Minimising the costs of reconnaissance at Air Force Base Makhado

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Submitted in partial fulfilment of the requirements for the degree of

BACHELORS OF INDUSTRIAL ENGINEERING

in the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

UNIVERSITY OF PRETORIA

October 2010

Executive Summary

With the increasing costs of reconnaissance at Air Force Base Makhado, they have requested for a solution that will reduce these reconnaissance missions' costs. After taking a close look at the costs involved in successfully completing any reconnaissance mission , it was seen that the costs of the film imagery system is the biggest contributor of costs to these missions. It is therefore proposed that the digital imagery system be replaced with the digital imagery system.

An extensive literature study was conducted to gather information that would help in the understanding of the problem and the environment it is in. it also describes the different alternatives for both the current film imagery system and the proposed digital imagery system.

The chosen method to compare these two alternatives is a cost benefit analysis (CBA). A cost benefit analysis was conducted for both alternatives and this will help us determine whether the proposed digital system is worthwhile or not.

The results from the completed CBA show an Internal Rate of Return of 96%. This indicates that the film system should indeed be replaced by a digital system. If the proposed system is implemented, the SAAF could save a total of R94 423 971 from the 20 years of the digital system life.

The risk analysis performed on the digital system shows that the risks associated with this system could easily be reduced by proper risk management. The different risks are listed and an appropriate action plan on how to reduce these risks is given.

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List of Acronyms

AFB	-	Air Force Base
ASU	-	Air Servicing Unit
CBA	-	Cost Benefit Analysis
CPSC	-	Central Procurement Service Centre
FA	-	Financial Approval
GO	-	Government Order
IPB	-	Intelligence Preparation of Battlespace
IRR	-	Internal Rate of Return
JDP	-	Joint Defence Publication
MRI	-	Military Regulations Instructions
NPV	-	Net Present Value
PFMA	-	Public Finance Management Act
SAAF	-	South African Air Force

Chapter 1: Project Proposal

1.1 Introduction and Background

Reconnaissance missions are very important in order for the Department of Defence to protect the country. The cost of conducting these missions is increasing drastically annually and this project aims to find a way to decrease them.

1.1.1 Background of Air Force Base Makhado

Air Force Base (AFB) Makhado is an airbase in the South African Air Force. It is the South African Air Force's northernmost base and is situated in Louis Trichardt, in the Limpopo Province, near the Zimbabwean border. The base is also known as ‘Fighter Town’ since it is home to the fighter aircraft. The base motto is Castrum Borealis which means Fortress of the North.

The base was officially opened on 14 October 1987 as AFB Louis Trichardt, but later changed its name to AFB Makhado on 7 November 2003. Makhado comes from the name of the Venda King that ruled in this region of the Limpopo Province in the mid-1800s.

Vision

TO BE RECOGNISED FOR EXCELLENCE IN COMBAT OPERATIONS SUPPORT

Mission

TO PROVIDE COMBAT OPERATIONS SUPPORT THROUGH A PROCESS OF TOTAL SYSTEM’S INTEGRATION

The Gripen and Hawk Mk 120 fighter aircrafts are housed at this base to ensure the mission of this base is achieved. The Hawk Mk 120 is a lead-in fighter aircraft trainer used to cost effectively train pilots. This aircraft is not only used for training, it may also be used for certain operational tasks in low threat environments. Some of these tasks include:

- Search and Rescue
- Border Control
- Reconnaissance
- Limited Close Air Support

This project will only be looking at the reconnaissance task.

1.1.2 Reconnaissance Missions

Reconnaissance is an exploratory military operation which entails a preliminary survey of a region and is used to collect information or to locate the enemy or as certain strategic features. The information obtained from this survey is used by Defence Intelligence to complete their Intelligence Preparation of Battlespace (IPB) templates used for strategic purposes. The IPB template helps in collecting and gathering information about an enemy's composition and capabilities via direct observation (images).

There are several ways in which reconnaissance can be done. These include patrolling by troops, ships or submarines, manned/unmanned aircraft, satellites or by setting up observation posts. For the purpose of this project only reconnaissance by manned aircraft will be considered.

When planning reconnaissance missions with manned aircraft, there are several aspects together with associated costs to consider. Some of these aspects include the following:

- Availability of an aircraft with sufficient fuel
- A competent imagery system
- Trained personnel to fly the aircraft and interpret the images from the operation
- The area which is being studied

AFB Makhado specifically deals with aerial reconnaissance (reconnaissance by manned aircraft). The aerial reconnaissance performed there is mostly for surveying tangible structures, specific areas and checking for any threats from an enemy. They capture the images by using a Hawk Mk 120 aircraft loaded with the VINTEN RECCE Pod. The VINTEN RECCE Pod uses photographic film that is loaded onto it to capture these images.

1.1.3 Problem Statement

AFB Makhado conducts the aerial reconnaissance missions and since the costs of completing these missions successfully are increasing, they are looking for ways in which they can reduce these costs.

The costs that will be studied in order to find alternative ways of completing these reconnaissance missions successfully are listed below.

- Aircraft fuel costs
- Cost of photographic film
- Costs of film development chemicals
- Costs of running a dedicated laboratory
- Cost of utilizing trained personnel
- Cost of specialized equipment for the loading of the film onto the VINTEN RECCE Pod and then loading it onto the aircraft

The biggest contributor to the increasing costs of reconnaissance is the cost of using a photographic film imagery system on the VINTEN RECCE Pod. This is due to the scarcity and increasing cost of procuring photographic film and the necessary film development chemicals. Seeing that conventional photography (uses film) will become obsolete long before the Hawk Mk 120 aircraft is phased out (in approximately 20 years), it is proposed that this film system be replaced with a modern digital system.

The findings from this project will help AFB Makhado reduce the total cost of their reconnaissance missions.

