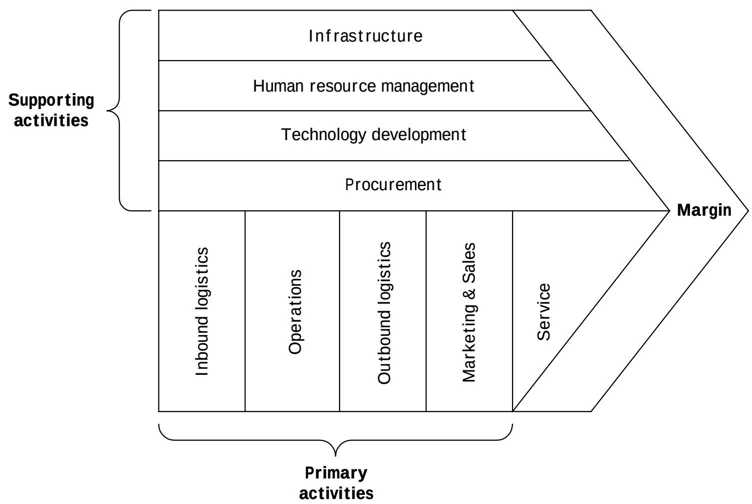

Figure 44: The Value Chain (Porter 1990: 41)

The value chain within the organisation is a subset of the larger stream of activities in which the organisation competes. This larger stream of activities is called the value system by Porter (1990: 42) and is illustrated in Figure 45. The suppliers of goods and services precede the organisation's value chain. The organisation's output Products or services are taken up by the channels and presented to the buyer.

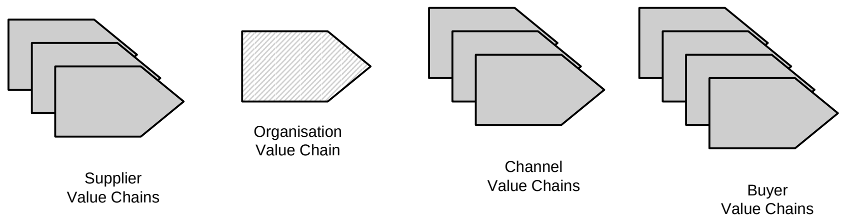

Figure 45: The Value System (Porter 1990: 43).

A. VALUE CHAIN MODELS

Value chain analysis affords a useful framework for assessing the set of activities that create value for the organisation (Dess *et al* 1995: 7).

Dess *et al* (1995: 8 – 14) presented three models of corporate architectures aimed at reducing boundaries and therefore increasing efficiency in value chains. These models are as follows:

- <u>The Modular Type:</u> In this case, the organisation retains full strategic control while outsourcing non-vital functions.
- <u>Advantages:</u> This approach can enable the organisation to improve the efficiency of new Product development by hiring superior external talent and thereby avoiding being locked into a potentially obsolete technology while allowing it to focus scarce resources in those areas where they hold a competitive advantage.
- <u>Disadvantages:</u> Ill-considered outsourcing can ultimately cause a firm to relinquish control over its core competencies and thereby lose its competitive advantage.
- <u>Requirements:</u> The organisation needs to gain access to loyal, reliable vendors that may be trusted with proprietary information and must know which competence to retain in-house.
- <u>How-to:</u> Develop a strategic plan that identifies core competencies to be retained internally and those non-critical functions that may be outsourced.

- The Virtual Type: In this case the organisation is part of a continually-evolving network of independent companies, linked together to share costs, skills and market access.
  - Advantages: This approach can improve the capacity of the organisation or its competitive advantage. Organisations of this type are able to pursue a collective strategy that enables them to better cope with the uncertainty in the environment through collaborative efforts. The alliances can be maintained for as long as mutual advantage is derived and then discontinued, whereas large monolithic organisations would then remain saddled with excess capacity.
  - Disadvantages: This type of value chain often fails to meet expectations. There is a potential for a loss of operational control among partners. A loss of strategic control over emerging technology can develop. This environment requires sophisticated managerial skills.
  - Requirements: This network of organisations requires tremendous analysis and consideration of the strategic issues, especially the identification of those core competencies should be retained internally, where the synergies between the partners should exist and what the common vision should be.
  - How-to: Develop a strategic plan that identifies core competencies to be retained internally, those non-critical functions that may be outsourced, how operational control will be exercised and the common vision.
- The Barrier-Free Type: The barrier-free organisation aims to bridge the differences in culture, function and goals to develop common ground in order to facilitate co-operative behaviour.
  - Advantages: This approach leverages the talents of all the organisation's personnel. Co-ordination and co-operation between the organisation's functions are enhanced. The organisation's response to market's demands is quicker.
  - Disadvantages: It is often difficult to overcome political and authority boundaries; sophisticated leadership and skills are required to promote co-ordination. Performance is very dependent on high levels of trust. This democratic process is time-consuming and difficult to manage.

- Requirements: This type of organisation must promote shared interests and trust, eliminate, or at least reduce the number of boundaries that stifle productivity. It must also raise the skill levels of personnel.
- How-to: Develop a strategic plan that addresses the requirements previously mentioned.

B. INTANGIBLE INTERRELATIONSHIPS

Porter (1985: 324) defined intangible interrelationships as those that involve the transfer of know-how or generic skills between separate value chains within the organisation. This sharing of know-how has the potential to reduce costs of value activities driven by learning or patterns of capacity utilisation (Porter 1985: 328). Intangible interrelationships lead to competitive advantage through the transfer of skills across separate value chains (Porter 1985: 350). Intangible interrelationships in business units within an organisation can be identified by (Porter 1985: 351):

- The business units sharing similarities in their strategies.
- The business units sharing similarities in their value chain configurations.
- The business units sharing similarities in their value activities.

3.5 THE MANAGEMENT OF PROJECTS

According to Nicholas (1990: 9) project management was brought to prominence by the changed environment of modern society. He identifies inter-dependence, complexity and rapid, radical change as the three characteristics that typify the modern environment. The centralised management style typical of bureaucracies encounters difficulties in dealing with situations requiring adaptability and rapid response. Project management requires high-level technical and managerial competence and a certain degree of latitude and decentralisation to deal with the risks and instability inherent in many modern situations.

Organisations must operate and survive in an environment of forces. These organisations each consist of interrelated elements that have their goals co-ordinated with those of the organisation. Project management integrates the system of interrelated tasks in progress in a dynamic environment and is therefore a systems-oriented approach (Nicholas 1990: 9).

Project management is based on the principle that projects are managed to satisfy the client's cost, schedule and performance requirements with a view to achieving a given outcome. Project management is therefore intended to provide the specified Product or service on schedule at the agreed cost (Nicholas 1990: 9).

The Project Management Institute (PMI) has published a Guide to the Project Management Body of Knowledge (PMBOK) to highlight those areas of knowledge that are important for the management of projects. The Guide to the PMBOK presents a well-structured reference work that deals with the key processes and information to be considered during the management of projects. British Association of Project Managers (APM) published a Body of Knowledge (BoK) in 1996. The purpose of both the PMI's Guide to the PMBOK and the APM's BoK is to define the areas in which a project management professional should be knowledgeable. (Morris 1999: 173)

Morris (1999: 176) believes that the task accomplishment or implementation of project management fails to accurately capture the real challenge of project management and that the primary concern should be with the delivery of project outputs to the customer or sponsor. He also states that ensuring that the technical, commercial and business, environment and other factors are aligned with organisational and control issues is fundamental to optimising the outcome. It was on the basis of this premise that the APM’s BoK was developed. In 1997 the University of Manchester (UMIST) Centre for Research in the Management of Projects started research to provide empirical data to support the upgrade of the APM’s BoK.

3.5.1 PROJECT STAKEHOLDERS

Each project has stakeholders who contribute to and depend on its success. According to the Project Management Institute (PMI) (PMI 1996: 15), the key stakeholders include the following:

- The project manager who is responsible for managing the project.
- The client who will use the outcome of the project. The client may be a multi-layered group, for example the doctor who prescribes a drug, the patient who uses it and the medical insurance that pays for it.
- The performing organisation most directly involved in the execution of the project.
- The sponsor that may be an individual or a group that support the project financially or otherwise.

3.5.2 DESCRIPTION OF PROGRAMME AND PROJECT MANAGEMENT

Project Management is the planning, monitoring and controlling of all aspects of a project and in motivating all those involved in it to achieve the project objectives safely, within an agreed time frame and within the bounds of set cost and performance criteria. The Project Manager is the single point of responsibility for achieving this. (APM 1996: 15)

A project is a temporary endeavour or undertaking to create a unique Product or service. A project has a distinct beginning and end to its existence. The output of the project can continue to exist after its termination. The output required of a project differs from other available Products or services. (PMI 1996: 4)

Project management is also the application of knowledge, skills, tools and techniques in the execution of project activities with a view to meeting or exceeding stakeholders’ needs and expectations. This requires that the project manager balance the way he meets competing demands between the following elements (PMI 1996: 6):

- Scope, time, cost and quality.
- Stakeholders with differing needs and expectations.
- Identified requirements (needs) versus unidentified requirements (expectations).

A project is a discrete undertaking with defined objectives often including time, cost and quality (performance) goals. Project objectives may be defined as financial, social or economic. Projects evolve through a set of life cycle sequences, each with its own beginning and end (APM 1996: 15).

A programme is a portfolio of projects.

Project Integration Management	**Project Scope Management**	**Project Time Management**
Project Plan Development Project Plan Execution Overall Change Control	Initiation Scope Planning Scope Definition Scope Verification Scope Change Control	Activity Definition Activity Sequencing Activity Duration Estimation Schedule Development Schedule Control
Project Cost Management	**Project Quality Management**	**Project Human Resources Management**
Resource Planning Cost Estimating Cost Budgeting Cost Control	Quality Planning Quality Assurance Quality Control	Organisational Planning Staff Acquisition Team Development
Project Communications Management	**Project Risk Management**	**Project Procurement Management**
Communications Planning Information Distribution Performance reporting Administrative Closure	Risk Identification Risk Quantification Risk Response Development Risk Response Control	Solicitation Planning Solicitation Source Selection Contract Administration Contract Close-out

Table 19: Competencies listed in PMI's Guide to the PMBOK (PMI 1996: 7).

The PMI Project Management Body of Knowledge (PMBOK) has key competencies that are classified into nine categories. Table 19 presents the PMBOK's list of competencies.

The APM Body of Knowledge has 40 key competencies that are classified into four categories namely Project Management, Organisation and People, Techniques and Procedures and General Management. The list of the APM BoK's list of competencies is presented in Table 20.

Morris (1998: 3) compared the 47 competencies of the process-based PMI Guide with those of the PMBOK and the APM's BoK. His finding was that 15 of the latter's competencies addressed all those of the former and that the latter was more widely based. The competency associated with the project environment of the APM's BoK covered all the external influences. The PMI Guide to the PMBOK does however indirectly address the external influences in the project integration (PMI 1996: 49) and risk identification section (PMI 1996: 111).

Morris (1999: 174) questions the validity of limiting project management merely to schedule, cost and performance. He suggests that this is only half the battle and that it should extend beyond these limits to delivering projects successfully to the requirements of the customer or sponsor. He believes that the project should give consideration to technical, commercial, business, environment and other factors.

1	**Project Management**	**2**	**Organisation and People**
1.1	Systems Management	2.1	Organisation Design
1.2	Programme Management	2.2	Control and Co-ordination
1.3	Project Management	2.3	Communication
1.4	Project Life Cycle	2.4	Leadership
1.5	Project Environment	2.5	Delegation
1.6	Project Strategy	2.6	Team Building
1.7	Project Appraisal	2.7	Conflict Management
1.8	Project Success/Failure Criteria	2.8	Negotiation
1.9	Integration	2.9	Management Development
1.10	Systems & Procedures		
1.11	Close Out		
1.12	Post-project Appraisal		
3	**Techniques and Procedures**	**4**	**General Management**
3.1	Work Definition	4.1	Operations/Technical Management
3.2	Planning	4.2	Marketing and Sales
3.3	Scheduling	4.3	Finance
3.4	Estimating	4.4	Information Technology
3.5	Cost Control	4.5	Law
3.6	Performance Measurement	4.6	Procurement
3.7	Risk Analysis and Management	4.7	Quality
3.8	Value Management	4.8	Safety
3.9	Change Control	4.9	Industrial Relations
3.10	Mobilisation		

Table 20: Competencies listed in APM's BoK.

3.5.3 CONTRACTS AND AGREEMENTS

A contract or agreement is the basis of any project. The Project Manager has to know and understand the scope of the work undertaken, and the result to deliver to the client.

Contracts have a legal basis. Although business units within an organisation are inclined to resort to agreements, the principle is similar to that of contracts. Not every agreement is a contract, though. A contract has to comply with the following essential elements to be binding (Gibson *et al* 1988:11):

- The agreement must be lawful.
- The parties entering into the agreement must do so within the limits of their contractual capacities.
- The parties must have a serious intention to contract.
- The parties must communicate their intentions to each other.
- The agreement may not be vague.
- There must be a meeting of the minds between the parties regarding the matter of the agreement.
- Performance must be possible.

If satisfying the client’s requirements is the principle of quality, then knowing and understanding the requirements is essential for the Project Manager. This also forms the basis of a contract.

Any agreement that lacks one or more of the elements listed above is void, or that is to say, it is not a contract and is therefore not enforceable by law.

3.5.4 PROJECT TEAMS

A project team consists of a cohesive group of people from differing disciplines and even differing organisations participating in the project wherever and whenever they are needed to contribute to its success. The team size and composition will change over time depending on the resources required during the life cycle phases of the project (Nicholas 1990: 11).

To manage projects effectively in a dynamic technological environment an understanding of the organisational and behavioural parameters and their interaction is required. While team-building is important in any environment requiring the co-ordination and integration of multi-disciplinary activities, it is especially crucial in a technological environment where projects are often highly complex and require the integration of many functional specialists in an equally complex organisational setting (Thamhain *et al* 1987: 302). It is furthermore necessary that a climate conducive to multi-disciplinary team building, is sustained (Thamhain *et al* 1987: 303).

Thamhain *et al* (1987: 304) found that there was a general agreement among a sample of 500 engineering managers the three most important criteria for measuring team performance were, in order of priority, technical success, performance to schedule and consumption of financial and other resources within the planned budget. Furthermore, these engineering managers consistently stressed that high-performing teams are also characterised by specific task- and people-related qualities. Those qualities most closely related to positive team performance are shown in Figure 46.

Thamhain *et al* (1987: 304) found that those drivers and barriers shown in Figure 46 had the strongest influence on project team performance.
It appears from these findings that project success is primarily determined by six driving forces and barriers that are related to leadership, job content, personal needs and the general work environment, shown in Figure 46 (Thamhain *et al* 1987: 308).

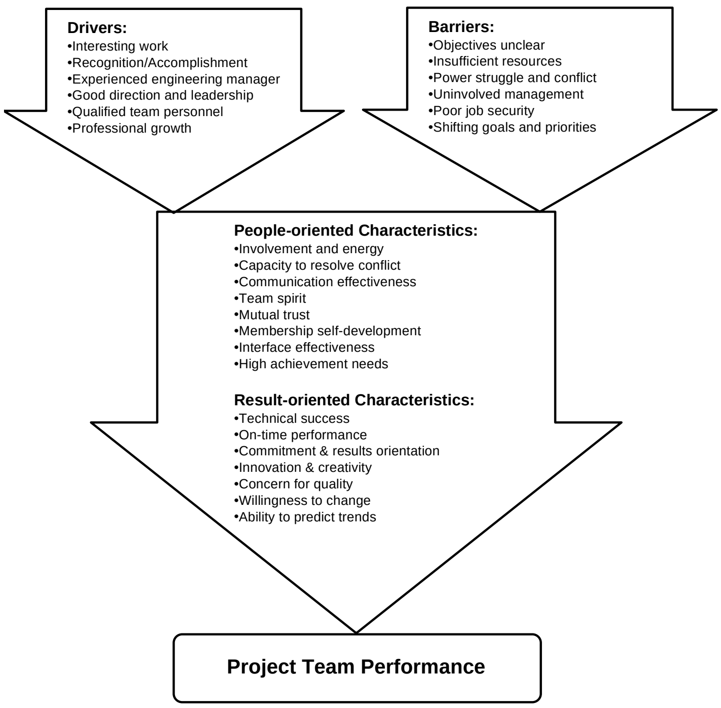

Figure 46: Major Drivers and Barriers to Project Team Performance (Thamhain *et al* 1987: 303).

Project success is also strongly correlated to a professionally stimulating team environment that is characterised by interesting and challenging work, visibility, growth potential and good project leadership. A professionally stimulating team environment also contributes to low levels of perceived conflict, high levels of commitment, high levels of personnel involvement, good communication, change orientation, innovation and on-time performance within the limits of the budget (Thamhain *et al* 1987: 308).

A. PSYCHOLOGICAL CLIMATE

Literature now discusses two types of climate, the organisational, which is studied at the group or organisational level and the psychological, which is studied at the individual level. Climate perceptions are the individual's description of organisational experiences and remain relatively stable over time. An organisation may have more than one climate at any given time (Koys *et al* 1991: 265- 266).

Perceptions of psychological climate may affect organisational commitment and job satisfaction and determine the extent of absenteeism and turnover (Koys *et al* 1991: 281).

Koys *et al* (1991: 273) proposes that psychological climate has eight dimensions . These dimensions are defined and described in Table 21.

B. RECOMMENDATIONS FOR TEAM MANAGERS

Thamhain *et al* (1987: 308) proposes the following recommendations to enhance the project manager's effectiveness in creating high performance teams:

- Remove or diminish barriers. Project managers must diminish those barriers to improved project team performance.
- Ensure objectives are clear. Project managers should develop clear project objectives and communicate them to the team.
- Management commitment. Project managers should regularly lobby to ensure that management is apprised of the project's status and that they support the project.
- Image building. Project managers should build a favourable image for the project. This favourable image would relate to those drivers listed in Figure 46 and other positive aspects such as the project's importance to the organisation. This engenders a climate of active participation and unifies the team.

Dimension	Definition	Examples
Autonomy	Perceived self-determination regarding work procedures, goals and priorities.	I make most of the decisions regarding the way my job is performed. I determine my own work procedure. I schedule my own work. I set the performance standards for my job. I organise my work as I see best.
Cohesion	Perceived togetherness or sharing within the organisational setting. This includes the willingness of members to provide material support.	The firm's people assist each other. The firm's people get along with each other. The firm's people take an interest in each other. There is a team spirit in the firm. I believe I have a lot in common with my colleagues.
Trust	Perceived freedom to openly communicate with management about sensitive or personal issues with the expectation that the integrity of these communications will not be betrayed.	I can trust my superior with confidential information. My superior has personal integrity. I can be candid with my superior. My superior keeps promises. My superior is unlikely to give bad advice.
Pressure	Perceived task completion standards in terms of time and performance.	I have inadequate time in which I can do my work. It is stressful to work for this firm. I dread being called at home to resolve a work-related problem. I feel like I never have a day off. Too many of my colleagues are burnt out by the demands of their work.
Support	Perceived tolerance of member behaviour by superiors, including the willingness to allow members to learn from their mistakes without fear of reprisal.	I can rely on support from my superior. My superior supports my career within the firm. It is easy to talk about work-related problems to my superior. My superior supports me in learning from my mistakes.
Recognition	Perception that the member's contributions to the organisation are acknowledged.	I can count on some form of recognition when I excel. I don't only hear about my work when I make a mistake. My superior lets me know that he is aware of my strengths. My superior doesn't hesitate to recognise good performance. My superior cites me as an example.
Fairness	Perception that organisational practices are equitable and non-arbitrary or capricious.	I can count on fairness from my superior. My superior sets reasonable job goals. My superior is impartial. If my superior disciplines someone, they normally deserve it.
Innovation	Perception that change and creativity are encouraged. This includes the risk-taking in new areas of business or experience.	My superior encourages me to develop my ideas. My superior appreciates me trying new ways of performing my duties. My superior appreciates me attempting to improve on his methods.

Table 21: A Definition and Description of Psychological Climate (Koys *et al* 1991: 273- 283).

- Leadership positions. The definition of team leadership and the staffing of team leadership positions at the beginning of a project, should be performed carefully. The credibility of project leaders among team members, senior managers and project sponsors is crucial for the project managers of they are to manage the multi-disciplinary team effectively across functional lines.
- Effective planning. Thorough and effective planning early in the life of the project, impacts favourably on the work environment and team effectiveness.
- Involvement. Project managers should strive through thorough project planning to involve project team members at all organisational levels. This may be achieved by initially using key project team members during the project definition phases. By an improved understanding of the project, the team will be encouraged to become more involved and more committed to the project and its goals.
- Project staffing. Prospective project team members should be thoroughly interviewed, the performance expected of them and the reporting relationships involved thoroughly explained to them. Only suitable, willing candidates should be considered for appointment.
- Team structure. The project team structure and the operating concepts to be used must be established during the formulation phase. The project plan, task structure, project charter and policy may be used for this purpose. The project manager should regularly apprise management of the status of the project and the team.
- Team building. The goal should be an effective team. The project manager should convene team-building sessions to enhance cohesion and co-operation among its team members.
- Team commitment. Project managers should seek out and eliminate instances where members show a lack of commitment. Conflict and insecurity often cause lack of commitment. Such instances should be identified and eliminated by bringing personal and project goals into congruence.
- Senior management support. A project’s support by senior management is crucial to its success. Using his influence with senior management, the project manager should ensure that the correct environment is created and that the required resources are made available. The project manager should therefore develop credibility to ensure their support from management.

- Organisational development. The project manager should monitor performance continuously. The sooner problems are addressed, the better. An organisational development specialist can assist with the diagnosis of team problems and in eliminating the causes. He may also be able to propose new perspectives to emotionally complex situations.
- Problem avoidance. The project manager should attempt to identify all potential problems and deal with them before they become a serious issue for the project team.

3.5.5 ROLES IN PROJECTS

Although each project has its own characteristics and compositions, there are certain roles that must be fulfilled in the process. As the scope of this study is confined to the role of the Engineering-Technical Family, only the role of the Project Manager and those of members of this group will be discussed. Other roles would include those of the Project Administrator, the Project Controller, the Project Accountant, members of the Customer Liaison service, the Field Manager and the Quality Assurance Supervisor (Nicholas 1990: 184).

A. PROJECT SPONSOR

A senior manager may assume this role. At the firm, Ericsson, the telephony company, the Project Sponsor is responsible for the outcome of the project and approves the various project phases. This role-player is responsible for the business case and updates it during each phase (Mulder 1997: 3)

B. PROJECT MANAGER

The Project Manager is responsible for the execution of the project, defining the project's goals and objectives and preparing the project plan and budget. Regarding the execution of the project, the Project Manager enters into contracts with the relevant line managers. This role-player is responsible for what is delivered and when it is delivered. The line manager in turn is responsible for how and by whom the deliverable is produced. This is referred to as the balanced matrix approach at Ericsson. The Project Manager reports to the project sponsor (Mulder 1997: 3).

The Project Manager's role is central to project management and it is the overriding force behind a project's success. His primary role is to integrate everything and co-ordinate everybody's activities to ensure that the goals of the project are achieved.

Many of the project's elements may be scattered and the activities involved diverse. The Project Manager is the hub of internal project communication and the single point of entry and exit for project communication with the external environment. In this role, the Project Manager is well poised to make project-related decisions. The Project Manager's responsibilities include (Nicholas 1990: 173)-

- Planning project activities, tasks, end results, work breakdown, schedule and budget.
- Project team organising, selection and placing and co-ordinating tasks and resources allocated to the project.
- Interfacing with functional management, contractors, clients and top management.
- Effective application of project team and client personnel.
- Monitoring the project progress.
- Identifying and solving technical and functional problems.
- Recommendation of termination or redirection where the desired project results are not achievable.

Project Managers should have at least managerial ability, technical competence, a broad background of experience and the ability to lead and motivate project teams (Nicholas 1990: 177).

Except in large projects, Project Managers are not delegated with legal authority, but rely on influence from expert and referent powers. Project Managers therefore depend on the goodwill of others to execute the work needed to achieve project goals (Nicholas 1990: 177).

The research of Grant *et al* (1997: 12) indicates that-

- The technical competence of Project Managers is absolutely essential or at least extremely important.
- The technical competence of Project Managers is most important during the demonstration and validation phase of the Product's life cycle.
- The importance of competence does not diminish as the Project Managers gain experience.
- Technical competence is perceived to be more important for Project Managers with teams that are technically competent than those with less competent teams.

C. PROJECT ENGINEER

The Project Engineer is responsible for co-ordinating activities in technological areas and assuring the integration of the various subsystem designs for the delivery of the final Product. This includes systems analysis, systems engineering, design, interface control, configuration management and systems integration and testing.

Where the project involves many disciplines, the Project Engineer-

- Derives design requirements from performance requirements.
- Oversees design and development.
- Supervises the communication, co-ordination and direction of functional areas.
- Plans, assesses and records the progress in design, development and testing of Product subsystems.
- Plans, monitors and assesses system integration tests.

The Project Engineer supervises configuration management which tracks and controls changes to the project's Product. The changes and their influences on other parts of the Product are analysed and documented. (Nicholas 1990: 184).

D. SYSTEMS ENGINEER

Systems Engineering is the discipline that is responsible for creating and managing the effective implementation of solutions to problems. Scientific and engineering effort is applied in an attempt to achieve the following goals (Blanchard *et al* 1986: 9):

- Deriving a set of system performance parameters and a preferred configuration from an operational requirement stated by the user.
- Integrating the system's technical parameters while ensuring that all of the interfaces are compatible, and optimising the total system.
- Incorporating producibility, reliability, supportability and safety in the engineering effort.

The relative position of Systems Engineering within the Project and Enterprise is presented in Figure 47 (Stevens *et al* 1998: 12). Systems Engineering is the engine that drives the technical direction of the project by defining the system requirements and creating the system architecture (Stevens *et al* 1998: 7).

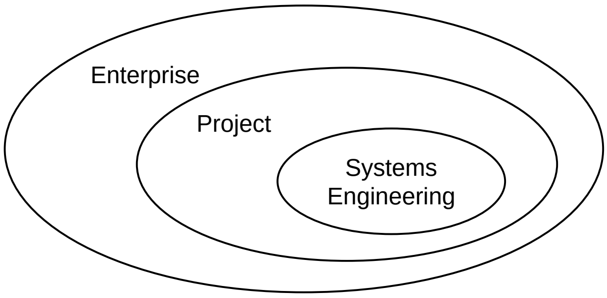

Figure 47:Context of Systems Engineering within the Project and Enterprise(Stevens *et al* 1998:2)

E. CONFIGURATION MANAGER

Configuration management provides visibility and permits control of the performance and functional and physical attributes of the Product over its life cycle. It thus facilitates the orderly management of information on and changes to the Product (EIA-649, 1998: v).

Configuration management links systems engineering to project management, as shown in Figure 48 (Stevens *et al* 1998: 158).

The purpose benefits of configuration management include (EIA-649, 1998: v):

- The Product attributes are defined, providing measurable parameters that give both buyer and seller a common basis for negotiation.
- The documented Product configuration presents a defined basis for making changes on correct, current information. It is possible to repeat production with identical results.
- Products can be identified and linked to their requirements, design and production information. Guesswork and errors are eliminated, as the relevant data is accessible.
- Proposed changes can be evaluated for their impact prior to implementation, thus reducing downstream costs.
- The cost of *ad-hoc* adjustments is eliminated by managing change using a defined process.
- The configuration information is captured and recorded during the definition, change, distribution, operation and disposal processes. This information is then available and accessible and consequently permits timeous and accurate decisions.
- The actual configuration can be verified by comparison with the required attributes during the various life cycles. This breeds a high level of confidence in the information available.

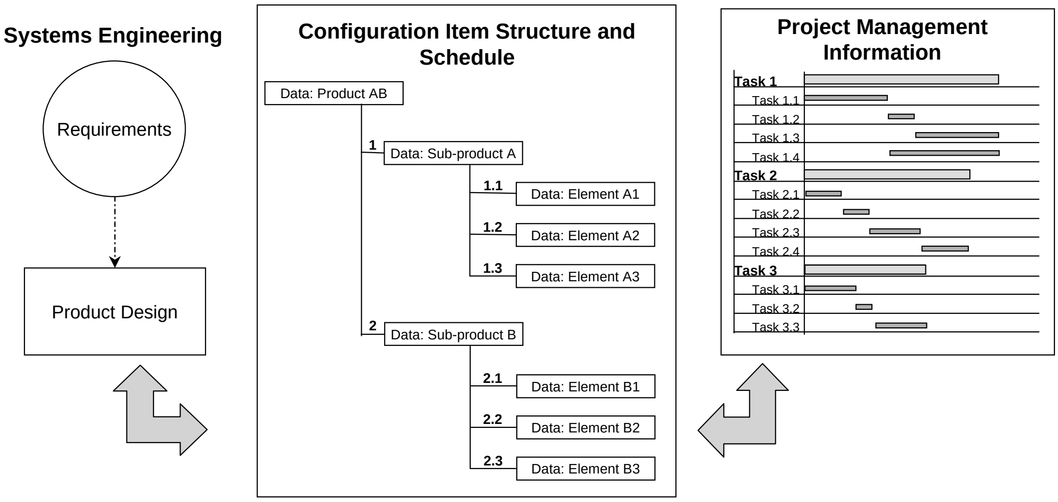

Figure 48: Linking Systems Engineering and Project Management (Stevens *et al* 1998: 158).

Configuration management, as described previously, regulates change, is typically performed by the organisation's facility and plays a very significant role in assuring the project's success.

Typical Configuration Management (CM) processes executed by the Configuration Manager include (EIA-649 1998: 10)-

- CM planning and management.
- Configuration identification.
- Configuration change management.
- Configuration status accounting.
- Configuration verification and audit.
- Configuration management of digital data.

Changes have an adverse influence on project cost and schedule goals. To reduce the number of changes and the negative impact on project performance it is necessary to employ a formal change review and control system. Drafting and implementing changes is similar to other project work that must be defined and scheduled. The change control system reviews and authorises design and work changes whilst rejecting unnecessary ones. (Nicholas 1990: 398).

