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THESIS

**DELIBERATING A CONTRACT-TYPE BASED RISK
MITIGATION STRATEGY FOR SOUTH AFRICAN
DEFENSE ACQUISITIONS**

by

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June 2016

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STRATEGY FOR SOUTH AFRICAN DEFENSE ACQUISITIONS**

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ABSTRACT

This project explores the possibility of applying a contract-type based strategy to manage acquisition program costs and schedule risks for the South African (SA) Department of Defense (DOD). The hypothesis proposes a strategy that consists of the wide variety of contract types for use within the acquisition process. The emphasis is on the application of incentive fees and award fees. The study analyzed three past programs and one current program from the SA DOD to establish a rationale for considering the application of the incentive and award fees for contract types as a risk mitigation plan. An analysis of three similar U.S. DOD programs that also implemented incentive and award fees based on contract type indicated that from a risk management perspective, the application of contract type is not inconsequential but the risks are manageable. In order to facilitate the application of this strategy, we find it is necessary to adapt regulations such as Preferential Procurement Policy Framework Act (PPPFA) and Public Financial Management Act (PFMA) and directive documents such as A-PRAC-1034. Further recommendation indicates that Earned Value Management (EVM) should be considered by the SA DOD to tie deviations between technical, cost and schedule performance.

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LIST OF ACRONYMS AND ABBREVIATIONS

AESA	Active Electronically Scanned Array
ALFA	Advanced Light Fighter Aircraft
AoA	Analysis of Alternatives
AP	Acquisition Plan
APB	Acquisition Program Baseline
CDR	Critical Design Review
CPAF	Cost-Plus-Award-Fee
CPFF	Cost-Plus-Fixed-Fee
CPIF	Cost-Plus-Incentive-Fee
DAG	United States Defense Acquisition Guide
DAP 1000	Defence Acquisition Policy 1000
D&D	Design Development
DOD	Department of Defense
DSMC	United States Defense Systems Management College
DT&E	Developmental Test and Evaluation
EMD	Engineering and Manufacturing Development
EVM	Earned Value Management
FAR	Federal Acquisition Authority
FBL	Functional Baseline
FFP	Firm Fixed-Price
FPAF	Fixed-Price Award Fee
FPI	Fixed-Price Incentive
FPEA	Fixed-Price with Economic Adjustment
FY	Financial Year
GAO	Government Accountability Office
GDP	Gross Domestic Product
GFE	Government Furnished Equipment
ICD	Initial Capability Document

IFF	Identification Friend or Foe
IP	Intellectual Property
IPT	Integrated Program Team
IOT&E	Initial OT&E
KPP	Key Performance Parameters
KSA	Key System Attributes
LIFT	Lead-In Fighter Trainer
LUH	Light Utility Helicopter
MBL	Manufacturing Baseline
MDAP	Major Defense Acquisition Program
MSA	Materiel Solution Analysis
OBL	Operational Baseline
O&S	Operations and Support
OSC	Operational Staff Council
OT&E	Operational Test and Evaluation
PFMA	Public Financial Management Act
PMO	Project Management Office
PPM	Pre-Production Model
PPPFA	Preferential Procurement Policy Framework Act
R	South African Rands
RBL	Requirement Baseline
RFI	Request for Information
RFP	Request for Proposal
ROC	Required Operational Capability
RSA-MIL-STD-3	Military Standard 3
SA	South Africa
SANDF	South African National Defence Force
SDP	Strategic Defence Package
SDR	Software Define Radio
SEP	Systems Engineering Process

SRR	System Requirement Review
SSR	Secondary Surveillance Radar
TMRR	Technology Maturation and Risk Reduction
URR	User Requirement Review
WBS	Work Breakdown Structure
XDM	Exploratory Development Model

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I. INTRODUCTION

Risk management is a critical focus of defense acquisition programs. Unstable government funding, the need to deliver capabilities to soldiers on time, and an increase in technological complexity of defense systems necessitate the implementation of effective risk management. According to Rendon & Snider (2008) acquisition program managers' responsibility and the application of the acquisition process to defense acquisition programs are to mitigate cost, schedule and technical performance risks. Therefore, risk management is applied through all phases of the acquisition process. However, Rendon and Snider (2008) further state that the level of risk decreases as the program progresses from the early to the last phases of the program life cycle because technological maturity increases.

The South African (SA) Department of Defence (DOD) acquisition environment implements risk management for acquisition programs as provided by the risk management plan document prepared for each program. The SA DOD Military Standard 3 (RSA-MIL-STD-3) document specifies acquisition phases in which a risk management plan is mandatory. According to RSA-MIL-STD-3, the risk management plan is required for the approval of each baseline from the Functional Baseline (FBL), and is listed as Category I (C1) element of the program baseline elements. This means a risk management plan is mandatory for each phase of the acquisition processes from the concept phase. Category I elements are those baseline elements that are deemed critical for risks control, and the baseline is rejected when these elements are not satisfactory to the SA DOD. Furthermore, RSA-MIL-STD-3 stipulates the United States (U.S.) Defense System Management College (DSMC) Risk Management Guide for DOD Acquisition, as the document to be used as guide for the development of the risk management plan (SA Department of Defence, 2007a).

The Defense Systems Management College (1989) states that proper risk management requires a systematic approach to the identification of all those factors that poses a risk to the acquisition program. The Defense Systems Management College (1989) further state that while many program managers may use intuitive reasoning as a

starting point in risk management, it is important that the manager goes beyond an intuitive approach for decisions that involve significant risks. For example, a program manager should identify root cause, probability and consequence, and effect on program performance. If the consequence is such that it causes the entire program to fail, then the risk cannot be accepted (Defense Systems Management College, 1989). In the modern defense acquisition environment, the survival of a program depends on understanding these factors and their potential impact on overall performance, including cost and schedule.

The U.S. DOD risk management process has not significantly changed overtime, although the specific program risk mitigation techniques have evolved. In 1989, the U.S. DSMC released a risk management guide in response to a Government Accountability Office (GAO) report on assessment of the U.S. DOD technical risk management efforts. The risk management guide was centered on two points, in addition to the fact that that program management is a risk management technique. The guide emphasized that risk management does not only require technical risks to be managed, but includes the management of schedule risk, cost risk, supportability risk, and programmatic risks (DSMC, 1989). It also underlined that the situations in which risk management effort are performed are different. Therefore, each situation or defense acquisition program will require a slightly different approach (DSMC, 1989).

With the view that risk management extends beyond the management of technical risks, the DSMC provides five facets of risk necessary to manage the overall program performance issues. These are technical, supportability, programmatic, cost, and schedule risks (1989). Furthermore, the DSMC guide (1989, p. 3–3) states that “Cost and schedule risks are somewhat differently than the other three in that they are (more or less) indicators of program status.” The technical and supportability risk affects performance, while programmatic risks are controlled by environment (DSMC, 1989). Therefore, there are few risk management techniques that directly address cost and schedule risk in program management. However, cost overruns and schedule delays can become a major source of overall program performance risks.

In recent approaches to risk management, U.S. DOD does acknowledge the management and treatment of cost and schedule risks, as opposed to treating these risks only as indicators of program status. The Risk Management Guide for DOD Acquisition of 2006 provides the general structure and baseline for conducting risk management. However, it does not prescribe any specific method or tool for mitigating any kind of risk. The guide suggests a risk management process, shown in Figure 1, for continuously identifying and measuring risks throughout the acquisition process. The process consists of key activities for risk management. The activities are Risk Identification, Risk Analysis, Risk Mitigation Planning, Risk Mitigation Plan Implementation, and Risk Tracking. The guide also provides characteristics of successful risk management approaches such as integration of System Engineering Process (SEP) and Test and Evaluation Management Plan (TEMP) within the acquisition process (U.S. Department of Defense, 2006). These risk management key activities are described, and applied to various SA DOD acquisition programs in Chapter III and Chapter IV, respectively.

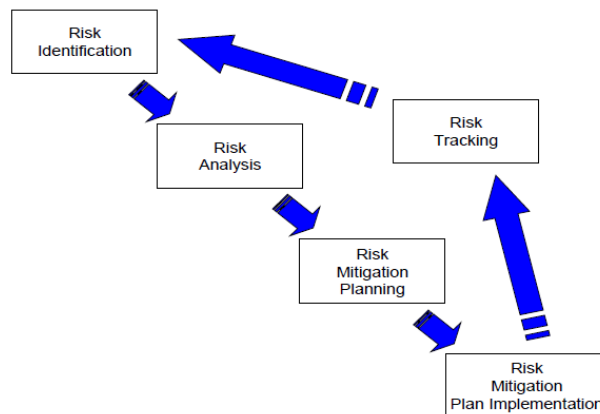


Figure 1. Risk-Management Process. Source: U.S. Department of Defense (2006).

Acquisition programs rely heavily on systems engineering technical processes as techniques to mitigate risks in complex programs with extensive development efforts (SA Department of Defence, 2010; and U.S. Department of Defense, 2015). System engineering

techniques includes models such as V-model and IEEE systems-engineering process (Blanchard & Fabrycky, 2011). These techniques are not only used in mitigating risks that are technical in nature, but indirectly control the resulting cost overruns and schedule slippage (Rendon & Snider, 2008). Nevertheless, the U.S. Defense Acquisition Guidebook (DAG) emphasizes the integration of system engineering processes with risk management implementation (U.S. Department of Defense, 2013).

The SA DOD acquisition environment implements systems engineering processes for acquisition programs as provided and approved by the System Engineering Management Plan (SEMP). As with the risk management plan, the SEMP is considered categorized as a C1 element and it is required for all phases of the acquisition process starting from the concept phase as required by RSA-MIL-STD 3 (SA Department of Defence, 2007a). SA DOD acquisition policy and process guidelines in the Defence Acquisition Policy 1000 (DAP 1000) stipulates and emphasizes that all systems should be acquired in accordance to the system engineering process in order to mitigate the risks. It further states that, although DAP 1000 does not specify a system engineering process, the following engineering principles should be incorporated into the SEMP (SA Department of Defence, 2010):

- Systems Hierarchy
- Work Breakdown Structures
- Requirements Management
- Technical Baseline Management
- Specification Practices
- Risk Management
- Quality Management
- Configuration Management
- Design and Development
- Logistics Engineering
- Life Cycle Integrated Logistic Support (ILS)

- Reliability and Maintainability Management
- Safety of Systems Management
- Test, Evaluation and Technical performance

A further approach to mitigate overall acquisition program risks is the use of the contracting management strategy, specifically the selected contract-type. The approach determines what contract-type to select, whether a cost or a fixed type, at a particular phase of the acquisition program, depending on the level of risks (Butler & Land, 2005). For example, an Integrated Program Team (IPT) may select a cost type contract during the early phases of the program because the requirement is broad, the technological solution is uncertain; therefore the risks level is high. A fixed type contract may be selected at the later phases because the risks level is low (Sanders, Lobkovsky, Meitiv, McCormick, McQuade, & Nzeribe, 2015).

Rendon and Snider (2008) and PMBOK (2004) presented a risk management process with different but similar logic key activities as the ones provided in DOD risk management guide. In the risk response planning phase of risk management process, Rendon and Snider (2008) uses contract-type as a technique to transfer the program cost risk impact between different parties in the acquisition program. In a typical situation, Rendon and Snider (2008, p. 133) states that “This is typically arranged between the government and the prime contractor or between the prime contractor and its subcontractors.”

Furthermore, this technique involves paying the cost risk premium to the party assuming the risk as a means to compensation. Figure 2 demonstrates how this technique is applied. Contract-types include cost-plus fixed fee (CPFF), cost-plus award fee (CPAF), cost-plus incentive fee (CPIF), fixed-price incentive (FPI), fixed-price with economic price adjustment (FPEA), and firm fixed-Price (FFP).

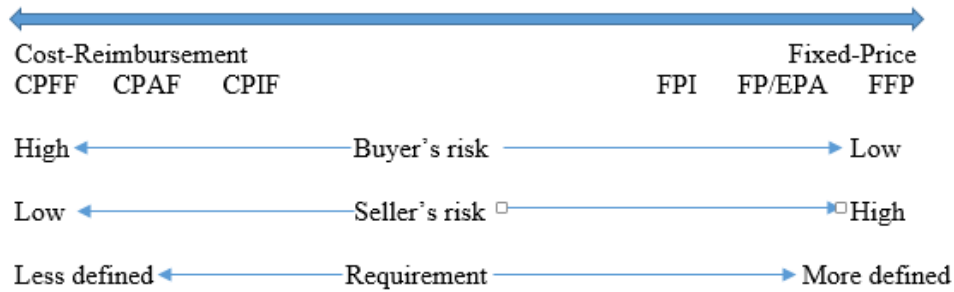


Figure 2. Relationship between Contract type, Requirement, and Risk.
Source: Rendon and Snider (2008).

As mentioned, the SA DOD acquisition organization also applies systems engineering processes to mitigate acquisition program risks and improve performance (SA Department of Defence, 2003). There has never been an emphasis on reviewing the effect of the contracting strategy, specifically the selected contract-type in relation to other types of risks, specifically cost overruns and schedule slippage. The goal of this project is to analyze the effect of contract-type strategy on SA DOD acquisition programs.

A. OBJECTIVE

The South African DOD has a formal acquisition process, which is used to manage the acquisition programs. The process delivers matured defense systems to the South African National Defence Force (SANDF). Figure 3 shows the acquisition process chart for this process, within the context of the system life cycle phases, milestones, and systems engineering technical reviews and configuration baselines as presented in DAP 1000 (SA Department of Defence, 2010).

The objective of this project is to propose a standard contract-type strategy for various phases of the SA DOD acquisition process. It is based on understanding the relationship between requirement certainty and risk. The strategy will provide for each particular phase of the acquisition process a recommended contract-type, either cost reimbursement or fixed type contracts. The strategy will thus be a risk mitigation technique for cost overruns and schedule slippage.

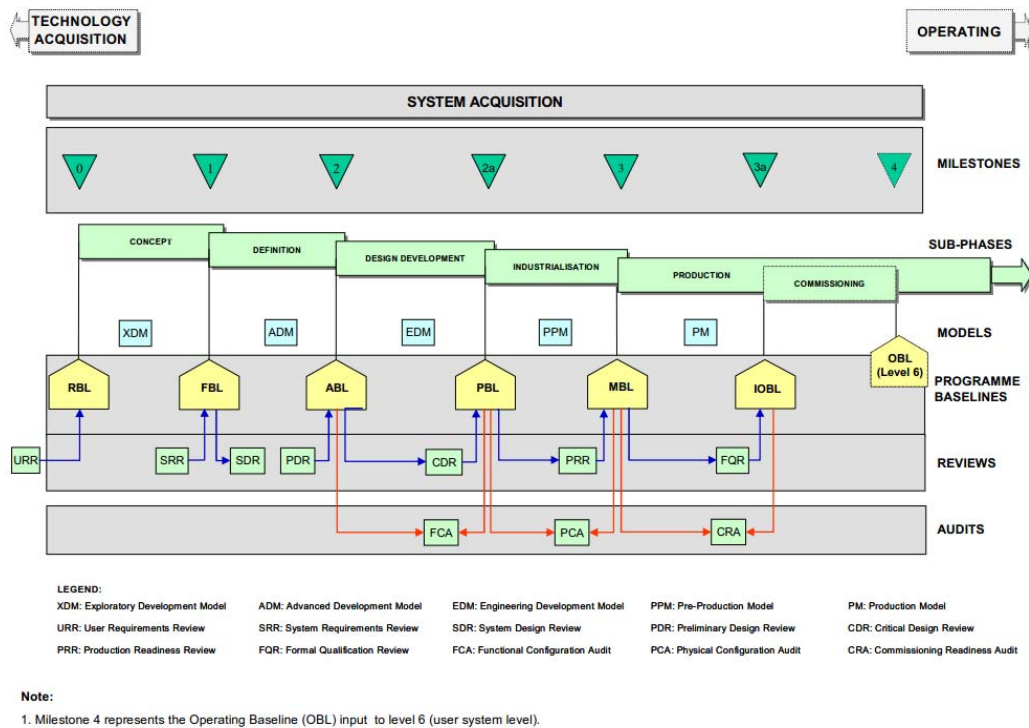


Figure 3. South African DOD Acquisition Process.
 Source: SA Department of Defence. (2010).

B. PROBLEM STATEMENT

The SA DOD measures the performance in acquisition activities during a particular Financial Year (FY) using cash flow of funds allocated to programs. Higher cash flow out of the program to the contractors most likely represents desired and good performance, while low cash flow most likely represents poor performance. This conception assumes that the technical performance is acceptable prior to the payment to the contractor. This in turn depends largely on the ability and capacity of the contractors to deliver on the contracted output.

Figure 4 shows the cash flow performance of various categories of acquisition programs managed by SA DOD during 2014/15 FY (Armscor Annual Report 2014/15, 2015). The cash flow unit is in South African Rands (R).

