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.

Product Type	AoS			
	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.

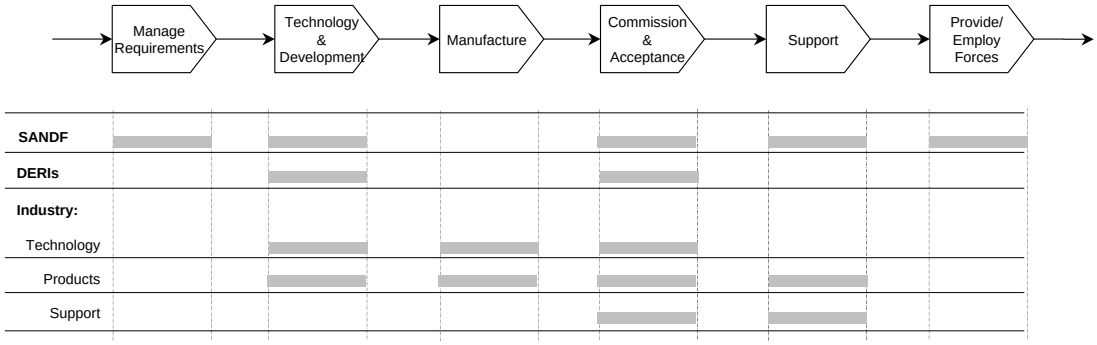

Figure 78: A Representation of the Products System Value System and the Role-Players.

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.

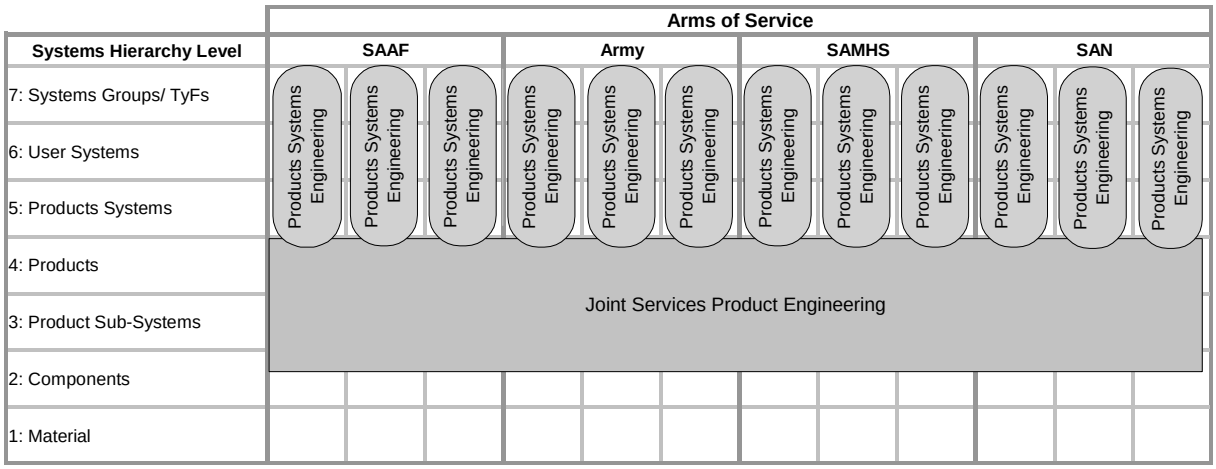

Figure 79: Roles for Engineering Services in the SANDF.

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.

