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.

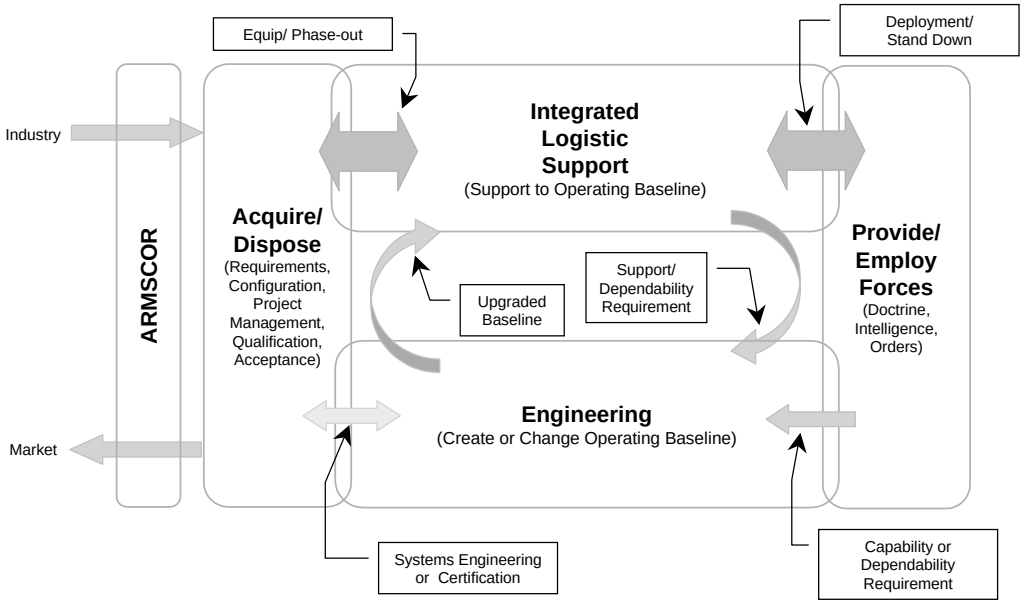

Figure 74: A High-Level Representation of the Support Process

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 The obsolete items are then withdrawn from the Integrated Support function, phased out of service and destroyed or sold, depending on the nature of the item(s).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.

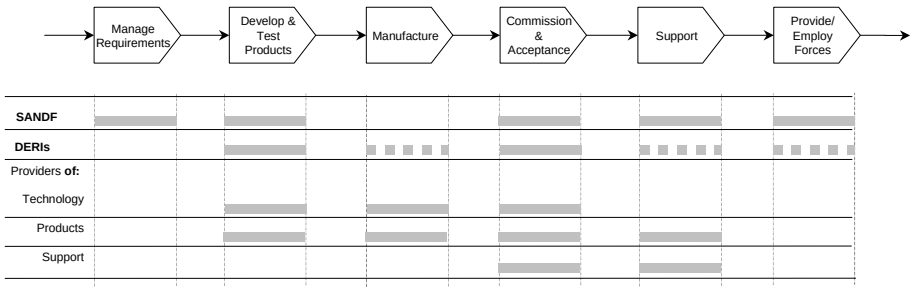

Figure 75: The Application of the ETF during the Various Life cycle Phases.

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																		Activities
Communications			Management			Interpersonal			Dexterity			Technological			Intellectual			
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																		Activities
Communications			Management			Interpersonal			Dexterity			Technological			Intellectual			
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 Developmet	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.

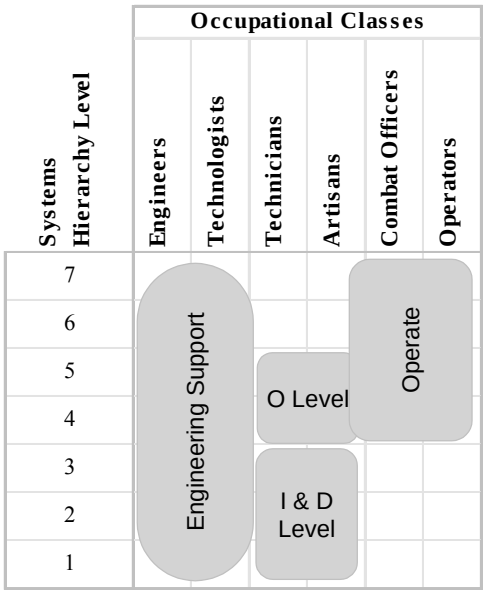

Figure 76: The Context of the Role-Players in the Systems Hierarchy.

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.