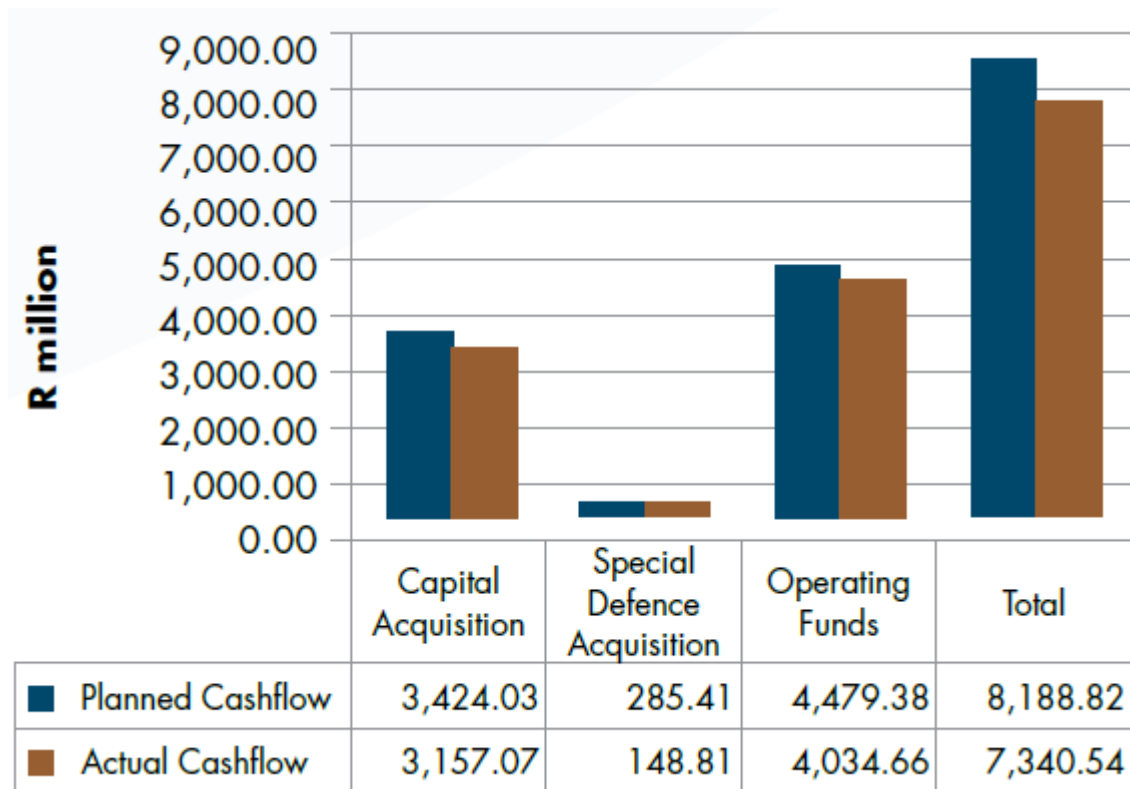


Figure 4. South African DOD Acquisition Cash Flow Performance for 2014/2015 FY. Source: Armscor Annual Report 2014/15 (2015).

The data shows that for all the program categories in the particular year, the actual cash flow is less the planned cash flow. In many cases, the difference in actual cash flow from the planned cash flow may lead to cost overruns and schedule slippage.

Table 1 shows the description, schedule and cost performance status for two SA DOD acquisition programs, Project Swatch and Project Porthole during FY 2013. The status was reported by the news article from defenceweb.com. The third column indicates that projects Swatch and Porthole are 36 months and 34 months behind schedule. The fourth column shows funds that were supposed to be committed to these programs within the specified period. The report further stated that the SA DOD has acknowledged to the Minister of Defence that there are few other programs that involve the provision of equipment to the deployed soldiers that are behind schedule (Politicsweb.com, 2013). This may lead to overall program schedule slippage.

Table 1. Status of Some SA DOD Acquisition Programs. Source: Politsweb.com. (2013).

Program Name	Description	“Schedule Slip”	Financial Cost
“Project Swatch”	Acquisition of a “transportable camping system.”	36 months	R44 467 000 remains uncommitted
“Project Porthole”	Acquisition of a “high altitude parachute system.”	34 months	R97 000 000 remains uncommitted

The risk management identification and analysis phases of the risk management process should have revealed the schedule and cost risks associated with these programs (Rendon & Snider, 2008).

The U.S. DOD uses Earned Value Management (EVM) to quantitatively address problems associated with tying technical performance, cash flow, and schedule. An EVM is defined by the U.S. Department of Defense Earned Value Management System Interpretation Guide as

An EVM System (EVMS) is the management control system that integrates a program’s work scope, schedule, and cost parameters for optimum program planning and control. To be useful as a program management tool, program managers must incorporate EVM into their acquisition decision-making processes; the EVM performance data generated by the EVMS must be timely, accurate, reliable, and auditable; and the EVMS must be implemented in a disciplined manner consistent with the 32 EVMS Guidelines. (U.S. Department of Defense, 2015a, p. 5)

The problem addressed in this project is; although the SA DOD applies system engineering processes successfully in mitigating technical risks, there are still cost overruns and schedule slippage. In view of the performance outcomes of some of the past and current SA defense acquisition programs, there is a legitimate necessity to examine a different risk mitigation technique to reduce overall risks. This project explores the possibility of applying the contract-type strategy, specifically the incentive and award fee contracts in mitigating overall risks.

C. RESEARCH QUESTIONS

The research questions addressed are, how can the contract-type based contracting strategy be implemented in mitigating program risks in the SA defense acquisition programs should this strategy be implemented in order to avoid acquisition program risks that lead to costs overruns and schedule delays, and what are the risk consequences if this strategy is not applied?

D. SCOPE

The contract-type strategy proposed in this project is intended to apply to any SA DOD acquisition program that implements the acquisition process shown in Figure 3. However, the strategy is tested using three past and one current acquisition programs. Therefore, the project does not provide the details on how the strategy should be integrated within a particular SA DOD programs, but only sets the conditions and predicts the possible overall performance improvement on future programs.

E. METHODOLOGY

This project begins by discussing some of important concepts of defense acquisition risk management, contract management and acquisition management concepts available in literature, with the focus on contract-types strategies. It then introduces the SA DOD acquisition process, its supporting policies and practices. A standard contract-type strategy for the SA DOD acquisition is proposed. The project then applies the contract-type strategy to past and current SA DOD programs as a technique to mitigate cost and schedule risks, and provides the analysis thereafter. The project the uses three similar U.S. DOD acquisition that applies contract-type strategy to test if there is a link between the contract-type selected and the acquisition program success, as proposed for the SA DOD. Finally, the project provides recommendations and proposes future work that can be undertaken.

F. REPORT ORGANIZATION

Chapter II provides the literature review, which reflects on concepts and previous endeavors in the field of risk management, contract management, U.S. DOD acquisition

process and SA DOD acquisition process. Chapter III presents the proposed contracting strategy for the SA DOD acquisition process. Chapter IV presents the analysis of three past and one current SA DOD programs, and how the proposed could be used to mitigate program risks. This chapter is tailored to the system elements that apply to risk and contract management. Chapter V presents an analysis of three U.S. DOD programs that applies contract-type strategy to test if one current SA DOD acquisition program, and applies the risk management process in order to test if there is a link between the contract-type selected and the acquisition program success. Chapter VI provides the conclusion, and recommended areas for future study.

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II. LITERATURE REVIEW

Most DOD acquisition systems around the world recognize risk management as important to acquisition program success (U.S. Department of Defense, 2013; SA Department of Defence, 2010; and Kausal & Markowski, 2000). Risk management is therefore as a function, generally integrated within the acquisition processes of most DODs. Although the approaches may differ, the structures of risk management processes are generally similar. In this chapter, a general overarching structure of risk management process is reviewed along with common terminology, techniques, and issues, as applied across some of the DOD acquisition programs. The chapter also reviews contract-type strategies, viewed as part of the government contract management framework. Finally, an overview of the SA DOD acquisition process is addressed.

A. RISK MANAGEMENT

According to the U.S. DOD risk management guide, risk is defined as

a measure of future uncertainties in achieving program performance goals and objectives within defined cost, schedule and performance constraints. Risk can be associated with all aspects of a program (e.g., threat, technology maturity, supplier capability, design maturation, performance against plan). (U.S. Department of Defense, 2006, p. 1)

Furthermore, the guide states that “Risk management is the overarching process that encompasses identification, analysis, mitigation planning, mitigation plan implementation, and tracking. Risk management should begin at the earliest stages of program planning and continue throughout the total life-cycle of the program.” (U.S. Department of Defense, 2006, p. 1). A risk is different from an issue in that an issue is the measure of an event that has already occurred. The U.S. DOD risk management guide states about how a risk differs from an issue as

An important difference between issue management and risk management is that issue management applies resources to address and resolve current issues or problems, while risk management applies resources to mitigate future potential root causes and their consequences. (U.S. Department of Defense, 2006, p. 1)

The DSMC (1986) states the factors that can be a source of risk such as technology, contract management issues, engineering design issues etc. Chapter I mentioned that in its 1989 risk management guide, the U.S. DOD specified six facets of risk, namely: technical, programmatic, supportability, cost, and schedule risks. Table 2 depicts an example from each facet of risk (DSMC, 1989). Each list is not exhaustive.

- Technical risk—A technical risk is defined as risk associated with new design or technology implemented in order to increase the level of performance. Typically, technical risks are due to requirements for greater system performance.
- Programmatic risk—A programmatic risk is related to those factors involving the provision and use of certain resources and activities that are outside program control, but has potential to disrupt the program. The examples are the interruption by decision made at higher level of authority, interruption by an event not directly related to the program, or interruption caused by imperfect capabilities.
- Supportability risks—Supportability risks involve those risks associated with fielding the system being developed, such as logistic support, training etc.
- Cost and schedule risk—A cost and schedule risk mean potential of cost and schedule growth. These risks are a function of IPT ability to manage technical, programmatic and supportability risks. As it was mentioned in Chapter I, most risk management techniques are developed to directly address technical, programmatic and supportability risks, in anticipation to control cost and schedule risks.

Table 2. Examples of Risks by Facets. Adapted from Defense Systems Management College (1989).

Typical Technical risk sources	Typical programmatic risk sources	Typical Supportability risk sources	Typical cost risk sources	Typical schedule risk source
Testing Modelling Interfacing Integration Immature technology	Material availability Personnel availability Regulation changes Labor strike Requirement changes	Reliability and maintainability Interoperability Transportability Facility consideration Manpower	Sensitivity to technical, programmatic, supportability, and schedule risks Overheads and G&A rates Estimating error	Sensitivity to technical, programmatic, supportability, and schedule risks. Degree of concurrency Number of critical path items

According to U.S. DOD risk management guide (U.S. Department of Defense, 2006), risks have three components: a future root cause, probability, and consequence. A future root cause is a factor or component of the risk that when corrected, would prevent the risk from occurring. A risk is most of time due to the future root cause. As defined by the U.S. Department of Defense (2006), a probability is the likelihood of future root cause occurring measured at present time. A consequence is the impact of that future root cause on cost, schedule, and technical performance (Department of Defense, 2006).

According to Ketzer (2006), conceptually the project risk can be represented as a function of both probability and the consequence as:

$$\text{Risk}_e = f(\text{probability, consequence})$$

This representation of risk leads to assigning individual risks a numerical level, in order to classify the extent of the likelihood and the impact on the program performance parameters (For example, schedule and costs). This method is termed “qualitative risk-analysis” (Rendon & Snider, 2008). In Chapters IV and V, this method is applied to SA DOD acquisition programs to analyze schedule and costs risks.

Figure 1 showed the risk management process as described by the U.S. DOD Risk Management Guide. In this section prior to describing each risk management activity in

the process, the depiction by Rene and Rendon (2008), and PMBOK (2004) is provided in Figure 5. The concept and principle of both processes are similar.

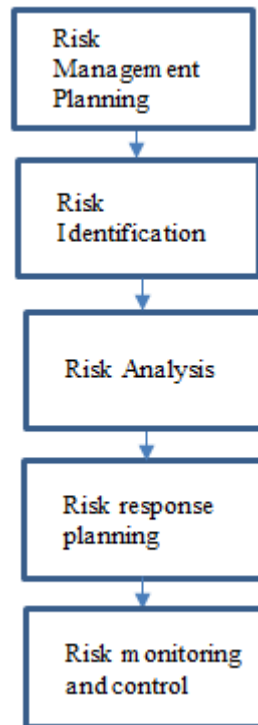


Figure 5. Risk-Management Process. Source: Rendon and Snider (2008).

1. Risk Management Planning

The initial activity on the risk management involves planning. This activity involves making decisions on how to approach risk management for a specific program. The approach includes specifying the risk levels, type, and the extent which the visibility is required for different risks. The popular project management tools used to achieve these activities is project scope, project Work Breakdown Structure (WBS), and risk WBS. The project scope covers all aspects that relate to project objectives, deliverables, cost, and schedule estimates. These aspects in turn determine the approach, risk levels, type, and the extent to which the visibility is required (PMBOK, 2004).

The Project WBS is used to decompose project expected deliverables and functions into categories and subcategories. Furthermore, the WBS is used to assign tasks

to different IPT members, make budget and schedule estimates etc. Risk WBS follows project WBS, it is used to decompose risks into categories and subcategories based on risk level, type, and the level of visibility. Risk WBS categories can also be based on technology, environment, organization, and requirement. After the approach to risk management to a specific program is determined, it is documented into a risk management plan prior to entering the next activity (Rendon & Snider, 2008) and (PMBOK, 2004).

2. Risk Identification

Risk identification involves identifying and documenting all the risks that have the potential to affect the program, and their characteristics. These include risks that affect program performance objectives such as cost, schedule, and technical objectives. Risks are identified by analyzing and going through the elements and information obtained from the project scope, project WBS, and risk WBS produced from risk management planning phase. As with the risk management planning phase, the risks are identified from the phase, and the characteristics are documented in the risk management plan. Risk identification processes should be continuously performed, because as the new information on the program is obtained, the level of uncertainty and risk might change (Rendon & Snider, 2008).

3. Risk Analysis

Risk Analysis entails determining the extent of the impact to which the risks identified from the previous phase have on program performance objectives, by determining the risk level. The impact is evaluated for cost, schedule and technical performance objectives. As mentioned, the risk level is a function of risk estimated likelihood and consequence. For formality and traceability purposes, it is important that the risk level is developed using systematic and possibly an objective approach.

Rendon and Snider (2008) described two types of risk analysis, qualitative and quantitative analysis. Qualitative analysis is based on detail analysis and assessment of the root causes of the risks identified, and therefore allocating an appropriate risk level as either low, medium or high. Johnson and Birkler (1996) illustrated how a qualitative

analysis was used as part of risk management in the acquisition of U.S. DOD FA-18E/F, F-22, and RAH-66 programs. A method for analyzing and assessing the root cause of the risk begin by directly extracting each specific risk from the risk WBS, and develop a required pair of numeric values representing the risk estimated likelihood and the consequence. These values are usually a whole number. They are plotted on the risk matrix (shown in Figure 6) used to determine the risk level (U.S. Department of Defense, 2006).

To assign an estimated likelihood value, for each risk ask what is the probability of the risk event to occur. As shown in Table 3, likelihood values are based on a range from 1 to 5. The value 1 represents not likely with the probability of 10%, and value 5 represents near certainty with the probability of 90% (U.S. Department of Defense, 2006).

Table 3. Risk Likelihood Values. Adapted from U.S. Department of Defense (2006).

Value/level	Likelihood	Probability of occurrence
1	Not likely	~10
2	Low likely	~30
3	Likely	~50
4	Highly likely	~70
5	Near certain	~90

To assign a value on the consequence or impact, for each program cost, schedule, and performance objective, the value 1 represents minimum or no impact, while value 5 represents severe impact as shown in Table 4. For each risk ask questions such as, does the risk impact the cost, schedule, or technical performance? Furthermore, does it impact operational or management performance? In terms of impact on cost, does it affect the acquisition or sustainment costs, or perhaps overall life-cycle costs? When it comes to impact on schedule, does the risk change the critical path of the program, meaning does it delay the program? It is important to note although each particular program will have its criteria for assigning an estimated likelihood and consequence, it should be systematic and less subjective (Rendon & Snider, 2008).

Table 4. Table 4 Risk Consequence Values. Adapted from Rendon and Snider (2008).