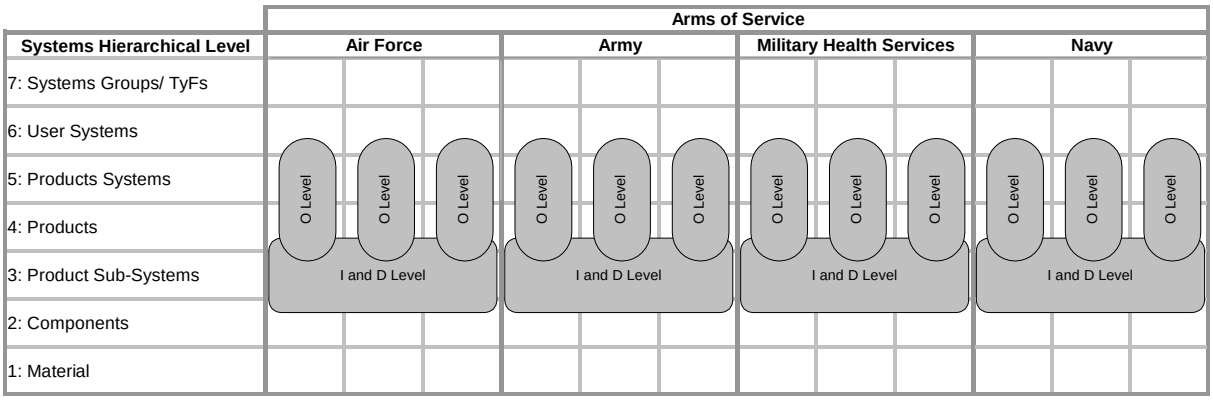

Figure 80: Roles for Technical Services in the SANDF.

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.

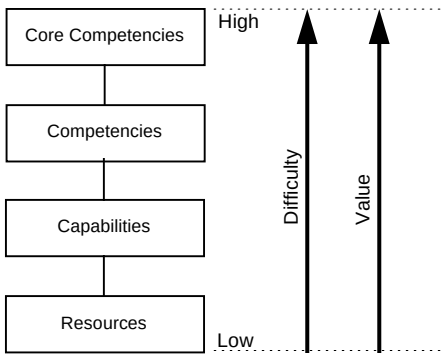

Figure 81: The Competencies Hierarchy (Javidan 1998: 62).

Engineering capabilities includes those abilities to provide optimal capability and dependability solutions for Products Systems and Users Systems at the lowest cost. Resources include:

- Personnel and competencies: 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.

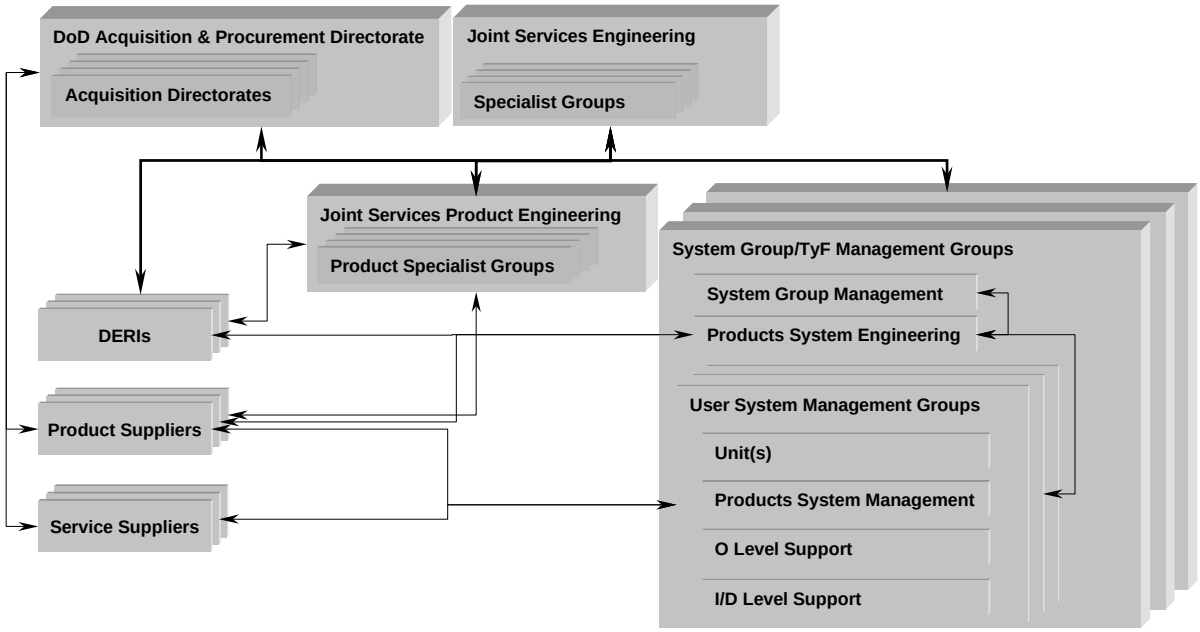

Figure 82: The ETF's Main Links.

- 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.