1.2 Project Aim

The aim of this project is to conduct a thorough analysis on the current execution of reconnaissance missions in order to find ways of minimizing the total cost of these missions. The project will also conduct a risk analysis on the proposed solution for minimising these costs. The results from this project will enable AFB Makhado to complete their reconnaissance missions in a more efficient and effective manner at the lowest cost possible.

1.3 Project Scope

Reconnaissance involves a survey of an area, zone or route to gain or collect information about that location or the enemy in that area. Usually images are used to obtain this information; therefore a competent imagery system needs to be used.

This project will consider all the costs incurred to complete a reconnaissance mission successfully. Once all these costs are identified, an in depth analysis of these costs will be conducted in order to find ways of reducing them. The primary costs of the photographic film imagery system will be the main focus of the analysis together with the proposed digital imagery system costs.

A CBA will be completed for both the current film and proposed digital imagery systems. The analysis will be used to evaluate the total anticipated cost of installing and maintaining of the digital system compared to the anticipated benefits to determine whether the implementation is justified or not. The results from the project will not only help AFB Makhado save on their spending but will also help them increase the effectiveness, efficiency, reliability and responsiveness of the missions.

Chapter 2: Literature Review

This literature review is to analyse existing literature about the problem experienced at AFB Makhado that will assist in identifying appropriate methods, tools and techniques that may help solve the problem. It will also enable the student to analyse the environment in which the project will be conducted.

2.1 Context of Problem

The problem addressed in this project originates from the need that AFB Makhado has identified. Their need is to decrease the overall costs of aerial reconnaissance at the base. According to Ferguson [4], the costs of these reconnaissance missions could be decreased in one of two ways. They can either be decreased by sacrificing the system performance or by implementing a functional system which allows the use of standard components with multiple uses. Since this is for military reconnaissance operations, sacrificing the system performance is not an option as the system must be as reliable, accurate and responsive as possible. That is why it was deemed necessary to identify the biggest contributors of cost to the operations and then try to reduce costs by replacing some of the current system with a new standardized system.

The major cost contributors are given below.

- Aircraft fuel costs
- Cost of photographic film
- Costs of film development chemicals
- Costs of running a dedicated laboratory
- Cost of utilizing trained personnel
- Cost of specialized equipment for the loading of the film onto the VINTEN RECCE Pod and then loading it onto the aircraft

To decrease these costs, it was suggested that the film used in the VINTEN RECCE Pod be replaced with digital imagery. A trade-off between the film and the digital imagery systems will be conducted in this project to determine the feasibility of the proposed solution of changing the film to digital is viable.

When completing this project, it is very important to take into consideration that the problem is of a military nature and certain aspects will have to be handled in a very professional and sensitive manner. The most important characteristics of all military operations are the responsiveness and reliability of every utilized system.

2.2 What is Aerial Reconnaissance?

Reconnaissance as a military term denotes a military survey conducted to gain or collect information about the terrain, battlespace or the enemy. The information obtained from the missions is interpreted and used as intelligence. Reconnaissance is generally used as an intelligence gathering tool. Aerial reconnaissance is therefore for surveying the weather, terrain and for observing tangible structures, areas and movement of enemy forces for military purposes.

There are two types of reconnaissance that AFB Makhado performs namely terrain-orientated reconnaissance and force-orientated reconnaissance. These two types of reconnaissance are usually conducted in conjunction with each other but since it is for military purposes, priority is given to the force-orientated reconnaissance.

2.2.1 Terrain-orientated Reconnaissance

This is the discipline of conducting a preliminary survey of the terrain or inland areas. It is used to gain information about the typography, hydrographical and other natural features in an area. A specific area, zone or route can be used as the subject of interest.

Area reconnaissance refers to the observation and information obtained about a specific location or area. Zone reconnaissance focuses on obtaining detailed information about a particular designated location before sending in our forces into that location. Route reconnaissance is orientated on a given route: a road, a railway, an infiltration line or a general direction of attack to provide information on the route conditions or activities along the route.

2.2.2 Force-orientated Reconnaissance

This kind of reconnaissance forms a very essential part of military reconnaissance. It focuses more on the enemy forces. It is conducted to get details of the opposing forces and needs to be completed in a timely and accurate manner. The information from the images taken is used as intelligence to confirm the Intelligence Preparation of the Battlespace (IPB) templates. The IPB templates help predict the intensions of the enemies' composition, capabilities and the environment conditions in which they are in.

The templates need to be as reliable and accurate as possible as they can help one win a battle. An example of an IPB template is given below.

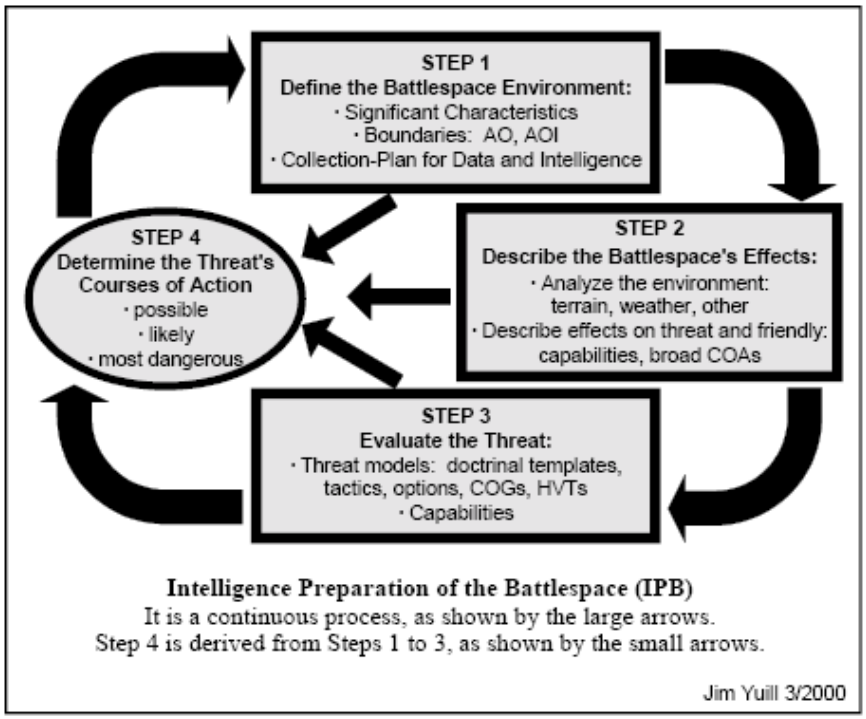

Figure 1: IPB Template

2.3 Depth of Penetration

Reconnaissance missions are characterized by the depth of penetration required in terms of time, resources and risk associated with the mission. They can be close, distant or deep.