F. OTHER FUNCTIONAL ROLES

Personnel falling under the organisational line functions also make up part of the project team and contribute towards its success. Typical roles of these team members include systems engineering, software engineering and other associated disciplines.

3.5.6 PROJECT LIFE CYCLE PHASES

Any Product passes through various phases in its life. The **EIA-649** (1998: vi) proposes the set of Product life cycle phases presented in Table 22. This table presents the names or aliases that are often used to describe these phases. Irrespective of whether the Product is a facility, aircraft or computer software, it will go through all or most of these phases.

Nicholas (1990: 91) divided the project's systems development cycle into the following four phases: Conception, Definition, Acquisition and Operation.

The depiction of the product life cycle phases proposed by the EIA and Nicholas (1990: 91) are similar in principle.

Ericsson attempts to use a common methodology in its projects. As it has many companies across the globe participating in its projects, it found it necessary to use a common methodology to make the processes manageable. A shared view on project management is a prerequisite for handling and resolving conflicts. Ericsson divides its projects into the following four phases: the pre-study phase, the feasibility phase, the execution phase and the conclusion phase. At the beginning of each phase, the project must pass what Ericsson terms a tollgate. This is a decision-making point where senior management or the project sponsor makes a formal decision regarding the aims and execution of the project and is based on the assessment of three concerns (Mulder 1997: 2):

- Project status in terms of requirements, the supply of deliverables, and progress.
- The benefit to Ericsson and the client.
- The use of resources in both the short and long terms.

Milestones in contrast with tollgates are concerned with the project's work model and are controlled by the Project Manager and the project team (Mulder 1997: 2).

Phases:	Aliases	Characteristics	
Conception	Marketing Concept Study Research Exploration Pre-development	Need Mission Trade-offs Survey Pre-concept & Concept	Opportunity Analysis Investigation Functions Definitions
Definition	Development Design Programme definition & Risk Reduction Engineering & Manufacturing Development Coding/Software build	System Definition Architecture Design Software Code & Test Planning Testing	Specification Preliminary Detailed Design Manufacturing Prototyping Evaluation
Build	Fabrication Production Construction Manufacturing	Facility Construction Assembly Inspection	Production Installation
Distribution	Sales Delivery Installation Fielding Deployment	Order Stock Acceptance Installation	Supply Transport Deployment Set-up
Operation	Operational Maintenance Warranties Service Life Performance Operation & Support Repair	Use Operate Service	Utilisation Maintain Depreciate
Disposal	Removal from Service Disposition Unsupported	Mothball Deactivate Disassemble Recycle	Discard Destroy Scrap Disposition

Table 22: Product life cycle phases EIA-649 1998: vi).

3.5.7 UNDERTAKINGS WHERE PROJECT MANAGEMENT IS APPROPRIATE

Project Management originated in the aerospace and construction industries where creative management is needed to cope with the demanding environments and types of activities. In some situations project management would be inappropriate as its implementation would be greater than the effort of the undertaking itself. Cleland and King (1983: 259) list five indicators for the appropriateness of project management when considering an undertaking:

- The magnitude of effort: When an undertaking demands more resources than usually applied in an organisation, the use of project management techniques would be advantageous.
- Unfamiliarity of undertaking: Where an undertaking differs from the normal routine processes used by an organisation, project management is a suitable for integrating the effort to achieve the desired goal. Nicholas (1990: 30) describes a project as always requiring that different things be done or that the same things be done differently. Project management is a more suitable way of handling unique or non-routine situations.
- Volatile environment: Project management provides the flexibility needed to pursue new opportunities and changing goals encountered in the volatile environments encountered in modern industry.
- Inter-relatedness: When joint effort from several functional areas is needed, conflict often arises between them, defeating the effort required to achieve the goals. Project management induces and co-ordinates lateral relationships across functional boundaries thereby reconciling the conflicting groups and inculcating a sense of common purpose.

Organisational reputation: If there is potential for project failure which could lead to the damage of the organisation's reputation, loss of future contracts, or other undesirable consequences, it is advisable to put the management responsibility in the hands of a single individual charged with ensuring the success of the project. This individual project manager assisted by his team would reduce the chances of failure.

CHAPTER 4 : VALUE SYSTEM AND VALUE CHAIN OVERVIEW

4.1 THE VALUE SYSTEM FOR SOUTH AFRICAN NATIONAL DEFENCE

The top-level value system consists of the DoD, the national and international environments. The DoD, as shown in Figure 49, is the element in the value system in which the value chain is located. The output of the DoD is those operations which fall within the role of the SANDF as defined within the Constitution. The SANDF's operations influence the environment, which includes the regional, local and international political, economic, socio-cultural and technological situation. In turn, the key parameters of the environmental situation influence the SANDF and serve as input to the DoD.

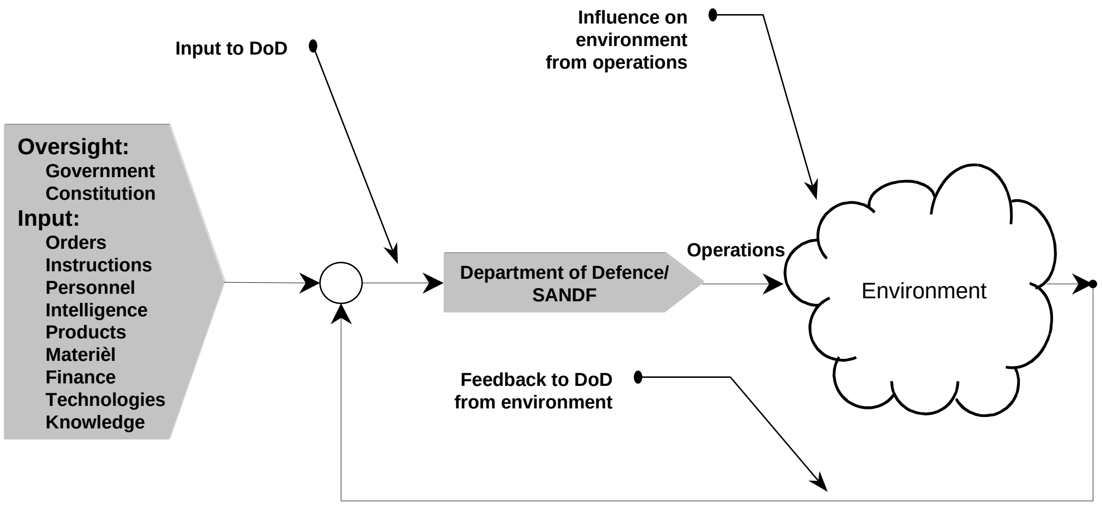

Figure 49: The Department of Defence in the National Value System.

From the discussion above, it can be seen that elements in the value system include both domestic and foreign firms in the defence and related industries.

Further elements in the value system include:

- The national environment.
    - The government of the RSA.
    - The RSA legal environment.
    - The RSA economy.
    - Local defence and related industries.
- The international environment.
    - Foreign countries.

- International defence and related industries.

4.1.1 THE PRODUCT LIFE CYCLE AND VALUE SYSTEM

At the lower level of the value system, the resources used to execute the SANDF's functions have a value system that also plays a part in Figure 49 above.

Products and Products Systems pass through the life cycle phases shown in Figure 50. Value is added during each of these phases. In the Operational and Support phase, the item is employed and, when required, supported. Support in this context includes logistic and engineering support, both of which are value-adding activities. The higher level use or employment of the item during training or war-fighting is also a value-adding activity. The value is then added at the User System or higher level.

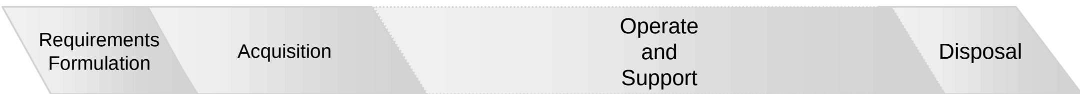

Figure 50: Typical Life cycle Phases of a Products System or Product.

The phases in the life cycle of items do not all occur entirely within the DoD's value chain. Each phase in the life cycle has its own role-players, as shown in Figure 51.

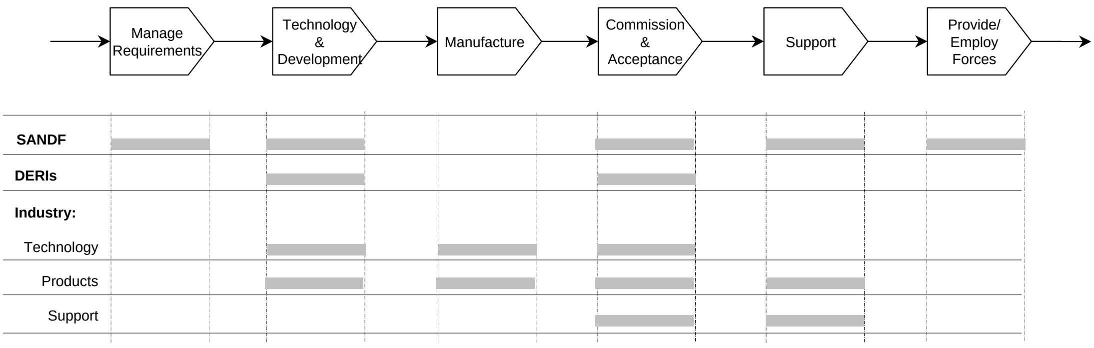

Figure 51: A Representation of the Products System Value System and the Role-Players.

The users within the AoSs should formulate their own requirements for operational capabilities.

The system specification developed from the requirement statement is a systems engineering task that can be executed by either the client's or contractor's engineers.

The individual Product or critical prime item development specifications are developed from the system specification: this is also a systems engineering task that can be executed by either the client's or contractor's engineers.

Further design and development of Products and items at lower levels on the systems hierarchy is primarily the domain of industry. Smaller or specialised projects to modify or upgrade items may be performed by the SANDF's engineering services.

The Products Systems often require upgrades during the operational phase of their life cycles. These upgrades may be to enhance capabilities in view of threats or to improve the dependability or supportability of the Products Systems.

4.2 THE VALUE CHAIN

This section outlines the value chain within the DoD. Further description of the parts of the value chain is presented in the following chapters.

4.2.1 ORGANISATIONAL TRANSFORMATION

The DoD is in the process of organisational transformation to enable it carry out its roles and functions efficiently and effectively within the framework of national values and policies. The main intent is to enhance performance management and to improve cost-effectiveness (Defence Review 1998: Ch 9 paragraph 21).

A. KEY CONCEPTS

The transformation of administrative, command and control and supporting structures of the DoD is based on the following key principles (Defence Review 1998: Ch 9 paragraph 22):

- Systems Approach: Adopt a systems approach to the management of defence.
- Jointness: Share resources between the AoS while preserving essential service uniqueness.
- Focus: Focus on the core business of defence and outsource non-core functions.
- Civilianisation: Appoint civilians where uniformed members are not required in posts.
- Reserve Force: Use the Reserve Force as far as possible.
- Information Technology: Exploit information technology.

B. SYSTEMS APPROACH

According to the Defence Review (1998: Ch 9 paragraph 22 –29), the DoD is considered as a system, divided into sub-systems working together to produce a specific output: those combat-ready forces that can be employed on operational missions. The combat forces can also be considered as systems.

The systems approach is based on four main processes: Strategic Direction, Support Forces, Provide Forces, and Employ Forces. The latter three are executive processes. The processes are presented in Figure 52 as the top level of the DoD's value chain, and are briefly explained below:

- Strategic Direction: The Strategic Direction process is vested in the integrated DoD, and directs the three executive processes through ministerial direction, the policy framework of the DoD, and the departmental strategy and plan.
- Support Forces: The vertical segment of the Support Forces in Figure 52 provides material and personnel to combat forces for the Provide Forces process, for deployment in operations. The horizontal segment of the Support Forces in Figure 52 maintains combat-readiness of Products Systems throughout the value chain.
- Provide Forces: The Provide Forces process integrates and transforms force components into combat-ready forces. This consists of three separate sub-processes:
    - User Systems, which are force components, are integrated and converted into combat-ready units, such as battalions, squadrons and ships.
    - Combat-ready User Systems are integrated and converted into combat-ready single-service forces or higher order User Systems such as brigades (i.e. forces drawn from one arm of the service).
    - Combat-ready single-service forces are integrated and converted into combat-ready JHOUS (task forces).
- Employ Forces: The Employ Forces process involves the deployment of forces in an operational capacity. C JOps employs combat-ready forces to accomplish specific missions as ordered by the appropriate directions from the President.

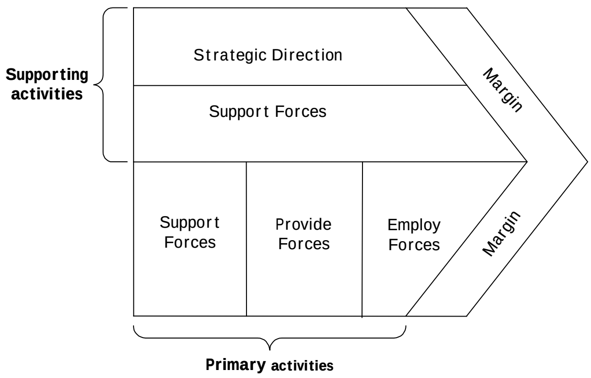

Figure 52: Value Chain of the Top-Level Process of the DoD.

The systems approach aims to achieve effectiveness, efficiency and economy and to facilitate the following policy objectives, although these objectives will only be achieved through careful planning and costing:

- Performance management is to be facilitated and accountability enhanced.

- Total costs of outputs are to be made visible.
- Empowerment of lower hierarchical levels is to take place and bureaucracy to be reduced.
- The separation of the Provide Forces and Employ Forces processes, should enhance control over military power.

C. JOINTNESS

Jointness seeks to enhance the effectiveness and efficiency of all military operations by synchronising the actions of the four Arms of Service (Army, Navy, Air Force and Military Health Service) and the civilian component of the DoD at every level. Joint integrators, such as technologies, command and control sub-systems and administrative and training procedures, will be nurtured in developing force components and preparing forces. Jointness, however, will not be achieved by destroying the unique features of the AoSs; their cultures are necessary for the different operating environments and will be maintained, although some adaptations may be necessary (Defence Review 1998: Ch 9 paragraph 30).

4.2.2 THE SUPPORT FORCES PROCESS

The DoD supports the SANDF through the Support Forces process. This makes forces available to the Provide Forces and Employ Forces processes. The Support Forces process includes the acquisition and support of appropriate human resources and equipment. Figure 53 presents the high-level process of supporting a Products System for employment in operations.

The DoD's high-level support process consists of the following main functions:

- <u>Acquisition:</u> The DoD acquires those Products Systems that are needed to satisfy the staff requirements of a particular user. The Acquisition Project Officer and the Products System Manager commission the Products Systems. The System Manager accepts the new Products Systems into service after qualification and commissioning. Engineering expertise is essential for development and verification during this process and is shown as the overlap between the two functional blocks. Integrated Logistic Support expertise is essential for the development and verification of the support system during the acquisition process, and is shown as the overlap between the two functional blocks.

- Integrated Logistics Support: The Products System Manager manages the support effort according to the baseline. The Products System Manager must provide the agreed availability of combat-ready Products Systems to the user. Requirements to improve reliability or supportability are referred to Engineering Support.
- Engineering Support: Engineering investigates cases of poor supportability, dependability or capability referred by the Products System Manager or User. Where necessary the operating baseline is changed and qualified. Engineering also supports the acquisition process.
- Disposal: Products Systems are phased out when they become obsolete or uneconomical to operate and support.

The subsequent chapters discuss these functions in more detail.

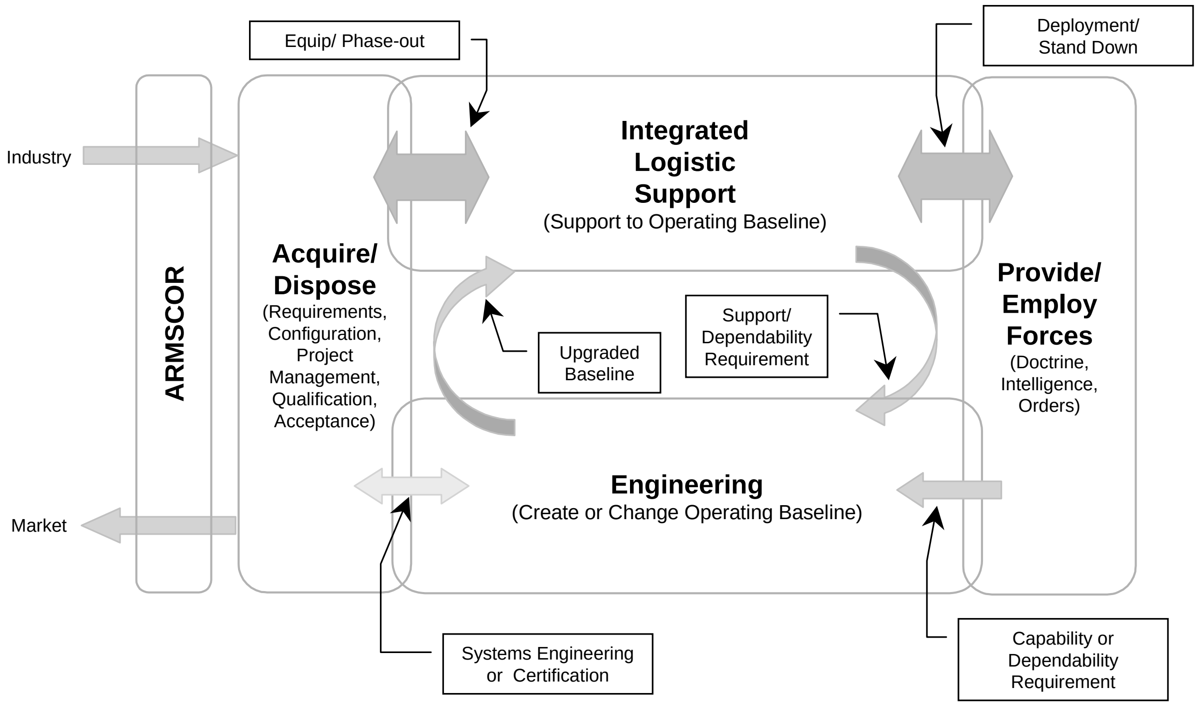

Figure 53: A High-Level Representation of the Support Process

CHAPTER 5 : STRATEGIC ANALYSIS

5.1 ENVIRONMENT

The environmental analysis discussed in more detail in CHAPTER 2 is summarised here.

The increasing complexity and urgency of regional and domestic issues, combined with the speed with which changes occur, have made accurate prediction of many developments difficult.

The RSA is not likely to be faced with conventional military threats in the foreseeable future. The tendency is toward regional and domestic conflicts. Africa is more likely to experience these conflicts than other parts of the world.

Many African economies are poor, with an uneven distribution of wealth. Weak governments remain unable to reduce or stop corruption or crime or improve their economies. Poverty has led to many armed rebellions and conflicts in the region. Globalisation has reduced employment in most African countries.

Several African states are in the process of upgrading, or have upgraded, the weapons inventories of their defence forces. The RSA has a larger, more capable weapons inventory than most African states.

The greatest threat to the RSA is its unacceptably high crime level. Factors that contribute to the growth of crime include:

- The RSA's large land and maritime borders.
- The general incompetence of the RSA's government officials, including the police.
- The ineffective policing of regions in neighbouring states.
- The poverty in many areas of the RSA and in neighbouring African states.
- Large numbers of illegal immigrants, often carrying contraband such as drugs or illegal firearms.
- Criminal syndicates who have demonstrated the ability to acquire and deploy sophisticated communications equipment, aircraft and weapons.

The RSA has the highest proportion of scientists and engineers in Africa, though at a considerably lower level than developed countries. Most African countries have few or no scientists or engineers. As they have insufficient skilled personnel, most African countries rely on foreign personnel to maintain their weapons. The RSA on the other hand, has the capability of developing and supplying most of the SANDF's Products Systems and supporting all of them.

The SANDF, however, has shown an inability to retain skilled personnel and has to use contractors to support many of its Products Systems at a significantly higher cost. It seems that the SANDF has lost a large part of its ability to act as an intelligent client and is now often reliant on the services of outside agencies.

Given that the key success factors of a defence force are the principles of war, the SANDF would require from the ETF:

- The availability and efficacy of Command, Control, Communications, Computers, Intelligence, Information, Surveillance, Reconnaissance and Electronic Warfare (C^4I^2 SR EW) capabilities and other Products Systems.
- Technological innovation capabilities.
- Improved or changed capabilities, availability and dependability of Products Systems.
- "Stealth" capabilities.
- Simplicity, robustness and ease of operation of Products Systems.

Formal and informal links with other government departments, ARMSCOR, the DERIs, the defence industry and foreign military forces are beneficial and should be encouraged. Closer co-operation between the AoS is desirable and requires strengthening.

The major client of the SANDF's ETF is the commander employing the User Systems.

The appearance of open systems, reducing risks and costs associated with upgrades and new procurements, has become an important technological trend.

5.2 RESOURCES

The SANDF has the following resources at its disposal:

- Technology: The SANDF has a large technology base developed through the Defence Research and Development Board (DRDB). Several companies in the defence industry also have a significant technology base. The government's technology policies as discussed in 2.3.5A reflect the SANDF as being regarded as a key role-player and repository of technology.
- Value Generation and Skills: The SANDF primarily upholds national security. As discussed in paragraph 2.3.2C, the SANDF's humanitarian operations have gained goodwill and respect for both the country and the organisation. The SANDF has lost a large proportion of its skills, but is attempting to recover these through training new members.
- People Skills: The SANDF has lost a significant part of its skills base. This is attributable to poor remuneration and the influence on career opportunities of affirmative action. The RSA has also lost significant numbers of skilled people to emigration, making replacement of the losses within the SANDF difficult.
- Financial Resources: The SANDF depends on the RSA government's budgeting for defence. The information presented in paragraph 2.3.3B shows that the RSA's defence expenditure as a percentage of GNP, is lower than the world average. The SANDF has difficulty executing its task with the financial resources at its disposal and is reducing its infrastructure to cut costs.
- Client Benefits: The national environment derives advantages from security and stability. Economic growth is then feasible, employment and equitable distribution of wealth are then possible. Recognition of the role of the SANDF is generally only visible in the event of contingencies such as the floods in Moçambique, or the collapse of neighbouring states such as Lesotho.
- Inventory: Although the SANDF has a larger weapons inventory than most African countries, many of the items are old, and require replacement. The procurement of modern Products Systems has begun and will continue over an extended period.

5.3 ANALYSIS OF STRATEGIC CHANGE IN THE SANDF

The SANDF is undergoing strategic changes. Figure 54 shows the relationship between the main issues. The organisation required is small a technologically advanced defence force with a defence posture. The pressures on the RSA to define this organisation are based on the following main factors:

- The new world order since the end of the Cold War and the conflicts in Southern Africa.
- The RSA government's focus on social, educational and developmental goals.
- The diminished regional threats to the RSA.

The SANDF is undergoing transformation from being a large organisation to one reduced in size, owing to strategic pressures. New demands on the SANDF are peace-keeping, humanitarian assistance and support to the SAPS in crime prevention.

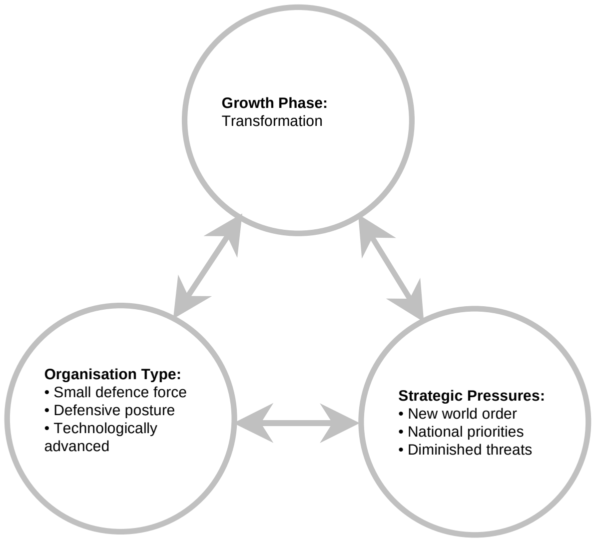

Figure 54: An Analysis of the Strategic Change of the SANDF.

The ability of the SANDF to cope with change appears to be closest to the prospector type than to the other two types of organisation described in paragraph 3.1.4A. Although it is a bureaucratic organisation, reluctant to accept and slow to respond to change, the transformation process has forced it to embrace change. Its ability to function effectively and efficiently after transformation is questionable, due to the loss of skilled, experienced personnel and capacity of personnel to gain the necessary skills and knowledge.

The SANDF is under pressure to transform because of change in the world order and hence defence requirements. Pressures such as those described in CHAPTER 2Environmental Analysis, have created new domestic and regional political imperatives dictating a smaller, more affordable defence force leveraged by technology. The nature of and the advances in technology dictate the way in which a defence force operates. Recent conflicts have shown the value of precision-guided weapons and information warfare techniques against powerful forces. The SANDF neglects the management of its technological capabilities at the nation's peril.

The stage of organisational growth is rather complex. The SANDF has a short history, but has inherited its equipment and processes from the SADF, which was integrated into the new organisation. The injudicious reduction and loss of personnel since the early 1990s has left the SANDF incapable of performing some functions and being forced to contract these out at great expense.

5.4 FINDINGS

The major challenge to the RSA is the achievement of sustainable growth-delivering employment. Poor security, crime and the incompetence of officials in the public service threaten the achievement of this goal. The DoD is therefore not a priority for the allocation of funds and therefore will have to allocate its resources skilfully.

Some African states are in the process of upgrading their military capabilities. Considering Africa's tendency towards armed conflicts and its instability, it is desirable that the SANDF maintain its credibility as an effective deterrent to any threat.

It is imperative that the SANDF efficiently employ its resources, described in paragraph 5.2 to develop and sustain its effectiveness as a deterrent. The ETF has a significant contribution to make in supporting the key success factors described in paragraph 2.5.

In spite of its large inventory, the SANDF has become progressively more resource-poor in terms of skills. Although the DoD is procuring new Products Systems, the SANDF is exposed to the threat of having insufficient skilled personnel to operate and support the equipment. This lack of skills is also a national problem.

The optimal utilisation of the SANDF's ETF is a priority, to ensure that it remains a technologically advanced force capable of acting as a cost-effective deterrent. This would be attainable by:

- The management of ETF competence.
- The management and execution of ETF processes.
- The management of technology.
- The development of an efficient ETF structure.
- The alignment of ETF activities.
- The optimisation of the ETF value chain.
- The elimination of the unnecessary duplication of ETF functions.

CHAPTER 6 STRATEGY DEVELOPMENT

6.1 ORGANISATIONAL SENSE OF PURPOSE

6.1.1 AREA OF ACTIVITY

The SANDF's prime area of activity is defence. Defence capabilities are also useful for other purposes such as humanitarian assistance, peace support operations and assistance to other government departments.

The ETF area of activity in support of the SANDF's main activities varies from the prescribed maintenance and repair procedures performed by artisans, to the undefined processes dealing with uncertainty that are carried out by technologists and technicians under the supervision of engineers. The work conducted by engineers, technicians and technologists, or at least under their supervision, includes the following:

- Identify, manage and apply technological innovations.
- Analyse requirements and develop conceptual solutions.
- Perform systems engineering.
- Develop specifications.
- Design and develop configuration items and operating procedures.
- Integrate, test, evaluate and qualify configuration items up to Products System level.
- Certify configuration items and procedures as safe and fit for purpose.

The work conducted by artisans, includes the following:

- Maintain Products Systems' combat readiness.
- Repair, test and prepare Products and Products Systems for service.
- Apply modifications as directed.
- Install Products.
- Perform operator duties as required of artisans in some cases.

6.1.2 COMPETITIVE ADVANTAGE

The ETF could best be applied to activities which will contribute most significantly to a competitive advantage for the SANDF. The key success factors discussed in paragraph 2.5 indicate the following focus areas for the ETF:

- Efficient and effective management to ensure the availability of combat-ready Products Systems for C JOps.
- Optimised support costs and effort through effectively and efficiently managed systems engineering.
- Capabilities flexibly optimised for surprise.
- Effective and efficient C^4I^2 SR EW capabilities.
- The development and exploitation of innovative technologies.

Given the focus areas, a favourable environment is necessary to realise the envisaged success. Some of the conditions that could provide competitive advantage include:

- Reducing the number and effect of boundaries in the SANDF's value chain.
- Improving linkages in the SANDF's value chain.
- Managing the organisation's carriers of competence.
- Linking carriers of competence.

6.1.3 Relative Importance to Stakeholders

The SANDF is a statutory organisation, owing its existence to the Constitution of the RSA, and is the only permissible military organisation in the country.

A. Identification of Stakeholders

The analysis of the industry environment in section 0 defines the SANDF's stakeholders. These include those shown in Table 23.

The RSA government	Defence industry
DoD personnel	UN, SADC and OAU
DERIs	Sub Saharan African states
ARMSCOR	RSA Government Departments
SAPS	Rural communities

Table 23: The SANDF's Major Stakeholders.

B. Detractor Stakeholders

Some detractors see a budget which, in their opinion, could be better spent on social services and some form of job creation than on defence. Considering the threat that poverty holds for the RSA, their concern is a valid one. These detractors include Non-Governmental

Organisations (NGOs) and some members of government. The success of the detractors could result in a considerable reduction in the defence budget, or a cancellation of the procurement of the arms packages. Some neighbouring SADC states moreover, feel threatened by the concept of a strong SANDF in their region and perceive the situation as a power imbalance.

C. SUPPORTER STAKEHOLDERS

The UN, SADC and OAU are increasingly seeking African solutions to provide sustainable relief to African problems. With this endorsement, the SANDF has played several roles in Lesotho, Moçambique and the DRC.

The SANDF's capabilities have enabled it to perform various humanitarian missions in the southern African region. International acclaim and awards have enhanced the standing of organisation and the country.

The DoD employs thousands of people who depend on the SANDF for their livelihood. The members have expectations of growth through training and experience. It is expected that, as volunteers, the employees will be motivated by conviction.