Value/Level	Technical Performance	Schedule	Cost
1	Minimal or no impact	Minimal or no impact	Minimal or no impact
2	Minor reduction in technical for supportability, can be tolerated with little or no impact on program	Able to meet key dates; Slip <=month(s)	Budget increase or unit production cost increase; <= (1% of the budget)
3	Moderate reduction in technical performance or supportability with little or no impact on program objectives	Minor schedule slip; able to meet key milestones with no schedule float; Slip <=months(s); sub-system slip>=months plus available float	Budget increase or unit production cost increase; <=(5% of the budget)
4	Significant degradation in technical performance or major shortfall in supportability might jeopardize program success.	Program critical path affected; Slip <= months	Budget increase or unit production cost increase; <=(10% of budget)
5	Severe degradation in technical performance; cannot meet KPP or key technical/ supportability threshold; will jeopardize program success	Cannot meet key program milestone; Slip >=months	Exceeds APB thresholds; >=(10% of the budget)

Following obtaining values for risk event likelihood and consequence, they are plotted on a 5x5 risk matrix shown in Figure 6. High-risk events (green area) will be located toward the top-right area, medium risk events will be located around the center (yellow area), while low risk events will be located toward bottom left area (green area), of the risk matrix. Each risk plotted on the matrix can be further be labelled according to its Risk Title (for example as in the risk WBS), Risk Casual Factor, and the Mitigation Approach which is the subject of the next phase (U.S. Department of Defense, 2006).

Quantitative risk analysis involves the use of modelling and simulation method to quantify program's level of identified risk events. Quantitative risk analysis techniques include monte Carlo technique, sensitivity analysis, value analysis, decision tree analysis etc. (Rendon & Snider, 2008).

4. Risk Response Planning

Risk response planning is an activity of developing options, and determining the specific approach to address the identified risks.

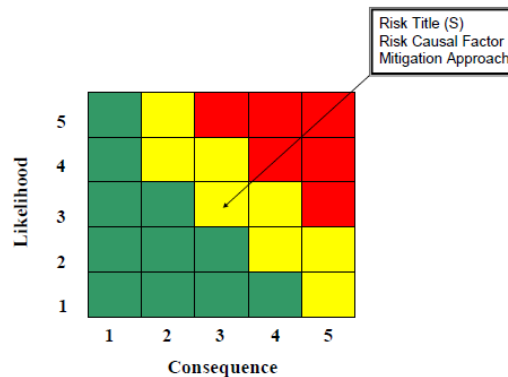


Figure 6. Risk Matrix. Source: U.S. Department of Defense (2006).

The specific approaches to address the risks as defined by U.S. DOD risk management guide include risk assumption, risk avoidance, risk mitigation, and risk transfer (U.S. Department of Defense, 2006).

- Risk assumption—Risk assumption involves intentionally accepting the risk without changing the program scope; cost, schedule or technical performance objectives. Usually, this option is selected when the risk consequence is not major. Furthermore, this approach can be coupled with the provision and approval of contingency reserve of resources such as additional funds, or extending target dates etc., to handle the risk being accepted (United States Government Accountability Office, 2012).
- Risk—avoidance Risk avoidance involves changing of the program scope; cost, schedule, and performance objectives. Usually, this option is selected when the risk consequence is so high to the extent that it is detrimental to the achievement of program's objectives. Risk avoidance techniques include changing of program concept, technical designs specifications, manufacturing process, and contracting processes (Ketzer, 2006) and (Rendon & Snider, 2008).
- Risk Mitigation—Risk mitigation involves developing strategies to reduce the risk likelihood of occurring, or the level of consequence. Risk mitigation does not focus on removing the root cause of the risk, instead on reducing the level of risk. Risk mitigation techniques include using prototypes, modelling and simulation, using configuration control boards,

extended tests in order to generate more technical information and better understand the program (Rendon & Snider, 2008).

- Risk transfer—Risk transfer techniques include the use of contract-type strategies such as cost-reimbursement and fixed-type contracts. In a cost-reimbursement contract, all the “allowable, allocable, and reasonable costs” are reimbursed by the DOD to the contractor, the cost risk are transferred from the contractor to the DOD (Rendon & Snider, 2008). In a fixed-price contract, the DOD only pays for fixed or adjusted price. Contract-type selection is the significant risk management strategy and requires technique. Figure 2 illustrates such a strategy (Rendon & Snider, 2008). The contract-type selection strategy has not been analyzed in the SA DOD acquisition environment as a technique to reduce the risk (Armstrong Practice for Selection of Contractual Sources, 2014). The contracting officer’s role in the SA DOD acquisition programs is performed by the program manager (Armstrong Practice for Selection of Contractual Sources, 2014), as opposed to the U.S. where this role is performed by the contracting officer (Garrett & Rendon, 2007). For example GAO found that the use of cost-reimbursement contracts by the U.S. DOD to acquire early production of F35 Joint Strike Fighter transferred significant risk to the DOD. This is because the technical designs were not mature, likelihood to be changed, which ultimately delay the production and increase costs (United States Government Accountability Office, 2006).

5. Risk Monitoring and Control

Risk monitoring and control activity where the identified risk, and implemented risk management approach or technique, is monitored for their effectiveness and impact on the performance. If the implemented techniques were found to be ineffective, alternatives techniques are may be considered and applied. Otherwise, if the techniques are effective, the risk event can be reassessed, and reallocated a lower risk level. Risk monitoring and control further involves identifying new risks, performing risk analysis and response planning. It is exactly the same as repeating the risk management process, as it was mentioned that risk management is iterative, and applied throughout the program life cycle. The example of techniques used for risk monitoring and control are earned-value management, trend analysis, technical performance measures etc. (Rendon & Snider, 2008).

B. CONTRACT MANAGEMENT

Contract management is a central element to defense acquisition activities. Contract management function is required and necessary for almost all phases of the acquisition processes. For many DOD's organizations, the acquisition of systems, product and services, is governed from the higher structures of the government through procurement regulations that are applied commonly through all government departments and agencies. These regulations formulate the contract management principles and processes that endeavor to achieve the best value, manage risk, and facilitate fairness for the procurement, and consequently the acquisition system.

Both U.S. government and SA government have the regulatory framework for contract management. The U.S. government has Federal Acquisition Regulation (FAR), as a governing and guiding regulation for government procurement, and applied across government executive agencies (Federal Acquisition Regulation, 2005). Similarly SA government has the Preferential Procurement Policy Framework Act (PPPFA), which governs the way in which government departments and agencies like SA DOD establish regulations for procurement during acquisitions (Preferential Procurement Regulations, 2001 Pertaining to the Preferential Procurement Policy Framework act: no 5 of 2000, 2000). The financial management system that supports the PPPFA and agency specific regulations is called Public Financial Management Act (PFMA) (Public Finance Management Act No. 1 of 1999, 1999). Defense acquisition policy documents such as DAP 1000, and contract management practice document such as A-PRAC-1034, and supplement PPPFA, are created and applied within the framework of PPPFA and PFMA (SA Department of Defence, 2010) and (Armcor Practice for Selection of Contractual Sources, 2014).

The contract-type strategy is part of FAR; it is used widely across the U.S. DOD as a mechanism to address the procurement risks associated with various circumstances arising during the acquisition. Section 16 of FAR, commonly referred to as FAR part 16 covers contract-type options available for the U.S. government executive agencies. The contract-type is selected by the contracting officer, and approved by the relevant body, and it is included in the AP by the IPT. The following subsection describes contract-types

as per FAR part 16 and factors affecting their selection. Thereafter, the chapter delves into the applicability of the contract-type to the acquisition process and risk management.

1. Contract Types

There are two broad categories of contract types namely, Fixed and Cost reimbursement type contract. The two categories are further divided into more specifically defined contract-types. Cost reimbursement consists of CPFF, CPIF and CPAF. Fixed-price contract consists of FFP, FPI, FPEA and fixed-price award fee (FPAF). For example in the CPFF, the DOD assumes most risks, and covers a significant part of the resulting costs and negotiated fixed fee (Profit). In the FFP, the contractor assumes most risks in terms of the resulting costs and profit (or loss). In between, a couple of incentive contracts in which the cost performance and profit are determined by the uncertainties affecting the contract performance (FAR, 2005) and (Butler & Land, 2005).

a. Fixed-Price Contracts

Fixed-price contract-type are contracts providing for a firm price, or adjustable prices based on the ceiling price or target price (or both). There are three types of fixed-price namely: FFP, FP/EPA, and FPI contracts. FFP and FP/EPA are used when Commercially-off-the-Shelf items are acquired, and cannot be used when in the acquisition of time-and-materials, and labor-hour contracts (FAR, 2005).

(1) Firm Fixed-Price Contract

A FFP contract is the contract which is characterized by the fact that price cannot be adjusted on the basis of contractor's performance costs. This makes it simpler to place a charge upon the contractor to control costs. (FAR, 2005). According to U.S. FAR (2005) FFP can be used with incentive or award fee contracts, as long as incentives or award fee are not based on costs.

FFP contracts are suitable in situations where the functional and technical specifications of the system or product being acquired are reasonably definite. An example would be in the situation where the IPT has determined that the technology

elements core to the system have matured enough, and there are no further risks associated with development (FAR, 2005).

(2) Fixed-Price contract with Economic Price Adjustment

The FAR describe the FPEA contract as the contract that “provides for upward and downward revision of the stated contract price upon the occurrence of specified contingencies” (FAR, 2005, p. 16.2-1). The FAR further states that the factors in which the price adjustments can be based on include adjustment based on the increase or decrease of the agreed upon published prices of specific item or specific contract end items, and end item cost of items such as labor, material and from associated indexes (FAR, 2005). These factors can arise due to, for example, instability of the markets or labor conditions that extends for a reasonable period during the performance of the contract or program phase. Likewise, FPEA contract can be used with incentive or award fee contract, as long as incentives or award fee are not based on cost. FPEA contracts are suitable in situation where the U.S. DOD determines that the contractor and the DOD needs should be protected against the specified contingencies (FAR, 2005).

(3) Fixed-Price Incentive Contract

A FPI contract is a contract whereby a final profit due to the contractor can be adjusted using a specified formula. According to FAR (2005, p. 16.2-3) definition a FPI contract is a “fixed-price contract that provides for adjusting profit and establishing the final contract price by a formula based on the relationship of final negotiated total cost to total target cost.” FAR however mention that the final price is limited by the specified ceiling agreed upon by the parties when the contract is initiated (FAR, 2005). FPI is further divided into two forms, firm target, and successive target (FAR, 2005).

In a FPI firm target contract, a final profit due to the contractor is determined using an adjusting formula agreed upon by the two parties at the beginning of the contract (FAR, 2005). When the contractor completes performance, the final profit is established using this formula. The amount of profit depends is determined by weather the final cost is greater, or less than the target cost (FAR, 2005). This formula will result in a loss for a contractor if the final costs exceed the specified ceiling (FAR, 2005). Therefore, the

ceiling protects the government, while the profit variation incentive the contractor. (FAR, 2005).

FPI successive targets contract provides for the parties to revisit the contract after the performance has begun because there inadequate pricing data in the beginning (FAR, 2005). These parties then determine if FFP or FPEA should be selected after a certain amount of contract performance has occurred using an incurred cost as a guide. (FAR, 2005).

(4) Fixed-Price Incentive contract with award fees

The Fixed-Price Incentive contract with award fees is defined by FAR as

Fixed-price contracts when the Government wishes to motivate a contractor and other incentives cannot be used because contractor performance cannot be measured objectively. Such contracts shall establish a fixed price (including normal profit) for the effort. This price will be paid for satisfactory contract performance. Award fee earned (if any) will be paid in addition to that fixed price. (FAR, 2005, p. 16.4-4 to 16.4-5)

b. Cost-Reimbursement Contracts

In a cost-reimbursement contract the government permits to contractor to perform, then at the later stage pays the allowable incurred costs, plus an agreed upon fee at the beginning as a profit (FAR, 2005). The price determined at the beginning of the contract performance is only based on the estimates of fair and reasonable costs, in order to obligate the funds and establish the ceiling amount. Cost-reimbursement contracts are in general used in situations where, the circumstances do not allow for the determination of the definite requirement with certainty, and when the costs cannot be estimated with accuracy so the exact price can be established. These factors have to be established first, and AP be approved, prior to the issuing of the cost-reimbursement contract (FAR, 2005).

There are additional requirement applicable to the IPT with regard to issuing of cost-reimbursement contracts, established to protect the government against possible unallowable costs. These requirements include, that the contractor accounting system should be adequate to determine the costs incurred during the performance of contract,

sufficient government resources should be available to provide contract oversight. It is typically not advisable to select cost-reimbursement contracts during the acquisition of COTS (FAR, 2005). Cost-reimbursement contracts are divided into various types, defined and applicable for differing situations. Each type is described as follows.

(1) Cost Contract

Cost contract is described by FAR (2005, p. 16.3-1) as “a cost-reimbursement contract in which the contractor receives no fee.” An application include “research and development work, particularly with nonprofit educational institutions or other nonprofit organizations” (2005, p. 16.3-1).

(2) Cost Sharing Contract

Cost sharing contract is described by FAR as

a cost-reimbursement contract in which the contractor receives no fee and is reimbursed only for an agreed-upon portion of its allowable costs. An application includes a situation when “the contractor agrees to absorb a portion of the costs, in the expectation of substantial compensating benefits” (FAR, 2005, p. 16.3-1)

(3) Cost-Plus-Fixed-Fee Contract

A CPFF contract is described by FAR as

a cost-reimbursement contract that provides for payment to the contractor of a negotiated fee that is fixed at the inception of the contract. The fixed fee does not vary with actual cost, but may be adjusted as a result of changes in the work to be performed under the contract. This contract type permits contracting for efforts that might otherwise present too great a risk to contractors, but it provides the contractor only a minimum incentive to control costs. (FAR, 2005, p. 16.3-1)

(4) Cost-Plus- Incentive-Fee Contract

A CPIF contract is described by FAR as

The cost-plus-incentive-fee contract is a cost-reimbursement contract that provides for the initially negotiated fee to be adjusted later by a formula based on the relationship of total allowable costs to total target costs. This contract type specifies a target cost, a target fee, minimum and maximum fees, and a fee adjustment formula. After contract performance, the fee

payable to the contractor is determined in accordance with the formula. The formula provides, within limits, for increases in fee above target fee when total allowable costs are less than target costs, and decreases in fee below target fee when total allowable costs exceed target costs. This increase or decrease is intended to provide an incentive for the contractor to manage the contract effectively. When total allowable cost is greater than or less than the range of costs within which the fee-adjustment formula operates, the contractor is paid total allowable costs, plus the minimum or maximum fee” (FAR, 2005, p. 16.4-5)

CPIF contracts are used in major systems development contracts where technical performance incentives are appropriate, and the requirement and performance objectives can at least be described in general terms. The contract is mostly used in development and test contracts (FAR, 2005).

(5) Cost-Plus- Award-Fee Contract

CPAF contract is described by FAR as

a cost-reimbursement contract that provides for a fee consisting of a base amount fixed at inception of the contract, if applicable and at the discretion of the contracting officer, and an award amount that the contractor may earn in whole or in part during performance and that is sufficient to provide motivation for excellence in the areas of cost, schedule, and technical performance. (FAR, 2005, p. 16.4-5)

2. Factors Affecting the Selection of Contract Type

The selection of the appropriate contract-type in contracting occurs as early as in the procurement planning phase, of the six phases of the procurement process (Garrett, 2010). The following factors affect the selection of contract type at any phase of the acquisition as per FAR 16.104, and should be considered by the acquisition officials when selecting the contract-type. They are based upon an extent to which the risk reduction is required:

- Price competition—adequate price competition allows for the determination of the realistic price, and it is relied upon when fixed-price type contracts are necessary (FAR, 2005).

- Total price analysis—price analysis provides the basis for contract type selection when adequate price competition cannot be attained. (FAR, 2005).
- Item costs analysis—It is used “in the absence of price competition, and price analysis,” and the contract-type that places a reasonable risk burden on contractor is negotiated (FAR, 2005).
- Type and complexity of the requirement—Complex and broad requirements, government unique requirements, and complex research & development contracts with great level of uncertainty of the solution places a greater risk burden to the government, and cost-reimbursement contracts are preferable during these types of requirement. (FAR, 2005).
- Combining contract-types—If the whole contract cannot be made FFP due to some circumstances, the acquisition officials should see if a certain portion of the contract cannot be made FFP (FAR, 2005).
- Urgency of the requirement—If the system being acquired is primary, the government may assume a risk, and offer an incentive-based contracts in order to motivate the contractor (FAR, 2005).
- Period of performance or length of the production run—Contracts extending over a long proposed period, and consumed significant amount of allocated funds may require an economic-price-adjustment-based contract (FAR, 2005).
- Contractor’s responsibility—When the technical capability and financial responsibility of the contractor is uncertain, cost price contract may be selected in order to allow for the provision of oversight by the government (FAR, 2005).
- Adequacy of the contractor accounting system—For contract-type contracts other than fixed-price, the government acquisition officials should ensure that the contractor accounting system is adequate to capture the costs data necessary for the selected contract-type (FAR, 2005).
- Concurrent contracts—If the performance of the current contract is based on the concurrent operation of the other contracts, the status of the contract already in operation may affect the selection of the current contract-type (FAR, 2005).
- Extent and nature of subcontracting—In the case where the contractor uses extensive subcontracting, the total contract risk should include the actual risk to the prime contractor, and the selection of contract-type should reflect this situation (FAR, 2005).