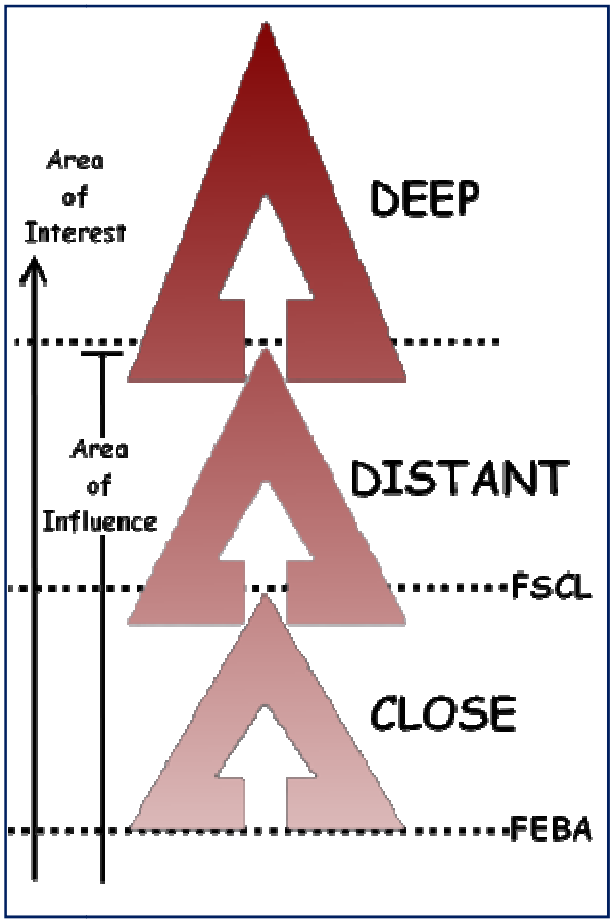

Figure 2: Depth of Reconnaissance in relation to battlespace

2.3.1 Close

Close (short-range) reconnaissance is conducted in the area between the Forward Edge of the Battle Area (FEBA) and the Fire Support Coordination Line (FSCL). This area is known as the Area of Operation (AO). Aircraft are not usually used for reconnaissance in this area so a further study will not be conducted for this area.

2.3.2 Distant

Distant (medium) reconnaissance collects data and information in the area of influence. The reconnaissance done in this area is usually conducted by the Army and use light-armoured and fast-attack vehicles. Although aircraft are sometimes utilized, the study will not concentrate on this area.

2.3.3 Deep

Deep (long-range) reconnaissance requires the highest level of a committed force and resources. The information and intelligence collected from this area is the most important of all as it is used to execute successful tactical operations and to plan for future operations.

Aircraft are one of the most important resources needed for this reconnaissance. The image capturing cameras on these aircraft should be able to take very high quality pictures. The film currently being used is getting very expensive and difficult to get as it is becoming obsolete and therefore it is proposed to change it to digital. Some literature on the current film imagery system and the proposed digital imagery systems is completed and documented below.

2.4 Description of Alternatives

2.4.1 Current System: Film Imagery

The current film imagery system was identified to have several issues that are causing problems. One of the biggest problems is the loading of the film onto the VINTEN RECCE Pod and then onto the Hawk Mk 120. It requires a lot of specialized equipment and man hours to complete and this therefore causes logistical issues.

The system is currently able to capture images for the purpose of reconnaissance but the only problem is that you cannot see the images until they are developed in the laboratory. If after developing the photos one sees that the images are not good enough the mission has to be restarted. This then causes a lot of extra costs for the base.

There are several costs involved within this system and the costs that play the biggest role are the following:

- Photographic film costs
- Film development chemicals costs
- Personnel costs

The fact that film is becoming obsolete also makes the prices increase as the film becomes very scarce. This also means the film development chemicals also get expensive due to the decrease in availability.

2.4.2 Proposed System: Digital Imagery

The digital system that is being proposed aims to reduce the total cost of reconnaissance missions in the long run by a substantial amount. Not only will this system decrease costs but it will also be used to improve quality of the images and increase the reliability and capability of the overall imagery system.

The following are some of the functional requirements requested by management (This is not a complete list as management is still busy reviewing and refining the complete system requirements). The system must be able to:

- Form a visible and clear image of the target area/scene.
- Send and receive real time images.
- Retrieve images on demand.
- Recognize predefined objects.
- Pre-program target coordinates.
- Convert the images taken to the required format (e.g. JPEG, raw image format, etc).
- Change certain image parameters such as contrast, sharpness, colour balance, zoom, focus, aperture, etc.
- Compensate for fast forward movement of the aircraft.
- Provide extended spectral response beyond visible light into the infrared spectrum.

The proposed system will comply with the required requirements. The feasibility and validity of the system will be verified at a later stage of the project with the aid of a cost benefit analysis.

2.5 Cost Benefit Analysis Method

A cost benefit analysis (CBA) is the chosen method to solve the above mentioned problem. It will help establish whether the proposed solution of replacing the current film imagery system with the digital imagery system is viable and worthwhile.