ARMSCOR, the DERIs and the local defence industry have a long relationship with the SANDF, much of it as partners in developing new Products and Products Systems. This has led to a significant defence industry with the associated economic advantages.

The police have difficulty providing adequate service in preventing crime. The rural communities are especially vulnerable. The SANDF provides support to the SAPS. The SAPS and communities are supporters of the SANDF's activities and existence.

6.2 VISION, MISSION AND OBJECTIVES

6.2.1 INTRODUCTION

A vision, mission and objectives are useful for developing a strategy. These define the direction of the organisation.

6.2.2 VISION

A vision presents the concept of the organisation's future. The vision of the ETF should be subject to and complement the vision of the DoD.

A proposal for a vision appropriate for the ETF within the SANDF is:

> *The SANDF a capable, technologically advanced, combat-ready deterrent, ensuring a peaceful, secure Republic of South Africa.*

6.2.3 MISSION

The ETF has two main areas of activity, as illustrated in Figure 53. These functions are Integrated Logistic Support and Engineering Support. These missions should be distinctly separated.

A. ENGINEERING MISSION

A mission proposed for Engineering is:

> *Engineering shall ensure and enhance the SANDF's capabilities, dependability and cost-effectiveness through providing engineering expertise to support the acquisition and upgrading processes and the efficacy of operations and support. The capabilities include those of the Products Systems and the members of both the User and Support systems.*

B. TECHNICAL SERVICES MISSION

A mission proposed for Technical Services is:

> *The Technical Services of the SANDF shall provide combat-ready Products Systems at the lowest cost and the rate required by the User System Manager.*

6.2.4 OBJECTIVES

The ETF can contribute towards the SANDF's success through sustaining or improving the organisation's competitive advantage and cost-effectiveness. The ETF can contribute to the SANDF's competitive advantage through the effective and efficient management of technology and engineering effort.

The ETF can contribute to the SANDF's sustaining or improving the cost-effectiveness of User Systems. User Systems consist of the Products Systems, personnel and methods, which include doctrine and procedures. Paragraph 2.5.3 describes the desired level of cost-effectiveness for User Systems.

Generally the ETF reduces life cycle cost and improves capability, availability and dependability of Products Systems. Figure 55 shows how their roles and objectives of Engineering and Technical Services sometimes differ due to the difference between their missions.

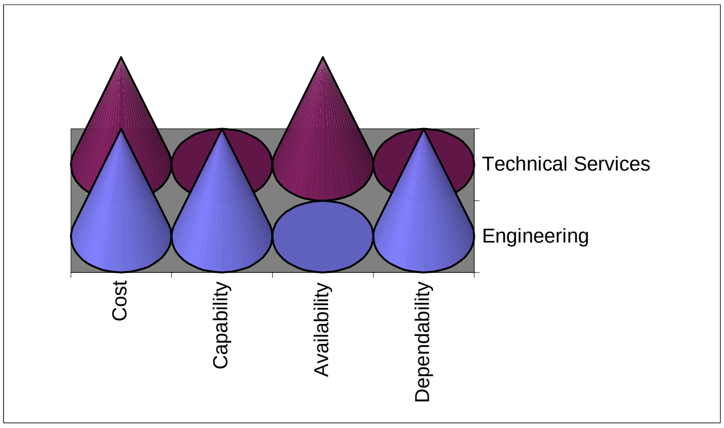

Figure 55: The Roles and Objectives of the Two ETF Branches.

A. ENGINEERING OBJECTIVES

Engineering shall provide Operating Baselines (OBL) that optimise the Products Systems' costs of acquisitions, upgrades, support and operation. Engineering shall ensure the integrity of these OBLs, and shall be held accountable for the safety, policy and legal compliance thereof.

This objective will be achieved through project management, technological innovation, systems engineering and design and development, to satisfy the users' requirements.

B. TECHNICAL SERVICES OBJECTIVES

The Technical Services shall optimise the Products Systems' availability and the operating and support costs through effective and efficient management of the Products Systems according to their Operating Baselines. This objective will be achieved through supply, storage, maintenance and testing according to the OBL standards, to ensure the required availability of combat-ready Products Systems.

6.3 FINDINGS

The SANDF appears to enjoy the advantages of having a group of supporters that is larger and more powerful than its detractors. This is due to the results of operations, development of Products and technologies, national prestige and regional stability. The SANDF must nurture the goodwill of these supporters to ensure the continued existence of its capabilities. The yardsticks by which to judge the organisation's performance include:

- Security in the RSA and the southern African region derived through:
    - Successful deterrence to any potential aggressors.
    - Sustainable competitive military advantage through competence and technology.
- Low cost of ownership and operation of defence capabilities.
- Satisfaction of personnel expectations.

CHAPTER 7 ACQUISITION

7.1 HUMAN RESOURCES

7.1.1 OVERVIEW

Technology and Products Systems have to be supported to a greater or lesser degree by human beings. These vary from highly skilled engineers and scientists to operators. The organisation must therefore acquire and develop appropriate candidates. The acquisition of human resources includes the recruitment of new members and the identification of members for redeployment. Human resource support involves the education, training and development of personnel.

The Support Forces process requires personnel with a broad spectrum of skills and competencies. The scope of this study is, however, limited to the ETF.

7.1.2 THE ENGINEERING PROFESSION

The term "Engineer" conjures up divergent images in discussions with people from various backgrounds. To a member of the Army, the term may call up images of the soldiers laying Bailey bridges, whereas in a factory environment, the engineer could be the manager whom controls maintenance.

Until the mid 19th century, it was military engineers who executed large-scale construction work including the preparation of topographical maps, the location, design and construction of roads, bridges, forts and docks. Thereafter, "civilian (or civil) engineers" performed this category of work for non-military purposes. With the increasing diversification of engineering into disciplines, new branches such as mechanical engineering emerged. The number of engineering disciplines has since expanded even further. (Microsoft Encarta Encyclopedia 2000)

The following were obtained from a list of definitions of engineering on the web page of the Institute of Electrical and Electronic Engineers (IEEE):

The activity characteristic of professional engineering is the design of structures, machines, circuits, or processes, or of combinations of these elements into systems or plants and the analysis and prediction of their performance and costs under specified working conditions. *M. P. O'Brien* (1954)

Engineers participate in the activities which make the resources of nature available in a form beneficial to man and provide systems which will perform optimally and economically. L. M. K. Boelter (1957)

Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgement to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind. Engineers Council for Professional Development (1961/1979)

Engineering is not merely knowing and being knowledgeable, like a walking encyclopedia; engineering is not merely analysis; engineering is not merely the possession of the capacity to get elegant solutions to non-existent engineering problems; engineering is practicing the art of the organized forcing of technological change … Engineers operate at the interface between science and society … Dean Gordon Brown; Massachusetts Institute of Technology (1962)

The term "Engineer" and specifically "Professional Engineer" has a particular context in this document and pertains to persons registered or registerable as a Professional Engineer in terms of the Act.

7.1.3 Engineering Professions Act

The Engineering Profession of South Africa Act, 1990, that replaced the previous Act and its amendments, established a baseline for engineering activities in the Republic of South Africa. In terms of the act, a council known as the Engineering Council of South Africa (ECSA) was established to administer and control these activities.
The Act sets out the powers of the ECSA in this statement:

The council shall have the power to take the steps which it may consider expedient for the protection of the public in their dealings with persons registered in terms of the Act, for the maintenance of the integrity and the advancement of the status of such persons and for the improvement of the services rendered by, and the standards of professional qualifications of, such persons.

7.1.4 Certification of Competence

ECSA certifies persons as competent in the engineering field. Persons are regarded as competent if they have the prescribed theoretical and practical training and experience in their discipline. The tertiary qualification and post-qualification experience required for each category of competence is presented in Table 24.

As an example, ECSA prescribes the requirements for consideration for registration as a Professional Engineer as follows:

- A recognised bachelor's degree in engineering.
- At least three years' appropriate post graduate experience in engineering work.
- The prescribed reports of work conducted, submitted by the candidate.
- Assessments of the candidate's work performance by at least two referees. At least one of these referees shall be registered as a Professional Engineer.

If the reports of the candidate and referees indicate satisfactory work over a period of at least three years as considered by a Professional Advisory Committee, and given that the engineering degree is recognised, the candidate may then be deemed competent to be registered as a Professional Engineer.

Registration	**Entry Qualifications**	**Experience [Years]**
Professional Engineer	B Sc. (Eng.) or B Eng.	3
Professional Technologist (Engineering)	M Dip Tech or B Tech (Eng.)	3
Registered Certificated Engineer	Government Certificate of Competency	3
Registered Engineering Technician	N. Dip	2
	Nat. N. Dip.	4

Table 24: ECSA Registration Qualifications and Experience Requirements.

Organisations with a Commitment and Undertaking to train engineering personnel registerable in one of the categories in Table 25 are expected to have at least one mentor to oversee the professional development. This leads to easier assessment of the candidates when they apply for professional registration.

7.1.5 ENGINEERING DISCIPLINES

ECSA has reserved the titles in Table 25 for persons registered as professional engineers. Any unregistered person making improper use of these titles or abbreviations is guilty of an offence and is liable to a fine not exceeding R 5 000. This is an indication of the seriousness with which the profession is regarded.

Aeronautical engineer	Electrical engineer	Mechanical engineer
Agricultural engineer	Electronic engineer	Metallurgical engineer
Chemical engineer	Industrial engineer	Mining engineer
Civil engineer	Marine engineer	Naval architect

Table 25: Professional Engineering Disciplines Registered by ECSA.

7.1.6 ROLES IN THE ENGINEERING TECHNICAL FAMILY (ETF)

The categories of persons involved in the ETF include the artisan, technician, technologist and engineer, each complementing the other in their respective roles. ECSA registers successful applicants in the categories listed in Table . ECSA does not currently register artisans but may do so in the near future.

Title	Abbreviation
Professional Engineer	Pr Eng
Professional Technologist	Pr Tech (Eng)
Registered Certificated Engineer	Reg Cert Eng
Registered Engineering Technician	Reg Eng Tech

Table 26: Categories of Registration by ECSA.

The level of work of each of the ETF occupational classes differs in the amount of theoretical and practical competence required. Competence will therefore require commensurate training and experience for each of these categories. Figure 56 attempts to illustrate the four occupational classes and their relative theoretical and practical profiles. The individual occupational 'spaces' overlap as reflecting the shared work. The individual will also vary in his or her mix of theoretical and practical competencies within each space, depending on the level of training and experience (Joubert 1988: 2).

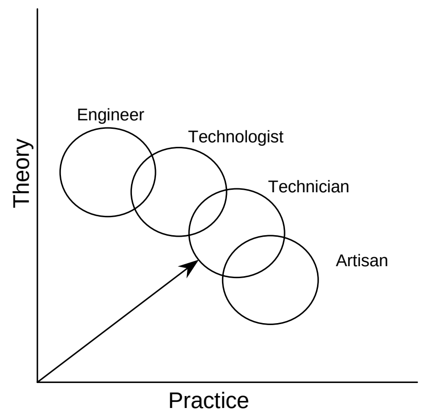

Figure 56: ETF Occupational Work Areas (Joubert 1988: 2).

Each of the occupational categories in the ETF has a specific combination of skill spread and competence. The skills are classified into two categories: technical and concomitant skills. Technical skills include manipulative and thinking skills as well as technological knowledge. Non-technical or concomitant skills include communication, management, personal and interpersonal skills. Concomitant skills are important to achieve success in tasks or projects and differ in importance depending on the occupational class and level of the person (Joubert 1988: 3).

Figure 57 attempts to show the combination of skill spread and competence required of each of the occupational categories in the ETF. The levels of competence in each of the skills areas for each category are shown in Figure 58 (Joubert 1988: 13).

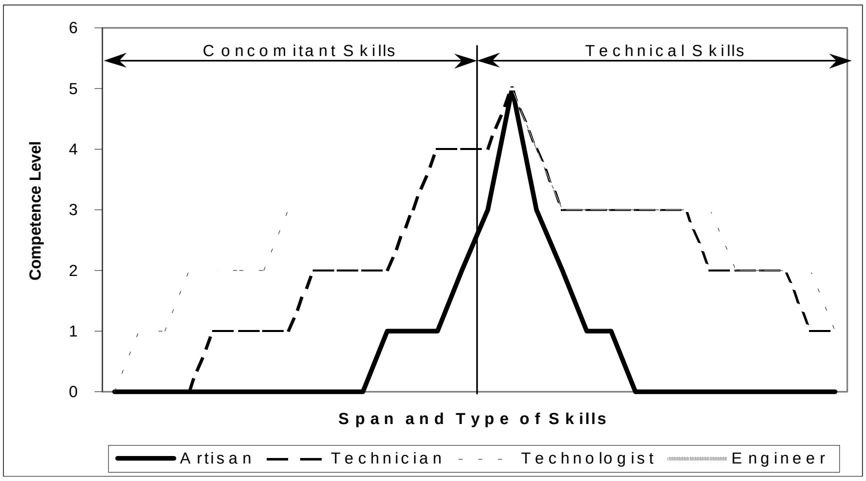

Figure 57: Occupational Skills Spread and Competencies (Joubert 1988: 13).

The ETF occupational class differences lead to differences in their suitability for various types of tasks. The higher level of theoretical skills and competencies of the engineers makes them more suitable for less well-defined or understood tasks.

Significant amounts of management and communication skills are essential for longer, more complex tasks. In those tasks using the skills or support of other people, interpersonal skills are also an essential asset. The higher level and spread of concomitant skills of engineers makes them most suitable for dealing with complex projects requiring the support of, and interaction with other people. The engineer deals with a high level of uncertainty in developing a solution that can be prescribed for the Artisan's execution. This engineer's solution is documented, qualified and certified by extensive tests as effective and safe enough to be a standard work process or a configuration item.

The artisans' skill strengths lie in their manipulative competencies. Their profile, however, also indicates underdeveloped communication, management, inter-personal and thinking skills.

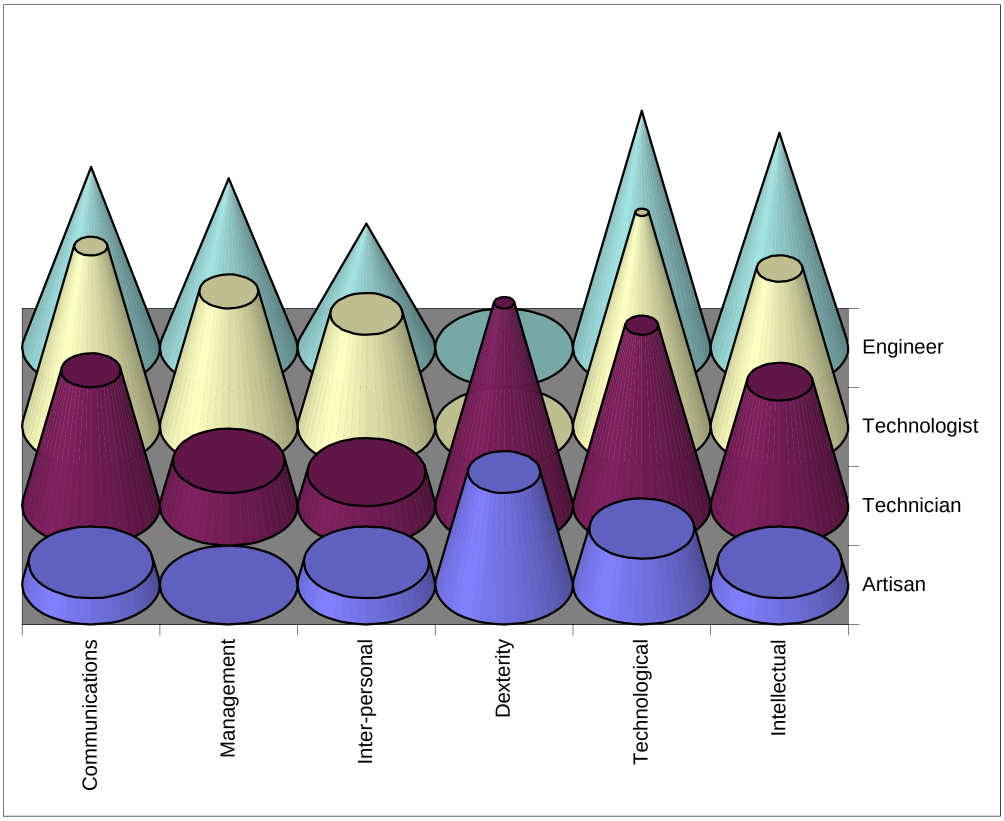

Figure 58: Competence Levels for each Skill in the ETF Categories (Joubert 1988: 13).

The differences in the profiles of the engineer, technologist, technician and artisan make them suitable for differing roles as already mentioned. Engineers appear to be more suitable for work with a larger content of uncertainty than do artisans at the other end of the scale. Based on their relative concomitant and technical skills, it is proposed that the task mix of the ETF could be defined as shown in Figure 59. Figure 59 below shows the engineer as being suitable for executing processes containing a higher level of uncertainty, while artisans are suited for well-defined and prescribed work processes. The manipulative skills for the various categories appear however to be questionable. Intuitively the artisan should display the highest competence levels across the broadest span. Engineers, technologists and technicians should also develop and sustain at least a moderate level of manipulative competence. Scientists would work with few prescribed processes, dealing mostly with uncertainty. The Operating Baseline of Products Systems prescribes the processes for operators.

For the purposes of this study, the engineers and technologists will be broadly referred to as engineering and the artisans and technicians will be broadly referred to as technical Services. These divisions are not absolute, as the services of artisans are often necessary to engineers.

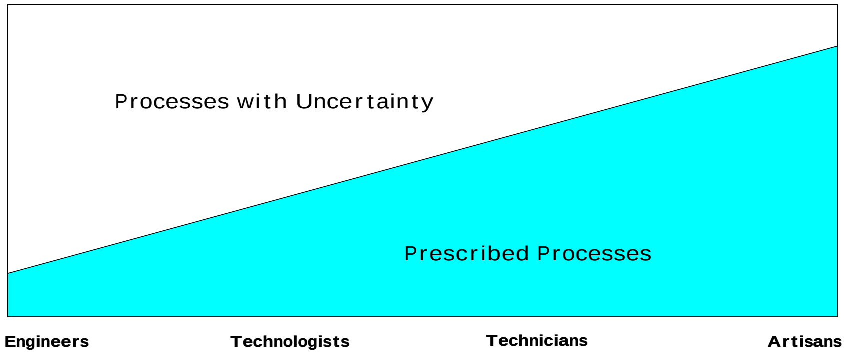

Figure 59: The Proposed Spread of the Scope of Engineering Work for the ETF.

7.2 PRODUCT AND TECHNOLOGY ACQUISITION FOR THE SANDF

The DoD's Support Forces process includes the acquisition of Products and people. The Departmental Acquisition and Procurement Division (D APD) is responsible for the acquisition of Products for the SANDF. The Defence Review (1998: Ch 13) describes in some detail the acquisition management process of the DoD.

The DoD acquires Products and technologies from local and foreign suppliers. The basis for acquisition is both strategic value and cost-effectiveness. Products and technologies that are of strategic value, will however be nurtured locally to ensure supply and possible competitive advantage to the SANDF. Local industry is also encouraged to supply its Products internationally to promote price competitiveness.

ARMSCOR is the DoD's acquisition agency responsible for the management of programmes, drafting of tender documents and the contracting of industry on behalf of the D APD. Within this division, the SAAF, Army and Navy each have a directorate to manage their acquisitions. The Technology Development directorate manages the corporate technology acquisition for the DoD. The Weapons Systems Management directorate oversees the integrity of the management of the other directorates' programmes. This directorate also manages the acquisition for SAMHS and common Products such as ammunition. Figure 60 diagrammatically presents the context of the D APD.

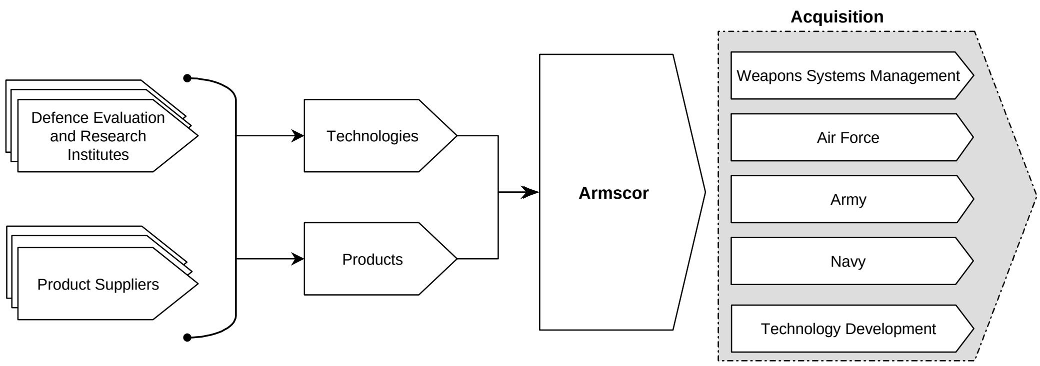

Figure 60: Product and Technology Input to the SANDF.

Where practically and economically justifiable, local industrial development will be promoted. In other cases procurement from foreign suppliers is preferable. A needs analysis indicated the following levels of importance (Defence Review 1998: Ch 13 paragraph 73 – 78):

- Military-Strategic Importance: The defence industry is the strategic asset ensuring the supply of Products and services to the SANDF.
- Military-Operational Importance: The local defence industry provides the following significant operational advantages for the SANDF:
- Technological Advantages: Local capabilities offer a winning edge over adversaries by providing access to unique solutions to threats.
- Tailor-made Equipment: Products more suitable to the RSA environment provide the SANDF with a winning edge over adversaries and are more easily supported.
- Logistic Support: A local support capability is essential for the combat readiness of Products.

Socio-Economic Importance: The competence of the local industry can be positively influenced by the local defence industry. This has socio-economic benefits.

High risks and costs generally accompany the advanced technologies typically used in the defence industry. COTS offer a hedge against some of these risks.

Products and Products Systems are generally expected to be available in the SANDF's inventory for use for up to 20 years or more.

Acquisition programmes consist of teams consisting of various specialists led by the ARMSCOR Programme Manager and the Project Officer. Their responsibility for the acquisition begins after the requirements formulation phase, and ends after the Product or Products System is accepted by the PSM for use. Upgrades to a Products System are managed on the same basis.

7.3 BEING A GOOD CUSTOMER

The DoD is a customer to those firms and other organisations offering Products and services for sale. The DoD has a responsibility to the stakeholders, including the taxpayer, to ensure that it acts as a ‘good’ customer on their behalf. This means that during acquisition the project team must become experts at handling problems to ensure that they timeously deliver a cost-effective solution to satisfy the user’s requirements. By employing the systems engineering principles presented in paragraph 7.5, the organisation will attain the ability to be good customers (Stevens 1998: 351):

7.4 THE ACQUISITION PROCESS

For purposes of convenience, the requirements formulation phase will be included in the discussion of the acquisition process.

Knowledge of the acquisition process facilitates the assessment of those activities and skills necessary for efficient and effective execution.

The acquisition process is a sequence of decision points interspersed with activity phases with the goal of achieving the overall programme objectives and reducing risks. It begins with the concept exploration phase and terminates with the commissioning phase. The increasing sophistication and capabilities of weapons has driven an increase in these systems' level of complexity. Complex systems have to be developed with great care to ensure their integrity in use. To this end, the structured programme management approach to acquisition is essential. The process is divided into several phases, each with its own main purpose. At the end of each phase, a set of values, contained in a baseline, is checked to ensure the integrity of the completed work, thereby creating a clear audit trail for rectifying or improving aspects of the subject.

A baseline is a formally allocated configuration description of information, an item or system, valid from a specific time during its life cycle. The baseline and the approved changes from the baseline constitute the current configuration identification of the system or its elements.

Each of the acquisition phases has a baseline as an output. The definition of the scope of deliverables at these milestones ensures that the work of the previous phase has been fully completed before the commencement of the next. Based on the information available at this point, an informed decision to proceed or terminate is possible.

To reduce the influence of complexity of a target system to be acquired, the process is fragmented to distinguish between the user's requirements, system requirements and engineering designs.

The acquisition process based on that of the US Secretary of Defence in the 1960s (Hatchett *et al* 1992: 87) is typically made up of the following phases and associated baselines, also shown in Figure :

- Requirements Formulation with a Requirements Baseline (RBL).
- Concept Exploration with a Functional Baseline (FBL).

- Demonstration and Validation with an Allocated Baseline (ABL).
- Full-Scale Engineering Development with a Product Baseline (PBL).
- Industrialisation with a Manufacturing Baseline (MBL).
- Production and Commissioning with an Operating Baseline (OBL).

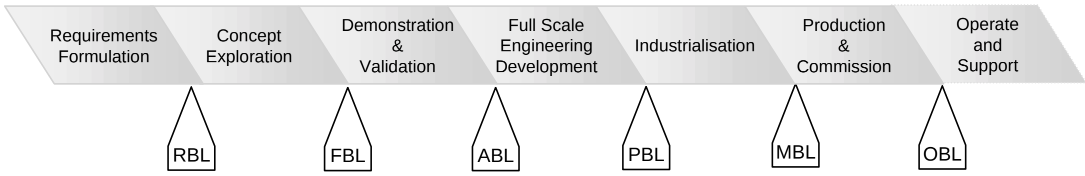

Figure 62: The Phases of the Acquisition Process.

The scope of the acquisition process activities can be visualised as the hierarchical structure shown in Figure 63 in a decomposed form illustrating the context of the main deliverables due at each milestone.

The process starts with a statement of the Required Operational Capabilities (ROC) after the Requirements Formulation phase. System Specifications are in turn, derived from the ROC. The ROC is therefore transformed into a set of potential solutions, each in the form of System Specifications, for consideration. After selection, the most suitable System Specification is decomposed into lower level specifications. These can be Item Development Specifications (IDSs) or Item Product Specifications (IPSs). The IDS is the specification to direct the development of the item. The IDSs can be further decomposed into either IDSs or IPSs at lower levels of the system hierarchy. The IPS is intended for use where an existing item is available for purchase without development being necessary. Lower level specifications are each derived from their higher-level specifications.

The data describing the manufacturing, operating and supporting of the item developed or purchased is held in the PBL.

The items' data is upgraded to MBL by means of the industrialisation process.
The main intention of the development process is to produce a set of documentation containing the data from which the Products can be provided, operated, supported and phased out. The integrity of this data must therefore be qualified and certified.

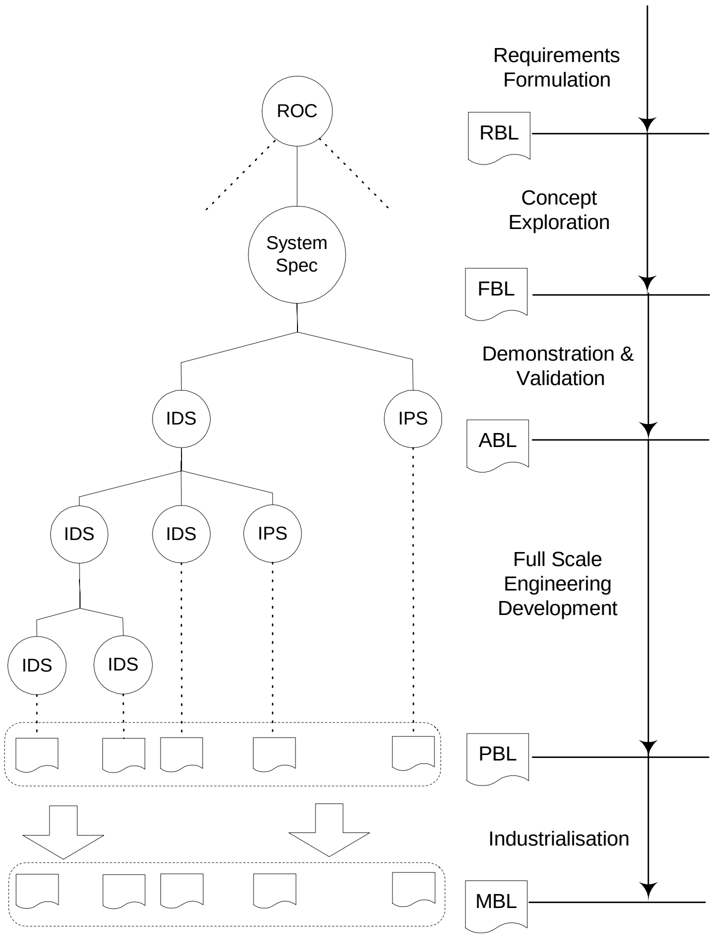

Figure 63: A Hierarchical View of Acquisition.

The target system of the acquisition has two general categories:

- The major equipment, which is the prime purpose of the acquisition, for example a missile and its launching system.
- That "enabling" category which supports the prime purpose of the acquisition, for example the test equipment, storage and repair facilities and the human resources to operate and support the major equipment.

Verification is the process whereby the integrity of a specification reflecting the higher origin is proven.

Validation is the process of confirming that the Product complies with the ROC. In other words, it is a formal process proving that the deliverable Product satisfies the requirements stated by the user.

7.4.1 REQUIREMENTS FORMULATION

This phase precedes the acquisition process and states the requirements that are sought.
The operational requirements necessary to succeed against a threat or range of threats form the body of input to the formulation of requirements.
The major intention of this phase is the accurate and complete documentation of the operational capabilities necessary to achieve the client's goals.
This phase requires the contribution of those knowledgeable in the operational scenarios in question and any evolving or new threats.
Simulation of scenarios can provide useful insights for those developing the requirements statements.

There are three general categories of requirements:

- <u>User requirements:</u> These are normally in the users' vernacular and typically in non-technical language.
- <u>Customer requirements:</u> The customers often tend to translate the users' requirements into a form that they perceive to be accurate. These requirement statements may originate from more than one customer.
- <u>Stakeholder requirements:</u> The system exists in an environment, which includes several stakeholders. Typical examples of these constraints include similar systems which may be expected to share facilities, platforms or other resources for design, technologies, manufacture, support, operation or disposal.

The management of requirements is therefore a complex and demanding business.