- Acquisition history—Overall risks decrease as the system is repetitively acquired, and the description and requirement can be defined more clearly. A fixed-price contract becomes more appropriate (FAR, 2005).

3. Contract Management in the SA DOD

According to A-PRAC-1034, when selecting the contractor during the procurement within the SA DOD, the IPT should strive to achieve objectives listed in the following text. These objectives further influence the flexibility of the SA DOD to implement the contract-type based risk mitigation strategy.

- Competition—Competition should be encouraged as far as practical, even if it means foreign contractors need to be considered (Armscor Practice for Selection of Contractual Sources, 2014). This means in principle that fixed-price contracts such as FFP, FPEA, or FPI can be selected for award. However, there is no given guidance on what parameters to consider when using FPI. This include parameters that are important to determine the final price of the FPI such target costs, ceiling price, and the relationship between them (FAR, 2005). Furthermore, the PPPFA does not mention any incentive based contracts (Preferential Procurement Regulations, 2001 Pertaining to the Preferential Procurement Policy Framework act: no 5 of 2000, 2000).
- Best value—The IPT should strive to award contracts based on best value, not necessarily on the lowest price. Best value may include among others, the total life cycle costs, and technology & industry mobilization goals (Armscor Practice for Selection of Contractual Sources, 2014) and (Defence in a Democracy, White Paper on National Defence for the Republic of South Africa, 1996). Qualitatively, the term best value, as used by A-PRAC-1034 is defined as performance, taking into account the risks.
- Risks—The IPT should acknowledge that there exists a significant amount of uncertainty regarding the final cost of the contract items and schedule. This means that the SA DOD does consider assuming a fair amount risk during the acquisition, including cost risk.
- Contract-type—There is further no formalized guidance on how to implement cost reimbursement contracts. There incentive and award fee based contracts are not possible according to the application of A-PRAC-1034, and PPPFA frameworks. This range of contract-type selection does not motivate contractors to contain costs, while achieving schedule and technical performance. This should be an ultimate view of best value as required by the SA DOD (Armscor Practice for Selection of Contractual Sources, 2014 and Preferential Procurement Regulations, 2001 Pertaining

to the Preferential Procurement Policy Framework act: no 5 of 2000, 2000).

- Oversight—Oversight is important and should be provided, as per PPPFA because defense acquisition programs cost government billions of dollars. Nevertheless, it is expected that there should be transparency and accountability even as when oversight is applied, as directed by the PPPFA. This even if it means the issue is elevated to the legal subject, especially if contract irregularities and corruption is involved (Government of the Republic of South Africa General Procurement Guidelines, n.d.) and (Government of the Republic of South Africa Policy Strategy to Guide Uniformity in Procurement Reform Processes in Government, 2003). However, should be noted that transparency, accountability and responsibility is influenced by the historical, cultural and moral background of the society. In a society where transparency and accountability are achievable, the level of confidence to procurement regulations such as PPPFA improves (The AEY Investigation, 2008) and (Inspector General Department of Defense, Defense Criminal Investigative Service Las Vegas Post of Duty c/o USAF OSI, 2008).
- Budget—The provision of incentive based contract-type is further influence by nation's defense budget. The higher the funds allocated for a program, the easier it becomes for the SA DOD to assume the risk and award incentives contract in order to improve performance. Therefore, under stringent budget conditions and strict schedule requirement it would be challenging to obligate funds for incentive fees. Primarily, these relationships are fundamentally influenced by the nation's priorities with respect to defense. For example, according to SA defense review (SA Department of Defence, 2014), the current spend on defense is less than 1.2% of nation's Gross Domestic Product (GDP). Therefore, the solution lies at the national policy level.

C. DEFENSE ACQUISITION FRAMEWORKS AND CONTRACT-TYPE

The U.S. DOD acquisition system consists of a process, with a series of phases and milestones. Phases represent the life cycle stages in which an acquired system goes through. Milestones represent the decision making points to provide for formal transition from one phase to another. This section summarizes broad objectives and activities of each phase of the U.S. DOD acquisition framework, and thereafter typical contract-types selected per each phase. The section then introduces the SA DOD acquisition process.

1. U.S. DOD Acquisition Framework

Figure 7 shows the U.S. DOD acquisition framework (Acquisition Process: Acquisition Process Overview, n.d.), typically used for Major Defense Acquisition Programs (MDAPs). The U.S. DOD Directive 5000.1 allows the process to be tailored to program specific requirements. For example, an IPT can be established during the Materiel Solution Analysis (MSA) phase that there is already sufficient technology maturation for the desired product, and obtain approval to move directly from MSA to EMD phase. It is mandatory that Request for Proposal (RFP) released before a particular phase is entered is based on competitive contracting. This means that the contractor performing one particular phase will not necessarily be awarded a contract for the next phase. In this regard, it is imperative that the IPT implements an Intellectual Property (IP) and data management strategy (U.S. Department of Defense, 2003).

The process begins after the Materiel Decision Development (MDD) point, directed by the Milestone Decision Authority (MDA). At this point, part of decision made by the MDA, is to determine the acquisition entry phase. The decision is based on the validated Initial Capability Document (ICD), approval of the Analysis of Alternatives (AoA) study guidance, and AoA study plan. If the MDA decision directs that further analysis is needed on the desired product, the acquisition entry point would be the Materiel Solution Analysis (MSA) (U.S. Department of Defense, 2015).

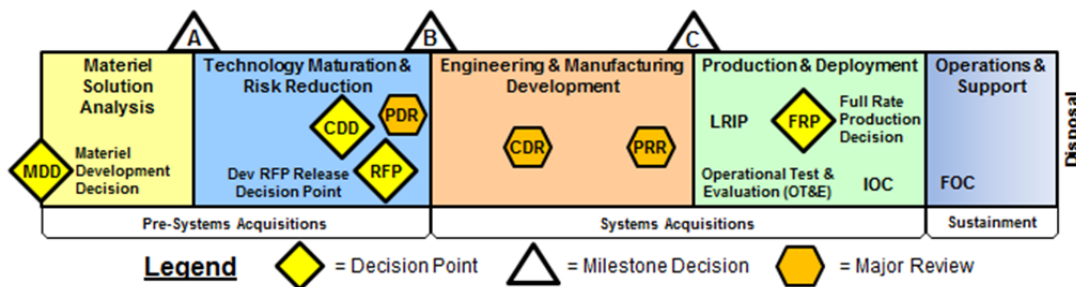


Figure 7. U.S. DOD Acquisition Framework. Source: Acquisition Process: Acquisition Process Overview (n.d.).

a. *Materiel Solution Analysis Phase and Milestone A*

The MSA phase involves the process translating capability gaps into system-specific requirements. This include conducting necessary analysis to develop concept of the required product, Key Performance Parameters (KPPs) and Key System Attributes (KSAs), gathering initial information to support acquisition strategy (U.S. Department of Defense, 2015). Key activities, as stated by U.S. Department of Defense (2015) include AoA, performing trade-off among cost, schedule and technical performance, affordability analysis, and risk management planning. The MSA phase is terminated after an approval is obtained from the MDA at Milestone A, to move to the next phase, the TMRR and release the RFP for the TMRR activities (U.S. Department of Defense, 2015).

b. *Technology Maturation and Risk Reduction Phase and Milestone B*

The TMRR phase as defined by U.S. Department of Defense (2015, p. 19) involves the process of “reducing technology, engineering, and integration & life cycle cost risks.” This is achieved through preliminary system requirement and design tradeoffs. This phase may further include building of prototypes as long as they are primarily intended for technology maturation and risk reduction before the development of the system. Product Design Review is conducted during the TMRR phase prior to Milestone B. The TMRR phase is terminated after an approval of Capability Development Document is obtained at Milestone B, an authorization to enter to the next phase, the EMD, and release the RFP for the EMD activities. The Acquisition strategy is approved at Milestone B. The decision at Milestone B also confirms the investment of significant resources to the program, and therefore the requirement process should have been satisfactorily fulfilled before RFP release point (U.S. Department of Defense, 2015).

c. *Engineering and Manufacturing Development Phase and Milestone C*

The Engineering and Manufacturing Development (EMD) phase consists of the complete development, build and test process of a product that satisfy the capability requirements. It includes detail engineering design activities such as the design and implementation of hardware and software prototypes, Critical Design Reviews (CDR), Production Readiness Review (PRR) to determine if Low Rate Initial Production (LRIP)

and Full Rate Production (FRP) are feasible, Developmental Test and Evaluation (DT&E), early Operation Test and Evaluation (OT&E), validation of that the designed system meets the capability requirements etc. The acquisition strategy is reviewed and updated prior to the release of RFP for the next phase. The EMD phase terminates after an approval of Capability Production Document at Milestone C (Department of Defense, 2015).

d. Production and Deployment Phase

The Production and Deployment (P&D) phase entails the production and delivery of the products to the operational organizations. The activities at P&D phase include: LRIP, limited deployment of the system, OT&E, FRP, Full deployment decisions, product support and sustainment (LCSP) decisions etc. This phase leads to full operational capability (U.S. Department of Defense, 2015).

e. Operations and Support Phase

The Operations and Support (O&S) phase entails the preparation, approval, and implementation of the Life Cycle Sustainment Plan (LCSP). This phase includes the delivery and deployment of the product support packages such as, IP and data right documents, training considerations activities, necessary facilities to perform maintenance at all depot levels, acquisition of operations, and maintenance tools and equipment which should be included in the LCSP (U.S. Department of Defense, 2015).

2. Typical Contract Type and Risk Management by Acquisition Phase

As mentioned, the objective of using the contract-type is to balance risks between the government and a contractor. Although there is no universal technique to use on deciding what contract-type to select at a particular acquisition phase, the technological risks decreases as the acquisition program life cycle progresses from early phases to later phases of the acquisition. Figure 8 shows a typical situation contract type by acquisition, taking risks into consideration (Griffin, 2011). Generally it is in the government preference to utilize the fixed-price contracts, however this is not possible when the

requirement and system specification is still broadly defined, and the technology is still immature (FAR, 2005).

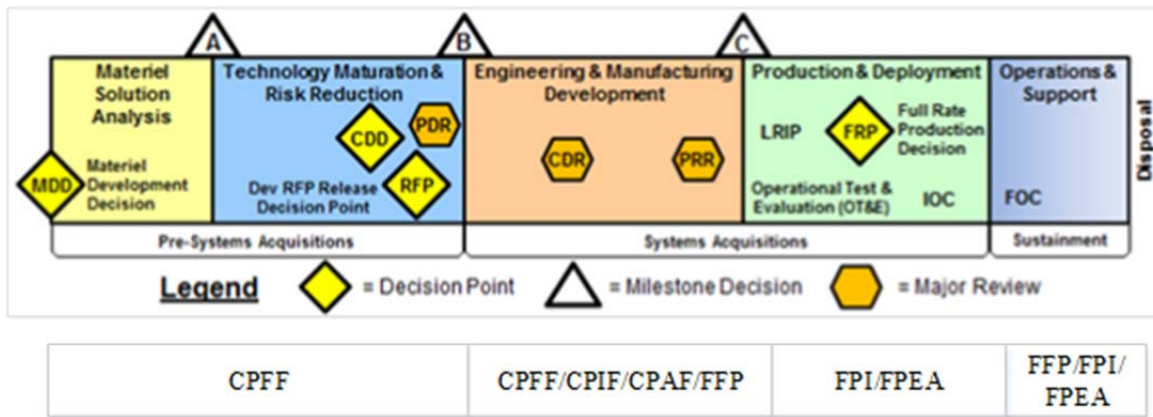


Figure 8. Typical Contract Type and Risk Management by Acquisition phase.
Source: Griffin (2011).

During the phases when the requirement is still broad, contract costs and schedules are uncertain, risks are high, and therefore potential contractors are usually pessimistic on taking risks by accepting the fixed type contract. This results in the situation where the government has to share the cost risks by negotiating for a contract type that will be more reasonable for a contractor to take risks, and provide incentive for achieving performance. Therefore, cost reimbursement-based contract-types are reasonable during the early phases of the acquisition. This typically corresponds to the MSA and TMRR phases of the acquisition process.

As the acquisition efforts move from Milestone B to EMD, the requirements and system specifications become more clearly defined, hence the major investment decision on a program by the MDA. However, the detail hardware and software performance, DT&E, OT&E are still uncertain as building and testing of prototypes is yet to materialize. During these phases of the acquisition process, hybrid of cost reimbursement, incentive, and fixed contract-type are appropriate. Costs containment, schedule, and technical performance are usually incentivized. This also corresponds to P&D phase.

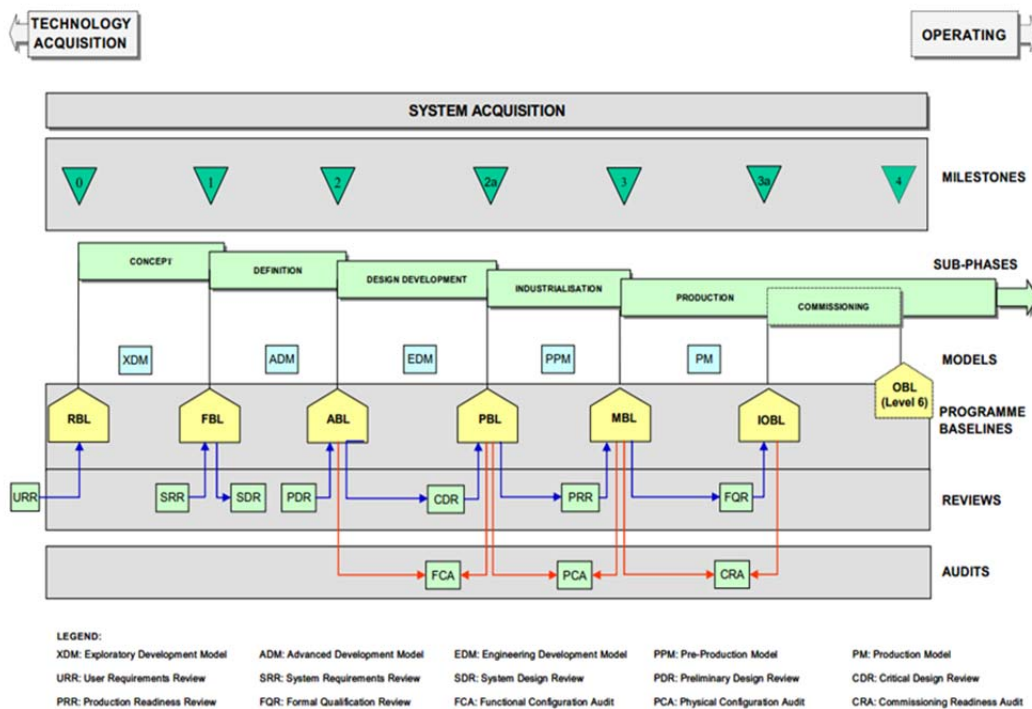
An acquisition that occurs during the O&S phase usually entails the procurement of products already having a well-defined requirement and reduced risk from the previous phases of the acquisition process. In some situation, this phase is characterized by the transition to the low risk commercial supplies of products, as the catered for provision in the LCSP (U.S. Department of Defense, 2015). During this phase, competitive contracting is possible and FFP contract are appropriate (FAR, 2005).

3. South African Department of Defence Acquisition Process

The SA DOD acquisition process is shown in Figure 9 (SA Department of Defence, 2010). Similar to the U.S. DOD acquisition framework, in general, there are key notable elements that relate to the goal of this research. They are: the major phase description corresponding to the system life cycle stages, decision milestones, system engineering technical reviews, and major RFP release points. Minor differences are noted and summarized.

a. Milestone 0

Milestone 0 entails the approval of the Required Operational Capability (ROC) document by the SA DOD milestone decision authority. The ROC documents the requirement specification, as guided by the operational shortcomings due to capability gaps, force design structure etc. ROC prepared by the end-user at the level of DOD services after possibly a series of User Requirement Reviews (URR), approved by the Operational Staff Council (OSC) at the Joint Operational Level. The approval of the ROC establishes a Requirement Baseline (RBL).