The CBA method is a method for economic analysis of a project or system (Rindfleisch, [9]). CBA was first used and recommended by Albet Gallatin in 1908. It was first used by the United States (U.S.) Bureau of Land Reclamation and the U.S. Corps of Engineers. The first guide to CBA was produced in 1946 and was called the Green Book. This book provided a practical guide on how to conduct a CBA. Although CBA's were initially mainly used for transportation related projects, this later changed in the 1970's when they were also used for other development projects. In recent years, CBA's are used in almost any field where a decision needs to be made as to which alternative is the best and must be chosen for implementation.

It helps stakeholders consider the return on investment of any project and provides guidance on the project trade-offs involved. The trade-offs involved in this project are between the current film imagery system and the proposed digital imagery system. The analysis is used to evaluate the total anticipated costs of a proposed project compared to the associated total benefits in order to determine whether the proposed project is worthwhile. The proposed project will be implemented only if the results of the comparative evaluation show that the overall benefits outweigh the incurred costs.

Before a cost analysis can be completed, the analyst must consider certain resources. These resources determine the quality of the results from the cost estimate. These resources are requirements, historical data, time and people.

❖ **Requirements**

A requirement documents the need for a certain system with what it should do. The requirement statement should state the required capabilities, characteristics and quality of the system. These requirements should be necessary, concise, consistent, complete, verifiable and unambiguous. Requirements are either functional or non-functional.

- Functional requirements state the tasks that a system should be able to execute. They are usually known as capabilities.
- Non-functional requirements are usually known as constraints. They are used to judge the operation of a system. They are classified according to performance, maintainability, safety, reliability and responsiveness.

The requirements for the proposed digital system are given in section 2.4.2 above.

❖ **Historical Data**

Historical data helps with the understanding of prior costs and will predict the future costs. This data is not limited to costs but may include performance information. This data must be consistent, timely and complete to be beneficial to the cost analysis.

❖ **Time**

Sufficient time is necessary to complete the cost benefit analysis successfully as it takes time to review and understand the given requirements. Once the requirements are understood, the collection and analysing of data to generate the actual cost estimates can take place. Documenting the results takes up a lot of time especially because one needs to make sure that the analysis is accurate and complete. This illustrates that time is a very important resource to any project.

❖ **People**

Good cost estimates need a competent team to bring different reasoning and understanding to the table so that the estimates are done based on different views. This requires the team to have good communication skills and must be willing to listen.

When performing a CBA, it should be kept in mind that the outcome of the analysis depends on how accurately the costs and benefits have been estimated. An inaccurate analysis carries a substantial amount of risk with regards to the planning of a project. This therefore means that the outcomes of a CBA should be treated with caution.

Boardman [2] believes that there are three steps to follow to successfully complete a cost benefit analysis. For the first step, all the potential costs that will be incurred by the implementation of the project must be identified and noted. During the second step, all the anticipated benefits associated with the project must be documented. The last step involves weighing the costs and benefits against each other to determine whether the positive benefits outweigh the negative costs.

2.5.1 Step 1: Identifying Costs

When identifying the costs to be used for the analysis, it is very important that only the correct and significant cost drivers be identified and used. This step is to identify and quantify all the costs involved in the project. To successfully identify all the potential costs of a project, the following steps must be executed.

i.) Draw a list of all the monetary implementation costs and costs incurred throughout the entire life of the project. These costs include development costs, installation costs, operation costs, recurring and non-recurring costs.

ii.) Draw a list of all the non-monetary costs that will likely be absorbed. These include time, potential risks, imperfect processes and the influence of the project on the organizations reputation.

iii.) Assign monetary values to the identified costs in step (ii). The values should be stated in present value terms.

iv.) Add all the anticipated costs to obtain the total cost value.

Contingency costs are not included in the total cost value but are evaluated separately.

2.5.2 Step 2: Identifying Benefits

During this step all the benefits anticipated as a result of the successful implementation of the project will be identified and quantified. To do this, the following steps must be completed.

i.) A list of all the monetary benefits that will be experienced if the project is implemented successfully must be made. Some of the benefits include decreased maintenance costs, increased contributions from investors and direct profits from the products or services.

ii.) A list of all the non-monetary benefits that is likely to be experienced. These include increased system capabilities, increased reliability and responsiveness, decreased operation times and improved organization reputation.

iii.) Assign monetary value to the benefits identified in the aforementioned step in present value terms.

iv.) Add the anticipated benefits to obtain the total benefits value.

2.5.3 Step 3: Evaluate Costs and Benefits

The final step of the CBA is to weigh the costs and benefits to determine if the project is worthwhile and valuable to the organization. To do so properly, the following steps need to be followed and completed.

i.) Compare the total costs value with the total benefits value. If the total costs exceed the total benefits value substantially then the project is not worthwhile and should not be implemented.

ii.) If the total costs and total benefits value are almost equal then the costs and benefits identified should be re-evaluated and the cost benefit analysis revised. This could be due to missed or incorrectly quantified items.

iii.) If the total benefits are much greater than the total costs it means that the project is worthwhile and should be implemented.

2.6 Strengths and Limitations of Cost Benefit Analysis

Kopp [7] says that a CBA is an important tool for assisting top management to do the best thing they can with the limited time, resources and funding at their disposal. Although a CBA is efficient, it exhibits both strengths and limitations mentioned below.

2.6.1 Strengths

- Costs and benefits are compared using the same equal terms
- Helps justify decisions at all levels
- The method allows for transparency. This increases the accountability of public decisions where the decisions vary with the analysis.
- Cost benefit is readily accepted by the public than other economic methods.

2.6.2 Limitations

- Benefits are difficult to estimate
- The analysis can be very costly and time consuming
- Some benefits can not be quantified in monetary terms

The overall strengths of this method outweigh the limitations and therefore it is a good method of comparing two projects against each other to find the best one out of the two.

2.7 Conclusion

The first chapter of the document documents the project proposal with the problem statement and the planning of how the project will be completed. The second chapter (literature review) shows the entire problem experienced at AFB Makhado in more detail and this helps us in understanding the context of the problem and the environment in which it is situated.