The role-players should review the finalised ROC and RBL. After the changes, if any, have been implemented, it is essential that these documents be formally approved (or authenticated) by the main role-players and then placed under configuration control. Any further changes may then only be incorporated in a later issue level of the document after a review and approval. The previous issues must then be withdrawn from circulation and the latest version issued to ensure that all the role-players work from the same baseline.

The prime selection criteria should be clearly identified and classified as mandatory or otherwise to facilitate the selection process downstream.

The authority to proceed with acquisition must be approved or denied at this point.
The Required Operational Capability (ROC) is the main Product of the Requirements Formulation phase. The ROC forms the core of the Requirements Baseline (RBL). The Requirements Baseline (RBL) defines the minimum user requirements for carrying out operations. The RBL defines the capability, availability, dependability and cost of the operational requirement.

The other Product of this phase is the decision whether or not to proceed with the acquisition process.

7.4.2 CONCEPT EXPLORATION

After receiving the authority to proceed, this phase of the acquisition process commences with the data pack from previous phase.
During the Concept Exploration phase, the acquisition team synthesises several alternative solutions to satisfy the ROC. These are typically conceptual solutions and not detail designs. The process should also establish the validity of the ROC by considering present and evolving threats.
The systems engineer derives a system requirement from the user's requirements. This system requirement serves as a conceptual design. The logistics aspects are also designed.
The life cycle costs for each alternative are estimated, allowing for its optimisation.
Using exploratory development models (XDM), the system concepts are then assessed in terms of their feasibility and cost-effectiveness. Simulation of scenarios can facilitate the effort of assessing the various concepts that could satisfy the requirements.
The most suitable alternative is selected for further consideration in the next phase in the acquisition process.

The authority to proceed with the acquisition process is considered and either given or the project terminated.

The output of this phase is the Functional Baseline (FBL) and the decision on whether to proceed with acquisition process.

7.4.3 CONCEPT DEMONSTRATION AND VALIDATION

After receiving the authority to proceed, this phase of the acquisition process commences with the data pack from the previous phase.
The concept is demonstrated using Advanced Development Models (ADM).
The performance of the ADM is compared with the RBL to validate the concept.
The output of this phase is the Allocated Baseline (ABL) and the decision on whether to proceed with the acquisition process.

7.4.4 FULL-SCALE ENGINEERING DEVELOPMENT

After receiving the authority to proceed, this phase of the acquisition process commences with the information in the EDM data pack from the previous phase.
The development personnel develop the system's lower level specifications. They then design and develop the Configuration Items that constitute the system. This includes their testing and evaluation to verify compliance with the specifications. These Configuration Items are the Engineering Development Models (EDM).
The output of this phase is the Product Baseline (PBL) and the decision of whether to proceed with acquisition process.

7.4.5 INDUSTRIALISATION

After receiving the authority to proceed, this phase of the acquisition process commences with the information of the data pack from previous phase.
During this phase, the design of the CIs is upgraded to the Manufacturing Baseline (MBL) for ease of the production process. The Pre-Production Models (PPM) are based on the MBL.

The output of this phase is the MBL and the decision on whether to proceed with the acquisition process.

7.4.6 PRODUCTION AND COMMISSIONING

After receiving the authority to proceed, this phase of the acquisition process commences with the data pack from the previous phase.

Products based on the MBL are subjected to qualification, acceptance testing and certification for fitness for use. The Air Force would for example require airworthiness certificates for airborne Products Systems, Products or Configuration Items.

The MBL is upgraded to the Operation Baseline (OBL) against which the Products are supported.

Combat-ready Products or Products Systems are allocated for use within User Systems.

7.4.7 FINDINGS

The acquisition process is an orderly, structured process with milestones at the end of each phase. The progress of the acquisition project can be assessed and if unsatisfactory, it can terminate at any of the milestones. The use of baselines enables a coherent approach to acquisition and provides a standard against which performance and upgrades can be managed.

7.5 THE SYSTEMS ENGINEERING PROCESS

7.5.1 INTRODUCTION

The Systems Engineering Process is a formal procedure designed to cope with the complexity of the acquisition and upgrade of weapons systems. It forms a subset of the Project Management activities. The US DoD's MIL-STD-499A (1974: paragraph 3.3) defines the Systems Engineering Process as:

> *A logical sequence of activities and decisions transforming an operational need into a description of system performance parameters and a preferred system configuration.*

The amount of documentation defining the system being created should be kept to a minimum. Stipulated plans, reports, and other data items should be used to record the engineering outputs wherever possible. The repository of the data accumulated in this process must be defined. Engineering data must be the sole source of performance requirements used in the design and production of the system being created. For each project the technical objectives must be established so that meaningful relationships between need, urgency, risks, and worth can be established. Each baseline along the acquisition life cycle phases must be developed progressively (MIL-STD-499A 1974: paragraph 4).

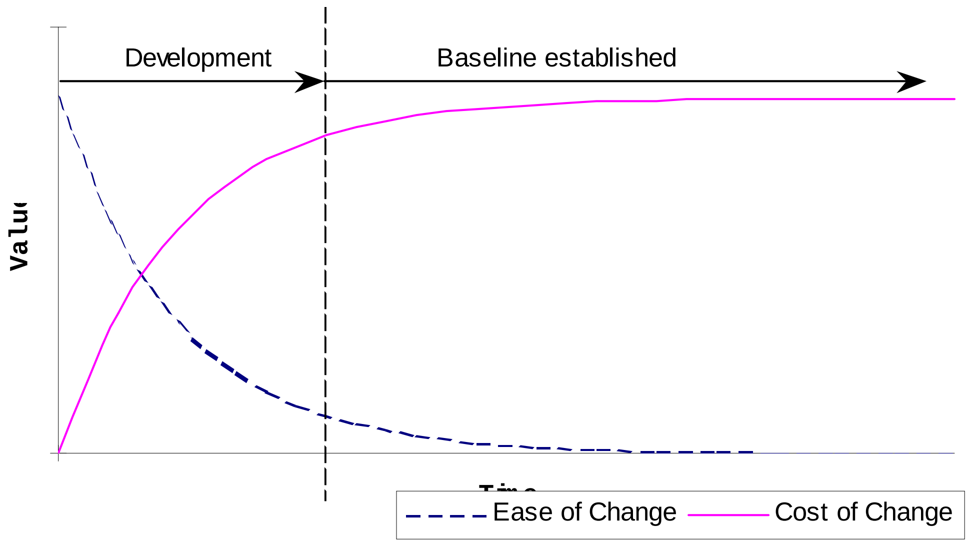

Figure 64: The Trend of Cost and Ease of Change Over Life cycle.

Figure 64 shows how changes to the design or configuration are considerably easier and less expensive earlier in the development phase of the life cycle (Blanchard et al 1998: 37). Therefore designs should be verified as soon as possible so that changes have a smaller cost effect. Poor decisions made upstream are considerably more expensive to rectify later, especially when the design is in the operational and support phase. Sound design requires competent engineers using processes with integrity.

7.5.2 SYSTEMS ENGINEERING ACTIVITIES WITHIN THE VALUE CHAIN

Rigby (2000: 1) proposed the basic model of the development process shown in Figure 66 illustrating its iterative nature. The significance of the data and its integrity is also prominent in the model.

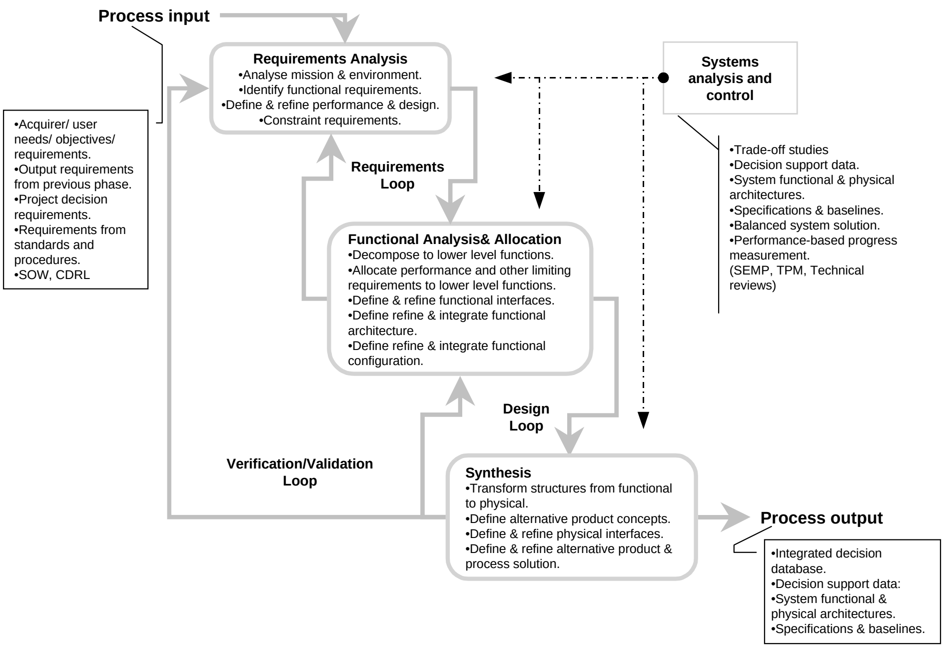

Figure 66: The Basic Systems Engineering Process Model (Rigby 2000: 1).

Figure 67 shows another perspective of the Systems Engineering Process described by the IEEE P1220 (1994: 13)

During the Concept Exploration phase of the Acquisition process, the Systems Engineer compiles a plan known as the Systems Engineering Management Plan (SEMP). The following activities form part of the Systems Engineering Process (SEP) (Rigby 2000: 1):

- Mission requirements analysis: This process includes the analysis of the stated operational characteristics, mission objectives, threats, environmental influences and minimum functional performances.

- Functional analysis: This includes those activities that systematically identify the modes and states of the system. In this manner it is possible to identify suitable alternatives for meeting system performance and design requirements.

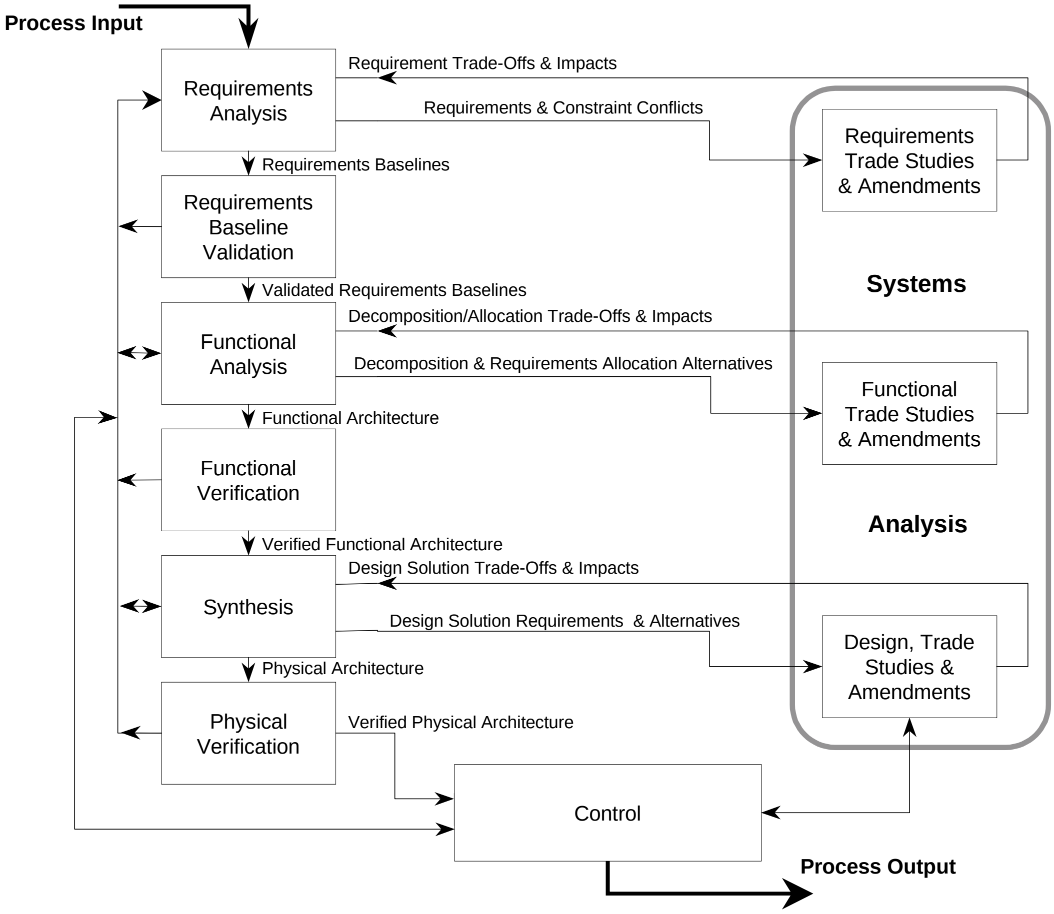

Figure 67: The Systems Engineering Process (IEEE P1220 1994: 13)

- Functional allocation: Each function within the system is allocated a set of performance and design characteristics. This is typically found in the interface requirements specification, software requirements specification and the critical item development specification.

- Synthesis: This should develop the preliminary design to the extent that the allocated performance and design requirements are sufficiently complete for detail design to be possible. Requirements must be stipulated so that new ideas and concepts are not inhibited. The Product of this synthesis must include the data needed to develop the following:

- The specifications for the Products System, Products, sub-systems, configuration items, and their realisation.
- Interface control documentation.
- Facility requirements.
- Procedural manuals, etc.
- The task loading of personnel.
- Computer software configuration items (CSCI) and designs.
- Specification trees.
- Project management plans such as WBSs and SOWs.

- Logistic engineering: This develops the cost-effectively optimal logistic requirements for the deployment and operational phases of the programme. The process for achieving this goal is the Logistic Support Analysis (LSA).
- Life cycle cost analysis: This analyses the cost of the system over its life cycle to enable the acquisition team to be able to quantify the cost of ownership for each of the alternatives. This should be performed regularly to reflect the latest concept design changes.
- Optimisation: It is necessary to consider the life cycle costs, risks, performances and schedules in optimising the alternatives.
- Production engineering analysis: This considers the feasibility of producibility, production engineering, and trade-off studies.

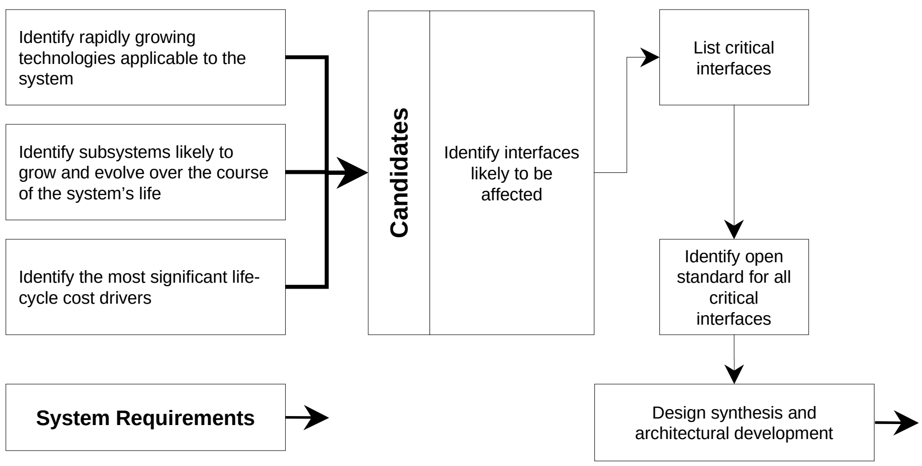

Figure 68: Open Systems Analysis for Integrated Design Solutions (Hanratty *et al* 1999: 53).

Systems Engineering is a key role for SANDF Engineering. The trend towards Open Systems requires a competence in analysis and defining the most suitable market-supported interfaces for the SANDF's applications. Figure 68 shows the process for Open Systems design (Hanratty *et al* 1999: 53).

7.5.3 THE CONTRIBUTION OF SYSTEMS ENGINEERING TO GOOD CUSTOMERSHIP

Employing the following systems engineering principles can ensure good customership (Stevens *et al* 1998: 351):

Acquire for upgradeability: The rate of technological progress dictates that capabilities do not remain static. Upgrades are cost-effective solutions to recover capability leadership.

Acquire Products in families: This minimises the level of effort in support, replacement and upgrading.

- Acquire systems of systems: Open interfaces between the system components ease integration, testing, support and upgrading. A Systems Engineering approach that straddles the individual Products Systems to ensure the compatibility and operation of the systems of systems is desirable.
- Evolutionary acquisition: During the procurement of high-risk items, an iterative approach can reduce risk. This however requires close interaction between the customer and the contractor.
- Employ simulation technology: Simulation technology offers powerful tools for assessing requirements, design and trade-off analysis.
- Acquire for minimum life cycle costs: Faulty or injudicious upstream decisions early in the life cycle may increase support costs. Considerable care in this regard is essential.
- Compatibility with the organisation's business processes: Understanding of the customer's internal business processes when specifying the item being procured can ensure its compatibility. This approach reduces the level of effort in achieving a fit between the organisation and its acquired Products.

CHAPTER 8 THE OPERATIONAL AND SUPPORT LIFE CYCLE PHASE OF PRODUCTS SYSTEMS

8.1 INTRODUCTION

For purposes of convenience, the Disposal phase is included in this chapter.

After commissioning the Products System or Product, the SANDF accepts it into operational service. The Project Officer hands over the Products System or Product to the PSM, who accepts it into service. This Operational/Support phase of the life cycle may extend beyond 20 years. The User System Manager is responsible for force provision and application. The PSM is in turn responsible for providing the User System Manager with sufficient combat-ready Products Systems.

The Products System will in all probability be upgraded during the Operational/Support life cycle phase. Upgrades are necessary to enhance the Products System's capability in the face of evolving or new threats or to improve its supportability or reliability. The life of an item resembles the so-called "bathtub" curve shown in Figure 69 below. Initially the item suffers high "infant" failures for a short period after its release to service. The reliability then stabilises until the Product reaches the end of its life cycle. At this time a Product replacement or upgrade will restore the reliability to acceptable levels again.

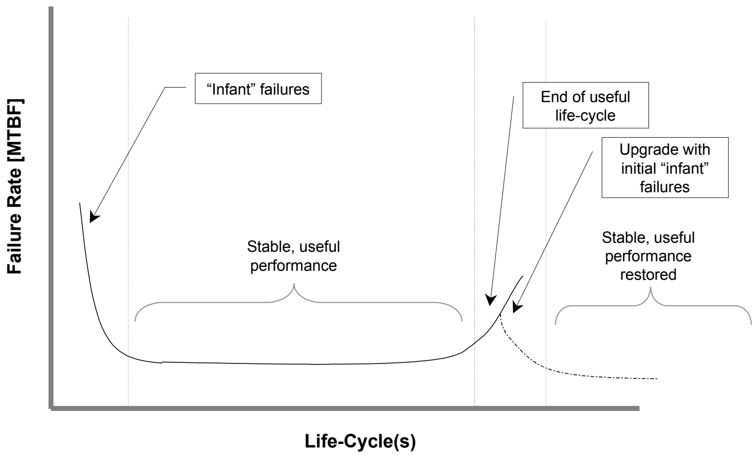

Figure 69: The "Bath-Tub" Curve during the Product's Life cycle.

Upgrades can be more cost-effective than replacing Products Systems. In the USA this has become the most common way for new technology to enter into service (Reppy 1992: 76). Upgrades generally need to follow the phases of the acquisition process to ensure and confirm their quality. Engineering expertise is essential for efficient and effective development or upgrade of Products or Products Systems.

8.2 ENGINEERING EFFORT

Although the development phases are complete when the Products or Products Systems enter service, some level of engineering expertise is still necessary. This expertise is concerned with the following functions:

- Ensuring the integrity of Products Systems.
- Developing new or superior capabilities.
- Integrating upgraded capabilities.
- Assessing the effectiveness of Products for operations.
- Directing capability development.

CHAPTER 9 and CHAPTER10 describe these functions more fully.

8.3 PRODUCTS SYSTEMS SUPPORT

After commissioning and acceptance, the PSM is responsible for managing the combat readiness and cost-effectiveness of the Products System. The PSM is also involved in the Commissioning to ensure the integrity of the Products System and the associated support system. The User contracts the PSM to supply combat-ready Products Systems at an agreed rate and configuration(s). The PSM manages the Products that constitute the Products Systems. This includes contracting support to ensure the combat-readiness required by the User System Manager.

Although the PSM's main duties occur during the Operate and Support phase, they also include activities through all the life cycle phases. The extent of the PSM's activities over the life cycle are shown in Figure 70. The PSM is required to contribute to the formulation of support requirements. During the acquisition phase, the PSM will assess the development of the support system and participate in the commissioning phase with the rest of the acquisition project team.

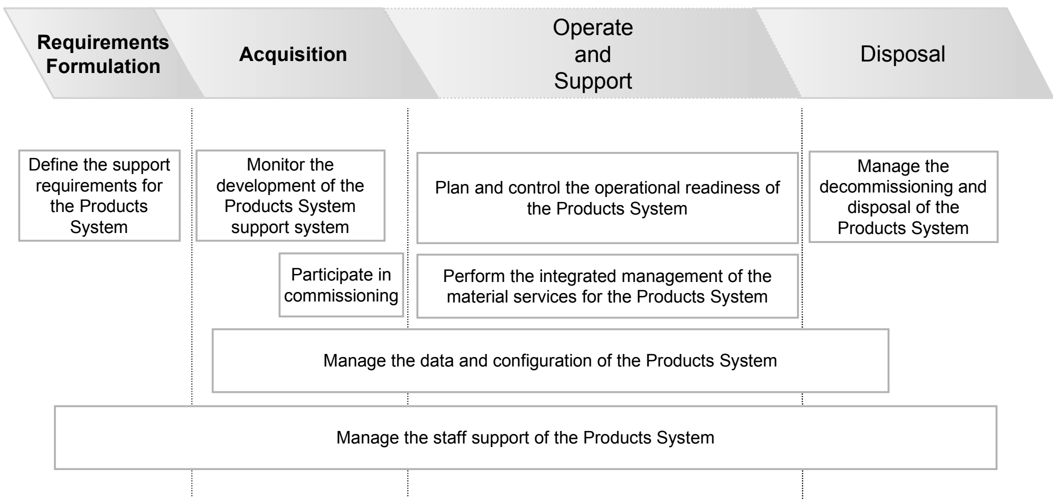

Figure 70: PSM Life cycle Activities (SA Army 1998: E.2).

The PSM contracts out support to organisations both within and outside the SANDF. The SAAF considers the support of Products Systems to consist of the following twelve logistic elements:

- Infrastructure and facilities
- Maintenance and technical support
- Material supply and management
- Personnel and training
- Technical publications
- Operating management system
- Reliability and maintainability
- Design expertise
- System expertise
- Logistics support analysis (LSA)
- Logistics support plan (LSP)
- Configuration management

8.4 THE PRODUCTS SYSTEM SUPPORT PROCESS

The User System Manager contracts the Products System Manager (PSM) to provide combat-ready Products Systems. The User System Manager executes the operation. The extent of the operation determines the level of force required to achieve the objective. From this requirement, the PSM is contracted to provide a certain number of combat-ready Products Systems to the User Systems Manager (USM). The PSM requires the following information to be able to plan and provide the combat-ready Products Systems to the USM:

- The number of Products Systems to be deployed.
- The Products Systems deployment rate.
- The configuration(s) required.
- The duration of the operation.
- Commencement date and time group of the operation.

With this information the PSM plans the operation's support. The PSM's human resources include the supply support, maintenance and administrative personnel. The PSM's physical resources include Line Replaceable Units (LRU), lower level configuration items (CI) associated with the Products, support equipment and facilities. The Technical Services of the ETF have the competence to deal with the maintenance tasks.

In two-level support system, the Products Systems are supported at Organisational Level (O Level) and Depot Level (D Level). Additional levels of support such as Intermediate Level (I Level) are used for some Products Systems, but tend to increase support costs.

The Products System support process includes the management of Products Systems and the associated support equipment and facilities. Figure 71 presents a conceptual view of the logistics and maintenance aspects of the process.

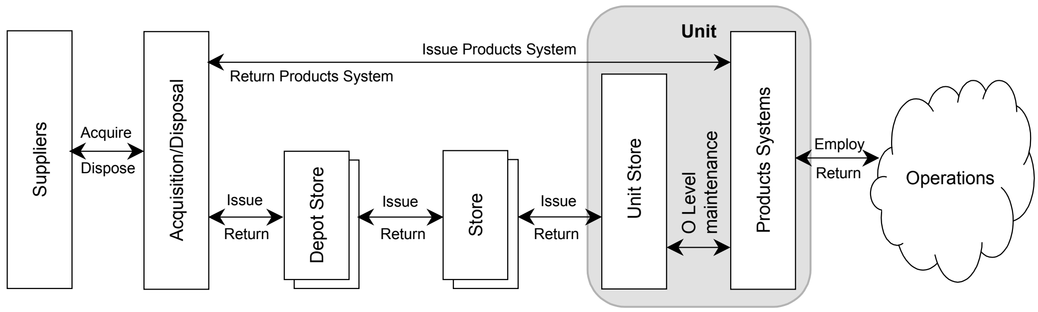

Figure 71: A Products System Supply and Support Materiel Value Chain.

Figure 72 shows a conceptual presentation of the flow of information during the Products System support process.

8.4.1 ORGANISATIONAL LEVEL SUPPORT

At O Level, the support personnel are responsible for ensuring that the Products Systems are combat-ready. This includes the following responsibilities:

- Maintain an adequate LRU stock level in the unit's store.
- Configure the Products System as required for the operation.
- Test the functions of each Product of the Products System.
- Correct malfunctions.
- Repair damage.
- Exchange damaged or malfunctioning LRUs for serviceable items from the unit's store.
- Exchange the unserviceable LRUs for serviceable items, from the store of the next level in the support organisation. (In some cases this could be the D Level organisation.)
- Prepare the Products System for use.
- Certify the combat-readiness of the Products System.
- Hand over the combat-ready Products Systems to the User.

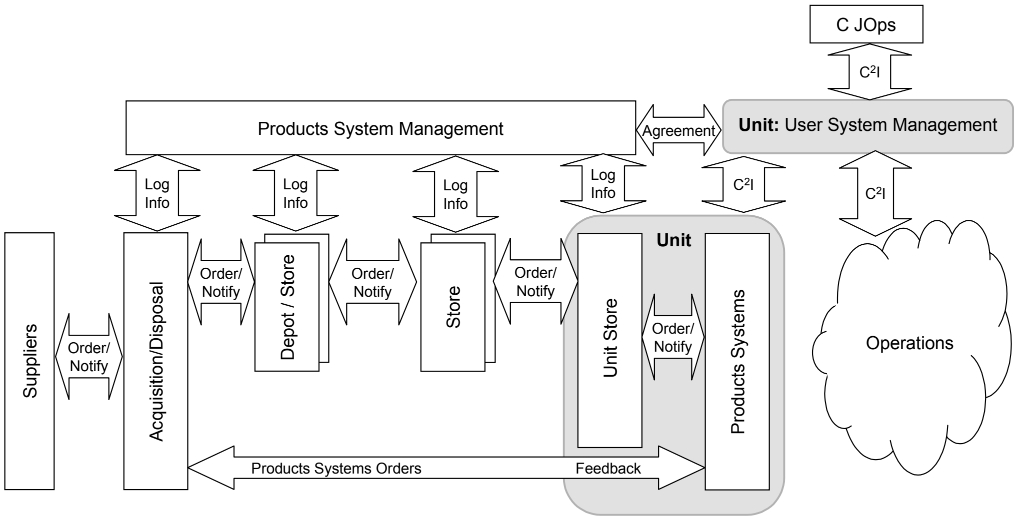

Figure 72: An Information Flow Diagram for a Products System Supply and Support Value Chain.

A. INPUT

The PSM requires the following information from the User System Manager to manage the support of the Products System:

- Budget available to support the Products System.
- Products System configuration(s).
- Spares.
- The above-mentioned requirements of the USM to conduct the operation.

B. OUTPUT

The required number of combat-ready Products Systems, in the agreed configuration(s), sustained for the period of deployment.

8.4.2 INTERMEDIATE LEVEL SUPPORT

At I Level, the support personnel are responsible for ensuring that a sufficient number of LRUs are serviceable and available for use on Products Systems to ensure operational availability.

8.4.3 DEPOT LEVEL SUPPORT

At D Level, the support personnel are responsible for ensuring that an adequate number of Configuration Items are serviceable and available for use on Products Systems.

8.5 PRODUCTS SYSTEM DISPOSAL PHASE

At the end of each Product's life cycle, it is phased out of service. This is a significant life cycle phase, especially in the case of Products such as small arms, explosives and other hazardous items. The capacity for disposal should be designed into the Products System during the Acquisition phase. An example of this principle is the self-destruction of an air-to-air missile if it fails to complete its mission of detonating near a target aircraft within a prescribed time. The launcher would not like to encounter the missile later after it had missed the target.
Certain Products such as small arms are rendered unserviceable to prevent the undesired possibility of their ending up in the wrong hands after disposal.

The Disposal phase typically entails the following main activities (SA Army 1998: R2):

- Perform the Phase-Out study to confirm the validity of the decision and the influence on defence capabilities.
- Plan the process for decommissioning the Products System.
- Manage the decommissioning process in line with the decommissioning plan.
- Manage disposal of equipment and associated data of the Products System by the supply support function.

CHAPTER 9 : ANALYSIS OF THE ETF APPLICATION

9.1 ETF APPLICATION DURING THE LIFE CYCLE PHASES

An assessment of ETF application during the Product life cycle phases requires re-examination of the high-level representation of the support process shown again in Figure 74.

Each of the major phases during a Product's life cycle derived from the diagram of the life cycle phases of a Products System or Product presented in Figure 73 are shown in the boxes in Figure 74.

Figure 73: Typical Life cycle Phases of a Products System or Product.