Note:

1. Milestone 4 represents the Operating Baseline (OBL) input to level 6 (user system level).

Figure 9. South African DOD Acquisition Process. Source: SA Department of Defence (2010).

b. Concept Phase and Milestone 1

The aim of the concept phase is to perform a functional analysis, to address the requirement specifications as contained in the RBL. This functional analysis is performed by the use of Exploratory Development Models (XDM) to explore different solution concepts. This includes but is not limited to systems engineering architectures, simulation and experimentations, development board's prototyping, etc. The concept phase is terminated when the FBL is established after possible series of System Requirement Reviews (SRR) and System Design Reviews (SDR) at Milestone 1. This involves the approval of the Functional User Requirement Statement (FURS) and Logistic User Requirement Statement (LURS) document.

c. *Definition Phase and Milestone 2*

The aim of the definition phase is to develop a well-defined system specification, primarily at the level of the operational requirement. This includes technical requirements expressed as a system “A” specifications together with the number of development “B” specifications for selected Configuration Items. The goals are achieved through building and testing Advanced Development Models (ADM). The definition phase is terminated after possibly a series of Preliminary Design Reviews (PDR) and the Allocated Baseline (ABL) is established, at Milestone 2. The AP, which includes important elements such as the make or buys decisions, is the product of the definition phase. The decision at Milestone 2 confirms the government investment intent on the program by acquiring the required capability. Formal acquisition, which includes developmental RFP release, begins after the approval of Milestone 2.

d. *Design Development Phase and Milestone 2a*

The aim of the Design Development (D&D) phase is to further define and develop the selected product system by development of workable production specification (product, material, and manufacturing specifications). The phase involves detailed developmental activities by which the Engineering Development Models (EDM) including hardware and software are produced, integrated to a form product, integration issues are addressed, and performing DT&E. Series of CDRs are conducted, to address low level design and implementation decision. The D&D phase is terminated when Product Baseline (PBL) is established at Milestone 2a.

e. *Industrialization Phase and Milestone 3*

The purpose of the Industrialization phase is to develop and qualify manufacturing specifications and processes that can be used to task the industry to manufacture the product in accordance to the specific SA DOD requirement. This includes design of production lines, process control, quality control etc. The concepts of Industrialization phase are tested through the production of Pre-production Models (PPMs), and performing Initial OT&E (IOT&E). In some cases, this phase becomes part of the DD phase. In situations where there is no DOD specific production processes

requirement, the flexibility is provided to combine this phase with D&D phase. The Industrialization phase is terminated when the Manufacturing Baseline (MBL) is established at Milestone 3.

f. Production Phase and Milestone 3a

The Production phase involves the process whereby the product system is manufactured in accordance with the stated user requirement specification, system requirement specification, product specification, and any other defined low level specifications developed during prior phases. The aim of the production phase is to qualify a system that can be accepted by the SA DOD at the combat capability level. Production Models and OT&E are used to test the compliance to specifications. The production phase is terminated when the Initial Operational Baseline (OBL) is established after possibly a series of Formal Qualification Reviews (FQR) at Milestone 3a.

g. Commissioning Phase and Milestone 3a

The purpose of the commissioning phase is to determine the manner in which the SA DOD service groups operationally employ the system in coordination with the supply baselines, combat grouping etc. Furthermore, the aspects of functional performance, safety, supportability requirements, logistic, documentation, training and interim support contracts are finalized. The commissioning phase terminates with the establishment of the OBL at Milestone 4, and handing over of the system by the IPT to services (Level 6 SA DOD component).

D. CHAPTER SUMMARY

This chapter presented various risk management processes available in literature, which can be applied by the IPTs when conducting risk management. Contract management principles, are applicable to both SA and U.S. DOD acquisition programs, and are commonly applied across all government departments and agencies. Contract-type provisions, as covered in the FAR, are used to balance risks between the government and the contractor in the U.S. DOD acquisition system, across the acquisition framework.

Achieving the best-value and competition is encouraged in the SA DOD acquisitions to improve overall performance, however A-PRA-1034 and PPPFA does not provide guidance on how to incentivize stakeholders using contract-types for achieving these objectives. Incentive-based and cost-reimbursement contracts are not explored.

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III. HYPOTHESIS

This research plans to address research questions by using the SA DOD acquisition process presented in Chapter II, and the hypothesis presented and described in this chapter. The research intends to investigate the possibilities of using the standard contract-type strategy aligned to different phases of the SA DOD acquisition process. As it was discussed in Chapter II, the contract-type strategy is neither a universal technique nor framework to select a contract-type for risk management purposes. However, to balance the risks between the government and contractor, some contract-type are more appropriate at certain stages of the acquisition than others.

This chapter uses an approach presented on Figure 8 for the U.S. DOD acquisition process, to allocate contract-types for each phase of the SA DOD acquisition process of Figure 9. The basis of allocation is based on the relationship of extent to which the requirement is defined, and risks anticipated in the particular phase. Unlike in the usual case as per the provision of PPPFA and A-PRAC-1034, the application of incentive-based and award fees contracts are considered for award. The proposed contract-type allocation per particular phase is shown in Figure 10.

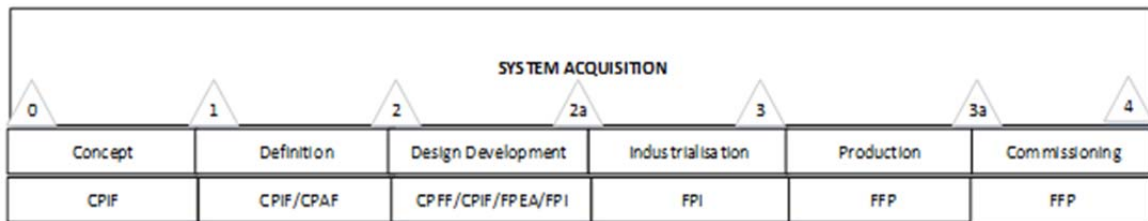


Figure 10. South African DOD Acquisition Process with a Proposed Contract-type Strategy.

During the concept phase the contracts awards mostly involve the delivery of architecture designs, the system requirement is still broad. The CPIF contracts are recommended to incentivize the contractor for both performance and costs containment. During the definition phase, the efforts involve the development of system specification, the CPIF contract can be selected to incentivize costs, and CPAF contract can be used to

provide motivation for improved performance. The contracts in the D&D phase involve the delivery of multiple activities of engineering developmental prototypes and items that are different in complexity, including building and testing of combination of hardware and software subsystems. Hence the hybrid of contract-type as shown in Figure 10 can be selected.

Any of the FPI contracts (firm, successive target, etc.) can be selected during the Industrialization phase to incentivize the contractor to contain the manufacturing costs of the development of PPM. The selection of an incentive contract implies that, although the solution is proven, innovation still needs to be incentivized to achieve cost effective manufacturing processes, and required schedule performance. However, once the manufacturing baseline is established for the Production phase the risks are reduced because the manufacturing specification has been created, hence the FFP contracts are appropriate during the Industrialization phase. Commissioning phase does not have any requirement uncertainty, because it occurs when the capability has been completely acquired. Mostly, it involves the supply of support equipment and services. Therefore, the risk is low, and FFP contracts are recommended.

It is hypothesized that the proposed contracting strategy shown in Figure 10, when used with the risk management process from in Figure 1 or Figure 5 as risk mitigation technique can reduce the costs and schedule risk. Therefore, cost overruns and schedule delays can be circumvented.

IV. ANALYSIS OF THE PAST AND CURRENT SA DOD ACQUISITION PROGRAMS

In this chapter, the acquisition outcome of three past and current SA DOD acquisition programs are presented, for the purpose of examining the recommended contract-type strategy on risk management. The impact of the contract-type strategy on risk mitigation will be assessed by the analysis of similar U.S. DOD programs in the next chapter using risk management approaches described in Chapter III.

A. PAST SA DOD ACQUISITION PROGRAMS

The past acquisition program to be examined includes the program portfolio components of the SDP. The strategic objective of the SDP was to modernize the SA DOD defense equipment and retain effective defense capability, as per the 1998 Parliamentary Defence Review (SA Department of Defence, 2008). The selected programs include the acquisition of Light Utility Helicopters (LUH), Gripen Advanced Light Fighter Aircraft (ALFA), and the Hawk Lead-In Fighter Trainer (LIFT).

1. Light Utility Helicopter Program

The acquisition of the LUH originated as the result of the capability need and a gap to upgrade the Alouette III SA DOD operational helicopter capability, which was about 30 years of old at the time. The objective of the LUH program was to develop a platform that will provide for a transport capability, combat support capability, and training capability. The concept phase began in 1992, and the milestone decision to continue with the definition phase was approved in 1996. During this year the Request for Information (RFI) was conducted by the project team, to establish the system requirement. No information was obtained on the contract-type used during these phases. However, the situation necessitated the award of cost reimbursement contract with CPFF as no incentive-based are on record for any SA procurement regulations. The Request for Offer (RFO) for development was issued to the three shortlisted contractors in 1998. The decision to shortlist contractors during the RFI was influenced by higher governmental structures, due to defense offsets requirement.

The offsets required that the contractors will be compensated based on the economic investment made in the country during the D&D through the commission phase. Furthermore, each contractor was required to produce a plan on how to achieve the offsets requirements. This necessitated that the contract be of cost reimbursement-type contract, and specifically CPAF. However, the Arms Procurement Commission Index to Statement Colonel F.K.S. Viljoen (2013) stated that the contract for the supply of LUH was fixed, at the price of \$199,778,887 at 1999 currency exchange rate. The D&D phase started in the year 2000. The length of the D&D phase, subsequent phases continued as summarized in Table 5 (Botha, 2003; Re: Arms Procurement Commission Submissions (Rationale), 2013 and Brauer & Dunne 2004).

Table 5 further summarizes other program outcomes associated with the LUH, such as costs. From Table 5, the costs summary, and the planned schedule for the early phases (Concept and Definition phases) of the LUH program are not shown as these phases include iterative activities, with the strong uncertainty of the solution definition (Defenceweb.com, 2010; A109 Costs Climb, 2011 and Re: Arms Procurement Commission Submissions (Rationale), 2013).

Table 5. Summary of the LUH Acquisition Outcomes Parameters. Adapted from Defenceweb.com (2010); A109 Costs Climb, 2011 and Re: Arms Procurement Commission Submissions (Rationale), 2013).

Acquisition phase	Contract type used	Proposed contract-type	Cost		Schedule		Issue/Remarks
			Planned (R Millions)	Actual (R Millions)	Planned (Years)	Actual (Years)	
Concept	CPFF	CPIF	No information (N/I)	N/I	Uncertain	4	No issue
Definition	CPFF	CPIF/CPAF	N/I	N/I	Uncertain	3	No issue
D&D	CPFF/FFP	CPFF/CPIF/FPEA/FPI	1,949	2,451	5	10	Schedule deviations were due to propulsion system design selection and tradeoffs. Cost deviations due to production and commissioning cost overruns.
Industrialization		FPI					
Production		FFP					
Commissioning		FFP					

a. *Further Issues and Remarks on Light Utility Helicopter Program*

By 2007, only 11 of 30 expected aircraft were delivered as part of the LRIP, and termination of the Industrialization phase. The delay during the D&D and production phases extended an already four-year delay for the commissioning phase, which included critical cost elements such as training (SA Department of Defence, 2007cb).

b. *Proposed Contract Type strategy for Light Utility Helicopter Program*

An application of incentive fee contract-type at the concept phase or award fee contract-type at the definition phase would have reduced the risks associated with the design of the propulsion system. This is because different architectures of the propulsion system would have been simulated and experimented. A better solution would have been obtained by incentivizing the contractor in order to encourage a development of easy to implement propulsion system architecture. Significant schedule delays experienced between the D&D and commissioning phase would have also been reduced if the better and easy to implement architecture was developed during the concept and definition phase.

An award of CPIF and FPI during the D&D phase could have been used to encourage the contractor to reduce the costs of some contract items, by incentivizing lower development cost (Griffin, 2011). CPFF and FPEA are appropriate for the contract items that cannot be incentivized. FPI would have been used during the Industrialization phase to encourage the contractor to develop cheaper to operate manufacturing capabilities, therefore technology and costs are incentivized. This would have reduced cost overruns experienced during production and commissioning phase. Therefore, by incentivizing costs the difference between the planned and actual costs would have the potentially been reduced. The FFP contract can be awarded at the production and commissioning phase as technology, cost and schedule risks are low. This is in line with the proposed contract strategy in Figure 10.

Alternatively to the contracting strategy, EVM could have been used during the acquisition strategy (Prior to the D&D phase) to tie the technical performance, cost and

schedule. The significant difference between the planned and actual schedule shown in the in the Table 5 could have been managed.

2. The Gripen Program and Its Contracting Strategy

The concept of the Gripen program was conceived after the delivery of the upgraded Mirage III fighter aircraft in 1986. The SA DOD had embarked on a joint program with Israel Aircraft Industry to upgrade their fighter aircraft trainer Mirage III to operational cheetah fighter aircraft standard in order to keep up with the advances on the airpower domain. During that period, aircraft manufactures had already started developing fly-by-wire controlled engines, digital cockpits with integrated avionic, and sophisticated electronic warfare. The SA DOD exposure to this digital era aircraft enabled the grasp of the value provided by these platforms. This created a capability need for a modern, state-of-the-art multi-role combat capability. The primitive needs included capabilities such as air-to-air and air-to-ground combat capability, In-flight refueling, air-combat training capability etc. The options to completely seal the capability gap using these modern systems were considered during the years 1994 to 1997. This represented the concept phase (Re: Arms Procurement Commission Submissions (Rationale), 2013).

When the defense review of 1998 mandated the SA DOD to maintain the modernized defense equipment, the current operational LIFT, Mirage II aircraft and upgraded front-line fighter aircraft Cheetah was aging very quickly, with the maximum life expected of up-to 2003 and 2012 respectively. The need to replace these platforms with digital-era, multi-role Hawk LIFT for training pilots, and Gripen ALFA was made during 1996. The RFI was conducted from the preferred contractors during the year 1998 and 1999. The contracts for the D&D and production phase of Hawk and Gripen were completed in three segments. The process would deliver 24 and 28 Hawks and Gripens in total respectively, per the Arms Procurement Commission (2013).

Table 6 shows the summary of the acquisition outcome parameters for the Gripen aircraft throughout the acquisition process. The contract value for 28 Gripens was R9, 952 million, fixed at 1999 exchange rates, excluding an escalation due to inflation. This means that when inflation changes, the price would change, a reasonable indication of

FPEA contract-type (Re: Arms Procurement Commission Submissions (Rationale), 2013).

Table 6. Summary of the Gripen Acquisition Outcomes Parameters. Adapted from: Defenceweb.com (2010); Botha, (2003), and Sylvester and Seegers (2009).

Acquisition phase	Contract-type used	Proposed contract-type	Cost		Schedule		Issue/Remarks
			Planned (R Millions)	Actual (R Millions)	Planned (Years)	Actual (Years)	
Concept	CPFF	CPIF	N/I	N/I	Uncertain	4	No issue
Definition	CPFF	CPIF/CPAF	N/I	N/I	Uncertain	2	No issue
D&D	CPFF/FPEA	CPFF/CPIF/FPEA/FPI	9,952	19,080	11	14	Most cost escalations occurred during the D&D, and commissioning phase. The contractor was not encouraged to contain the costs. The schedule delay occurred during the commissioning phase.
Industrialization		FPI					
Production		FFP					
Commissioning		FFP					

Furthermore, because part of the capability need for the acquisition of Gripen and Hawk was the ambition by the operational forces to transform to new technology and digital-era-based platforms, there was a financial requirement set by the higher government structures. The contract requirement had to balance affordability and technical requirement. The affordability study was conducted, included as part of the RFO, and was part of the criteria to offer selection. The department of finance provided an oversight to this requirement. The expected final delivery of Gripens was in 2011 (Botha, 2003), (Sylvester & Seegers, 2009), and (Re: Arms Procurement Commission Submissions (Rationale), 2013, 2013).

The first delivery of the Gripen aircraft occurred in 2007. This indicated the termination of the successful Industrialization phase, as the overall project was supposed to be finalized end of the year 2011. The project was well on schedule. However, most of schedule delays and cost overruns for the Gripen project were due to the unforeseen support activities and costs at the commissioning phase.

The costs overruns experienced at the D&D could have been contained by awarding the CPIF and FPI with primary incentive based on cost containment. Therefore, it would not have been a necessity to select CPAF and FPEA at the commissioning phase in order to resolve the issues. FFP contract would have been selected, as most of the technological risks would have been reduced. The risks should have been shifted to the contractor at the commissioning phase. This is in line with the proposed contract strategy in Figure 10. Similar to the LUH program, an alternatively to the technique, EVM could have been used during the acquisition strategy (Prior to the D&D phase) to tie the technical performance, cost and schedule. The difference between the planned and actual costs, and planned and actual schedule shown in the in the Table 6 could have been managed.

3. The Hawk Program

The capability need for the acquisition of Hawk LIFT is identified in the previous sections. The primary capability gap was the aging of the current capability, which was due to retire in 2003. The capability need was to move toward digital-era LIFT capability,

as it was trending in most of the DODs around the world. Therefore, the initial accounts of the acquisition outcome during the first two phases of the Hawk program were similar to the Gripen program. The deviations occurred starting from the D&D phase. The data in Table 7 shows the acquisition parameter outcomes for the Hawk program.

Table 7. Summary of the Hawk Acquisition Outcomes Parameters. Adapted from Hawk LIFT Support Costs Approaching R1bn (2011); Botha (2003), and Sylvester and Seegers (2009).