A CBA will be conducted for both the current film imagery system and the proposed digital imagery system. The analysis will determine whether the proposed project is worthwhile or not.

Chapter 3: Development of Conceptual Design

For the CBA, the costs and benefits listed below shall be used. The costs and benefits are categorized as follows:

Costs	Benefits
Development costs	Quantifiable benefits
Operational costs	Non-Quantifiable benefits

Table 1: Costs and Benefits Categories

3.1 Proposed Digital System

The following development and operational costs will be considered for the CBA.

Development Costs

- Acquisition
- Installation

Operational Costs

- Maintenance
- Fuel

Note: The salaries of the personnel have not been included in the analysis of both the Film and Digital System as it will remain the same for both systems. The same people will be trained to use the new digital system.

Quantifiable Benefits

Quantifiable benefits are benefits of the system that can be translated into monetary value. These benefits are from operating and maintaining the system over its system life. These include:

- Decreased operational costs

Non-Quantifiable Benefits

These benefits can't be quantified in terms of monetary value but are assigned values in terms of estimates and tradeoffs. The following are the non-quantifiable benefits for the digital system:

- Increased system capabilities
- Increased system reliability and responsiveness
- Decreased operation times

3.2 Current Film System

Since the film system is already in use, there is no development costs involved with this system. The costs that are applicable to this system are as follows:

Operational Costs

- Film development chemicals
- Photographic film
- Maintenance
- Fuel

3.3 Cost-Benefit Analysis Expected Results

Upon successful completion of the analysis, the following results will be obtained. These results will clearly show which system is the best one for AFB Makhado.

- Total cost of each system
- System cost over the system life
- Benefits associated with each system
- Benefit/cost ratio
- Payback period
- Break-even point

3.4 Conclusion

The development of the conceptual design documented in chapter 3 is a guideline of how the CBA will be carried out and completed. More detail on the solving of the CBA is given in the following chapter. Chapter 4 will also give the final results of the completed analysis and will help in deciding which system is better and therefore which should be discarded.

Chapter 4: Solving the Cost-Benefit Analysis

The Hawk Mk 120 aircraft is going to be in operation for approximately another 20 years in the SAAF and therefore the CBA will be completed for 20 years. The base year for all the calculations is 2011 as this is assumed to be the year in which the project will commence. Certain assumptions were made for the solving of the CBA. These assumptions are listed below.

Assumptions

- AFB Makhado completes an average of 460 (2 per week) sorties (missions) for reconnaissance annually with the current film system. The extra sorties are due to the fact that some of the reconnaissance missions need to be redone due to inadequate/unclear images. An estimate of 416 sorties (10% less than the film system because none of the missions will have to be re-done).
- A constant interest rate of 6.5% will be used throughout the project life cycle.
- The cost of filling the 823 lit re fuel tank of the Hawk Mk 120 is R4567.36 at the moment but an average increase of 8% is used for each of the following years. The increase was obtained from the recent trend in the fuel market.
- A full tank of fuel can on average complete 2 reconnaissance sorties.

4.1 Costs

The following table shows the total costs for the digital system and the anticipated costs for the proposed digital system. Table 2 below shows the costs for the first 5 years of operation for both systems. A complete table with all the costs for the 20 years will be shown in the attached disc.

DIGITAL SYSTEM

	2011	2012	2013	2014	2015
COSTS					
Development Costs					
Acquisition	R 6 250 000				
Installation	R 1 000 000				
Total Development Costs	R 7 250 000	R -	R -	R -	R -
Operational Costs					
Maintenance	R 385 000	R 423 500	R 444 675	R 466 909	R 490 254
Fuel	R 950 011	R 1 026 012	R 1 108 093	R 1 196 740	R 1 292 479
Total Operational Costs	R 1 335 011	R 1 449 512	R 1 552 768	R 1 663 649	R 1 782 734
TOTAL COSTS	R 8 585 011	R 1 449 512	R 1 552 768	R 1 663 649	R 1 782 734

FILM SYSTEM

	2011	2012	2013	2014	2015
COSTS					
Development Costs	R -	R -	R -	R -	R -
Operational Costs					
Film development costs	R 983 270	R 1 032 434	R 1 135 677	R 1 249 245	R 1 374 169
Photographic film	R 1 025 000	R 1 076 250	R 1 237 688	R 1 423 341	R 1 636 842
Maintenance	R 300 000	R 330 000	R 379 500	R 436 425	R 501 889
Fuel	R 1 050 493	R 1 134 532	R 1 225 295	R 1 323 318	R 1 429 184
Total Operational Costs	R 3 358 763	R 3 573 216	R 3 978 159	R 4 432 329	R 4 942 083
TOTAL COSTS	R 3 358 763	R 3 573 216	R 3 978 159	R 4 432 329	R 4 942 083
COST SAVINGS/ LOSS	R -5 226 248	R 2 123 704	R 2 425 391	R 2 768 680	R 3 159 350

Table 2: Total costs for both digital and film system

4.2 Benefits

The total benefits are shown in the table below. Table 3 below shows the benefits for the first 5 years but a complete table for the 20 years is shown in the attached disc.

The non-quantifiable benefits were given ratings (1 being the smallest benefit and 5 being the most benefit).

- Increased system capabilities 5 - R1 000 000
- Increased reliability and responsiveness 4 - R800 000
- Decreased operational times 4 - R800 000

The basic value for each of these benefits is R200 000 and the total benefit value used in the table is the basic value multiplied by the rating given to each benefit. The rand value of the benefits increase by 5% each year. This method is used to represent the non-quantifiable benefits as quantifiable benefits. The value stays constant throughout the 20 years of the expected life of this project.