The functions that embody the categories of activities associated with each phase of the Products' life cycle are shown in Figure 74. The overlap of the functional blocks indicates the degree of their interaction. It is essential that the Integrated Logistic Support function should assist the Acquisition in the definition of the support requirement and in the acceptance of the support system. The same is true for engineering. Both the engineering and ILS function should interact closely with the users to gain greater understanding of their requirements and expectations. This knowledge will contribute to greater support competence.

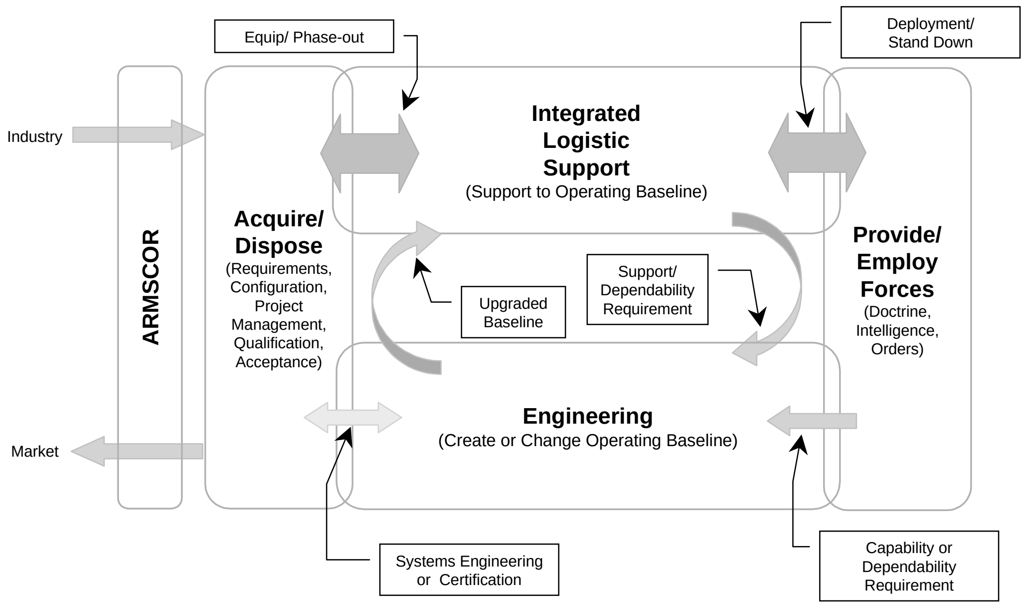

Figure 74: A High-Level Representation of the Support Process

The Operate function develops a User's Requirement Statement (URS) or Required Operational Capability (ROC) that defines the capability required to successfully execute their mandate.

The Acquire/Dispose function sources new Products and Products Systems as defined in the Requirements Baseline (RBL). The test of a successful acquisition is the validation that the Products System satisfies the RBL.

At the end of a Product or Products Systems operational life, it requires disposal. The obsolete items are then withdrawn from the Integrated Support function, phased out of service and destroyed or sold, depending on the nature of the item(s).

The Acquire/Dispose function supplies the Products or Products Systems to the Products Systems Management for Integrated Logistics Support. The Products Systems Management supports the Products as prescribed in the Operating Baseline (OBL).

The Integrated Logistics Support function includes the processes of storage, transport, packaging, handling, repair, maintenance, configuration control and testing of the Products and Products Systems. The purpose of these processes is to provide the User System Manager with combat-ready Products Systems for deployment as part of User Systems. On completion of use, the User System Manager returns the Products Systems to the Products Systems Manager. When returned, the Products Systems are restored to a combat-ready state, ready for the next demand from the User System Manager. The ETF's Technical Services forms an integral part of the ILS function by attending to the maintenance activities

The Products Systems Manager refers any requirements for supportability or reliability improvement to the engineering Support function in a formal request. This support function analyses and assesses the requirement, presenting a potential solution in a formal report. Should the solution appear to be unfeasible or require the correction of operator error, the OBL will remain unaltered. In the case of a change being required, the engineering Support function will develop a solution. The rigorous engineering change process ensures a safe, cost-effective capability. The engineering changes are placed under configuration control. The Products Systems Manager issues modification instructions for execution on Products in inventory.

The Operate function of the User System Manager either employs, trains or prepares forces for force application, using the Products Systems.

The User System Manager will present any new operational requirements as capability or dependability requirements to the engineering support function. As described in the previous paragraph, engineering support will present a change proposal to the User System Manager and Products Systems manager. Approved proposals are developed, tested, evaluated and certified for operational use. These certified changes in the OBL are placed under configuration control. These modification instructions are issued for fleet embodiment.

In certain cases where the size and scope of the project merit it, engineering support will hand over the management of the upgrade project to the acquire/dispose function.

Several parties with ETF expertise are involved during the Product life cycle shown below. External organisations also execute ETF activities supporting the SANDF. The SANDF is involved in all but the manufacturing activities. The SANDF is the main player in requirements management, the Provide Forces and Employ Forces processes.

The DERIs contribute mainly during the development, commissioning and acceptance phases with their human and infrastructural resources. During the manufacturing phase they occasionally provide expertise in developing niche areas of strategic independence, reducing vulnerability to suppliers and contributing to local employment and wealth creation by the ability to export high value-added Products. In some instances they provide expertise to the Products Systems support effort or operations research for force preparation and employment (Anderson 2000: paragraph 3.2).

Firms providing technologies or Products are involved throughout the development, testing and manufacturing phases. Firms providing Products or support may also support the Products and Products Systems.

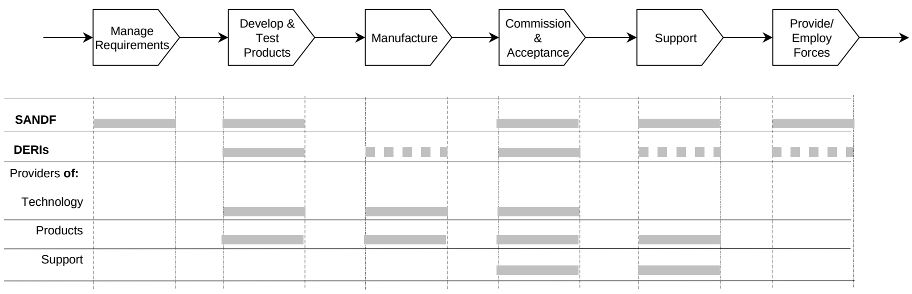

Figure 75: The Application of the ETF during the Various Life cycle Phases.

Each phase of the life cycle requires an appropriate set of skills profiles to achieve the associated goals.

9.2 ETF SKILLS AND COMPETENCIES

Joubert (1988: 3) identified six areas of skills required of ETF members. He found that the spread and levels of competency in each of the skill areas differed between the ETF categories. This can therefore, classify the ETF category required for a task by identifying the competency/skills profile needed for the task. By considering the sum of blocks in the skill columns of each engineering category one can derive a single figure of merit for competence. Table 27 shows the result of this effort. The dexterity of the engineers and technologists was not evident from Joubert (1988: 13) and this aspect was left as zero as its value could not be calculated.

	Occupational Class			
Skills	Artisan	Technician	Technologist	Engineer
Communications	2	12	16	16
Management	0	4	12	15
Inter-personal	2	3	10	11
Dexterity	10	18	0	0
Technological	5	16	19	21
Intellectual	2	11	14	19

Table 27: An Approximation of the Competencies of the ETF Derived by Joubert (1988: 13).

To facilitate categorising the levels of the competencies during the life cycles, a scale of three levels of competence is preferable. This attempt, presented in Table 29, is based on the decision table in Table 28. The upper and lower limits are evenly spaced up to the highest score for each case and shown on the left side of the table.

If:	Level:
Competence Score < Lower Limit	L
Lower Limit ≤ Competence Score < Upper Limit	M
Upper Limit ≤ Competence Score	H

Table 28: Competence Decision Table.

The artisan's competency according to Joubert (1988: 13) is two, which being lower than the lower limit of five is therefore classified as a low (L) level of competency. The resultant competency levels appear on the corresponding right-hand side of Table 29.

Limit			Occupational Class			
Lower	Upper		Artisan	Technician	Technologist	Engineer
5	10	Communications	L	H	H	H
5	10	Management	L	L	H	H
4	8	Inter-personal	L	L	H	H
7	13	Dexterity	M	H	L	L
8	15	Technological	L	H	H	H
7	13	Intellectual	L	M	H	H

Table 29: A Three-Level Derivation of the ETF Competencies from Joubert's (1988: 13) Findings.

Some of the results in Table 29 are still unsatisfactory when compared to general experience. These results are adapted in Table 30 with the following reasoning:

- The communication skills of the technicians may be lower than those of the technologists, and are therefore adjusted to medium.
- The interpersonal skills of the technologists and engineers are generally lower than those of people involved in the human sciences, whose work requires a high level of competence. Medium interpersonal skills levels have therefore been noted for technologists and engineers.
- Artisans are typically more dexterous than the other ETF categories. High competencies have therefore been applied for artisans, and medium for the others.
- By virtue of their training, engineers should have a higher level of intellectual and technological competence than the technicians and technologists. Low and medium level competencies are therefore allocated to the latter ETF categories.
- Engineers have a higher level of training in the basic natural sciences and are therefore better equipped for the intellectual processes in engineering than are the other ETF classes. The intellectual competence level of technologists is therefore adjusted to medium.

	Occupational Class			
Skills Areas	Artisan	Technician	Technologist	Engineer
Communications	L	M	H	H
Management	L	L	H	H
Inter-personal	L	L	M	M
Dexterity	H	M	M	M
Technological	L	M	M	H
Intellectual	L	M	M	H

Table 30: A Modified Three-Level Interpretation of the ETF Competencies.

9.3 THE ETF ROLES IN THE PRODUCTS SYSTEM LIFE CYCLE

The ETF category needed for each of the processes in the Products System life cycle phases can be identified by specifying the competence/skills requirement of each task. For ease of analysis, the competencies in these skills are rated as low (L), medium (M) and high (H). Table 31 shows the profile of competencies in these skills needed for the Requirements Formulation phase.

Skills																		
Communications			Management			Interpersonal			Dexterity			Technological			Intellectual			Activities
H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	**Requirements Formulation**
x			x				x				x		x		x			Manage User Requirements
x			x				x				x		x		x			Support User Requirements management
x			x				x				x		x		x			Manage projects
x			x				x				x		x			x		Manage configuration

Table 31: Competency Requirements for the Requirements Formulation Phase.

The profile of competencies in these skills needed for the Acquisition phase is shown in Table 32.

Skills																		
Communications			Management			Interpersonal			Dexterity			Technological			Intellectual			Activities
H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	**Concept Demonstration and Validation**
x			x				x				x		x		x			Manage projects
x			x			x					x	x			x			Plan and execute Systems Engineering Process
x			x				x				x		x			x		Manage configuration
x				x			x				x	x			x			Functional Analysis and Allocation
x			x			x					x	x			x			Synthesis of solutions
x			x			x					x	x			x			Investigate capability, dependability and supportability.
x			x			x					x	x			x			Simulate and validate
x			x			x					x	x			x			Define interfaces
x			x			x					x	x			x			Review and document System Requirements
																		Full Scale Engineering Development
x			x			x					x	x			x			Manage projects
x			x			x			x	x		x	x	x	x	x	x	Design and develop Configuration Items
x			x			x				x			x		x			Test and evaluate Configuration Items
x			x			x					x	x			x			Review and document designs
x			x			x					x	x			x			Integrate Configuration Items into higher systems
x			x			x					x	x			x			Test and evaluate systems
x			x			x					x		x		x			Verify compliance with specifications
x			x				x				x		x			x		Manage configuration
																		Industrialisation
	x		x				x		x			x			x			Industrialise Configuration Items
x			x			x				x			x		x			Test and evaluate Configuration Items
x			x			x					x	x			x			Review and document designs
x			x			x					x	x			x			Integrate Configuration Items into higher systems
x			x				x				x		x		x			Test and evaluate systems
	x		x				x				x		x		x			Verify compliance with specifications
x			x			x					x		x		x			Manage projects
x			x				x				x		x			x		Manage configuration
																		Commissioning and Acceptance
x			x			x					x	x			x			Test and evaluate systems
x			x				x				x		x		x			Qualify and certify Products Systems
x			x				x				x		x		x			Certify safety of Configuration Items
x			x				x				x		x		x			Operational Test and Evaluation (OT&E) (Validation)
x			x			x					x		x		x			Manage projects
x			x				x				x		x		x			Manage configuration
x			x			x					x	x			x			Integrate new Products into service

Table 32: Competency Requirements for the Acquisition Phase.

Table 33 shows the profiles of competencies in those skills needed for the Operational and Support, Upgrade and Disposal Phases.

Skills																		
Communications			Management			Interpersonal			Dexterity			Technological			Intellectual			Activities
H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	**Operation and Support**
x			x			x					x		x		x			Manage Products System and activities
x			x			x					x		x		x			Manage Products and activities
x			x			x					x		x		x			Manage projects
x			x				x				x		x			x		Manage configuration
		x		x				x			x			x			x	Package, store and transport Configuration Items
		x			x		x		x					x		x		Maintain, test, repair and fit Configuration Items
		x			x		x		x					x		x		Maintain, test, repair and fit Products
	x			x			x				x			x	x			Certify combat readiness of Products Systems
	x		x				x				x		x		x			Manage Reliability, Availability and Maintainability
x			x			x					x		x		x			Manage staff support
																		Upgrade
x			x			x					x		x		x			Support User Requirements management
x			x			x					x	x			x			Manage projects
x			x				x				x		x			x		Manage configuration
x				x			x				x	x			x			Functional Analysis and Allocation
x			x			x					x	x			x			Synthesis of solutions
x			x				x				x	x			x			Investigate capability, dependability and supportability.
x			x				x				x	x			x			Simulate and validate
x			x				x		x			x			x			Develop or upgrade Configuration Item baselines
x			x				x		x			x			x			Industrialise Configuration Items
x			x			x					x	x			x			Test and evaluate systems
	x		x				x				x		x			x		Qualify and certify Products Systems
	x		x				x				x		x			x		Certify safety of Configuration Items
	x		x				x				x		x			x		Certify and accept Products Systems
x			x			x					x		x		x			Integrate upgraded Configuration Items into service
																		Disposal
x			x				x				x			x		x		Manage configuration
x			x			x					x			x		x		Manage project
	x		x				x				x			x		x		Package, handle, store & transport Items
	x		x					x			x		x		x			Certify safety of Items
x			x				x				x			x		x		Remove obsolete Items from inventory

Table 33: Competency Requirements for the Operational and Support, Upgrade and Disposal Phases.

The matrix in Table 34 showing the competence levels for each skill was derived by grading the ETF competence profiles in Figure 58 into the three levels.

	Skills					
Occupational Classes	Communications	Management	Interpersonal Relationship	Dexterity	Technological	Thinking
Engineers	H	H	M	M	H	H
Technologists	H	M	M	M	H	M
Technicians	M	L	L	H	H	M
Artisans	L	L	L	H	L	L

Table 34: A Profile of ETF Competencies Graded into Three Levels.

A comparison of the competencies employed in the life cycle phases shown in Table 31, Table 32 and Table 33 with the ETF competence profiles in Table 34 allows an assessment of the ETF categories required in the phases. From the preceding tables, the profiles of the ETF role-players are derived in Table 35 below.

	Life-Cycle Phases								
Skills	Requirements Formulation	Concept Exploration	Demonstration & Validation	Full Scale Engineering Developme	Industrialisation	Commissioning & Acceptance	Operate & Support	Upgrade	Disposal
Communicatons	H	H	H	H	H	H	H	H	H
Management	H	H	H	H	H	H	H	H	H
Interpersonal Relationships	H	H	H	H	H	H	H	H	H
Dexterity	L	L	L	H	H	L	H	H	L
Technological	M	H	H	H	H	M	M	H	M
Thinking	H	H	H	H	H	H	H	H	M
Occupational Classes Required									
Engineers	Y	Y	Y	Y	Y	Y	Y	Y	
Technologists	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technicians			Y	Y	Y	Y	Y	Y	Y
Artisans				Y	Y	Y	Y	Y	Y

Table 35: The Profiles of the ETF Role-Players in the Product Life cycle Phases.

The initial two phases of the life cycle need personnel with the profiles of engineers and technologists. The subsequent phases have a higher demand for technicians and artisans.

The phases of the life cycle requiring engineers and technologists deal with the higher levels of the systems hierarchy. Designs of new Products Systems influence both the higher order User Systems, and the User Systems down to the first level of the systems hierarchy.

Technicians and artisans have those competencies in the skill areas required for both the organisational or first-line, and the depot-level support functions.

The roles of the combat officers and operators in User Systems are concerned only with the systems hierarchy from the Product or level 4 upwards. At level 4, the operators will use the Products during the Employ Forces process. In some cases such as in the SAN, the operators may also be artisans or technicians

Figure 76 presents the context of these role-players in the systems hierarchy.

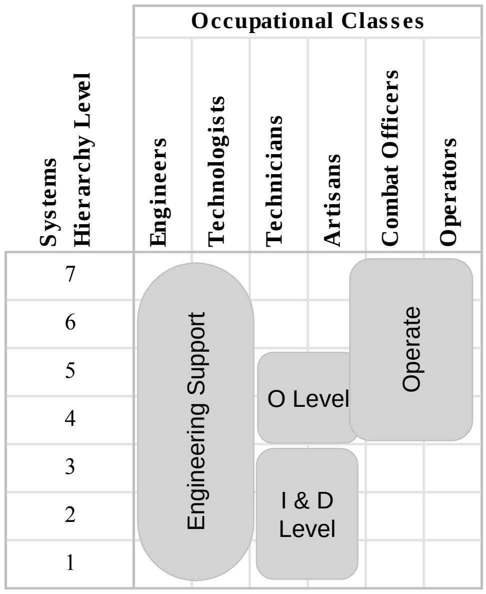

Figure 76: The Context of the Role-Players in the Systems Hierarchy.

9.4 CLASSIFICATION OF RISKS ASSOCIATED WITH PRODUCTS AND PRODUCTS SYSTEMS

The risks associated with software engineering work have been categorised to assess their implications (RTCA/DO/178B 1992: 7). These categories are adopted to represent all engineering design and development work and are briefly described as follows:

- Catastrophic: Those failure conditions that would prevent further safe operation.
- Hazardous/ Severe Major: Those failure conditions that would reduce the capability of the Products System or the operators to cope with adverse operating conditions to the extent that there would be:
    - A large reduction in safety margins or functional capabilities.
    - Physical distress or higher workload such that the operators could not be relied upon to perform their tasks accurately or completely.
    - Adverse effects on occupants including serious or potentially fatal injuries to a small number of those occupants.
- Major: Those failure conditions that would reduce the capability of the Products System or the operators to cope with adverse operating conditions to the extent that there would be:
    - A significant reduction in safety margins or functional capabilities
    - A significant increase in operator workload, or in conditions impairing crew efficiency, or discomfort to occupants, possibly including injuries.
- Minor: Those failure conditions that would not significantly reduce Products System safety, and would involve operator actions which are well within their capabilities.
- No Effect: Failure conditions which do not affect the operational capability of the aircraft or increase crew workload.

9.5 MANAGING RISK WITH ENGINEERING COMPETENCE

The designer is responsible for the consequences of the ownership and operation of a Products Systems. The designer is therefore responsible for the integrity of the Products System. The concept of integrity includes quality, safety, legal compliance and environmental responsibility.

The safety of any Products System is addressed in the Occupational Health and Safety Act 85 of 93 and the White Paper on Defence (1996: Chapter 3 paragraph 43.6). The State is required to ensure the safety of the working environment. The DoD is therefore accountable for the safety of the SANDF's Products Systems.

Quality embraces all the performance capabilities, efficiency and effectiveness of the Products System and its support systems.

The competence levels of each of the categories of the ETF have been discussed in some detail in paragraphs 7.1 and 9.2. In that context, they are, however, still basic competence levels. Applicable experience in a discipline develops competence (Österlund 1997: 135). This process is also known as the Socialisation, Externalisation, Combination and Internalisation (SECI) process (Nonaka *et al* 2000: 12).

Assuming that competence is a function of Products Systems integrity, then the integrity requirements of SANDF Products Systems make designer competence a crucial issue.

On completion of tertiary education, the ETF member undergoes a few years of training before professional registration. The person's performance during training and the professional experience thereafter is a yardstick for measurement of competence.

The degree of risk associated with a Products System should therefore dictate the competence level including the experience, of the person working on it. Certain activities carry greater risks than do others. The design and development of Products Systems is a risky process.

Some of the risk-increasing factors associated with Products Systems include:

- Design and development: Some items are difficult to design and develop while eliminating risks in the Product.

- The application: A military platform may perform high-risk operations, such as in aircraft, ships or land vehicles where failure could result in death, injury, loss of equipment or aborting the operation.
- The application environment: A military platform must be able to operate under adverse conditions. The risk or failure of the Products Systems under these conditions can be high.
- Table 36 presents the roles and minimum experience required for each ETF member for each category of risk.

		Occupational Classes			
		Engineers	Technologists	Technicians	Artisans
Risk Levels	**Catastrophic**	10	S	S	S
	Hazardous	5	10	S	S
	Major	3	5	10	S
	Minor	1	3	5	S
	No effect	0	1	3	S

0 : Applicable experience [years].

S : Work only under supervision.

Table 36: Competence and Experience Requirements for Engineering Responsibilities.

9.6 FINDINGS

The life cycle phases of Products and Products Systems require differing levels of competency in the skill set proposed by Joubert (1988: 13).

Several external organisations such as DERIs and firms from the defence industry contribute towards the SANDF's ETF effort.

Engineers appear to be required throughout the life cycle except for the Disposal phase.

Technologists appear to be required throughout the life cycle.

Technicians appear to be required throughout the life cycle except during the Requirements Formulation and Concept Exploration phases.

Artisans appear to be required throughout the life cycle except during the Requirements Formulation and Concept Exploration and Demonstration phases.

In certain cases such as in the SAN, artisans have dual roles as operators and first line support personnel.

The level of risk inherent in the application of an item determines the ETF category and experience, required to lead the process and to verify its compliance with safety and functional requirements.

CHAPTER 10 ALIGNING ENGINEERING PROGRAMMES

10.1 INTRODUCTION

The main activities of ETF personnel are concerned with the SANDF's inventory of Products Systems. The users are reliant on the capabilities, availability and dependability of their Products Systems. CHAPTER 9 describes the activities of the ETF categories over the life cycle phases. This chapter assesses the Product types of the AoSs and aligns them with the engineering disciplines and their roles within the SANDF.

10.2 ORGANISATION OF ENGINEERING ACTIVITIES IN THE SANDF

The SANDF owns and operates many types of Products in its Products Systems. Table 37 presents an attempt to list the types of Products used by the SANDF. A cross in the corresponding cell in the table indicates Product usage by that AoS employing the Product in its Products Systems.

	AoS			
Product Type	Air Force	Army	Navy	SAMHS
Airfields, bridges & roads	x	x		
Ammunition	x	x	x	x
Armoured structures		x	x	x
Chemical & biological defence	x	x	x	x
Communications systems	x	x	x	x
Displays	x	x	x	x
Electrical drives		x	x	
Electrical storage and supply		x	x	x
Electronic warfare	x	x	x	
Fuel transport & processing	x	x	x	x
Guided weapons	x	x	x	
Gunnery/Artillery systems		x	x	
Inertial systems	x	x	x	
Internal combustion engines	x	x	x	
Light arms	x	x	x	x
Medical systems				x
Mission computers	x	x	x	
Navigation systems	x	x	x	
Opto-electronics	x	x	x	x
Propulsion systems	x	x	x	x
Radar	x	x	x	
Refuse disposal systems		x	x	x
Simulators	x	x	x	x
Sonar			x	x
Structures, airframe	x			
Structures, ship			x	
Structures, vehicle		x		
Turbines	x		x	
Underwater weapons	x		x	
Water processing		x	x	x
Weapons computers	x	x	x	

Table 37: A List of the Product Types used by the SANDF.

The many cases in this table where more than one AoS uses a particular Product type shows that the AoSs share many common Product-related technologies. This enables an assessment of the engineering disciplines required for the Product types. This list of the usage of Product types by the AoS is expanded into a form showing the applicable engineering disciplines supporting the Products' technologies. Table 38 shows the set of engineering disciplines that address the SANDF's Products. The SANDF should, however, not itself employ the full range of expertise needed to develop, manufacture, qualify, certify and support the Products.

Product Type	AoS				Engineering Disciplines						
	Air Force	Army	Navy	SAMHS	Chemical	Civil	Electrical	Electronics	Industrial	Mechanical	Computer
Airfields, bridges & roads	x	x				x					
Ammunition	x	x	x	x	x		x	x		x	
Armoured structures		x	x	x		x			x	x	
Chemical & biological defence	x	x	x	x	x	x		x	x		
Communications systems	x	x	x	x				x		x	x
Displays	x	x	x	x				x			x
Electrical drives		x	x				x	x		x	x
Electrical storage and supply		x	x	x			x		x	x	x
Electronic warfare	x	x	x					x		x	x
Fuel transport & processing	x	x	x	x	x	x			x	x	
Guided weapons	x	x	x		x		x	x		x	x
Gunnery/Artillery systems		x	x				x	x	x	x	x
Inertial systems	x	x	x					x		x	x
Internal combustion engines	x	x	x						x	x	
Light arms	x	x	x	x					x	x	
Medical systems				x	x	x	x	x	x	x	x
Mission computers	x	x	x					x		x	x
Navigation systems	x	x	x					x		x	x
Opto-electronics	x	x	x	x				x		x	x
Propulsion systems	x	x	x	x	x					x	
Radar	x	x	x				x	x		x	x
Refuse disposal systems		x	x	x	x	x			x		
Simulators	x	x	x	x			x	x	x	x	x
Sonar			x	x			x	x		x	x
Structures, airframe	x					x				x	
Structures, ship			x			x				x	
Structures, vehicle		x							x	x	
Turbines	x		x							x	
Underwater weapons	x		x				x	x		x	x
Water processing		x	x	x	x	x			x		
Weapons computers	x	x	x					x		x	x

Table 38: Engineering Disciplines associated with the SANDF Products Types.

The defence industry firms are able to perform certain sections of this work more efficiently. The shareholders establish these firms to receive a return for satisfying a market demand for their Products or services. In competition with other firms, they attempt to develop and manufacture their Products as efficiently and effectively as possible to ensure that they can generate a profit. Firms that fail to do so, fail. Defence forces benefit from the private firms' endeavours through being able to procure capable, competitive Products at relatively low cost. Product supplier firms, and not the military, should therefore undertake the development and manufacture of Products. When the work would not be feasible for a firm, or when a new or an enhanced capability becomes available during a conflict, the defence force may undertake the development and manufacturing of the item for a short period. Thereafter the SANDF should transfer the Product development and manufacture processes to a firm.

Although some are unique to an AoS, most of the Products in Table 38 share common technologies supportable by a single specialist ETF group. Products unique to an AoS would need support by their own specialist ETF group.

Technicians and artisans require training to repair, service and test the Products. This training is generally Product-specific and presented by the Original Equipment Manufacturer (OEM). Product support by Technical Services is therefore relatively specialised. Technical Services would therefore tend to specialise in supporting Products operated by the AoS. More than one Products System may share a common Product and therefore the Technical Service's specialists on that item type.

Engineering deals with Products at a systems level, deriving solutions from first principles or design and from system expertise. Concerned more with the principles and theories, their knowledge will therefore be considerably less OEM-specific. Their commitment to a particular Product type would be *ad hoc,* or when required. Product Specialist Engineers would therefore be able to deal with design, development and support of a Product type across all AoSs.

Engineers with OEMs perform systems engineering, development and other processes with a greater focus on manufacturing and production. Engineers with the SANDF are concerned with the item's military application.

10.3 ETF VALUE-RELATED ACTIVITIES

10.3.1 OVERVIEW OF ETF VALUE-RELATED ACTIVITIES

Vertical integration is the extent to which an organisation executes the activities over the full scope of the value system. The organisation's strategy determines the level of vertical integration. The SANDF's vision, mission and objective give a basis for the ETF's strategy presented in paragraph 6.2. The SANDF's role in the defence value system is based on its mission defined in paragraph 1.2.1, essentially the defence of the RSA. The Products Systems value system shown in Figure 51 is reproduced below in Figure 78 for clarity on this issue.

The prime activities of the SANDF are support, provide and employ forces. These are contained in the last two blocks of the value system diagram in Figure 78.

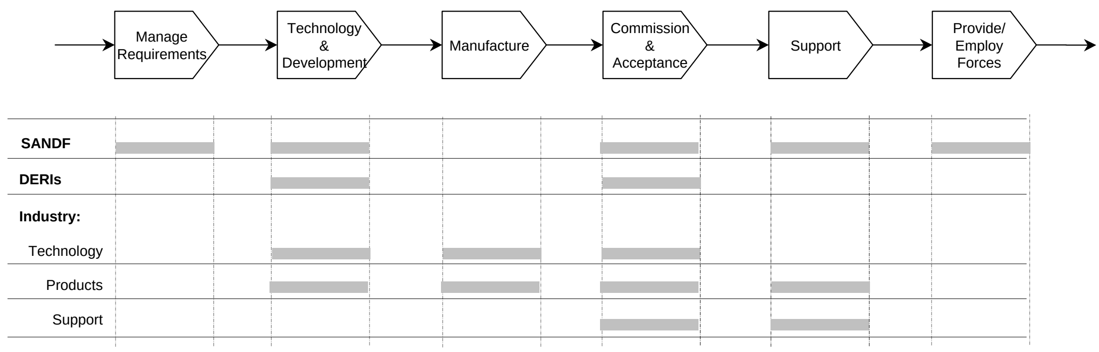

Figure 78: A Representation of the Products System Value System and the Role-Players.

As depicted in Figure 74, the ETF roles within the Support, Provide and Employ forces activities are separated into the two missions of Engineering and Technical Support.

The SANDF consists of the AoSs, each with their Systems Groups/Type Formations. The objective is to sustain the User Systems within the Systems Groups/Type Formations, at the required level of combat readiness. Forces employ people, Products Systems and procedures or doctrines. Products are the building blocks of Products Systems. Figure 76 shows a high-level representation of the ETF roles.