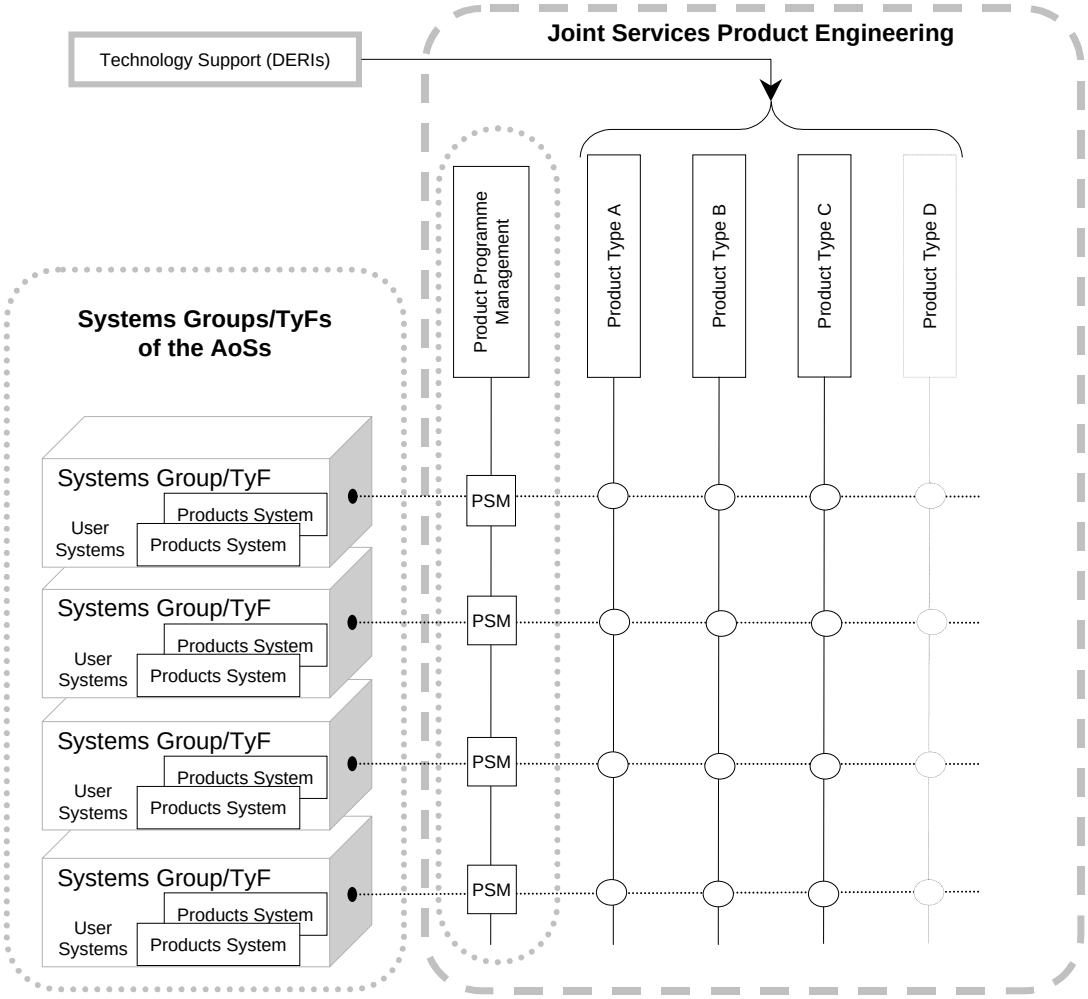

Figure 83: Context of Engineering Support to Systems Groups/TyFs.

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.