DIGITAL SYSTEM

	2011	2012	2013	2014	2015
BENEFITS					
Quantifiable Benefits					
Decreased operational costs	R 2 023 752	R 2 123 704	R 2 425 391	R 2 768 680	R 3 159 350
Total Quantifiable Benefits	R 2 023 752	R 2 123 704	R 2 425 391	R 2 768 680	R 3 159 350
Non-Quantifiable Benefits					
Increased system capabilities	R 1 000 000	R 1 050 000	R 1 102 500	R 1 157 625	R 1 215 506
Increased reliability & responsiveness	R 800 000	R 840 000	R 882 000	R 926 100	R 972 405
Decreased operational times	R 800 000	R 840 000	R 882 000	R 926 100	R 972 405
Total Non-Quantifiable Benefits	R 2 600 000	R 2 730 000	R 2 866 500	R 3 009 825	R 3 160 316
TOTAL BENEFITS	R 4 623 752	R 4 853 704	R 5 291 891	R 5 778 505	R 6 319 666

Table 3: Total benefits

4.3 Summary of Results

Table 4 is a summary of the results from the CBA. The table only shows the calculations of the results for the first five years of the project life, the complete table of results can be seen in the attached disc.

DIGITAL SYSTEM: RESULTS CALCULATION

	2011	2012	2013	2014	2015
UNDISCOUNTED CASH FLOW					
Costs	R -8 585 011	R -1 449 512	R -1 552 768	R -1 663 649	R -1 782 734
Benefits	R 4 623 752	R 4 853 704	R 5 291 891	R 5 778 505	R 6 319 666
Net cash flow	R -3 961 259	R 3 404 192	R 3 739 124	R 4 114 856	R 4 536 933
DISCOUNT FACTORS					
Interest rate (discount rate)	6.5%				
Base year	2011				
Year index	0	1	2	3	4
Discount factor	1	0.9390	0.8817	0.8278	0.7773
DISCOUNTED CASH FLOW					
Costs	R -8 585 011	R -1 361 044	R -1 369 012	R -1 377 250	R -1 385 760
Benefits	R 4 623 752	R 4 557 469	R 4 665 645	R 4 783 730	R 4 912 422
Net cash flow	R -3 961 259	R 3 196 425	R 3 296 633	R 3 406 480	R 3 526 662
Cumulative flow	R -3 961 259	R -764 834	R 2 531 799	R 5 938 279	R 9 464 941
DISCOUNTED BENEFIT/COST RATIO	0.5385843	3.3485096	3.4080381	3.4733920	3.5449303
NET PRESENT VALUE	R 33 830 324				
INTERNAL RATE OF RETURN	96.0%				

Table 4: Results Calculation

4.3.1 Interpretation of Results

- The current interest rate of 6.5% is used throughout the project life.
- The discount factor shows how much less the cash flows over the years are worth because they are in the future.
- The discounted costs and benefits are in terms of the base year's rand value.
- The cumulative discounted cash flow represents the net value for all the years so far. When this value becomes positive, it means that the payback of the project has been completed.
- The Net Present Value (NPV) shows the economic equivalence of the project right now. It shows the value of the project in rand value at the present moment based on the interest rate (discount rate used).

The NPV of a cost/benefit X received in time t (years) is calculated as follows:

$$PV(X_t) = X_t \left[\frac{1}{(1+i)^t}\right]$$

Where *i* is the interest rate used.

- The Internal Rate of Return (IRR) is the interest rate that would make the project break-even. It could also be interpreted as the interest rate that would give the same profit as going through with the project if the money were to be put into a bank account at that interest rate.

The Undiscounted Cash Flow chart in Figure 3 shows the actual costs expended and benefits accrued in **current** rands.

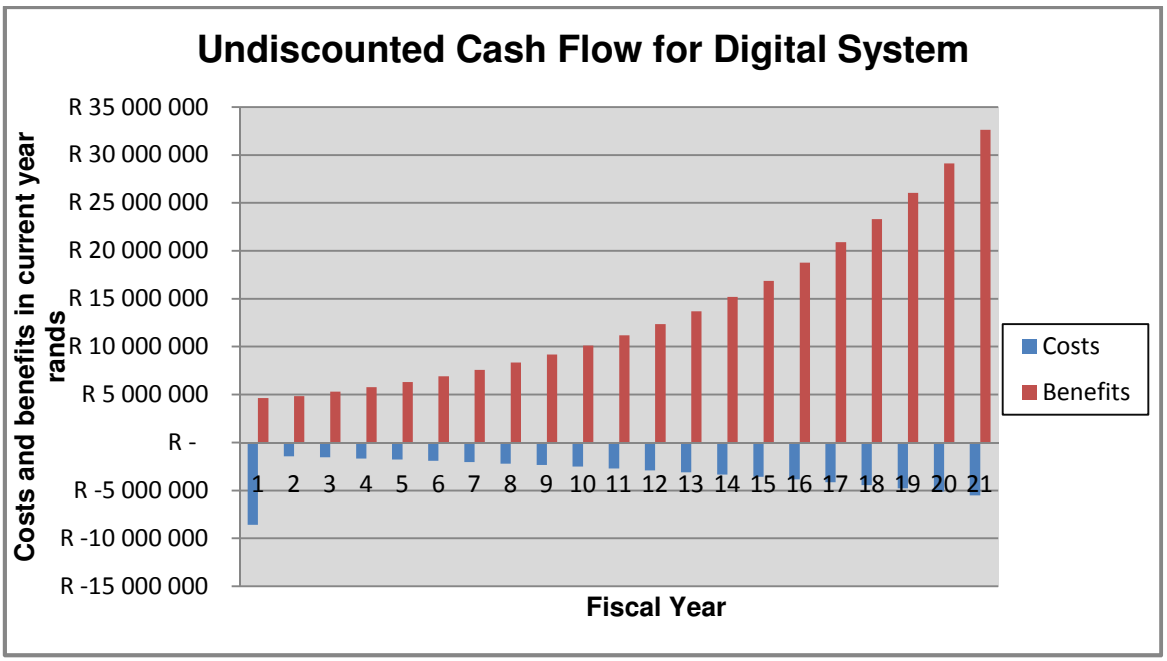

Figure 3: Undiscounted Cash Flow

The Discounted Cash Flow in Figure 4 below shows the costs expended and benefits to be accrued in **base year** rands.