10.3.2 ENGINEERING ROLES

Competence requirements of the Occupational Health and Safety Act of 1993 demand that engineering assures the integrity of the Products Systems and procedure baselines to sustain a safe working environment for the personnel using them. The Act also requires that the Technical Services personnel be competent to maintain the Products Systems.

Table 35 indicates that the engineer and technologist occupational classes are required for the Requirements Formulation life-cycle phase. During this phase, the acquisition team develops the requirement for a particular capability. The designer then embodies this capability in a Products System. The ETF members of this team are therefore participants in the activities listed in Table 31, which are the embryonic stages of the Products System.

Table 32 likewise shows the activities of the ETF occupational classes in the Acquisition phase of the life cycle. Initially only engineers and technologists conduct work during the Concept Exploration phase. Technicians support them during the Concept Demonstration and Validation phase and later during the Full-Scale Engineering, Industrialisation and Commissioning and acceptance phases they employ the support of artisans.

Table 33 shows that the services of all the occupational classes of the ETF are required, except for engineers during the last of the Operational and Support, Upgrade and Disposal Phases.

A. User System and Products System Engineering

The figure below is an attempt to present Systems Group/TyF in the Systems Hierarchies across the AoSs. For simplicity, the figure shows only three Systems Groups or Type Formations (TyFs) for each AoS. The relationship of the higher levels to their lower levels is one-to-many. There may therefore be many Products Systems for each User System, and in the same way, many Products in each Products System.

During the Operational and Support phase, the combat readiness and integrity of Products Systems are the responsibility of a team led by a Products Systems Manager (PSM). The PSM’s team therefore ensures that the configuration of Products is ready for use by the User Systems Manager and that it complies with the Operating Baseline (OBL). The engineering group within the PSM team concerns itself with the capability, operation and integrity of the configuration of Products and the associated interfaces within the Products System. Examples would include a corvette, a fighter aircraft or an infantry fighting vehicle, each with their on-board Products.

The engineers, technologists and technicians of the PSM’s team would tend to confine their activities to the areas of the vertically aligned shapes labelled “Products Systems Engineering”, in the figure. These ETF members of Products Systems Engineering ensure that the Products Systems comply with the OBL, and design and manage the Products Systems support processes and the integration of new capabilities and Configuration Items into the major system. They are therefore responsible for work at levels 5, 6 and 7 of the systems hierarchy. The Products Systems Engineering group is well suited to work at the User System and Systems Group levels because of their competence at the Products Systems level and their understanding of the processes employed at those levels.

B. PRODUCT ENGINEERING

Product Engineering is an area of expertise separate from the PSM's team. The Product Engineering group is concerned with the capability, operation and integrity of the Products. The engineering personnel in this group would be Product specialists and consultants to the PSM's team, and would advise on the optimal support and application of the Product. The tables above list the examples of the SANDF's Products types. Although Products are within level 4 of the systems hierarchy, Product Specialists require certain expertise at Products Systems level to deal with the interfaces with other Products. They also require expertise at the Products Sub-systems and components level. Table 38 shows the span of Product Engineering support required across the AoSs. Specialists within the Joint Services Product Engineering group shown in the figure below provide this support.

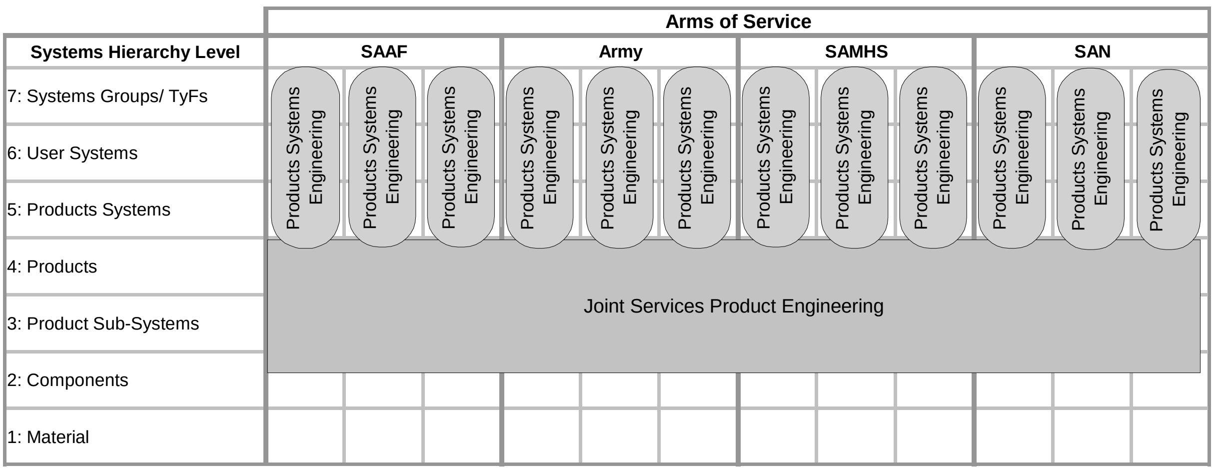

Figure 79: Roles for Engineering Services in the SANDF.

C. JOINT SERVICES ENGINEERING

It is essential that engineering activities be aligned to the corporate goals. There should therefore be a group attending to the operational compatibility of the User Systems of the AoSs at the joint Services or corporate level. It is desirable that this multi-disciplinary team include military operations research, legal and engineering expertise. They will ensure the alignment with the DoD's corporate goals and compatibility of the AoSs' User Systems to ensure that joint operations are performed efficiently and effectively. They will therefore ensure that the Products Systems and User Systems of the AoS are compatible in operations. Engineering would ensure compatibility of the interfaces between the AoSs' Products Systems. This group should also offer advice to commanders on optimal force utilisation and new technologies suitable for operations. The advice to the commanders may be derived through scenario simulations and studies.

10.3.3 TECHNICAL SERVICES ROLES

User requirements demand that Technical Services sustain a specified level of combat-readiness of the Products Systems. To sustain a safe working environment for the operators, Technical Services support the Products Systems as defined by the baselines. These personnel are required to maintain a level of competence to ensure a safe working environment as required by the Occupational Health and Safety Act 85 of 1993 and the Defence White Paper. The competence of the Technical Services ETF personnel is therefore a legal requirement.

The Technical Services' roles during the Acquisition phase of the life cycle have been described in section 10.3.2 above. Their roles are mainly in support of engineering. Table 35 shows the activities of the ETF occupational classes in the Acquisition phase of the life cycle. technicians support the engineers during the Concept Demonstration and Validation phase and later during the Full-scale Engineering, Industrialisation and Commissioning and Acceptance phases they employ the support of Artisans.

The expertise developed by the Technical Services personnel during this phase is invaluable to the PSM's team during the Operational and Support, Upgrade and Disposal Phases. The Technical Services personnel's knowledge of the Operational and Support environment is also valuable to the acquisition team.

Figure 80 shows that Technical Services consists of two distinct types of group. The relationship in the diagram, of the higher levels to their lower levels is one many, as in the case of the previous figure. Some Products may, however, need more than one Intermediate level.

A. PRODUCTS SYSTEM SUPPORT BY TECHNICAL SERVICES

The Organisational Level (O Level) is responsible for the combat readiness of the Products System at the User System level. Figure 80 shows that the O Level area of competence should cover the Product Sub-systems, Products, and Products Systems. The main activities of the O Level group are:

- The testing and certification of Products Systems' combat readiness.
- The diagnosis and correction of malfunctions.
- The replacement of defective Product Sub-systems.

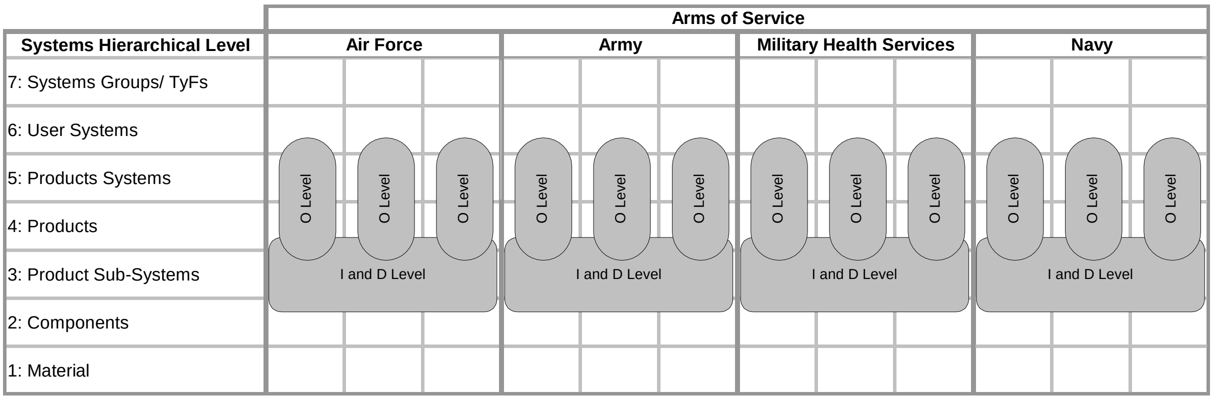

Figure 80: Roles for Technical Services in the SANDF.

B. PRODUCT SUPPORT BY TECHNICAL SERVICES

The other Technical Services group provides a supply of serviceable Product Sub-systems to O Level. For simplicity this latter group is referred to as the Intermediate and Depot Level (I and D Level) group. This group may consist of several subgroups at separate locations at various points in the value chain. Their function includes the diagnosis and correction of Product Sub-systems malfunctions through the replacement of defective components or material.

10.4 VERTICAL INTEGRATION

Vertical integration is the extent to which the organisation performs the tasks along the value chain. In a hypothetical case of vertical integration taken to its fullest extent, the SANDF would

- Mine all the raw materials and manufacture all the items that compose the physical parts of the Products Systems.
- Conceive every idea and develop all the procedures to operate and support the Products Systems.

Full vertical integration is therefore neither the SANDF's core business, nor practical nor cost-effective. Yet a defence force that only executes operations, leaving all support and engineering to outsourced contractors, loses its control over those functions and the ability to influence or adapt to changing operational situations.

Ideally, the SANDF should control the value chain as far as possible, while doing as little as possible. As this is a contradiction, the compromise solution should be based on what the SANDF can do to control the outcome of the value chain.

Should the SANDF fail to control the value chain linkages, the contractors performing the outsourced tasks will be in a position to dictate the terms of future contracts. As an example, an organisation that outsources all its maintenance functions loses control of its management and the skilled personnel. The organisation has little leverage to retrieve the function or personnel. In the case of specialised defence-related items, there may not be any competition to the outsourced contractors. The organisation will then be at the mercy of the outsourced contractors without bargaining power over the cost-effectiveness of the services rendered.

Similarly, loss over key engineering functions will lose the organisation its ability to bargain over the services' cost-effectiveness. The strategic competitive advantage derived from an integral engineering capability will therefore also be at risk.

The SANDF must very carefully consider the extent of vertical integration that provides the optimal balance and benefit to the organisation itself and its contractors.

10.5 CORE COMPETENCIES OF THE SANDF

10.5.1 IDENTIFICATION OF THE CORE COMPETENCIES OF THE SANDF

The core competencies of the SANDF should be aligned with the defence of the RSA. The competencies of all other divisions within the SANDF, including the ETF, should be aligned with the SANDF's core competencies.

For the purposes of this study, it is assumed that the SANDF's core competency is its ability to defeat potential aggressors in an armed conflict. As discussed in paragraph 3.1.8A, this is the achievement of the highest level of value when the various strategic business units harmonise and share their individual competencies.

The divisions within the SANDF each have their own competencies. The competencies of the Infantry Corps, for instance, would consist of a set of capabilities to execute effective and efficient land-based battle drills according to doctrine. The resources, which include personnel, training, Products Systems and doctrine, enable the capabilities.

The ETF competencies include those activities that ensure the timeous provision of combat-ready capabilities to the commander employing the forces.

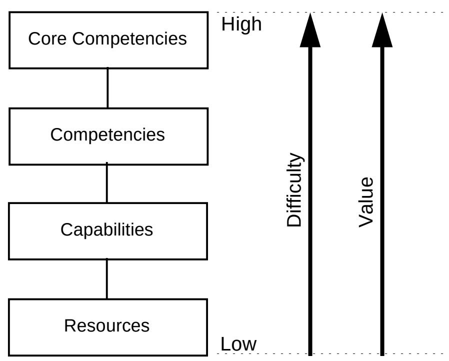

Figure 81: The Competencies Hierarchy (Javidan 1998: 62).

Engineering capabilities includes those abilities to provide optimal capability and dependability solutions for Products Systems and Users Systems at the lowest cost. Resources include:

- <u>Personnel and competencies:</u> Engineers, technologists, technicians, managers and administrative staff.

- Facilities: Offices, test ranges, laboratories, DERIs, IT resources, engineering software and information resources.
- Processes: Systems engineering, Product engineering, management of technology, engineering and configuration, qualification, evaluation, certification and integration.
- Finances: Adequate finances to achieve goals.

	Engineering	Technical Services
Core Competencies	Deterrence, and where unavoidable, the ability to win a conflict.	
Competencies	Provide, sustain and where needed, enhance capabilities and dependability cost-effectively to sustain the SANDF's competitive advantage.	The ability to ensure an adequate supply of combat-ready Products Systems.
Capabilities	Systems engineering, Product engineering, project management, technology management	Maintenance, diagnosis, repair, of Configuration Items.
Resources	Expertise, experience, technology, facilities, skilled human resources and finances.	Expertise, experience, technology, facilities, skilled human resources and finances.

Table 39: The ETF's Contribution to the SANDF's Core Competence.

The Technical Services' capabilities should include the ability to provide the required availability and dependability of Products Systems at the lowest cost. Resources include:

- Personnel and competencies: Managers, technicians, artisans and administrative staff.
- Facilities: Offices, tools, instruments, workshops, stores, transport, IT resources, information resources, training and development.
- Processes: Management and execution of supply, transport, maintenance and configuration processes, testing and fitting,.
- Finances: Adequate finances to provide services.

10.5.2 LINKAGES

In the SANDF's value chain processes, there are several significant linkages to be heeded in an ETF strategy. The high-level view of the support processes presented in Figure 74 is described below. The main linkages between the functional areas include:

- Provide/Employ Forces and Integrated Logistic Support (ILS): There is a bilateral flow of information and Products Systems between these functions. The User Systems Manager determines the resources needed to execute a given operation and informs the

PSM of the requirements. The requirements, described more fully above in paragraph 8.4, include operational details, the Products Systems type, configuration, quantity and rate of supply. The PSM will inform the USM of the Products Systems' availability and cost.

- Provide/Employ Forces and Engineering: In their application within the constraints of the OBL, the Provide Forces function may well experience shortcomings with the Products Systems. These shortcomings may include inadequate capabilities or dependability. The User Systems Manager conveys these shortcomings to engineering. The results of an investigation may include an item's upgrade or replacement, or new operating procedures. In some cases, a new Products Systems acquisition may be needed to cope with the new threat. Engineering presents this information to the User Systems Management. The Users should share their knowledge with engineering to enhance their understanding and hence the quality of solutions.
- ILS and Engineering: When encountering supportability or reliability problems, the PSM presents ILS's requirements to engineering. Engineering can then investigate the cause of the problem and propose an upgrade to the OBL.
- ILS and Industry: This is a contractual relationship whereby the SANDF receives Products, services and training.
- Acquisitions and Engineering: Acquisition should contract the SANDF's ETF for Systems Engineering activities during upgrades or procurement. Engineering should refer larger upgrades to Acquisition for the benefit of their specialised competencies. Acquisition can cost-effectively exploit engineering's competence in specifications, qualification, certification, testing and evaluation when dealing with technology, Product and service providers in industry.
- ILS and Acquisitions: ILS specifies the Products Systems support design concept. ILS qualifies the support system supplied by the service provider and submits the findings to Acquisitions.
- Acquisitions and industry / market: The interface between these entities is formal and contractual. The industry offers proposals to Acquisitions, which then contracts the selected organisation. The Acquisitions group also controls the Directorate of Technology, which supervises the development and evaluation of new defence-related technologies.

- Engineering and Industry: This link is generally through Acquisitions. The ETF act as consultants on military engineering issues during contractual interaction with industry. They also gain Product competence from industry.

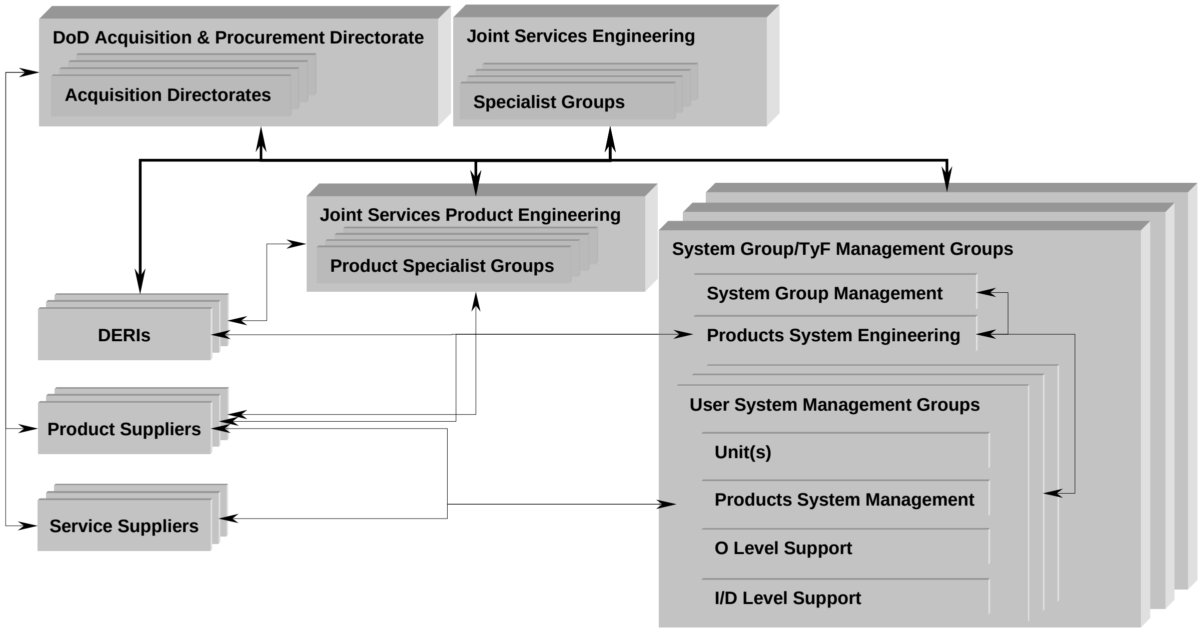

Figure 82: The ETF's Main Links.

- Engineering and DERIs: The ETF can act as a conduit between the operations community and the DERIs. The DERIs can perform their mandate more effectively with the knowledge of operational requirements. The ETF members' academic training, exposure to and experience of the operations community's needs and expectations make them ideal for briefing the DERIs' personnel. The ETF also assesses the DERI's deliverables.
- Engineering and Operations: The operations community may convey their needs and expectations to the ETF. The ETF attempts to understand their needs and discusses potential solutions with the operations community. This is an ideal way to discover applications for new technologies.

Engineering is concerned with the acquisition and application of their systems and technological skills, whereas the Technical Services is concerned with the acquisition and application of skills and physical items. Engineering uses the skills to develop and certify baselines and to provide technical advice on the use of Products Systems. Technical Services uses the skills and items to support Products Systems. Figure 82 shows the main communication links between the ETF groups within the SANDF and the external role-players.

10.6 ORGANISATION OF ENGINEERING PROGRAMMES IN THE SANDF

10.6.1 ORGANISATION OF MAIN ACTIVITIES

Commanders of forces occasionally require upgrading of the capabilities and dependability of their User Systems. Changing processes or Configuration Items achieves these results. Upgrades of processes generally do not always require changes to Products Systems.

Products Systems Managers (PSM) monitor the cost of supporting their Products Systems to assess their cost-effectiveness. The Products Systems Manager may then determine a requirement for upgrades to Products to improve reliability or supportability in order to reduce the cost of the support effort.

A. ENGINEERING ACTIVITIES

Changes to baselines should be directed to the Products Systems Manager who, in conjunction with the User Systems Manager and Products Systems Engineering, formulates and defines the requirement. Where appropriate, the requirement will be addressed by Products Systems engineering, by the Products Specialists or a combination of both.

As described in section 10.3.2 defining the differing roles of the Products Systems engineering and the Product Specialist engineering, the latter would be a function shared by the AoSs. An appropriate name proposed for this function is: Joint Services Product Engineering.

At any given time, each of the Products Systems will have several engineering tasks or projects in process, pending completion. It is essential that the Products Systems Manager ensures that they are all aligned with the operational requirement for the User System. This means that the Products Systems Managers, supported by their Products Systems Engineers, will manage portfolios of projects to form programmes for each of the Products Systems. The Programme Management office of the Joint Services Product Engineering will support the Products Systems Managers in this process, ensuring a coherent approach and process. Figure 83 shows this structure and the interfaces between the main role-players, which include the Products Systems engineer (PSE) who is most competent to deal with technical issues pertaining to user requirements. This simplified figure portrays the Systems Groups/TyFs of the AoSs as well as Product engineering specialist areas employed by the SANDF.

The Joint Services Product Engineering should concentrate its Product specialist groups in one location as far as possible, but be flexible enough to accommodate them at the most efficient centres. It would not be sensible, if the Joint Services Product Engineering centre were situated in Pretoria, to expect the SA Navy's sonar specialists to operate from there.

Joint Services Engineering co-ordinates the direction of the AoSs' growth and harmonises these activities with the DoD's /SANDF's corporate mission, vision and objectives.

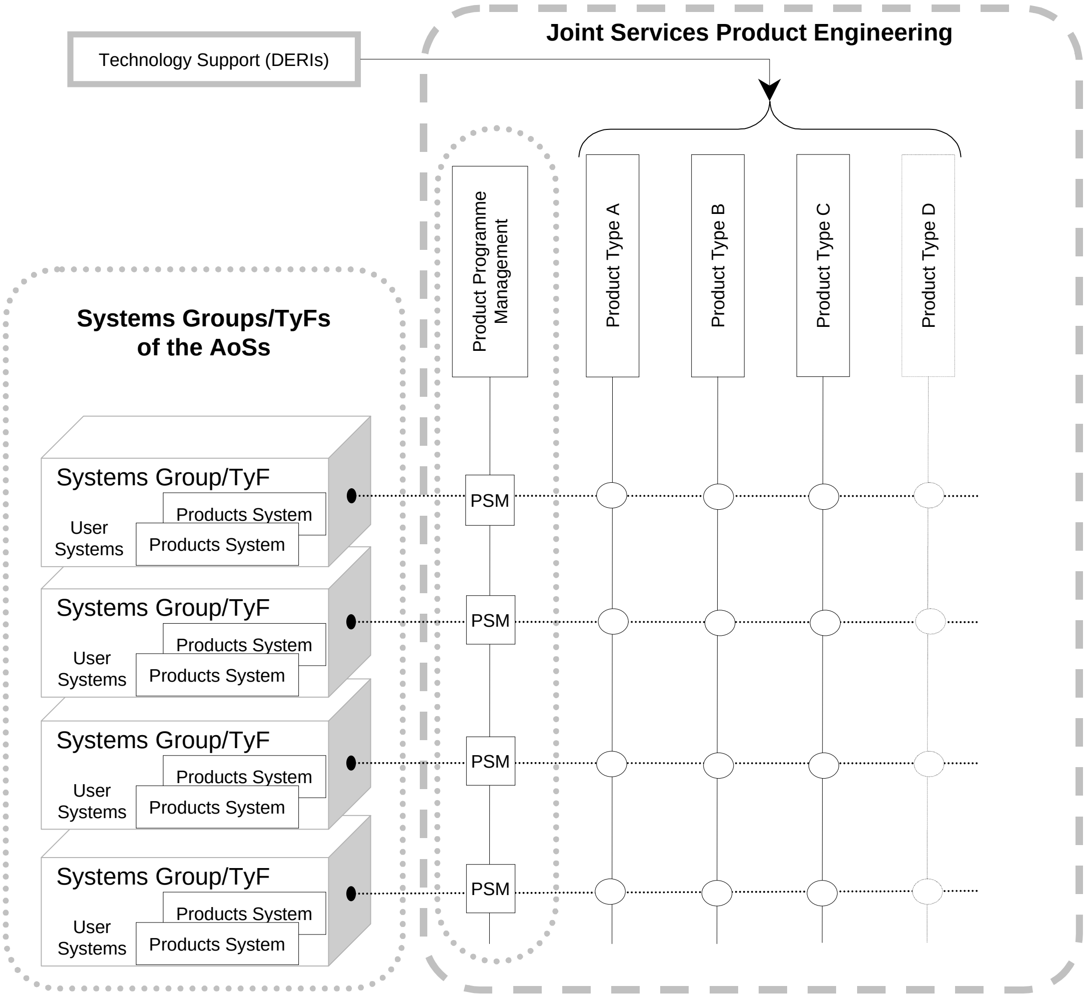

Figure 83: Context of Engineering Support to Systems Groups/TyFs.

B. TECHNICAL SERVICES ACTIVITIES

Products Systems managers manage the availability of their Products Systems through the value chain between the User System and the Depot maintenance facilities as described in section 8.2. Figure 84 presents a higher-level view of the links between the role-players. This figure shows the context of the Products Systems Managers' dealings with the Technical Services.

The Products Systems Manager plays a pivotal role in co-ordinating and contracting services from Joint Services Product Engineering and the various levels of Product Systems support. The Product Systems support organisations shown in Figure 84 differ from the Joint Services Product Engineering capability due to their optimal physical location in the value chain for each of the clients. These organisations may be mobile facilities or, in the case of depots, housed within a larger unit, and in some cases at the premises of a contracting company. The figure shows more than one I Level Support, as this may be the case in certain supply chains.

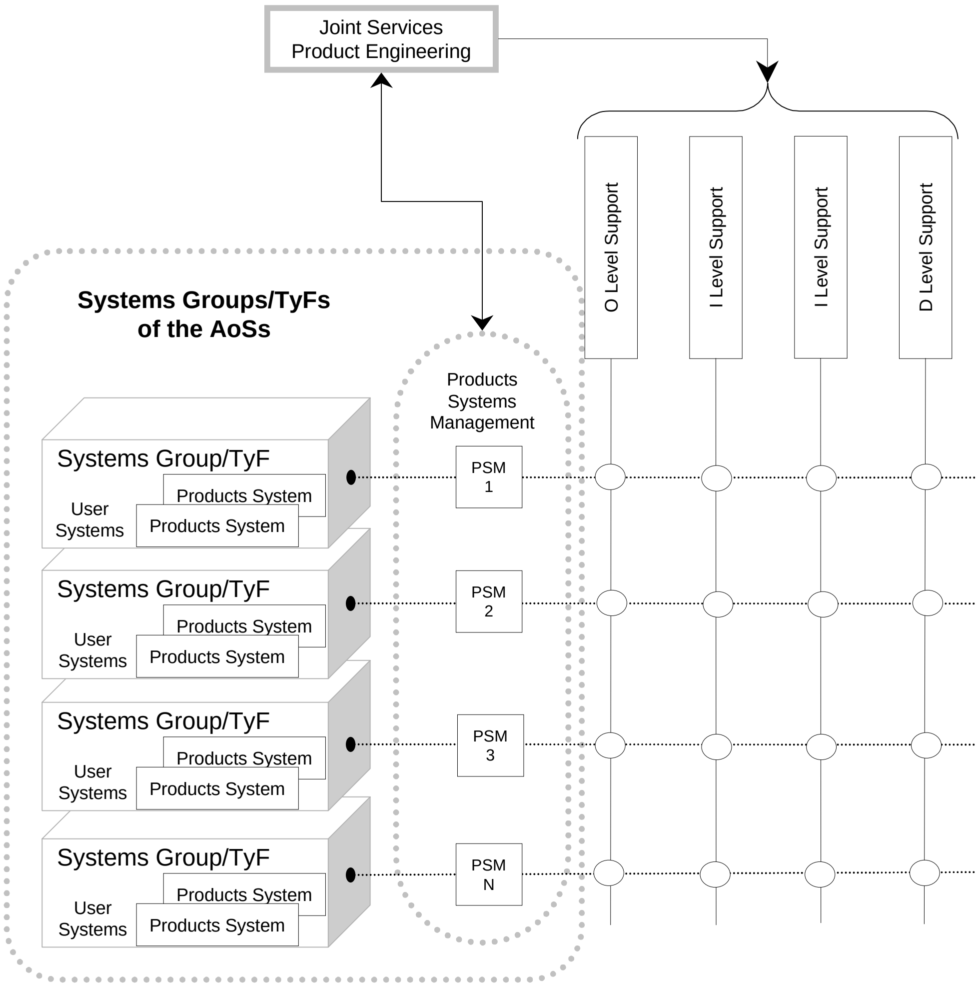

Figure 84: Context of Technical Services Support of Systems Groups/TyFs.

10.6.2 THE MANAGEMENT OF LINKAGES

Linkages in the context of this study are the interfaces between organisations or sections within the organisations. Poorly managed they, may become barriers. Correctly managed, they can become vital links in the value chain.

The SANDF is a large, complex organisation distributed over a large geographical area. The transformation process is an attempt to align the organisation with the core processes. It is imperative that efforts to facilitate the efficient and effective execution of work across the SANDF are successful. The principles and practices of Project Management described in section 3.5 are particularly suitable and relevant in transforming the organisation into one that can coherently execute actions accountably and transparently throughout despite its size.

Of the indicators for the appropriateness of Project Management listed in Section 3.5.7, unfamiliarity of the undertaking, organisational reputation and inter-relatedness appear to be the most significant for the SANDF's ETF activities. The latter two indicators are most significant to the Technical Services activities supporting Products Systems.

A central factor in Project Management is the delegation of accountability and responsibility to the Project Manager. There is therefore one person that has overall authority, accountability, control and responsibility for the success or failure of the project.

Delegation of responsibility for tasks accompanies the tasking of project members and participants. A Project Manager can hold sections within the SANDF responsible for the successful and timely execution of tasks. This approach used in a matrix structure can be both effective and efficient.