Acquisition phase	Contract-type used	Proposed contract-type	Cost		Schedule		Issue/Remarks
			Planned (R Millions)	Actual (R Millions)	Planned (Years)	Actual (Years)	
Concept	CPFF	CPIF	N/I	N/I	Uncertain	4	No issue
Definition	CPFF	CPIF/CPAF	N/I	N/I	Uncertain	2	No issue
D&D	CPFF/FPEA	CPFF/CPIF/FPEA/FPI	3,728	7,200	7	8	The significant costs increase due to the addition of steady-state design authority support, and other unforeseen support elements.
Industrialization		FPI					
Production		FFP					
Commissioning		FFP					

a. *Further Issues and Remarks on Hawk Program*

The one year delay shown in Table 7 was due to the commissioning of the last elements of a capability to maintain some elements of the aircraft, such as the hydraulic system and the auxiliary power unit (Armcor Annual Report 2013/14, 2014).

b. *Proposed Contract Type Strategy for a Hawk Program*

The schedule delay of one year is reasonable considering the extent and nature of the technical work specified in the previous paragraph. The significant cost overruns due to unforeseen design authority support, and other elements indicates that the supportability risks were not addressed. The supportability risk was supposed to be addressed when the system architecture design tradeoffs and analysis were performed. These activities occur at the concept and definition phase (Defenceweb.com, 2011).

Similar to the LUH program, a better solution would have been obtained by selecting CPIF during the concept and definition phase to encourage the contractor to develop innovative system architecture solution. Significant cost overruns experienced between D&D by awarding CPIF and FPI in order to incentive cost containment. Similar to the Gripen program, it would not have been a necessity to select CPAF and FPEA at the commissioning phase in order to resolve the issues. FFP contract would have been selected, as most of the system support risks would have been reduced. The risks should have been shifted to the contractor at the commissioning phase. Once again, this is in line with the proposed contract strategy in Figure 10.

Furthermore, EVM could have been used during the acquisition strategy (Prior to the D&D phase) to tie the technical performance, cost and schedule. The significant difference between the planned and actual costs, shown in Table 7 could have been managed.

B. SUMMARY OF THE ANALYSIS OF PAST SA DOD ACQUISITION PROGRAMS

The analysis of three past SA DOD programs, and associated contracting strategies indicates that the use of incentive based and award fee contracts to encourage innovative solutions, containing costs, and schedule control is limited. The analysis shows that, most of the issues experienced downstream of the acquisition phases, were due to the risk not being identified upstream of the acquisition process. It would therefore be advantageous to the program performance to consider the selection of incentive-based and award fee contracts.

However, as it was noted in Chapter II, this requires that the costs incurred by the incentive-based and award contracts be allowable in the regulation document PFMA. The PPPFA would widen its contract-type base, to include incentive-based and award contracts. This will eventually include the SA DOD specific contracting directive document, the A-PRAC-1034.

It should be noted that there was insufficient data pertaining to the specific planned and actual cost, and schedule per phase from the D&D phase to commission phase. There was also no data pertaining to the cost and planned schedule for the concept and definition phase. The contracting strategy shown in Figure 10, which is incorporated to the risk management process, would have significantly, indirectly reduced the schedule delays and cost overruns. Therefore, this fact addresses the research question presented in Chapter I, should this strategy be implemented in order to avoid acquisition program risks that lead to cost overruns and schedule delays? Although not deliberated in detail, the EVM system was proposed for the acquisition strategy in order to manage deviations showed in Tables 5, 6 and 7.

C. ANALYSIS OF THE CURRENT SA DOD ACQUISITION PROGRAM

The objective of this section is to hypothetically apply the contracting strategy shown in Figure 10 to a selected current SA DOD program, as the means of testing its effectiveness in risks management. The risk management process of Figure 5 is used. The contract-type is recommended for each particular phase of the acquisition process, as guided by the principles reviewed in Chapter II of this report; literature review. The

selected program is at the early phases of the acquisition program, hypothetically at the concept phase. Therefore, the risk management is performed from the perspective of the information gathered at the concept phase. The justification for the selection of particular contract-type is explained, and the outcomes are predicted.

1. Introduction of the Current SA DOD Acquisition Programs

The SA DOD embarked on revitalizing the operational air surveillance radar capabilities. The radar capability is categorized into air defense and air traffic radar systems. There are several types of radars systems that are addressed by the project study during the concept phase. These include Tactical Mobile Radar (TMR), Precision Approach Radar (PAR), and Secondary Surveillance Radar (SSR) (Project Chutney (Replacing South African Air Force Radars), n.d.). Depending on the outcome of the concept phase, the solution may involve the replacement or upgrade in order to fill the capability gap (Pearson & Rocca, 2000). Furthermore, the report assumes that an analysis that leads to the selection of materiel solution over other operationally-based alternatives has been performed.

a. Capability Gap Analysis

This capability gap analysis provides a formal approach to translate the user stated needs with user terminology, into effective needs usable in developing system technical specification and thereafter a system requirement (Blanchard & Fabrycky, 2011). Although operational analysis (CONOPS) is an important technique of achieving capability gap analysis, it will not be covered explicitly in this report due to the details it contains.

b. Problem Statement

The current radar systems used by SA DOD to provide surveillance service are aged, require constant maintenance, and are becoming economic liability. Furthermore, these systems are not compatible with the new communication systems, such as data links, that are required to share data together.

c. Capability Needs

There is a need to replace the current radar systems used by the SA DOD, in order to continue to execute the mandate as provided by the constitution. There are at least three radar systems encompassed by the problem statement. The operational guidelines require that these systems should provide a primary and secondary radar coverage over a certain specified depth, height across the borders, and mobile radar coverage anywhere in sub-Saharan Africa. The acquisition of three new radar systems will enable the SA DOD to fill this capability gap (Pearson & Rocca, 2000). This very high-level stated capability need is referred to as primitive capability need (Blanchard & Fabrycky, 2011).

d. Translating Primitive Capability Needs to Effective Capability Needs

Figure 11 translates the capability needs into contextualized effective needs. The effective needs provide a revised problem statement and capability needs, obtained after a capability based assessment. Additionally, effective needs provide a system thinking approach and effort, in describing and filling the capability gaps. The process results in the need for the replacement of each radar systems as shown in Figure 11. For the purpose of this research, and due to the complexity of the specification and requirement for each radar, only one radar system will be analyzed, the SSR radar.

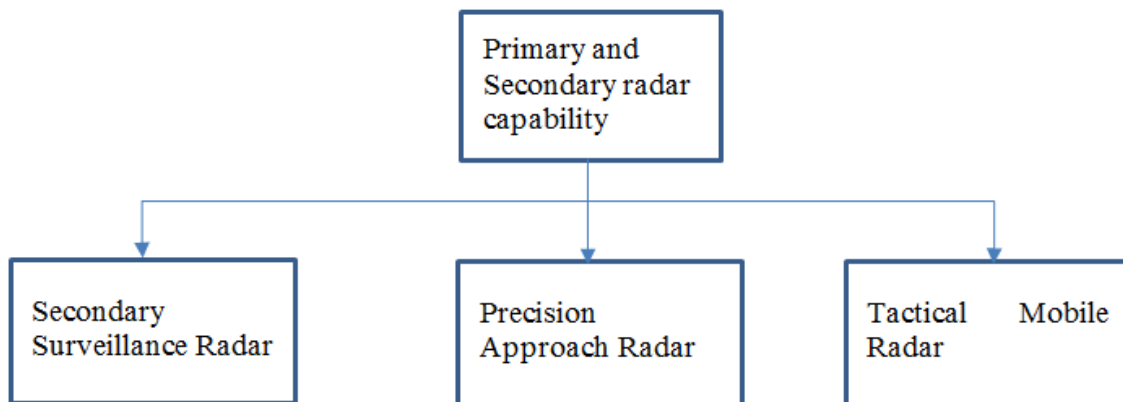


Figure 11. Translation of Primitive Radar Capability Needs Into Effective Radar Capability Needs.

2. RISK MANAGEMENT FOR THE ACQUISITION OF SECONDARY SURVEILLANCE RADAR

The SSR capability in the SA DOD is used for the purpose of Air Traffic Management and Air Defense. In the current setup, some SSR are integrated with Primary Surveillance Radars, hence the AD function. The new system has to be incorporated with the new interrogating system modes, the Identification Friend or Foe (IFF) in order to be interoperable to current platforms (Pearson & Rocca, 2000). The risk management for the acquisition of the SSR program, formulated for the purpose of this report is performed as follow.

a. Risk-Management Planning

This activity involves making overall decisions on how to approach to approach risk management for a specific program. This will include for example, deciding on what processes, risk mitigation techniques etc., the IPT is going to implement for risk management purpose. Risk management planning defines the project scope and the WBS for the SSR acquisition program as follows.

(1) Project Scope

The replacement of SSR system shall be conducted in a one-for-one fashion due to the criticality of the function they perform. The time schedule to fill the capability gap limited and the requirement is urgent. Under current fiscal difficulties and resulting budgetary constraints, the SA DOD is looking to minimize the overall costs of the program. Table 8 provides the summarized scope of the program in terms of functions expected from the desired system and the program requirement. In Table 8, each function and requirement is mapped to the expected stakeholder, and the rationale for the stakeholder needs for each particular requirement (Pearson & Rocca, 2000).

Table 8. Summary of the SSR Acquisition Program Scope.

Functions/Requirement	Main stakeholder	Rationale for the need
Air Traffic Control services within the designated area of operation in cooperation with all relevant national and international flight control agencies. The specific functions includes provision of Aerodrome and Approach control to regulate all air traffic within allocated airspace around airbase, flight information service, and Alerting services.	Air Traffic Controller	Operator
Air Defense services which includes territorial air defense, theatre air defense, area air defense, point defense.	Mission Controller	Operator
Surveillance services which include provision of positional data of airborne objects at specified levels for the purpose of creating a rapid air picture for cooperative and non-cooperative targets.	Operational Commander	Client
Low Mean-Time-Between-Failures and Mean Time to Repair, part and tool standardization, open architecture design.	Maintenance and logistic support personnel	Indirect user
Low development (acquisition) and total ownership cost, minimum acquisition schedule, and long life time.	Secretary of Defense/ Executive branch of the government	Funder

(2) Program WBS

Figure 12 shows the Program WBS of the SSR acquisition program. Three-level WBS is presented for the purpose of identifying and managing risk areas at the concept phase from the Program Management Office (PMO) point of view. This WBS is purely established for the purpose and use of testing concepts presented in this report; it does not reflect the actual WBS, or complete elements that constitute the SSR (Hutchings & Street, 2000).

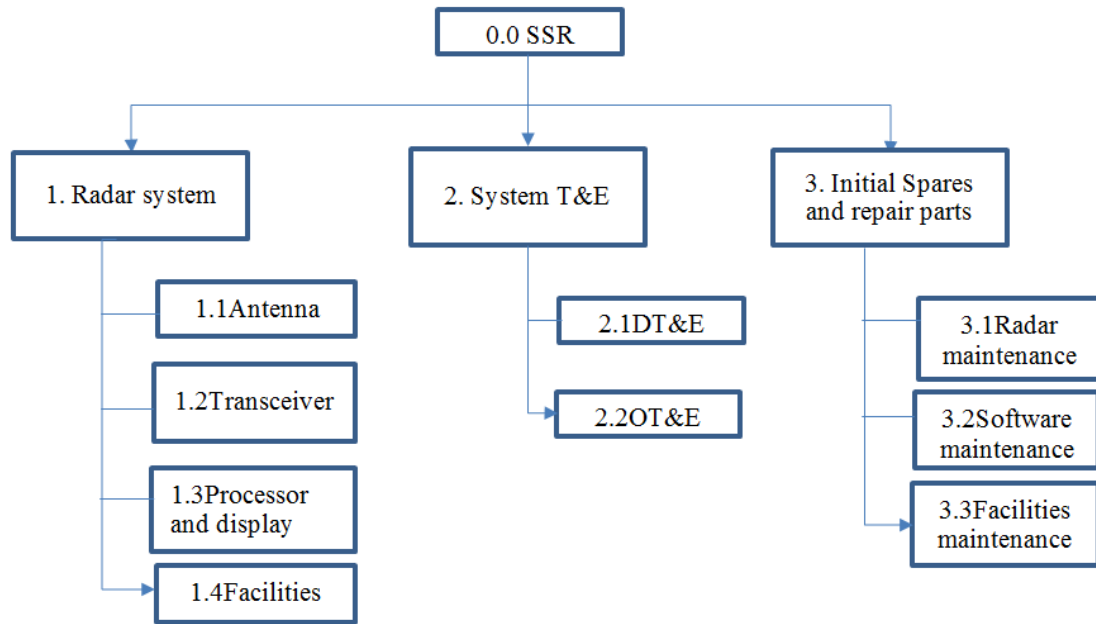


Figure 12. Program WBS for SSR Acquisition Program.

b. Risk Identification

The risk identification activity presented here for the SSR uses the Program WBS elements from Figure 11 which systematically determine which risk might affect the program. Most of the risks identified with an aid and guidance from the WBS are technical risks, as the WBS structure elements are technical in nature. However, the WBS can be expanded to include other critical elements of the program such as program systems engineering and program management requirement that are addressed at the PMO. Table 9 provides identified SSR risks.

Table 9. Risk Identification Categorized by Facets for the SSR Acquisition Program.

Risk No.	Risks root cause	Risk facet	Impacted Life-cycle phase
Radar system			
1.1 Antenna			
1. Antenna architecture	SA DOD requires the selection of the Active Electronically Scanned Array (AESA). This is a new technology radar antenna architecture optimized for tracking and scanning. The technology is not matured yet.	Technical and schedule	Concept
1.1.2 Antenna architecture limitations	There is a limited research support on AESA within the SA.	Technical supportability and	Definition and D&D
1.2 Transceiver			
1.2.1 Transceiver architecture	A selection of AESA antenna locks the transceiver architecture selection to state-of-the-art new technology solid-state transceivers. This is because AESA antennas are only compatible to AESA solid-state transceivers. Solid-state transceivers are still new technology, and therefore are expensive.	Cost	Definition, Industrialization and production
Processor and display			
1.3.1 Processor	The research is currently underway to migrate radar processor to Software Defined Radar (SDR) technology, selecting a processor based on current technology might introduce obsolescence issues at the commissioning phase.	Technical supportability and	Production and commissioning
System T&E			
2.1 DT&E			
2.1.1.IFF	The IFF integration with the current SA aircraft platforms. This interrogation technology although successfully implemented in many SSR systems around the world, it is a new requirement for the SA DOD. The implementation might involve couple trial and error efforts.	Schedule	D&D and Industrialization
2.2 OT&E			
2.2.1 Integration	There is a potential that a couple selected subsystem architectures entails new technology with no prior guidelines. Therefore, the compatibility, integration and testing of different software and hardware subsystems might involve trial and error.	Schedule	Industrialization
2.2.2 Supply of Government Furnished	Testing the radar requires supply of GFE such as mobile power generators.	Programmatic	Industrialization

Risk No.	Risks root cause	Risk facet	Impacted Life-cycle phase
Equipment (GFE)			
2.2.3 Interoperability	There is a potential that there is incompatibility of communication standard and interfacing between the acquired radar and couple of SA DOD legacy communications links, which are expected to share data.	Cost and schedule	Commissioning
Initial spares and repair parts			
3.1 Radar maintenance			
3.1.1 Antenna	There is few potential manufactures of AESA within the SA, therefore spares availability and supply will be limited.	Supportability	Commissioning
3.1.2 Transceiver	If solid state solid-state transceivers are selected, they consume a lot of power.	Cost	Commissioning
3.1.3 Maintenance personnel training	Training maintenance personnel for radar based on new; state-of-the-art components such as solid-state transceivers radar may take some time.	Cost and schedule	Commissioning
3.2 Software Maintenance			
3.2.1 Availability of software support	Software-based subsystems such as radar processor and IFF fail constantly, and require on-demand maintenance support. Government may not have such support capability in-house, and contracting it out maybe costly.	Cost and Supportability	Commissioning
3.3 Facilities maintenance	The installation and maintenance of infrastructure that house the radar such as building, electrical, HVAC systems etc., may delay as it is supplied by Department of Public Works which SA DOD have not control over it.	Schedule	Industrialization and commissioning
Requirement creep	The client may change the scope of the requirement any point of the acquisition process.	Cost and schedule	Any phases

The first column assigns each risk, a risk identity number that can be used to reference the risk. The middle column provides a risk description, and the last column classifies each risk by a risk facet.

c. Risk Analysis

The analyses of the SSR risks identified in Table 7 are analyzed using risk analysis matrix shown in Figure 6 on page 38. The likelihood and the consequence level for each risk is predicted and assigned, as per the description of Table 3 and Table 4 respectively. Table 3 and Table 4 are again shown again in this section as Table 10 and Table 11 for the purpose of facilitating the interpretation of Table 8. Then based on the combination of these two measures, the risk coordinated is created and mapped in the matrix. The position of the risk coordinate in the risk matrix determines whether the risk event will have a moderate or severe outcome if it occurs taking both likelihood and consequence levels. Table 8 and Figure 13 show this analysis as it is narrated.