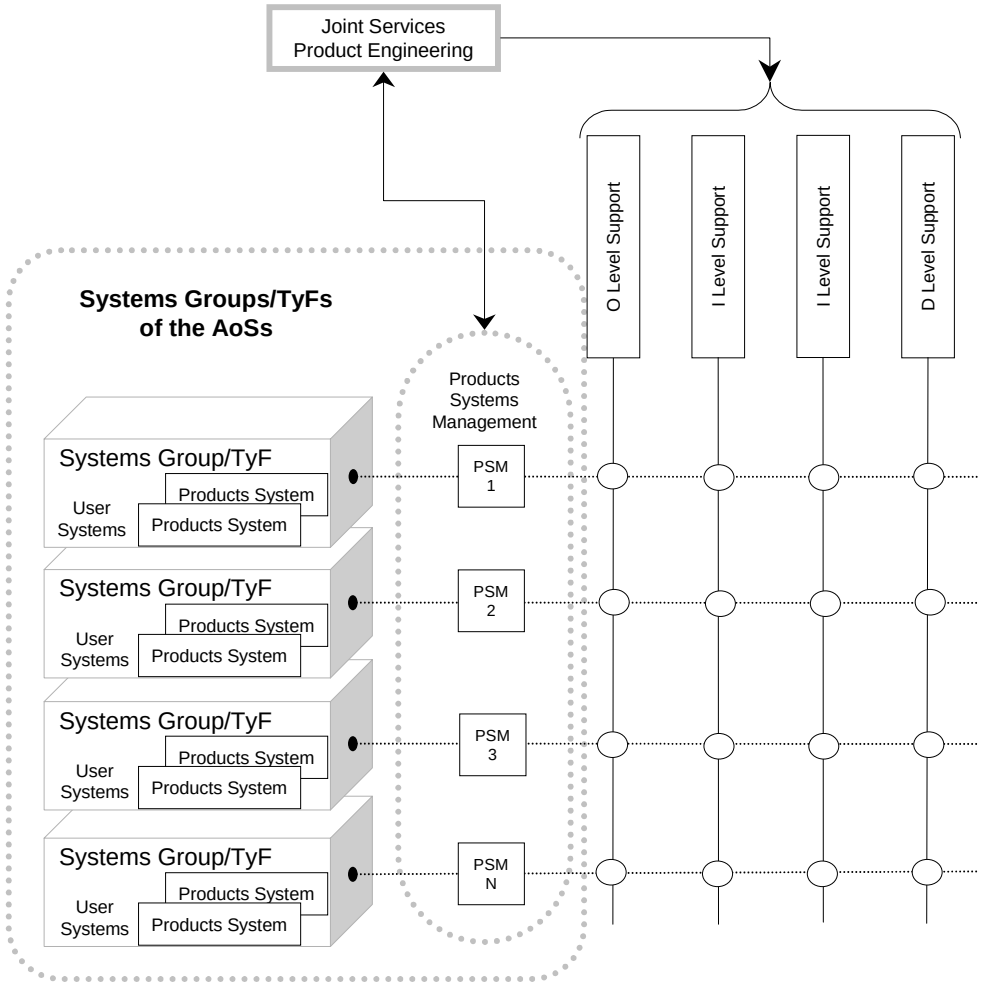

Figure 84: Context of Technical Services Support of Systems Groups/TyFs.

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.