As tasking of a person takes the form of an agreement or contract, the method of tasking is important. The description of contracts in section 3.5.3 indicates the importance of the elements of a contract. A competent Project Manager ensures that the role-players understand the schedule, scope and quality of the deliverables expected of them. Failure to define work may result in an undesirable and unusable Product. Project Managers in the SANDF should therefore clearly define the results required from the allocated work.

The agreements for many of the Technical Services functions are relatively simple, as the OBL defines the scope and quality of the work and the User Systems Manager defines the schedule. However, defining agreements for engineering work is more difficult, due to the greater complexity of the projects and the risks associated with the outcomes.

Figure 85 presents an example of the structure of engineering projects. The Systems Engineer derives the major system specification from a requirement statement. The Systems Engineer then decomposes the major system specification into its lower level-specifications.

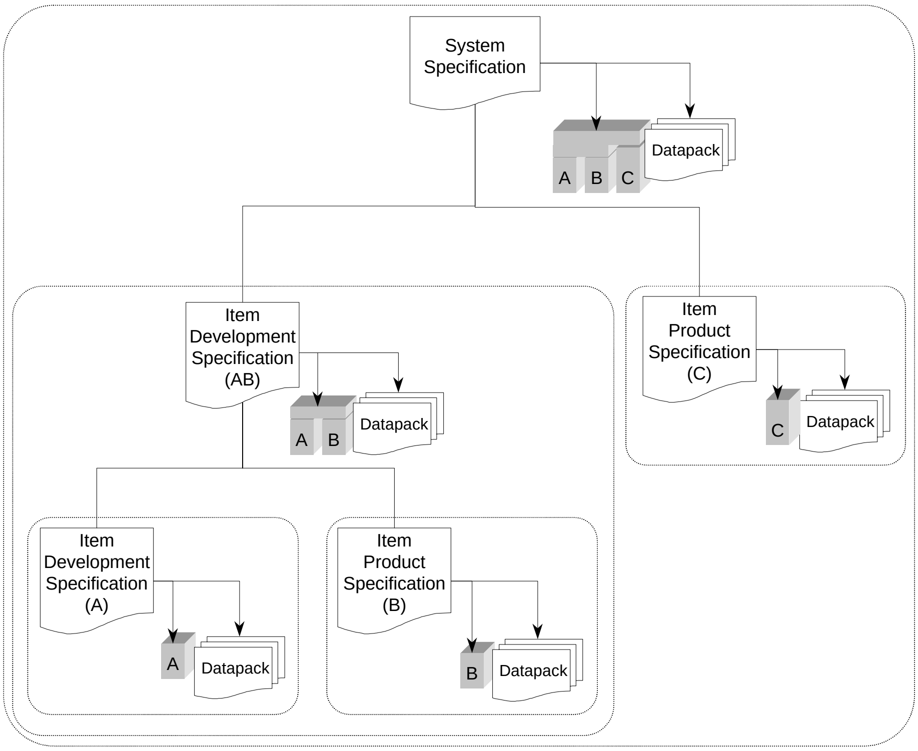

Figure 85: An Example of Tasking in the Specification Tree Hierarchy.

The Project Manager allocates each specification to an engineer to design and develop a physical model with the associated data. Figure 85 shows how Configuration Items “A” and “B” and their associated data may be developed or purchased and passed upwards to be integrated into the next higher Configuration Item “AB”. The Item Product Specification “C” defines the Configuration Item “C” for purchase as a Product off the shelf. The major Configuration Item is integrated from “A”, “B” and “C”.

More than one organisation may develop these Configuration Items. Competent tasking however ensures successful integration of the individual models into the major system. The integration of the Configuration Items is the key competence that should be held by the Products System Engineer within the SANDF. The appropriate specialist group within Joint Services Product Engineering should acquire the knowledge of each of these Configuration Items from the supplier. It is also essential that a configuration management capability within the SANDF hold and manage the data associated with the Configuration Items and their integration. This information is the key to the SANDF’s ability to use, support and upgrade its inventory.

Formal agreements or contracts are important tools in the alignment of separate activities to the project goal. They also aid the effective and efficient management of the associated activities. The formal, written agreement defines the parties' authorities, roles, performance and project responsibilities.

The following is an example of the information that should typically be included in a project agreement:

- Statement of Work (SOW).
- Work Breakdown Structure (WBS).
- The relevant specification.
- Standards applicable to the project.
- Schedule of work and deliverables.
- Identity of the Programme Manager and Project Managers.
- Identity of the other main participants and their roles.
- Customer-furnished equipment.

After the tasking, monitoring of project performance is important. Regular project reports are essential to judge progress and identify difficulties before they become problems.

The SANDF could operate internal agreements between the role-players shown in Figure 83 above. The Products Systems Managers could operate internal agreements between the role-players shown in Figure 84 above. Agreements outside the DoD would be contractual. described in section 8.4 indicates the User Systems Manager's requirements. These requirements are deemed necessary to provide the required level of combat-readiness. Products Systems Managers base their maintenance and repair agreements accordingly. The service provider performs according to those guidelines in the agreement or contract.

10.7 OPTIMISING ETF APPLICATION

10.7.1 APPROACH TO STRUCTURE

The division of Engineering and Technical Services into the two categories focussed on the Products and Products Systems described in Section 10.3, has a parallel in Österlund's (1997: 141) model described in paragraph 3.3.5.

A. ENGINEERING

Engineering is also divided into three roles: the Joint Services Engineering, Products Systems Engineering and Joint Services Product Engineering. Figure 86 is a simplified adaptation of the model for SANDF Engineering, derived from this study and briefly described below.

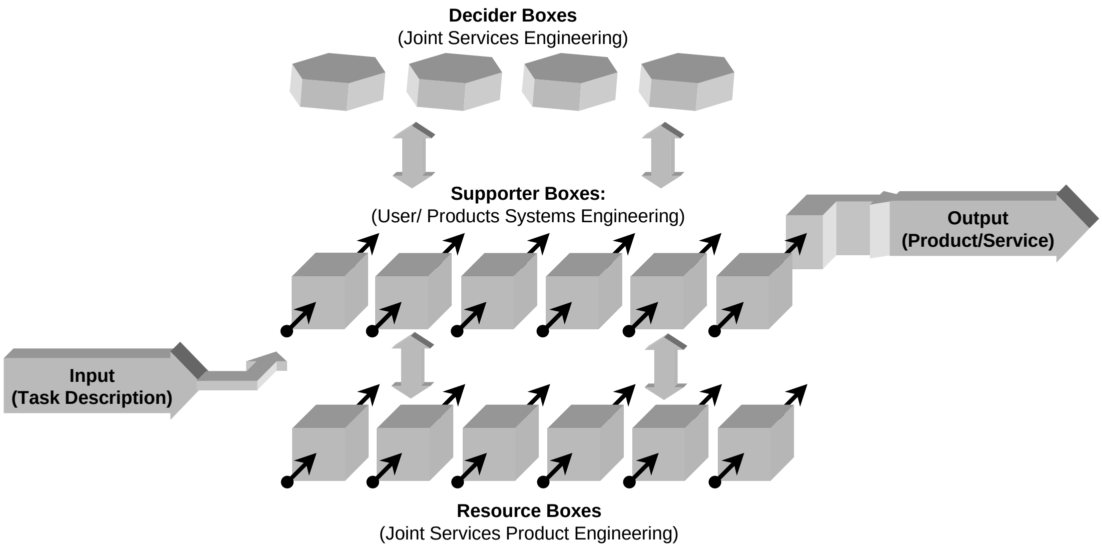

Figure 86: A Model for a SANDF Engineering Structure based on Small Competence Groups.

Products Systems Engineering will typically function within the Systems Groups/Type Formations. Joint Services Engineering and Joint Services Product Engineering will be separate capabilities at the disposal of all the AoSs' Systems Groups/Type Formations.

The operative resource boxes would represent the Joint Services Product Engineering sections of each Product type or type group. The supporting resource boxes would represent the Products Systems Engineering sections of each Systems Group or Type Formation across the AoSs of the SANDF. The decider boxes are a high level group, for convenience labelled Joint Services Engineering, that manage the SANDF weapons strategy. It should be a multi-disciplinary group comprising of military strategists, operations researchers, logistics specialists and experienced engineers. This mix of competencies should provide optimal and well-considered decisions.

The input to this process would typically be a capability requirement from the User System Manager. Utilising the competence of role-players in Joint Services Engineering, Products Systems Engineering and Joint Services Product Engineering specialist groups, will enable them to produce an optimal solution to satisfy the user. This solution will then consider the total SANDF as a system.

B. TECHNICAL SERVICES

The O Level and other maintenance levels of Technical Services provide combat-ready Products Systems for the Users. O Level and other I Levels will typically form part of the PSM's team. D Level may be part of a support formation. The structure shown in Figure 71 and reproduced below could be effectively retained.

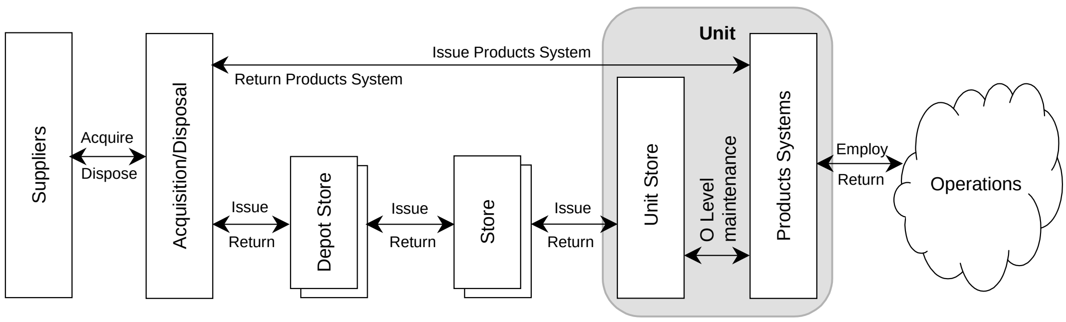

Figure 87: A Products System Supply and Support Materiel Value Chain.

10.7.2 APPROACH TO VALUE CHAIN LINKAGES

Reducing the delay and bureaucracy in the linkages discussed in paragraph 10.5.2 is essential to improving the responsiveness of the organisation to demands on it. The fewer links that a process has to cross the simpler and more streamlined the result. Section 3.1.7 entitled "Strategy in Not-for-Profit Organisations" describes the difficulties encountered in them, and is relevant to the situation in the SANDF. Programme and Project Management are well suited to alleviating or even resolving the problems encountered in a public-sector organisation.

The large gap between the personnel executing operations and those developing defence technology, reduces the responsiveness of the system in identifying and appropriately applying the most valuable innovations. As engineering and application are the two main aspects of innovations, the knowledge of technology projects by the SANDF's engineering and operations personnel would be beneficial to all parties involved. Sharing needs and possibilities stimulates new strategies and applications. The approach proposed by Österlund (1997: 1) for the transmission of competencies is suitable for deployment within a project-oriented SANDF environment.

10.7.3 APPROACH TO TECHNOLOGY STRATEGY

In the SANDF, the Directorate of Technology and the Senior Staff Officer Technological Intelligence carry out the important function of technology scanning.

The information gained from technology scanning presents the SANDF with a picture of real and potential technological threats, and appropriate nascent technologies. This picture is essential for developing and sustaining a coherent technology strategy to support the key success factors presented in Appendix C:

The Joint Services Engineering, Joint Services Product Engineering and the Products Systems Engineering should at least be exposed to the development of technology and, where required and feasible, involved in the process. Their exposure to technologies under development may stimulate new applications. This is an essential competence in exploiting the benefits of Open Systems described in paragraph 7.5.2.

Internationally, technology and Product life cycles have become progressively shorter due to the increasing pace of innovation. Technology forecasting is essential to avoid investment in Products that will become obsolete, and to initiate investment in competitive Products Systems.

User Systems Managers, Engineering and Products Systems Managers could, using the techniques and processes described in chapter 3.2, derive the following benefits:

- Identify technological and Product development requirements to create or enhance capabilities.
- Predict technology obsolescence.
- Identify a nascent technology to replace an older one.
- Identify processes to reduce support cost or effort.

The communication between the role-players of their strategies, knowledge and expertise will enable them to realise the above-mentioned benefits.

10.7.4 APPROACH TO THE MANAGEMENT OF COMPETENCE, KNOWLEDGE, EXPERTISE AND CULTURE

The literature survey in paragraph 3.3 is the basis of this approach towards the management of competence, knowledge, expertise and culture. According to Österlund (1997: 135), competence is the combination of knowledge, skill, experience, communication with peers, upholding of values and the ability to use externally sourced knowledge. Culture influences competence.

The effectiveness of the SANDF as a deterrent is dependent on the competence of its members. Technology provides an additional advantage to a military organisation, but requires competent personnel to design, develop, operate and support the organisation's capabilities. Competence in these areas enhances the effectiveness, efficiency and cost-effectiveness of the organisation. Evaluation, which is part of the development process, is regarded as the highest level of learning. It is also an important key to success in the SANDF's acquisition/procurement process. It is during the acquisition/procurement process, that the greatest learning occurs and this can be the most important source of competence needed during the operational and support phases of Products Systems' life.

With the shortening life cycles of technologies and Products and the international migration to Open Systems architectures, competence in ETF personnel becomes all the more important.

Engineering Productivity is a function of the knowledge worker. Knowledge should be seen as part of the SANDF's quality strategy. Engineers that know and understand the SANDF and its business are better able to propose and design appropriate solutions.

A culture conducive to competence is essential. The factors for a psychological climate presented in paragraph 3.5.4 A are suitable for developing the desired climate and thereby the culture. Communication is the channel for competence: The Integrated Problem Solving Mode described in paragraph 3.3.5 requires rich, intense communication between upstream and downstream groups to integrate practical and theoretical knowledge. This could form part of a culture spreading competence throughout the organisation.

Competent ETF personnel are attracted to the private sector, which is experiencing a diminishing skills pool nationally. The SANDF has to compete in this arena to recruit and retain suitable people.

Continuous development of ETF personnel is essential. Groups of similar competence should be co-located. The number of members in competence groups found within Joint Services Engineering, Product Systems Engineering and Joint Services Product Engineering should not exceed ten to ensure meaningful, professional dialogue. They should, however, maintain communication between the groups.

CHAPTER 11 : CONCLUSIONS AND RECOMMENDATIONS

11.1 OVERVIEW

The RSA's prime concern is the alleviation of poverty through the development of the national economy. The government has paced a high priority on social and development programmes to this end. Because of this priority and the absence of an external threat to the RSA, the Department of Defence receives a disproportionately small allocation of the national budget.

The prime purpose of the SANDF is the defence of the RSA. Secondary roles such as humanitarian aid, support of the SA Police Service and peace-keeping have put pressure on the organisation's ability to operate within its budget.

Rampant crime in the region, increasingly involving criminal syndicates, and the instability of Africa are a dire threat to security and thus the economy. Foreign direct investment has been slow to materialise for various reasons, probably including the crime and regional instability, and this has weakened the growth opportunities for the national economy.

The RSA has significantly fewer scientists and engineers than are found in developed countries. This situation is exacerbated by the emigration of skilled citizens. The DACST, however, has what appears to be a coherent policy to build a competitive science and technology base for the RSA, though. Poor education and a lack of interest in science and technology are a challenge to accomplishing that goal. Overzealous application of affirmative action and "fast-tracking" is depriving people in the designated groups of the opportunity to consolidate their learning growth and competence. The requirement for "representivity" often deprives new entrants to a field of expertise of access to experienced scientists and engineers.

The SANDF has great difficulty in attracting and retaining ETF personnel, mainly due to poor salaries. This study has discussed a case where the cost of paying contractors to supply the same service was about ten times greater than it would have been to triple the salaries of the NCOs that previously carried out the work. It appears that adherence to remuneration policies enjoys greater priority than cost-effectiveness of the department. The acquisition of new Products Systems would restore and enhance many of the SANDF's capabilities. However, the loss of skilled, experienced personnel places the SANDF's ability to sustain its capabilities in dire peril.

The SANDF has to maintain its defence capability as a credible deterrence to any aggressors. It is expected to do this as a small, technologically advanced force.

This study has addressed the contribution that the Engineering Technical Family (ETF) could make towards the following:

- Sustaining and enhancing the SANDF's capability to ensure its role as an effective deterrent to potential aggressors.
- Reduce the cost of ownership, operation and support of the SANDF's resources.

An effective defence force is one that is a successful deterrent by virtue of its military capabilities. The efficient design, evaluation and support of Products Systems would reduce the cost of ownership and sustain an appropriate degree of competitive military advantage. Through achieving the two goals mentioned above, the ETF would improve the cost-effectiveness of RSA's defence capabilities. This would contribute towards the success of the national economy.

As discussed with proposed examples in section 6.2, the ETF's vision, mission and objectives must support those of the SANDF.

11.2 ETF ROLES AND FUNCTIONS

The two main groups within the ETF proposed by this study are:

- Engineering Services develop and upgrade baselines. They ensure the capability, dependability and supportability/cost of Products Systems. The Engineering Services can be divided into three main groups:
    - Products Systems Engineering is responsible for the integrity of the Products Systems within each of the Systems Groups/TyFs.
    - Joint Services Product Engineering is responsible for the integrity of the Products of the AoS within the SANDF.
    - Joint Systems Engineering is responsible for overall systems integrity, compatibility and optimal application of the Products Systems of the SANDF. The Joint Services Engineering function may exist as a virtual organisation.
- Technical Services support Products Systems according to the baselines. They ensure the availability and optimise the support cost of Products Systems:

- Products Systems Support at O Level provides support and maintenance services to the Products Systems of the Systems Groups/TyFs.
- Products Systems Support at D Level and one or more intermediate level(s), supports and maintains the Products Systems' Products.

This process-oriented categorisation of the ETF can be effectively and efficiently employed in the structures proposed in CHAPTER 10: Aligning Engineering Programmes.

11.3 ETF COMPETENCE AND CULTURE MANAGEMENT

Design influences the quality of Products Systems and processes. The ETF could directly influence the capabilities of the Products Systems and processes through design and evaluation. Engineers, technologists and technicians perform design and evaluation work. The quality of design is directly dependent on the competence of the designer.

It is crucial that intensive communication between the Users and ETF takes place, so that they have a common understanding of expectations, requirements and constraints. This influences the quality of the services provided.

Competence resides in people and is lost with the departure of the competent person. Competence is dependent on culture. A favourable psychological climate is essential to the promotion of competence and its development. Competence must therefore be managed effectively, as sustainable competitive advantage can be derived from it. Competence is a valuable resource derived from:

- Training and education.
- Collegial communication and interaction with peers, both engineering and operational.
- Experience.
- Intelligence.
- Defence Evaluation and Research Institutes (DERIs).

The sources of competence should be exploited by:

- Enabling and encouraging communication between the following role-players to stimulate ideas and innovations:
    - The ETF role-players in Joint Services Engineering, Products Systems Engineering and Joint Services Product Engineering.
    - Operations or Combat personnel.
    - DERIs.
    - Product and Service suppliers.
    - Acquisitions.
    - ARMSCOR
    - Technology Intelligence.

  - Technical Services personnel.
- Exposing personnel within the Engineering functions to procurement, development and evaluation projects.
- Continuing education, training and development in both engineering and military areas.
- Regular feedback on project progress and design reviews.
- As described in section 3.5.4, develop a psychological climate conducive to competence development and innovation.

The wealth of knowledge in the defence industry must be harnessed. The SANDF is the main organisation for which the knowledge is developed and maintained. The SANDF should therefore harvest, nurture and use the knowledge to develop its core competence and the associated competencies, capabilities and resources, described in section 10.5.

The proposed Joint Services Product Engineering function would create a centre of excellence for the AoS to share. Apart from the functional advantages, this approach would have significant cost benefits.

Technology is an important factor in gaining a competitive advantage in capabilities against threats. Engineering should be at least aware of the technology projects in process.

11.4 CAPABILITY AND COST MANAGEMENT

The principle of capability management depends on optimal utilisation and support of the Products Systems, personnel and processes that constitute the User System.

The principle of cost management is based on the concept that Products Systems, personnel and processes that constitute the User System, if well managed, will cost less to own, operate and support.

The life cycle cost of Products Systems and processes is a result of the design. A competent designer will ensure the lowest life cycle cost.

Upstream changes to Products Systems and processes are considerably less expensive than downstream changes. Seemingly large investments in upstream activity have a multiplying effect, reducing costs downstream. Controlling configurations of Products Systems and their design and baseline information can ensure effective and efficient management.

The costs of the SANDF's value chain, could be reduced through the stimulation of effective communication and the removal of duplication of effort. The concept of jointness reduces cost. In many cases a joint resource, such as the proposed Joint Services Product Engineering function, is more efficient and effective than many resources separated into the AoSs. Programme and Project Management is suitable for driving the processes in the support of User Systems and Products Systems.

Technology is an important factor in gaining a competitive advantage in reducing costs. This advantage may be embodied in the physical artefacts or processes used in the operation and support of User Systems.

11.5 CONCLUDING STATEMENT

In conclusion, this study has shown that by strategically using a systems approach to the application of the ETF, it could align engineering programmes with the core business of the SANDF to ensure its competitive advantage. South Africa will then have an affordable, technologically advanced defence capability that is a deterrent to potential aggressors.

APPENDIX 1

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APPENDIX A: THE PRINCIPLES OF WAR

A.1 THE PRINCIPLES OF WAR USED BY THE SANDF

The principles of war used by the SANDF, are presented here (Schultz 1994: 1).

THE PRINCIPLES OF WAR

INTRODUCTION

1. A principle of war is a fundamental truth governing the execution of war. The principles of war are not exact principles, but rather constitute a collection of ideas. Principles of war must be understood in their entirety and should not be applied as dogma, but as a checklist for a successful operation. The principles of war apply not only to a war situation but can apply to every form of military activity whether in war or peace.

   The Importance of the Principles of War

2. Success in all military operations can be influenced by several factors, eg, the time factor, the influence of danger, availability of information, fatigue, and many more. The fact of the matter is that in modern warfare there is little if any opportunity for righting basic errors in strategic or tactical planning. Therefore it is essential that every commander must have a sound knowledge of the principles of war. In fact knowledge of the principles of war should be second nature to every soldier.
3. It must however be stated that the relative importance of the principles of war may vary from one situation to another. Disregard of the principles will also not automatically result in defeat. Nor will their strict observance guarantee success. The principles of war therefore simply indicate methods of action that have proved successful in the past, and they serve as a warning that their disregard involve risk and has often brought failure.

   Efficiency of the Principles of War

4. As previously mentioned it is true that none of the principles are absolute, like for instance the laws of physics or economics. Nevertheless, the principles of war can be used as a practice checklist to assist sound judgement, concepts and plans, provided they are administered sensibly. Users simply should recognise that no two situations are quite alike, and apply the principles accordingly. The principles of war are therefore dynamic principles and must be used accordingly.

   The Principles of War as Accepted by the SANDF

5. The following fourteen (14) principles are accepted and used in the SANDF. Take note that the fourteenth principle (Intelligence) has been incorporated due to lessons learnt from studies on recent global conflicts and is therefore included.
   a. Selection and maintenance of the aim.
   b. Maintenance of morale.
   c. Security.
   d. Surprise.
   e. Offensive action / Initiative.
   f. Flexibility.
   g. Concentration of force.
   h. Economy of force.
   i. Co-operation.
   j. Maintenance of reserves.
   k. Manoeuvre.
   l. Unity of command.
   m. Logistic / Administrative support.
   n. Intelligence.

6. The selection and maintenance of the aim is the overriding and most important principle. The order of the remaining 13 principles can vary depending on the situation in hand.
    a. Selection and Maintenance of the Aim. There is a distinct difference between the selection and the maintenance of the aim.
        i. The Selection of the Aim. The importance of defining the aim before the attempting to accomplish it by whatever means cannot be over-stressed. In war the definition of the aim of the military operation prior to the start of the battle is vital.
        ii. Directives on the highest levels will usually define the military aim in broad terms. It must be remembered that all military action is governed by political motives, and that war is the means of achieving the political aim when peaceful methods have failed. Thus, the political aim is always supreme, even in war. All military operations must evolve out of National Strategy. The broad military aim will give the senior commanders due latitude in interpreting these terms. The aim will then be defined with increasing precision at each lower level.
    b. The Maintenance of the Aim. Failure to maintain the aim will decrease the chances of success and may well lead to defeat. In peacetime, the political aim may have to be adapted from time to time to meet changing circumstances. The military aims of the and control is a force multiplier.
        i. Logistic / Administrative Support. Logistic Services should be adapted accordingly, and this may well call for changes in the size and structure of the armed forces. Every plan of action, on whatever military level, must be tested by the extent to which it contributes to the attainment of the military aim at the next highest level of command, and ultimately to the overall military aim.
    c. Maintenance of Morale. Morale is a mental state, which is an invaluable asset to success in all forms of war. Morale is very sensitive to material conditions. High morale can be achieved by making sure that personnel are equipped for the task. Keep the people informed and set high standards of discipline. Make sure that accommodation and messing facilities are at a high standard. The most important of all is that a battle cannot be won without fighting men. High morale therefore implies good logistic support and effective medical treatment.
    d. In present day and future circumstances the morale of the civilian population is and will be just as important a factor as the morale of the armed forces. National morale is the foundation upon which a nation’s will to resist aggression is built, and should therefore be maintained at a high level by all possible means.
    e. Security. Security preserves power and reduces the probability that enemy activity, direct or indirect, might interfere unduly with vital friendly interest, assets, plans or operations. This by no means implies undue caution or the avoidance of risks. A good offensive often is an outstanding defence. Thus, a prerequisite for offensive action is a sufficiently secure base from which the forces can operate effectively. Part of the art of war is to strike the right balance between security and offensive action, and to allot the proper proportion of resources to each.
    f. Surprise. Surprise, aided and abetted by various combinations of secrecy, speed, deception, originality and audacity, can shift the balance of power decisively, paving the way for victories far out of proportion to the efforts expended. Surprise however, does not vouch-save success, but it vastly

increases the odds in its favour. Surprise can assume many shapes, namely military surprise, political surprise, psychological surprise and technological surprise. ***Surprise can invariably only be achieved with good intelligence, hence the fourteenth principle of intelligence.***

g. Offensive action / Initiative. This principle states that offensive action is necessary to achieve decisive results and maintain freedom of actions. This principle must be applied even within the defensive. Offensive action therefore is as much an attitude of mind as it is a practical policy. It requires qualities of determination, boldness, courage and the will to win. The choice of the right place, time and objective is of major importance in the use of offensive action to achieve the aim.

h. Flexibility. This principle recognises the inevitability of change in purposes, policies, plans and procedure. Flexibility therefore entails good training, organisation, discipline, communications and staff work. It also needs good Standing Operation Procedures (SOP's) which can incrementally be adjusted when the need arises. There is no place for democratic inertia when flexibility must be addressed.

i. Concentration of Force. Concentration of superior force at the decisive time and place is usually essential to success in war. This principle requires the achievement of superiority of combat power. To achieve this more than superior numbers are required. The concentration must be so rapid that the enemy has insufficient time to counter it before a decisive strike is delivered. Proper application of this principle in conjunction with the other principles of war may permit numerically inferior forces to achieve decisive combat superiority.

j. Economy of Force. This principle is closely associated with that of force, and it is an acceptable dictum to say that no more force than is necessary should be devoted to any task.

k. Co-operation. Co-operation entails the co-ordination of all units so as to achieve the maximum combined effort from the whole. In modern warfare military commitments involves joint action. Co-operation between the different service arms is therefore essential. To achieve the best results in warfare, a joint plan is vital.

l. Maintenance of Reserves. It is essential that every battle plan must allow for reserves. Before the battle / operation the reserves must be established, and as soon as a reserve is committed, a new reserve must be established. The worst possible action during wartime (under normal circumstances) is the commitment of the entire force to the battle. Reserves must be established and maintained. When reserves must be committed, it must be to solve a crisis situation or to apply more force, which will eventually ensure victory.

m. Manoeuvre. Manoeuvre can be regarded as a fundamental truth governing the prosecution of war. The object of the principle is to dispose of a force in such a manner as to place the enemy at a disadvantage and thus achieve results that would otherwise have been more costly. Manoeuvre is not limited to combat forces; there is also the manoeuvre of political forces, logistics and many more. Manoeuvre is the antithesis of mental stagnation or static physical positions. It further implies a faculty for rapidly shifting strategic emphasis from one mode to another.

n. Unity of Command. The principle of unity embraces solidarity of purpose, effort and command. Since human nature is often opportunistic and individualistic, proper orchestration can better be assured if responsibilities and authority are vested in command. This principle implies that the decisive application of full combat power requires unity of effort under one responsible commander. It is essential that one commander be in control of all affected units. Good command and administrative support is essential to the organisation, planning, training and operation of any military force. These arrangements which provide the backing for operations must be designed to give the commander maximum freedom of action. He must on the other hand be fully briefed and understand the limitations. There is no advantage in operational progress outstripping administrative and logistical support.

o. Intelligence. Good intelligence will be the foundation of any military operation. Intelligence encompasses not only the political and military situation, but also encompasses the health assessment in the area of operations as well as the logistic assessment. Intelligence is entrenched in the principles of Security, Surprise and Logistic / Administrative support.

A.2 THE PRINCIPLES OF WAR USED BY THE US ARMY

According to Payne (1998: 153), the United States Army recognises the following nine of these principles of war:

- The objective. Every military operation must be directed towards a clearly defined, decisive, and attainable objective.
- The offensive/initiative. This is the commander's only means of attaining a decisive, successful goal. Even when the political goal is defensive, the best defence is frequently a vigorous offensive. This forces the enemy to react to one's initiatives rather than the other way around. This provides one's own forces with the ability to dictate the terms of the conflict.
- Mass. In every conflict, a moment arises where the superiority in a particular characteristic will provide victory. The commander must discern what that characteristic is, and whether his own forces possesses or is able to acquire it. The commander must then concentrate that combat power at the decisive place and time.
- Economy of force. To apply mass as described previously, the force capability in other less significant sectors may have to be reduced. Thus apply forces economically so to obtain the maximum return.
- Manoeuvre (mobility). The commander should place his forces at the decisive place at the right time to gain the initiative.
- Unity of command. For every objective, ensure unity of effort under one commander responsible for the operation. The objective of this principle is co-ordination of forces.
- Security. Never permit the enemy to acquire an unexpected advantage. The commander should never become so intent on what he plans to do to his enemy, that he forgets what the enemy might plan to do to him.
- Surprise. Strike the enemy at a time, at a place, or in a manner for which he is unprepared.
- Simplicity. The friction in war often makes the simplest manoeuvres difficult and the more complex ones impossible. A simpler plan executed promptly is therefore preferable to a more complex plan executed later.