Table 10. Risk Likelihood Values. Adapted from U.S. Department of Defense (2006).

Value/level	Likelihood	Probability of occurrence
1	Not likely	~10
2	Low likely	~30
3	Likely	~50
4	Highly likely	~70
5	Near certain	~90

Table 11. Risk Consequence Values. Adapted from Rendon and Snider (2008).

Value/Level	Technical Performance	Schedule	Cost
1	Minimal or no impact	Minimal or no impact	Minimal or no impact
2	Minor reduction in technical for supportability, can be tolerated with little or no impact on program	Able to meet key dates; Slip $\leq$ month(s)	Budget increase or unit production cost increase; $\leq$ (1% of the budget)
3	Moderate reduction in technical performance or supportability with little or no impact on program objectives	Minor schedule slip; able to meet key milestones with no schedule float; Slip $\leq$ months(s); sub-system slip $\geq$ months plus available float	Budget increase or unit production cost increase; $\leq$ (5% of the budget)
4	Significant degradation in technical performance or major shortfall in supportability might jeopardize program success.	Program critical path affected; Slip $\leq$ months	Budget increase or unit production cost increase; $\leq$ (10% of budget)
5	Severe degradation in technical performance; cannot meet KPP or key technical/supportability threshold; will jeopardize program success	Cannot meet key program milestone; Slip $\geq$ months	Exceeds APB thresholds; $\geq$ (10% of the budget)

Table 12. Risk Analysis for the SSR Acquisition Program.

Risk Identity	Likelihood level	Consequence level	Risk rating (Extracted from the risk matrix)
1.1.1	(5) Near certainty due to the processing advantage offered by AESA antenna patterns for IFF purposes.	(3) Moderate impact because if AESA technology cannot be obtained, IFF functionality can still be obtained by the existing current antenna architecture, just processing becomes complex or limited.	Severe
1.1.2	(5) Near certainty because there are currently limited radar antenna research organizations in SA. Therefore, most design level collaborations will only be found outside SA.	(3) Moderate impact because if AESA design support cannot be secured, older antenna design can be selected. However, tradeoffs involving specific performance specifications at the design level will be made.	Severe
1.2.1	(4) Highly likely because AESA antenna works well with solid-state transceivers.	(3) Moderate because it might slightly increase the budget.	Moderate
1.3.1	(4) Highly likely because most the manufacturing organization are migrating to SDR.	(4) Major shortfall in supportability might affect availability during production and maintenance activities during operations.	Severe
2.1.1	(4) Highly likely due to the unviability of IFF experience within SA DOD.	(2) Schedule can slip by few months if it takes longer to configure the IFF. However, IFF technology is not complex, anyone with electronic engineering design insight can configure it.	Moderate
2.2.1	(4) Highly likely because operating and configuration of any new	(3) Minor schedule slip because some systems may require additional contract support. The contracting process may take longer but can be anticipated, and can be synchronized to milestones.	Moderate

Risk Identity	Likelihood level	Consequence level	Risk rating (Extracted from the risk matrix)
	technology systems involve learning, and therefore is always coupled to uncertainty how long it will take.		
2.2.2	(5) Near certain because currently many radars requires auxiliary equipment, which cannot be procured before it is near certain that the program will be successful.	(1) Minimal because GFE support can be formally requested from the operational units.	Low
2.2.3	(4) Highly likely because most there are legacy systems still operated by the SA DOD.	(2) Minor because how legacy systems works is already well understood.	Moderate
3.1.1	(4) Highly likely because AESA uses different components than other older radar antennas.	(4) Significant shortfall in supportability because there are few companies that operate AESA within SA, therefore spares should be imported. Maintenance plans will project high cost of operation.	High
3.1.2	(3) Likely because AESA works well with solid-state transceivers.	(2) Minor because it might slightly increase the budget.	Low
3.1.3	(2) Low likelihood because most operators are young aged, familiar with software based system, therefore they will learn quickly. Furthermore, software systems are designed in such a way that it is easier to interact with.	(2) Minor because there are few operators in the SA DOD, therefore not all of them can take time to learn the new systems. On-job training can also be facilitated.	Low

Risk Identity	Likelihood level	Consequence level	Risk rating (Extracted from the risk matrix)
3.2.1	(4) Highly likely because most current radar are software-based and requires constant maintenance.	(4) Because software problems occurs constantly, and when they pile they can cause serious degradation in performance.	Severe
3.3	(5) Near certain because requesting a service from the separate government department involves lengthy processes. Additionally, public works has many clients as it supports other government departments. SA DOD programs might not be prioritized because it does not have an insight of how critical is it.	(4) Program critical path may be affected because Industrialization and commissioning phase cannot be terminated before the installation of infrastructure is completed.	Severe
4	(2) Low likelihood because of the budget cuts within in the government departments. The client might assume that a change in a requirement will jeopardize future funding.	(4) Critical path affected, and budget increase because this may involve adding subsystems and functionality.	Moderate

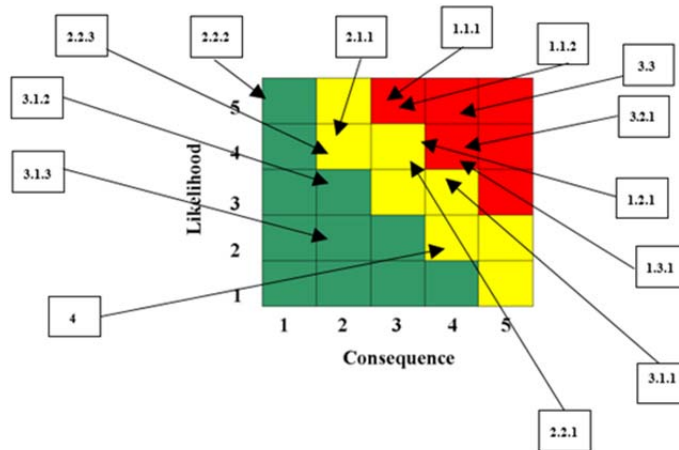


Figure 13. Risk Matrix for SSR Acquisition Program.

The last column on Table 8 indicates that if according to the likelihood and consequence levels of the risk analysis, the risk coordinates are located at the red portion of the risk analysis matrix in Figure 13; the risk effectively has a severe impact. If the risk coordinates are located at the yellow portion, effectively the risk has moderate impact. However, if the risks coordinates are located at the green portion of the risk matrix, the risk has effectively a low impact. For example, a risk with risk identity 1.1.1 has a risk coordinates (5, 3), hence it is located on the red portion of risk matrix in Figure 13.

d. Risk-Response Planning

This section develops options, and determines the specific approach to address the specific risks identified in the Table 7. The objective is to identify those risks, and the associated program phase, that are possible to address using a selected contract-type. The resulting contract-types pattern is then compared to the contract-type strategy in Figure 10. Table 9 provides the proposed risk response planning for each identified risks.

Table 13. Risk Analysis for the SSR Acquisition Program.

Risk Identity	Planned mitigation (what, when, who, funding)	Consequence type	Impacted Life-cycle phase
1.1.1 Antenna architecture	Risk mitigation. Award the technology development contracts to expand the AESA research. Award CPIF contract-type to incentivize the schedule.	Technical and schedule	Concept
1.1.2 Antenna architecture limitations	Risk mitigation Award the technology development contracts to expand the AESA research. Award CPIF to incentivize performance.	Technical and supportability	Definition and D&D
1.2.1 Transceiver architecture	Risk mitigation & transfer. Award CPIF during the definition phase to incentivize the contractor to develop innovative solutions. Award FPI during Industrialization phase to motivate the contractor to develop cost effective manufacturing technologies. FFP will satisfactory during the production phase if the objective of obtaining better manufacturing methods during the Industrialization phase was achieved.	Cost	Definition, Industrialization and production
1.3.1 Processor	Risk avoidance. This risk can be mitigated by delaying the program until the SDR technology is fully developed, and does not provide any risk.	Technical and supportability	Production and commissioning
2.1.1IFF	Risk Mitigation. Award the CPAF, where the award fees can be used when the contractor achieved a specified schedule performance.	Schedule	D&D and Industrialization
2.2.1 Integration	Risk mitigation. Award FPI during Industrialization phase to incentivize a specified schedule performance.	Schedule	Industrialization
2.2.2 Supply of Government Furnished Equipment (GFE)	Risk assumption. Establish contingency plans such as making requests of the required GFE from several government units.	Programmatic	Industrialization
2.2.3 Interoperability	Risk assumption. Undertake a well-timed communication with the operating units that they prepare for the arrival of the new system. Preparations can include modifying the legacy systems, operating procedures etc.	Cost and schedule	Commissioning
3.1.1 Antenna	Risk transfer. Award an extended contract to the developer of the AESA to provide support during the commission phase. The selected contract-type should be a FFP.	Supportability	Commissioning

Risk Identity	Planned mitigation (what, when, who, funding)	Consequence type	Impacted Life-cycle phase
3.1.2 Transceiver	Risk assumption. Advise the operating units to increase their budgets in order to cater for the additional energy requirement.	Cost	Commissioning
3.1.3 Maintenance personnel training	Risk transfer. Award an extended contract to the developer to provide training to the maintenance personnel during the commission phase. The selected contract-type should be a FFP.	Cost and schedule	Commissioning
3.2.1 Availability of software support	Risk assumption. Advise the operating units to increase their budgets in order to cater for the continuous software support.	Cost and Supportability	Commissioning
3.3 Facilities maintenance	Risk assumption. Forward a well-timed requirement to the DPW.	Schedule	Industrialization and commissioning
Requirement creep	Risk avoidance. If the nature of the additional or modified requirement is in such a manner that it is impossible to achieve overall planned performance objectives, these objective will be changed by, for example modifying a contract.	Cost and schedule	Any phases

e. Risk Monitoring and Control

The risk monitoring and control will involve assessing the outcome of the risk mitigation plan by tracking the level of the risk as the acquisition program progresses. This will be achieved by documenting each of the identified risk discussed earlier, and the associated mitigation plan in the risk management plan. As it was mentioned in Chapter I and Chapter II, the risk management plan is to be treated as a living document which should be updated as the risk changes. Within the SA DOD, this process is catered for by including the risk management plan document as part of each baseline requirement, and it is treated as Category 1 element.

D. SUMMARY OF THE ANALYSIS OF CURRENT SA DOD ACQUISITION PROGRAM

Table 8 indicates several identified risks, in which selecting a contract-type can contribute in controlling or mitigating the risk. It should be noted that this is certain for each acquisition phase of the SA DOD acquisition process. In particular, for a selected acquisition program, the SSR program, the proposed contract-type per the acquisition phase corresponds to the proposed contract strategy in Figure 10. Figure 10 is again shown, labelled as Figure 14, and it is used together with Table 8 in order to facilitate the discussion.

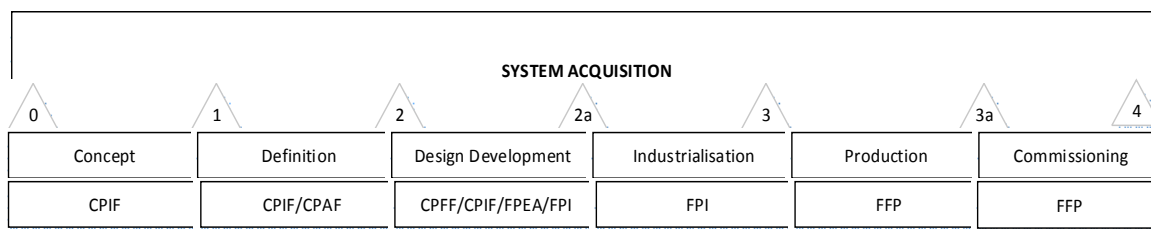


Figure 14. South African DOD Acquisition Process with a Proposed Contract-type Strategy.

Risk 1.1.1 is predicted for the concept phase, and proposed contract-type mitigation plan is CPIF. Risk 1.1.2, and 1.1.2 are for the definition D&D phase, and similar, CPIF can be used as a mitigation plan at these phase. Furthermore, it is proposed that FPI contract-type is applicable to risk 1.2.1, which is further predicted for the Industrialization and production phase. CPAF is proposed for risk 2.1.1, which occurs at the D&D and Industrialization phase. Finally, risk 1.2.1 and 2.1.1, indicates that FFP can be selected for the purpose of mitigating the risks at production and commissioning phase.

In concluding this chapter, the undertaken risk management process illustrated for the SSR, coupled with the use of contract-type as a mitigation plan addresses the research question presented in Chapter I. The research question addressed is, how can the contract-type based contracting strategy be implemented in mitigating program risks in the SA defense acquisition programs? Finally, the predicted risk consequence levels identified in the third column of Table 8 rationally address the research question; what are the risk consequences if this strategy is not applied?

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V. ASSESSMENT OF THE RELATIONSHIP BETWEEN THE PROPOSED CONTRACT-TYPE STRATEGY AND PROGRAM SUCCESS

The purpose of this section is to determine if a relationship exists between the incentive contracts and award fee contracts as recommended for the SA DOD, and the desired acquisition performance outcomes. The objective is to predict the success of the proposed contract-type structure in order to analyze and evaluate performance. The section will use selected scenarios from the U.S. DOD because these types of contracts are applied within their contracting environment (FAR, 2005). The qualitative analysis is provided. As it was mentioned in Chapter I, EVM is the quantitative method used to measure this kind of program performance and it provides better resolution on the results. The U.S. DOD programs selected are comparable in capability to the past and present SA DOD selected for analysis in two subsequent chapters, hence they are selected. The programs include the U.S. Army's RAH-66 Comanche helicopter, the U.S. Air Force's (USAF) F-22 fighter aircraft, and the U.S. Marine Corps (USMC) AN/TPS-80 Ground/Air Task Oriented Radar (G/ATOR).

A. RAH-66 COMANCHE HELICOPTER

The objective of the RAH-66 Comanche helicopter program (Comanche) by the U.S. Army was to develop a capability to counter threats in the 1980s by, extending the capability of the Apache helicopter. It was expected to be the Army's armed reconnaissance helicopter for the 21st century. Although the program experienced termination in 2004 after experiencing funding problems, changing requirements, and technology issues; it is comparable to SA DOD Light Utility Helicopter (LUH) program considered in Chapter III (Johnson & Birkler, 1996). Therefore, it will be used as a baseline to assess the probability of success of the proposed contracting strategy for the LUH program.

In operation, the Comanche was intended to fly ahead of Apache to scout its targets, and conduct air-combat missions using guided bombs and missiles, and perform reconnaissance operations. Additional capabilities are advanced avionics and targeting

systems, improved engines for lift, lower detectability through low radar-cross-section area, stealth technologies, and minimal logistical burden (United States GAO, 1992).

The Comanche program was initiated in 1982, and the technology development continued until 1988. In 1989, the program was tailored to two contractors who were expected to develop two prototypes for the purpose of developmental risk reduction. During this phase, the Comanche IPT identified a number of risks associated with the program. The overall technical risks that were included were increased weight of the aircraft, Mission Equipment Package (MEP), Software development, Integrated Logistic Support, Training, Propulsion and cost risks. The MEP and possibility of increased production unit cost provided greater risks in terms of probability of failure and consequence. For example, there was a risk associated with “Electro-Optical Target Acquisition Designation System, and Night Vision Piloting System may smear or bloom during weapons fire” (U.S. Department of Defense Office of the Inspector General, 2003, p. 27). The mitigation plan recommended “monitoring at system level for weapon flash and for bloom adverse effects during armament integration” (U.S. Department of Defense Office of the Inspector General, 2003, p. 27).

Government Accountability Office (GAO, 2001) reported the following facts about the Comanche program’s first two phases, the research and development phases, just prior to the EMD phase, the total cost estimate had increased by \$4.795 million, from \$43,339,000.30 to \$48,134,000.30. The schedule estimates had been revised, there was delay of 19 months to the total planned program schedule. The program had experienced couple of restructuring already. All these issues were attributed to the technical risks mentioned in the previous paragraph.

In order to allow for further assessment of these risks, the project’s EMD and production phase undertook an evolutionary approach. The plan was to overlap between EMD and production. However, according to the GAO’s assessment study of possible restructuring of the program, the Comanche’s “acquisition schedule meant that production could have started before substantive technical risks were addressed” (GAO, 1992, p. 29).

Incentives contracts were awarded during the EMD phase and LRIP of the Comanche program (Johnson & Birkler, 1996). The GAO study was undertaken in 2005 on the assessment of the effect of incentives and award fees on acquisition outcomes. GAO (2005) found that by 2002 the Comanche program had experienced cost, technical and schedule issues despite 85% of award fees having been paid already. There was \$202.5 million paid through 2004 since inception to LRIP. Specifically, technical MEP was the only aspect that was incentivized using award fees, whereby the risks dropped from high risk to moderate risk. The other aspects that were incentivized were cost and schedule. However, the cost had increased by 41.2% over the baseline, and schedule had extended by 14.8%. Figure 11 shows the risk matrix for the Comanche program as summarized by Comanche program manager in 2002 (GAO, 2005).