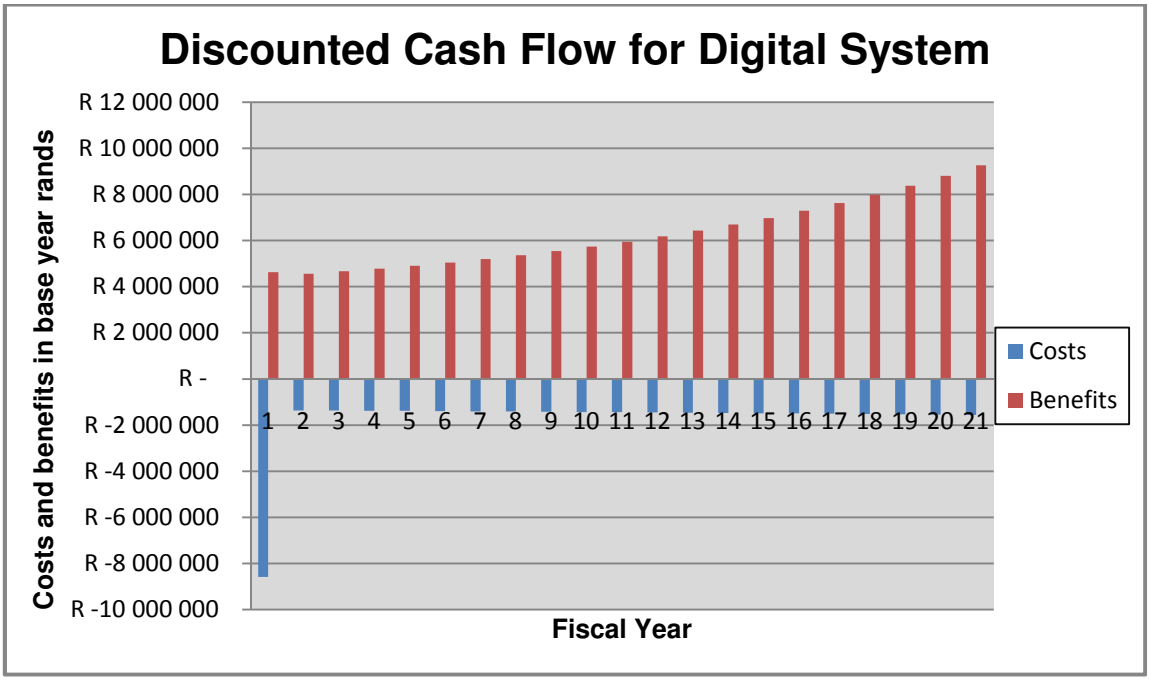

Figure 4: Discounted Cash Flow

The Payback Schedule below shows the benefits accrued minus the costs expended in base year rands. When the graph crosses the zero line, it means the project has achieved profitability. This point is called the break even point. The break even point for this project will be reached after the second year of the project.

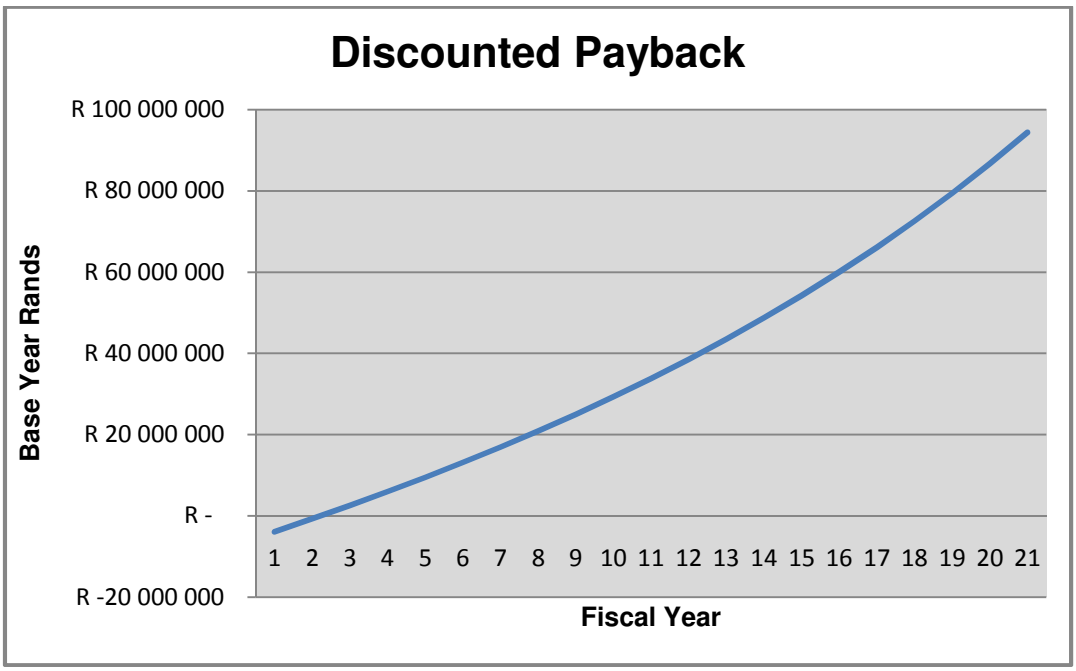

Figure 5: Payback Schedule

4.4 Recommendations

Looking at the results from the CBA, it is recommended that the Digital System be implemented to replace the current Film System. With an Internal Rate of Return of 96%, it is clear that the project is highly profitable and would save the SAAF as a whole a large amount of money. The total savings that will be made within the 20 year project life would be R94 423 971.