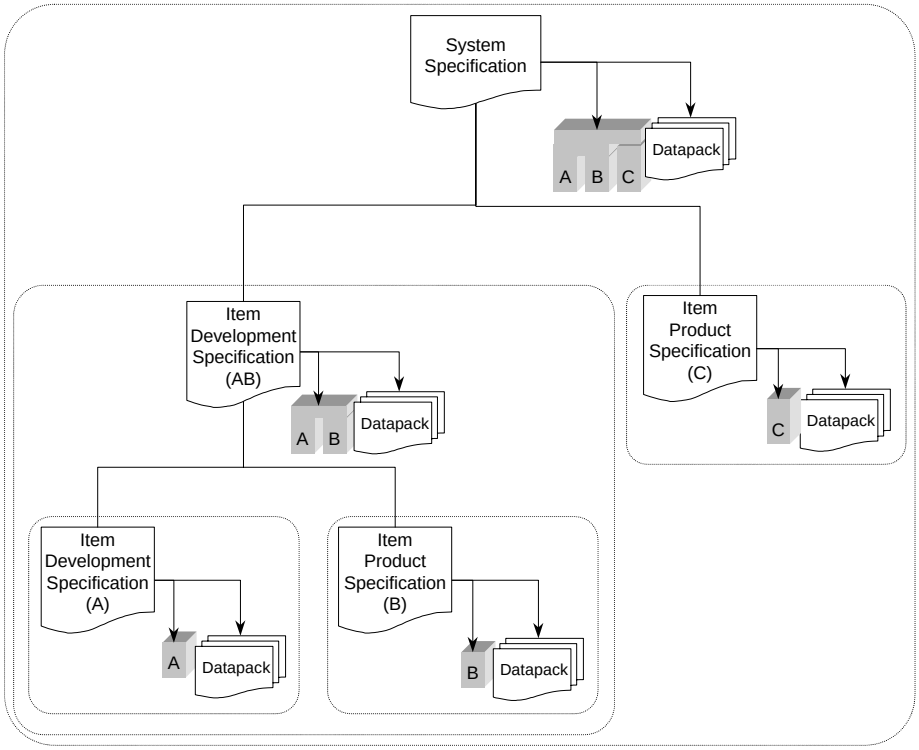

Figure 85: An Example of Tasking in the Specification Tree Hierarchy.

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.

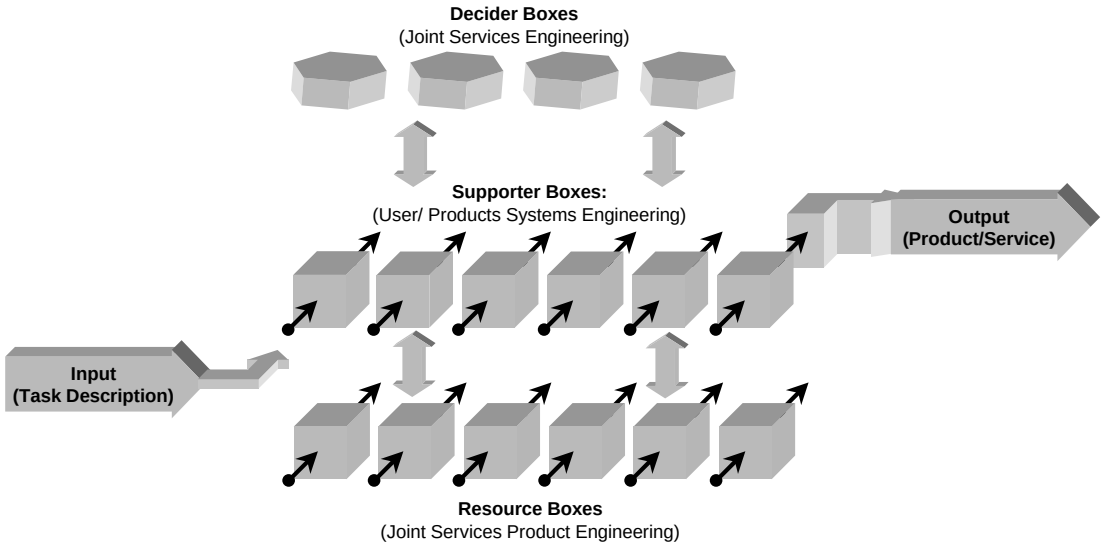

Figure 86: A Model for a SANDF Engineering Structure based on Small Competence Groups.

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.

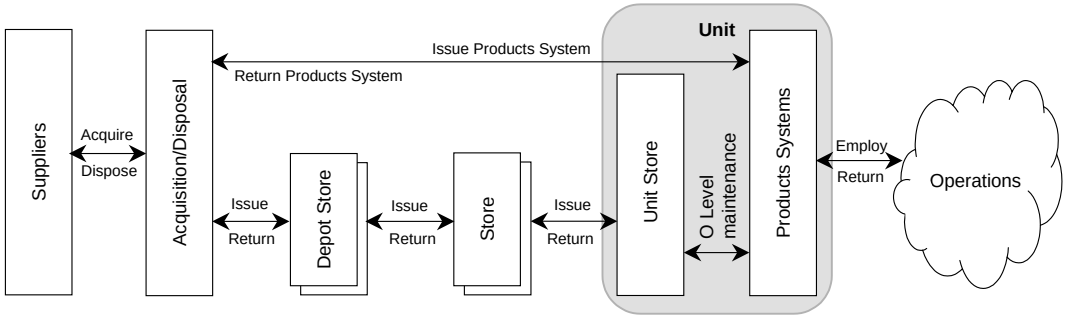

Figure 87: A Products System Supply and Support Materiel Value Chain.

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.