According to the Comanche program manager, “the Comanche Program reported that there were no high risks, and 19 moderate risks carried at the program level” (GAO, 2005; Department of Defense Office of the Inspector General, 2003, p. 7). This is illustrated in Figure 11. These risks could still lead to cost overruns and schedule slippage even if the award fees were paid, as it was already mentioned. Therefore, according was to the GAO, the Comanche program demonstrated that there is no positive correlation between the award-fees contracts and overall program performance (GAO, 2005; U.S. Department of Defense Office of the Inspector General, 2003).

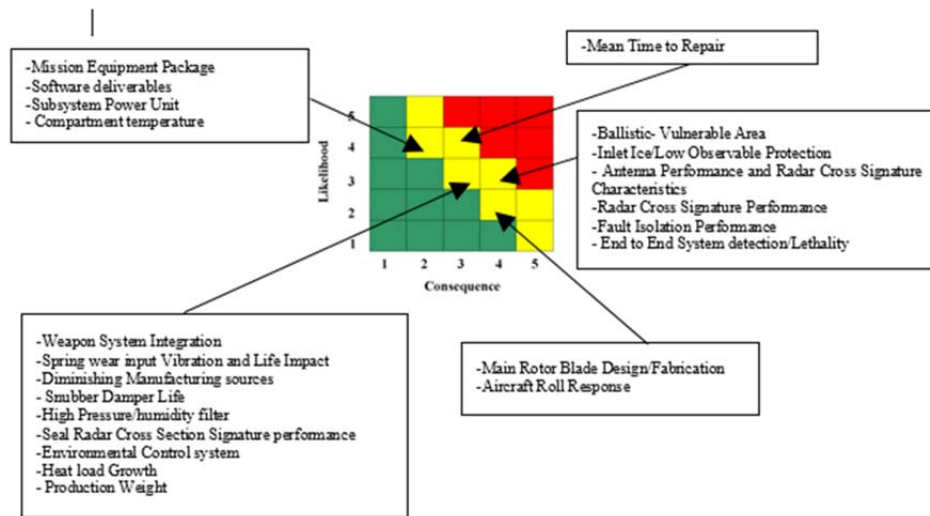


Figure 15. Comanche Program Level Risk Matrix. Source: U.S. Department of Defense Office of the Inspector General (2010).

B. F-22 FIGHTER AIRCRAFT

The USAF F-22 fighter aircraft program is comparable to the SA DOD Gripen and Hawk programs considered in Chapter III because it involved the revitalization of the respective DOD air superiority capability. Therefore, it will be used as a baseline to assess the probability of success of the proposed contracting strategy for the Gripen and Hawk program. The U.S. Air Force (USAF) F-22 fifth generation fighter aircraft program was officially started 1986, as the result of the requirement for a new air superiority fighter to replace F-15 and F-16 aircraft. The EMD phase was entered in 1991, and stretched over 11 years until 2002. The production started in 1999, and partially ran concurrently with the unfinished EMD. The aircraft was first delivered into service in 2005, representing the FRP and achievement of Initial Operational Capability. Full Operational Capability was confirmed in December 2007. The production was stopped in 2012 (Kato, 2012).

The primary capability it provides is air superiority; additional capabilities are ground attack, electronic warfare, and signal intelligence. Furthermore, “the F-22 incorporates stealth technology, super-cruise, thrust-vectoring for high maneuverability, and integrated avionics that fuse information from on-board and off-board sensors” (Gertler, 2013, p. 3).

In order to address the program total costs and technical risks during the early phases of the program, the U.S. DOD awarded two FFP contracts to two teams of contractors, with two companies per team. The objective was to provide a solution that would reduce the total program development, production, and operation costs. Furthermore; provide innovative solution on the development of airframes, engines, and avionics for a typical modern tactical fighter. Each team was expected to come up with better solutions to address these risks (Gertler, 2013).

According to Johnson & Birkler (1996), during the EMD phase, the prime contractors were performing on USAF CPFF and CPAF. Risks addressed during the EMD phase are related to broad requirement and technology maturity. The following specific critical-technical areas were identified and addressed as risks that could have costs overrun and schedule delay consequence. All these risks were considered moderate, with the exception of engine and radar related risks which were high:

- Airframe—Static and Fatigue Tests Completion Flight Test
- Engine—Redesigned Engine Ground Test and First Flight Engine Delivery
- Low Observables—Pole Model and Flight Testing
- Radar—Hardware and Software Flight Testing
- Passive Surveillance and Electronic Warfare—Hardware and Software Flight Testing
- Sensor Control/Sensor Fusion/Pilot Interface—Hardware and Software Flight
- Flight Control/Vehicle Management—Early Flight Testing

There was no best risk mitigation approach to risk areas identified as high risk. The IPT decided to assume the risks. This would lead to accepting reduced F-22 performance, with the slip in the schedule, or some combination of both. However, even if performance was reduced in the specified risk areas, it would still represent a major increase in military capability (Office of the Under Secretary Of Defense for Acquisition & Technology, 1995).

The contract-type awarded during the production of F-22 was the hybrid of CPFF, FPIF, FPEA and FFP. The EVM was used to track performance for the CPFF contracts. The incentivized contract elements included number of produced aircraft per batch for different lots. There were further specific tasks involved within the contract, such as Modernization of Laboratory Infrastructure at the contractor production site, maturation of Reliability and Maintainability programs, squadron level maintenance support (U. S. Department of Defense, 2010).

According to the GAO study undertaken in 2005 on the assessment of the overall effect of incentives and award fees on acquisition outcomes, the F-22 program had experienced cost increases, and development delays up to the point when the study was conducted. The prime systems contractors had received 91% (\$848.7 million) of the award fee made available to that date. The significant aspect that was incentives, as it was mentioned was the technological innovation. However, the cost had increased by 47.3% over the baseline, and schedule had extended by 13.3% (GAO, 2005). This was despite the fact that there were relatively few elements classified as high risk throughout the acquisition of the F-22, in that the program was considered for restructuring or cancellation.

C. AN/TPS-80 GROUND/AIR TASK ORIENTED RADAR

The AN/TPS-80 G/ATOR is the program that has recently passed through the EMD phase (Milestone C) and entered the LRIP, for the acquisition of the USMC mobile multi-role radar, and ground weapons locating radar capability. This integrated radar achieve the proposed capabilities by performing three radar type tasks in one system: air surveillance, air defense, and ATC. It will replace five USMC radars, the AN/TPS-63 air defense radar, AN/TPS-73 air traffic control radar, AN/MPQ-62 short range air defense radar, AN/TPQ-46 counter fire and target acquisition radar. It will further complement AN/TP-59 long-range radar. The program is analogous to SA DOD SSR program (U.S. Marine Corps Concepts and Programs, 2015).

The program implements the evolutionary acquisition approach, in that the production will be divided into four blocks. Each block will produce radar's slightly

unique characteristics, in lots format. For example, Block 1 will produce basic radar equipment which supports air defense and air surveillance capability. Block 2 will produce radar with software that performs the missions of ground counter-battery and fire control. The last defined block will provide the expedition airport surveillance radar capabilities (U.S. Department of Defense of the Office Inspector General, 2015).

The risks addressed during the EMD phase consist of requirement maturity risk, costs risk and technology maturity risks. On the requirement risk area, according to Program Executive Office Land Systems (2012) the G/ATOR system was reported that it does not meet the reliability requirement due to the fact that it fails repeatedly during operations. This risk has been considered low, and it was carried through to the LRIP after the approval of TEMP at Milestone C by the MDA (Program Executive Office Land Systems, 2012).

The costs risk involves the high costs of manufacturing process associated with the following elements, the production and assembly of air ducts that provides precise mounting and cooling of the transceiver modules and antenna array elements, transceiver modules requires expensive material and hermetic sealing which reduces yield, and circulator isolator boards required for transceiver modules requires a multiple yield manufacturing process and thus expensive. The risk mitigation adopted by the IPT for costs risks was conducting an additional research to devise alternatives manufacturing processes. The initiative included involving the small businesses for the purpose of expanding the innovative solution base. The initiative was called Small Business Innovative Research (SBIR). The overall solution adopted included the transition from the Gallium Arsenide (GaAs) based transceivers to next generation Gallium Nitride (GaN) based transceivers. Although it is still a new concept, GaN transceivers works better, cost less, weigh less and consume less power (Program Executive Office Land Systems, 2012).

The technology risk follow-on the cost risk in that it involves the reliability challenges of producing GaN transceivers. The testing process of GaN transceivers is yet to mature. Although not yet implemented, the risk mitigation plans will include SBIR to devise further risk reduction plans for the production phase. This risk has been considered

low, and it was carried through to the LRIP after the approval of TEMP at Milestone C by the MDA (Program Executive Office Land Systems, 2012).

The G/ATOR program was considered by GAO a low-risk program because it achieved the expected acquisition performance outcome. The GAO (2016) states that the program has remained on schedule and decreased the estimated total program cost by more than 15%. The phases prior the EMD were completed in 66 months, and the EMD phase in 138 months. The early phases had the total costs of \$1,572.7 million. The total program cost at the end of 2015 was \$2,775.4 million, with the major part spent during the EMD phase. The program had estimated cost re-baselined only once in 2010 when there were cost overruns of \$14 million, however overall savings of \$40 million are expected in production and deployment phase. The FRP are going to be finished in 2020 (GAO, 2016). As per the Selected Acquisition Report of the program published in 2015, the program awarded FPI (Firm Target), FFP, and CPIF during the EMD phase (U.S. Department of Defense, 2015b).

D. CHAPTER SUMMARY

This chapter provided a qualitative analysis of some of the U.S. DOD acquisition programs analogous to SA DOD programs presented in Chapter IV. The U.S. DOD programs selected applied contract-type as part of their contracting strategy. The purpose was to establish whether there is a correlation between the contract-type strategies based on incentives fees and award fees and acquisition program success. The analysis of the U.S. DOD Comanche program, similar to the SA DOD LUH program indicates that even though 85% of the available award fees were paid, the program was canceled.

The analysis of the U.S. DOD F-22 program, similar to SA DOD Gripen and Hawk program, indicated the following. The F-22 program experienced some increase in costs and development delays even with the use of award fees. The incentives fees were instrumental in managing the technological innovation. The incentive fees contracts further contributed in mitigating risks during the production phase. Therefore, despite the unsuccessful outcome of the award fees and success of incentive fees, the deployment of F-22 aircraft still represented a major increase in military capability.

The incentive fees, together with fixed contracts were awarded during the EMD phase of the G/ATOR program, which is similar to SSR program. The acquisition performance objectives were achieved thus far in that the program remain on schedule, and the total estimated program costs decreased. The conclusion from the analysis of the three U.S. DOD program suggests that, the Comanche program was unsuccessful, the F-22 program was partially successful, and the G/ATOR program is progressing on target. Therefore, from risk management perspective, the application of award fee and incentives fees contract-type is not inconsequential, but is manageable.

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VI. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this project was to explore the possibility of applying the contract-type strategy in order to mitigate acquisition program risks for the SA DOD. The focus was on cost overruns and schedule slippage risks. The objective was to propose a standard contract-type based strategy for various phases of the acquisition process of the SA DOD. The strategy is based on understanding relationship between the requirement certainty and the risk.

The objective of this project was achieved through addressing the following research questions how can the contract-type based contracting strategy be implemented in mitigating program risks in the SA defense acquisition programs, should this strategy be implemented in order to avoid acquisition program risks that lead to costs overruns and schedule delays, and what are the risk consequences if this strategy is not applied?

The research began by conducting a literature overview on risk management processes commonly applied in the U.S. defense acquisition programs. The literature overview then covered some important contract management principles that are applicable to the defense acquisition such as selecting a contract-type, and how these are used to balance the risk between the stakeholders in the acquisition program. This process also compared the risk management, and contract management approaches of the U.S. DOD and SA DOD, and some underlying factors that influence the application of these processes, such as political and cultural backgrounds. The U.S. contract management guiding principles are contained within the FAR, while SA DOD are contained within the PPPFA. These agency specific regulations for the SA DOD, such as DAP 1000 and A-PRAC-1034, are derived from the PPPFA framework.

Defense acquisition frameworks were introduced, for the purpose of providing a foundation for the proposed contract-type strategy. U.S. DOD acquisition framework, as contained in the U.S. DOD Directive 5000.2 was introduced first because in literature and in practice, there is research conducted that relates to using a contract-type strategy. The SA DOD acquisition process as contained in DAP 1000 was introduced later, because in

subsequent chapters this process is repeatedly used to test the proposed contract-type strategy as a hypothesis.

A. FINAL CONCLUSIONS

The proposed contract-type strategy for the SA DOD was introduced in Chapter III. The strategy, unlike in the provision of PPPFA and A-PRAC-1034, considers the use of incentive-based and award fee contracts in order to address the costs and schedule risk encountered in some phases of the acquisition programs. The strategy suggested that during the concept phase, CPIF contracts are appropriate, as the requirement is still broad and uncertain, risk is high, and therefore incentives should be used to motivate the contractors to achieve cost savings and performance. During the definition phase, CPIF can be used to incentivize cost savings, and CPAF can be used to promote better performance. Hybrid of CPFF, CPIF, FPEA and FFI contract-type are recommended for D&D phase as this phase include a various development activities that are of different complexity. FPI contract-type is recommended for the Industrialization phase because although the solution is proven, innovation still need to be incentivized to achieve cost effective manufacturing processes, and required schedule performance. FFP contracts are appropriate during the production and commissioning phase because the requirement is well known, and risk is low.

The analysis of three past SA DOD program in Chapter IV indicted the following. Part of the issues encountered during the LUH, Gripen and Hawk programs are the deviation of the actual costs and schedule from planned objectives from D&D phase to commissioning phase of the programs. There was a limited use of incentive-based contract-types to achieve cost and schedule objectives. Most issues experienced downstream, are due to risks not identified upstream. Finally, if the incentive-based and award fee contract-type strategy similar to the one proposed in Chapter III was selected, risk that results in cost overruns and schedule delays could have been avoided. This is the rationale that this strategy should be implemented in order to indirectly avoid overall program risks, and therefore improve performance.

The application of the risk management process, to one of current SA DOD programs, the SSR program found that it is possible to use contract-type strategy as a risk mitigation plan for some of the predicted risks throughout all phases of the acquisition process. Actually, contract-type risk mitigation plan for the SSR program corresponds to the proposed contract-type strategy in Chapter III. It was concluded that this process indicates, how a contract-type based risk mitigation strategy would be applied to the SA DOD acquisition, and the risk consequences if this strategy is not applied.

The analysis of three U.S. DOD acquisition programs was conducted with the purpose of assessing if there is a relationship between an award fee and incentives fees, and acquisition program success as proposed for the SA DOD. It was concluded from the analysis that from risk management perspective, the application of award fee and incentives fees contract-type is not inconsequential, but the risks are manageable.

B. RECOMMENDATIONS FOR FUTURE STUDY

This project did not cover significant, overarching facts that pertain to the SA DOD acquisition environment. This is because of the limited amount of data from the SA DOD acquisition programs available in open literature, and the difficult and involving process required in accessing such data from relevant authorities. Therefore, there are several factors influencing the implementation of the recommended contract-type strategy that were not addressed by this project. These factors require to be deservedly explored should such data become accessible.

The analysis of the past SA DOD program did not cover the precise acquisition performance outcomes between the concept phase and definition phase, and D&D and commissioning phase. For example for cost and schedule performance, an overall cost and schedule were not presented into actual outcome per phase. The information on the actual spending per year (or per phase), number of years taken for each phase, and actual number of contracts and contract-type awarded for each phase was not obtained. Only overarching information was analyzed. If this low level information is obtained in the future, it would be beneficial to perform a further analysis as it might reveal better resolution to the answer for the research question, should the contract-type based risk

management strategy be implemented in order to avoid acquisition program risks that lead to costs overruns and schedule delays?

It would be beneficial as well if the proposed contract-type strategy could be tested in more than one acquisition program that are at different phases of the acquisition process. Contrary to this project where an analysis was only performed for one program, the SSR program, which is in the concept phase. Testing the strategy with one distinct program per phase, with the program being at that particular phase, will provide a better resolution of the feasibility. The strategy may also be tested on procurement of COTS projects, and service acquisitions.

Further studies that may benefit this project are as follows, the implementation of the EVMS in the SA DOD acquisition environment in order to manage deviations between technical, cost and schedule performance, feasibility study involving adapting regulations such as PPPFA and PFMA; the directive documents such as A-PRAC-1034 to cater for the incentive-based and award contracts, and effect of the SA defense industrial base on the wide variety of contract-type based risk management approaches.

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