APPENDIX B: THE PROJECT MANAGEMENT INFORMATION FLOW

B.1 THE PROJECT MANAGEMENT PROCESSES AND THEIR ASSOCIATED INPUT AND OUTPUT.

The figure below presents the Project Management information flow derived from the PMI's PMBOK. This is an example of an approach to the process, suitable for a large, complex programme. Not all projects will however require such a rigorous effort to achieve success.

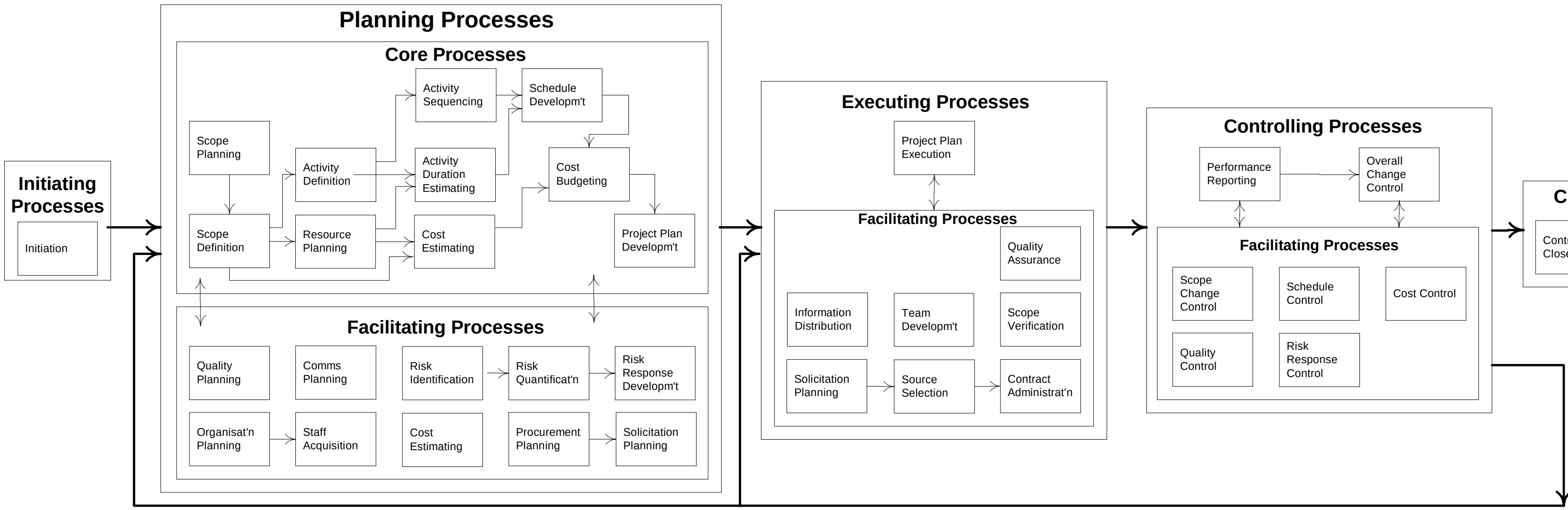

Figure 88: Overall Project Management Flow of Information

B.2 THE PROJECT MANAGEMENT PROCESSES AND THEIR SUB-PROCESSES.

The types of processes and the sub-processes with which they are associated, are presented in the table below.

Processes	Chap	Sub-processes
Project Integration Management	4.1	Project Plan Development
	4.2	Project Plan Execution
	4.3	Overall Change Control
Project Scope Management	5.1	Initiation
	5.2	Scope Planning
	5.3	Scope Definition
	5.4	Scope Verification
	5.5	Scope Change Control
Project Time Management	6.1	Activity Definition
	6.2	Activity Sequencing
	6.3	Activity Duration Estimation
	6.4	Schedule development
	6.5	Schedule Control
Project Cost Management	7.1	Resource Planning
	7.2	Cost Estimating
	7.3	Cost Budgeting
	7.4	Cost Control
Project Quality Management	8.1	Quality Planning
	8.2	Quality Assurance
	8.3	Quality Control
Project Human Resources Management	9.1	Organisational Planning
	9.2	Staff Acquisition
	9.3	Team Development
Project Communications Management	10.1	Communications Planning
	10.2	Information Distribution
	10.3	Performance reporting
	10.4	Administrative Closure
Project Risk Management	11.1	Risk Identification
	11.2	Risk Quantification
	11.3	Risk Response Development
	11.4	Risk Response Control
Project Procurement Management	12.1	Procurement Planning
	12.2	Solicitation Planning
	12.3	Solicitation
	12.4	Source Selection
	12.5	Contract Administration
	12.6	Contract Close-out

Table 40: The PMI PMBOK's Processes and Sub-Processes

B.3 THE PROJECT MANAGEMENT PROCESSES AND THEIR INPUT AND OUTPUT.

The types of input, output and the processes with which they are associated, are presented in the tables below.

Chap	Input	Output
4.1	Other planning output	Project plan
4.1	Historical information	Supporting detail
4.1	Organisational policies	
4.1	Constraints	
4.1	Assumptions	
4.2	Project plan	Work results
4.2	Supporting detail	Change requests
4.2	Organisational policies	
4.2	Corrective action	
4.3	Project plan	Project plan updates
4.3	Performance reports	Corrective action
4.3	Change requests	Lessons learnt

Table 41: The Input and Output of the Project Integration Management Processes (PMBOK 1996: Chapter 4).

Chap	Input	Output
5.1	Product description	Project charter
5.1	Strategic plan	Project manager identified
5.1	Project selection criteria	Constraints
5.1	Historical information	Assumptions
5.2	Product description	Scope statement
5.2	Project charter	Supporting detail
5.2	Constraints	Scope management plan
5.2	Assumptions	
5.3	Scope statement	Work Breakdown Structure (WBS)
5.3	Constraints	
5.3	Assumptions	
5.3	Other planning output	
5.3	Historical information	
5.4	Work results	Formal acceptance
5.4	Product documentation	
5.5	Work Breakdown Structure	Scope changes
5.5	Performance reports	Corrective action
5.5	Change requests	Lessons learnt
5.5	Scope management plan	

Table 42: The Input and Output of the Project Scope Management Processes (PMBOK 1996: Chapter 5).

Chap	Input	Output
6.1	Work Breakdown Structure	Activity list
6.1	Scope statement	Supporting detail
6.1	Historical information	
6.1	Constraints	
6.1	Assumptions	
6.2	Activity list	Project network diagram
6.2	Product description*	Activity list updates
6.2	Mandatory dependencies	
6.2	Discretionary dependencies	
6.2	External dependencies	
6.2	Constraints	
6.2	Assumptions	
6.3	Activity list	Activity duration estimates
6.3	Constraints	Basis of estimates
6.3	Assumptions	Activity list updates
6.3	Resource requirements	
6.3	Resource capabilities	
6.3	Historical information	
6.4	Project network diagram	Project schedule
6.4	Activity duration estimates	Supporting detail
6.4	Resource requirements	Schedule management plan
6.4	Resource pool description	Resource requirement updates
6.4	Calendars	
6.4	Constraints	
6.4	Assumptions	
6.4	Leads and lags	
6.5	Project schedule	Schedule updates
6.5	Performance reports	Corrective action
6.5	Change requests	Lessons learnt
6.5	Schedule management plan	

Table 43: The Input and Output of the Project Time Management Processes (PMBOK 1996: Chapter 6).

Chap	Input	Output
7.1	Work Breakdown Structure	Resource requirements
7.1	Scope statement	
7.1	Historical information	
7.1	Resource pool description	
7.1	Organisational policies	
7.2	Work Breakdown Structure	Cost estimates
7.2	Resource requirements	Supporting detail
7.2	Resource rates	Cost management plan
7.2	Activity duration estimates	
7.2	Historical information	
7.2	Chart of accounts	
7.3	Cost estimates	Cost baseline
7.3	Work Breakdown Structure	
7.3	Project schedule	
7.4	Cost baseline	Revised cost estimates
7.4	Performance reports	Budget updates
7.4	Change requests	Corrective action
7.4	Cost management plan	Estimate at completion
7.4		Lessons learnt

Table 44: The Input and Output of the Project Cost Management Processes (PMBOK 1996: Chapter 7).

Chap	Input	Output
8.1	Quality Policy	Quality management plan
8.1	Scope statement	Operational descriptions
8.1	Product description	Checklists
8.1	Standards and regulations	Input to other processes
8.1	Own process outputs	
8.2	Quality management plan	Quality improvement
8.2	Results of quality control measurements	
8.2	Operational descriptions	
8.3	Work results	Quality improvement
8.3	Quality management plan	Acceptance decisions
8.3	Operational descriptions	Rework
8.3	Checklists	Completed checklists
8.3		Process adjustments

Table 45: The Input and Output of the Project Quality Management Processes (PMBOK 1996: Chapter 8).

Chap	Input	Output
9.1	Project interfaces	Role and responsibility assignments
9.1	Staffing requirements	Staffing management plan
9.1	Constraints	Organisational chart
9.1		Supporting detail
9.2	Staffing management plan	Project staff assigned
9.2	Staffing pool description	Project team directory
9.2	Recruitment practices	
9.3	Project staff	Performance improvement
9.3	Project plan	Input to performance appraisals
9.3	Staffing management plan	
9.3	Performance reports	
9.3	External feedback	

Table 46: The Input and Output of the Project Human Resources Management Processes (PMBOK 1996: Chapter 9).

Chap	Input	Output
10.1	Communications requirements	Communications management plan
10.1	Communications technology	
10.1	Constraints	
10.1	Assumptions	
10.2	Work results	
10.2	Communications management plan	
10.2	Project plan	
10.3	Project plan	Performance reports
10.3	Work results	Change requests
10.3	Other project records	
10.4	Performance measurement documentation	Project archives
10.4	Documentation of the Product of the project	Formal acceptance
10.4	Other project records	Lessons learnt

Table 47: The Input and Output of the Project Communications Management Processes (PMBOK 1996: Chapter 10).

Chap	Input	Output
11.1	Product description	Sources of risk
11.1	Other planning outputs	Potential risk events
11.1	Historical information	Risk symptoms
11.1		Input to other processes
11.2	Shareholder risk tolerances	Opportunities to pursue, threats to respond to
11.2	Sources of risk	Opportunities to ignore, threats to accept
11.2	Potential risk events	
11.2	Cost estimates	
11.2	Activity duration estimates	
11.3	Opportunities to pursue, threats to respond to	Risk management plan
11.3	Opportunities to ignore, threats to accept	Input to other processes
11.3		Contingency plans
11.3		Reserves
11.3		Contractual agreements
11.4	Risk management plan	Corrective action
11.4	Actual risk events	Updates to Risk management plan
11.4	Additional risk identification	

Table 48: The Input and Output of the Project Risk Management Processes (PMBOK 1996: Chapter 11).

Chap	Input	Output
12.1	Scope statement	Procurement management plan
12.1	Product description	Statement(s) of Work (SOW)
12.1	Procurement resources	
12.1	Market conditions	
12.1	Other planning outputs	
12.1	Constraints	
12.1	Assumptions	
12.2	Procurement management plan	Procurement documents
12.2	Statement(s) of Work (SOW)	Evaluation criteria
12.2	Other planning outputs	Statement of Work updates
12.3	Procurement documents	Proposals
12.3	Qualified seller lists	
12.4	Proposals	Contract
12.4	Evaluation criteria	
12.4	Organisational policies	
12.5	Contract	Correspondence
12.5	Work results	Contract changes
12.5	Change requests	Payment requests
12.5	Seller invoices	
12.6	Contract documentation	Contract file

Table 49: The Input and Output of the Project Procurement Management Processes (PMBOK 1996: Chapter 12).

B.4 INPUT AND THEIR PROCESS DESTINATIONS.

The types of input and the processes with which they are associated, are presented in the table below.

Input	To Process
Activity duration estimates	Cost Estimating
	Risk Quantification
	Schedule development
Activity list	Activity Duration Estimation
	Activity Sequencing
Actual risk events	Risk Response Control
Additional risk identification	Risk Response Control
Assumptions	Project Plan Development
	Scope Planning
	Scope Definition
	Activity Definition
	Activity Sequencing
	Schedule development
	Communications Planning
	Procurement Planning
	Activity Duration Estimation
Calendars	Schedule development
	Cost Budgeting
	Overall Change Control
	Scope Change Control
	Schedule Control
	Contract Administration
Chart of accounts	Cost Estimating
Checklists	Quality Control
Communications management plan	Information Distribution
Communications requirements	Communications Planning

Input	**To Process**
Communications technology	Communications Planning
Constraints	Project Plan Development
	Scope Definition
	Activity Definition
	Activity Sequencing
	Schedule development
	Communications Planning
	Procurement Planning
	Activity Duration Estimation
	Organisational Planning
	Scope Planning
Contract	Contract Administration
Contract documentation	Contract Close-out
Corrective action	Project Plan Execution
Cost management plan	Cost Budgeting
Cost baseline	Cost Budgeting
Cost estimates	Risk Quantification
	Cost Budgeting
Discretionary dependencies	Activity Sequencing
Documentation of the Product of the project	Administrative Closure
Evaluation criteria	Source Selection
External dependencies	Activity Sequencing
External feedback	Team Development
Historical information	Scope Definition
	Activity Definition
	Activity Duration Estimation
	Resource Planning
	Cost Estimating
	Initiation
	Risk Identification
	Project Plan Development
Leads and lags	Schedule development
Mandatory dependencies	Activity Sequencing
Market conditions	Procurement Planning
Operational descriptions	Quality Assurance
	Quality Control
Opportunities to ignore, threats to accept	Risk Response Development
Opportunities to pursue, threats to respond to	Risk Response Development

Input	To Process
Organisational policies	Project Plan Development
	Project Plan Execution
	Resource Planning
	Source Selection
Other planning output	Scope Definition
	Project Plan Development
	Procurement Planning
	Risk Identification
	Solicitation Planning
Other project records	Performance reporting
	Administrative Closure
Own process outputs	Quality Planning
Performance measurement documentation	Administrative Closure
Performance reports	Team Development
	Cost Budgeting
	Overall Change Control
	Scope Change Control
	Schedule Control
Potential risk events	Risk Quantification
Procurement documents	Solicitation
Procurement management plan	Solicitation Planning
Procurement resources	Procurement Planning
Product description	Quality Planning
	Initiation
	Scope Planning
	Risk Identification
	Procurement Planning
	Activity Sequencing
Product documentation	Scope Verification
Project charter	Scope Planning
Project interfaces	Organisational Planning
Project network diagram	Schedule development
Project plan	Information Distribution
	Team Development
	Performance reporting
	Overall Change Control
	Project Plan Execution

Input	**To Process**
Project schedule	Cost Budgeting
	Schedule Control
Project selection criteria	Initiation
Project staff	Team Development
Proposals	Source Selection
Qualified seller lists	Solicitation
Quality management plan	Quality Control
	Quality Assurance
Quality Policy	Quality Planning
Recruitment practices	Staff Acquisition
Resource capabilities	Activity Duration Estimation
Resource pool description	Resource Planning
	Schedule development
Resource rates	Cost Estimating
Resource requirements	Activity Duration Estimation
	Schedule development
	Cost Estimating
Results of quality control measurements	Quality Assurance
Risk management plan	Risk Response Control
Schedule management plan	Schedule Control
Scope management plan	Scope Change Control
Scope statement	Resource Planning
	Quality Planning
	Procurement Planning
	Activity Definition
	Scope Definition
Seller invoices	Contract Administration
Shareholder risk tolerances	Risk Quantification
Sources of risk	Risk Quantification
Staffing management plan	Team Development
	Staff Acquisition
Staffing pool description	Staff Acquisition
Staffing requirements	Organisational Planning
Standards and regulations	Quality Planning
Statement(s) of Work (SOW)	Solicitation Planning
Strategic plan	Initiation
Supporting detail	Project Plan Execution

Input	To Process
Work Breakdown Structure	Cost Budgeting
	Activity Definition
	Cost Estimating
	Resource Planning
	Scope Change Control
Work results	Information Distribution
	Performance reporting
	Contract Administration
	Scope Verification
	Quality Control

B.5 THE PROJECT MANAGEMENT PROCESSES AND THEIR OUTPUT.

The types of processes and the outputs with which they are associated, are presented in the table below.

Output	To Process (Destination)
Acceptance decisions	Quality Control
Activity duration estimates	Activity Duration Estimation
Activity list	Activity Definition
Activity list updates	Activity Sequencing
	Activity Duration Estimation
Assumptions	Initiation
Basis of estimates	Activity Duration Estimation
Budget updates	Cost Control
Change requests	Performance reporting
	Project Plan Execution
Checklists	Quality Planning
Communications management plan	Communications Planning
Completed checklists	Quality Control
Constraints	Initiation
Contingency plans	Risk Response Development
Contract	Source Selection
Contract changes	Contract Administration
Contract file	Contract Close-out
Contractual agreements	Risk Response Development
Corrective action	Risk Response Control
	Overall Change Control
	Scope Change Control
	Schedule Control
	Cost Control
Correspondence	Contract Administration
Cost baseline	Cost Budgeting
Cost estimates	Cost Estimating
Cost management plan	Cost Estimating
Estimate at completion	Cost Control
Evaluation criteria	Solicitation Planning

Output	**To Process (Destination)**
Formal acceptance	Administrative Closure
	Scope Verification
Input to other processes	Risk Identification
	Risk Response Development
	Quality Planning
Input to performance appraisals	Team Development
Lessons learnt	Administrative Closure
	Overall Change Control
	Scope Change Control
	Schedule Control
	Cost Control
Operational descriptions	Quality Planning
Opportunities to ignore, threats to accept	Risk Quantification
Opportunities to pursue, threats to respond to	Risk Quantification
Organisational chart	Organisational Planning
Payment requests	Contract Administration
Performance improvement	Team Development
Performance reports	Performance reporting
Potential risk events	Risk Identification
Process adjustments	Quality Control
Procurement documents	Solicitation Planning
Procurement management plan	Procurement Planning
Project archives	Administrative Closure
Project charter	Initiation
Project manager identified	Initiation
Project network diagram	Activity Sequencing
Project plan	Project Plan Development
Project plan updates	Overall Change Control
Project records	Information Distribution
Project schedule	Schedule development
Project staff assigned	Staff Acquisition
Project team directory	Staff Acquisition
Proposals	Solicitation
Quality improvement	Quality Assurance
	Quality Control
Quality management plan	Quality Planning
Reserves	Risk Response Development
Resource requirement updates	Schedule development

Output	**To Process (Destination)**
Resource requirements	Resource Planning
Revised cost estimates	Cost Control
Rework	Quality Control
Risk management plan	Risk Response Development
Risk symptoms	Risk Identification
Role and responsibility assignments	Organisational Planning
Schedule management plan	Schedule development
Schedule updates	Schedule Control
Scope changes	Scope Change Control
Scope management plan	Scope Planning
Scope statement	Scope Planning
Sources of risk	Risk Identification
Staffing management plan	Organisational Planning
Statement of Work updates	Solicitation Planning
Statement(s) of Work (SOW)	Procurement Planning
Supporting detail	Project Plan Development
	Scope Planning
	Activity Definition
	Schedule development
	Cost Estimating
	Organisational Planning
Updates to Risk management plan	Risk Response Control
Work Breakdown Structure (WBS)	Scope Definition
Work results	Project Plan Execution

APPENDIX C: KEY SUCCESS FACTORS

Key Success Factors	Military Requirements	Resource Requirements	ETF Contribution
Concentration of Force	The superiority of own forces in a particular area of the conflict.	Superior capability, availability and dependability of User Systems. C4I2 SR EW capabilities Mission and weapons planning tools	Superiority in technology. Superiority in capability, availability and dependability of Products Systems. Supportability of Products Systems Availability and efficacy of C4I2 SR EW capabilities Availability and efficacy of mission and weapons planning tools
Co-operation	The ability of the parts of the military to synergistically co-ordinate their efforts.	C4I2 SR EW capabilities. Mission and weapons planning tools	Availability and efficacy of C4I2 SR EW capabilities Availability and efficacy of mission and weapons planning tools Compatibility of User Systems
Economy of Force	The economic application of forces with the greatest return.	C4I2 SR EW capabilities. Efficacy of User Systems. Mission and weapons planning tools	Availability and efficacy of C4I2 SR EW capabilities Availability and efficacy of mission and weapons planning tools Efficacy in C4I2 SR EW capabilities design. Availability and efficacy of Products Systems Supportability of Products Systems
Flexibility	The inevitability of change demands that a force be able to adapt.	User Systems. C4I2 SR EW capabilities. Mission and weapons planning tools	Ensure efficacy of C4I2 SR EW Design for ease of operation and support Availability and efficacy of mission and weapons planning tools
Intelligence	Intelligence is the foundation of planning and conducting any military operation.	C4I2 SR EW capabilities.	Availability and efficacy of C4I2 SR EW capabilities Availability and efficacy of mission and weapons planning tools
Logistic Support	It is essential that forces be supplied with the required resources at the correct time and place.	Information Systems. Transportation. Procedures.	Design and validation of Products Systems’ support system Supportability of Products Systems Efficacy of Products Systems’ support system Availability and efficacy of mission and weapons planning tools
Maintenance of Morale	Moral of personnel is essential to operational success.	Dependable, capable Products Systems Sufficient Products Systems	Design and validation of Products Systems’ capability and dependability Supportability of Products Systems Efficacy of Products Systems’ support system Availability and dependability of Products Systems Availability and efficacy of C4I2 SR EW capabilities

Maintenance of Reserves	Reserves are essential to attend to crises or to apply more force in battles.	Sufficient Products Systems Mission and weapons planning tools	Design cost-effective, affordable Products Systems Supportability of Products Systems
Manœuvre	Develop and employ the mobility of forces to apply the initiative at the optimal place and time to gain the initiative.	C4I2 SR EW capabilities. Superior mobility of platforms. Superior tactical mobility. Superior strategic mobility	Availability and efficacy of Products Systems. Flexible design qualities of Products Systems. Technological innovations. Efficacy in C4I2 SR EW capabilities. Supportability of Products Systems Availability and efficacy of mission and weapons planning tools
Security	Denial of an expected advantage to the enemy.	Cryptography Deception Detection denial resources C4I2 SR EW capabilities. ICT infrastructure penetration denial	“Stealth” technology C4I2 SR EW technologies Development and support of deception systems Development and support of ICT penetration denial systems
Key Success Factors	**Military Requirements**	**Resource Requirements**	**ETF Contribution**
Selection and Maintenance of the Aim	Define the objective clearly and adhere to it.	C4I2 SR EW capabilities Mission and weapons planning tools	Availability and efficacy of C4I2 SR EW capabilities Availability and efficacy of mission and weapons planning tools
Surprise	Strike the enemy at an unexpected time, place or manner.	New capabilities & associated doctrines in User Systems. C4I2 SR EW capabilities. ICT infrastructure penetration denial	Technological innovation. Improved or changed capabilities, availability or dependability of Products Systems Availability and efficacy of mission and weapons planning tools Supportability of Products Systems Availability and efficacy of C4I2 SR EW capabilities
The Offensive	Dictate the terms of the conflict to the enemy through taking the initiative.	C4I2 SR EW capabilities. Effective User Systems. Mission and weapons planning tools	Availability and efficacy of C4I2 SR EW capabilities Availability and efficacy of mission and weapons planning tools Availability and efficacy of Products Systems. Supportability of Products Systems
Unity of Command	The optimal co-ordination of forces to achieve the objective.	C4I2 SR EW capabilities. Mission and weapons planning tools Doctrine	Ensure efficacy of C4I2 SR EW Development and availability of mission and weapons planning tools

Table 50: A Relationship between the SANDF's Principles of War as Key Success Factors and the ETF Contribution.

LIST OF ABBREVIATIONS

ABL	:	Allocated Baseline
ADM	:	Advanced Development Model
AIDS	:	Acquired Immunodeficiency Syndrome
ANC	:	African National Congress
AoS	:	Arms of Service
APM	:	British Association of Project Managers
AWOL	:	Absent Without Leave
BoK	:	Body of Knowledge
C JOps	:	Chief of Joint Operations
C SANDF	:	Chief of the SANDF
Ch	:	Chapter
CI	:	Configuration Item
CM	:	Configuration Management
CORE	:	Code of Remuneration
COSATU	:	Congress of South African Trade Unions
COTS	:	Commercial off-the-Shelf
CSCI	:	Computer software configuration items
CSIR	:	Council for Scientific and Industrial Research
D APD	:	Departmental Acquisition and Procurement Division
D Level	:	Depot Level
DACST	:	Department of Arts, Culture, Science and Technology
DEA	:	Drug Enforcement Agency
DERI	:	Defence Evaluation and Research Institute
DoD	:	Department of Defence
DRC	:	Democratic Republic of the Congo
DRDB	:	Defence Research and Development Board
ECSA	:	Engineering Council of South Africa
EDM	:	Engineering Development Models
EIA	:	.Electronic Industries Alliance
ETF	:	Engineering Technical Family
EW	:	Electronic Warfare
FBL	:	Functional Baseline
FDI	:	Foreign Direct Investment
FRELIMO	:	*Frente para a Libertação de Moçambique* (Front for the Liberation of Mozambique)
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
GPS	:	Global Positioning System
HOUS	:	Higher Order User Systems

HQ	:	Headquarters
HUMS	:	Health and Usage Monitoring Systems
I Level	:	Intermediate Level
ICT	:	Information and Communications Technology
IDS	:	Item Development Specifications
IEEE	:	Institute of Electrical and Electronic Engineers
ILS	:	Integrated Logistic Support
IPS	:	Item Product Specifications
IT	:	Information Technology
JHOUS	:	Joint Higher Order User System
JSCD	:	Joint Standing Committee on Defence
LCC	:	Life cycle Costs
LCD	:	Lesotho Congress of Democracy
LRU	:	Line Replaceable Units
LSA	:	Logistic Support Analysis
LSP	:	Logistics Support Plan
MBL	:	Manufacturing Baseline
MoD	:	Ministry of Defence
MTBF	:	Mean Time Between Failures
NCO	:	Non-commissioned Officer
NPV	:	Net Present Value
O Level	:	Organisational Level
OAU	:	Organisation for African Unity
OBL	:	Operating Baseline
OEM	:	Original Equipment Manufacturer
PBL	:	Product Baseline
PEST	:	Political, Economic, Socio-cultural and Technological factors
PMBOK	:	Project Management Body of Knowledge
PMC	:	Personnel Management Code
PMI	:	Project Management Institute
PPM	:	Pre-Production Models
PSE	:	Products Systems Engineering
PSM	:	Products System Manager
R & D	:	Research and Development
RBL	:	Requirements Baseline
RENAMO	:	*Resistencia Nacional Moçambicana*
ROC	:	Required Operational Capabilities
RSA	:	Republic of South Africa
SAAF	:	SA Air Force
SACP	:	SA Communist Party
SADC	:	Southern African Development Community

SADF	:	SA Defence Force
SAM	:	Surface to Air Missiles
SAMHS	:	SA Military Health Services
SAN	:	SA Navy
SANDF	:	South African National Defence Force
SAPS	:	SA Police Services
SARB	:	SA Reserve Bank
SECI	:	Socialisation, Externalisation, Combination and Internalisation
SEMP	:	Systems Engineering Management Plan
SEP	:	Systems Engineering Process
SET	:	Science, Engineering and Technology
SETIs	:	Science, Engineering and Technology Institutes
SOP	:	Standard Operating Procedure
SOW	:	Statement of Work
TPM	:	Technical Performance Measures
TyF	:	Type Formation
UK	:	United Kingdom
UMIST	:	University of Manchester Institute for Science and Technology
URS	:	User Requirement Statement
US	:	United States (of America)
USA	:	United States of America
USM	:	User Systems Manager
WBS	:	Work Breakdown Structure
XDM	:	Exploratory Development Model
ZANU(PF)	:	Zimbabwe African National Union (Patriotic Front)

ABSTRACT

Sub-Saharan Africa with its poor economy, appears to be doomed to increasing conflict. Economic growth is, however, needed for reducing poverty. Regional instability, crime, corruption and insufficient skilled people, impede the economic progress needed by African States to extract themselves from their undesirable situations. Every state requires a strong security apparatus to cushion itself from the undesirable influences of wayward neighbours.

South Africa's lack of economic growth frustrates attempts to create and distribute wealth. The lack of confidence in an Africa that is unstable causes foreign direct investment to be diverted elsewhere. A credible defence force is one of the instruments that the government of South Africa can use to bolster confidence in the region. The government aims to transform the defence force into a small, technologically advanced, but affordable organisation.

The research conducted in this study focuses on the contribution the Engineering Technical Family (ETF) may make. It then examines how these efforts may be aligned with South African defence strategies.

This study found that the ETF may be divided into two main categories: Engineering Services which create or upgrade the baselines of systems and products, and Technical Services, which employ the baselines and use them to support the systems and products.

This study also found that employing the principles of war as the key success factors for a defence force made it possible to identify the most significant areas in which the ETF could make a contribution to the organisation.

Further analysis showed that Engineering Services could be divided into three levels. Firstly, the Products Systems Engineering groups propose and implement solutions to satisfy operational requirements for User Systems. Secondly, the Joint Services Product Engineering groups propose and implement solutions to satisfy operational requirements for Product types common to the Services. Lastly, the Joint Services Engineering ensures that the desired joint capability and interoperability between the Services is identified and established. This last group would also define the support policy for Products and Systems.

These approaches in employing the ETF will align the effort of the ETF with that of the SANDF.

The management of projects, competence, technology and culture will ensure that the proposed approach is sustainable and that the SANDF becomes more cost-effective.

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