Chapter 5: Risk Analysis

Every new system has risks associated with it. Some of these risks are manageable but there are some that need to be eliminated in order for the system to be a success. According to Engert and Landsdowne [3]: Risk is defined as an event or occurrence which measures a projects inability to achieve its system life cycle objectives. It is measured in terms of likelihood and consequence.

Risks often results from four different sources of failure. These risks may lead to system failure and therefore need to be dealt with appropriately. To eliminate these risks, the failures must be addressed effectively. Figure 3 illustrates these four sources of failure.

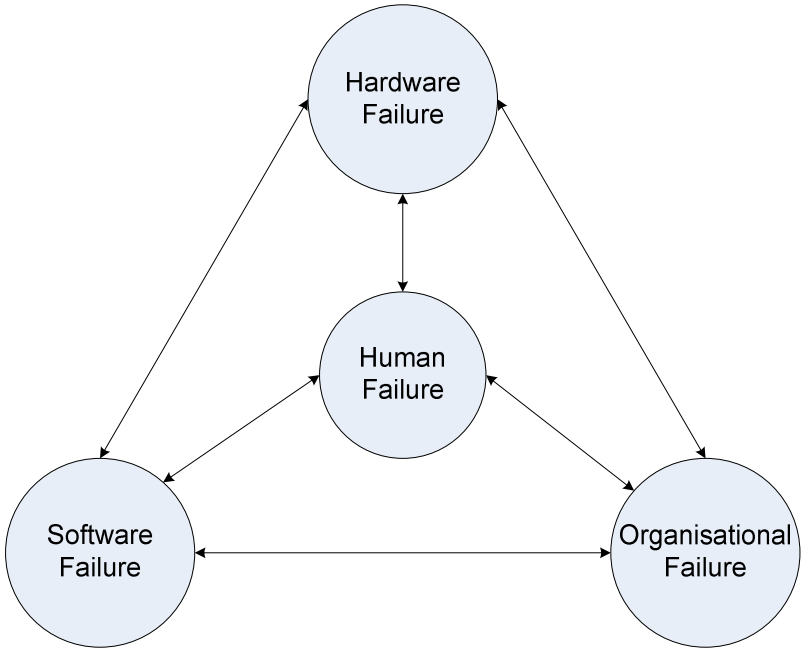

Figure 6: Four Sources of Failure, Haimes [5]

Risk management is defined as the act or practice of controlling risk. This process includes identifying risk areas, developing risk mitigation plans and procedures, monitoring the risks and performing risk assessments to determine how risks have changed.

The risk management approach used by the Australian Capital Territory Insurance Authority (ACTIA) which uses the Risk Management Standards (AS/NZS 4360:2004) will be used as the basis for the risk management process. The process follows the following steps:

1) Establishing goals and context (risk environment)
2) Identifying risks
3) Analysing the identified risks
4) Evaluating the risks
5) Treating or managing the risks
6) Monitoring the risks and the risk environment regularly
7) Continuous communication

5.1 Establishing goals and context (risk environment)

The relevant environment is the reconnaissance section in a military institution (SAAF). All their goals, tactical and strategic policies of the organisation apply. The purpose for this first step is to help with the understanding of the organisation and its environment. The following goals were identified from the environment and are relevant to the digital system:

- System reliability and responsiveness
- Safety (personnel)
- Operational efficiency and effectiveness
- Benefits to section
- Financial Viability

5.2 Identifying the risks

When identifying the risks, only the risks associated with the digital system to be installed were considered. The identified risks are:

- **Design risk:** The risk associated with incorrect specifications for the system. It also includes the risk of the system not meeting performance criteria, cost and time overrun and delivery delays.
- **Installation risk:** The risk of the system not being installed according to specifications.

- ❖ **Maintenance risk:** The risk of incorrect maintenance procedures or untrained maintenance personnel. The risk of maintenance not being done on time and correctly.
- ❖ **Management and personnel incompetence risk:** The risk of not managing and running the system in the correct manner. The risk of poorly trained personnel using the system. Management failures are a major source of risk in overall system failure.
- ❖ **Financial risk:** the risk of project cost overrun and not having enough funds to complete/obtain the system. The cost overrun also causes a delay in the projects schedule and may prevent the system from meeting its performance criteria.

5.3 Analysing the Identified Risks

5.3.1 The Consequences of Risks

Once the risks have been identified, the risks are assigned levels of impact or consequence. The impacts used, their levels and their definitions are given below.

- **Negligible (Level 1):** If the risk event occurs, it won't affect the system. All the necessary requirements would have been met.
- **Minor (Level 2):** If the risk event occurs, there will be a small increase in cost/schedule. The minimum acceptable requirements will be met and most of the secondary requirements will also be met.
- **Moderate (Level 3):** If the risk event occurs, there will be moderate increases in the cost/schedule. The minimum acceptable requirements will be met and some of the secondary requirements will also be met.
- **Major (Level 4):** If the risk event occurs, major increases in cost/schedule will be encountered. The minimum acceptable requirements will be met but secondary requirements may not be met.
- **Critical (Level 5):** If the risk event occurs, the system will fail. Minimum acceptable requirements will not be met.

The three most important goals that were used for the impact/consequence assessment were safety, system reliability and responsiveness and financial viability. Table 5 below shows the impact assessment table.

	CONSEQUENCES				
	Negligible	**Minor**	**Moderate**	**Major**	**Critical**
Reliability and responsiveness	Small system errors or small delay on responsiveness	Minor system errors or minor delay on responsiveness	Serious system errors or serious delays on responsiveness	Major system errors or inability to respond	Complete system failure
Safety of personnel	Injuries not requiring medical treatment	Minor injury or first aid treatment case	Serious injury causing hospitalization or multiple medical treatment cases	Life threatening injury or multiple serious injuries causing hospitalisation	Death or multiple life threatening injuries
Financial viability	1% of budget	2.5% of budget	>5% of budget	>10% of budget	>25% of budget

Table 5: Impact Assessment

5.3.2 The Likelihood/Probability of Occurrence

The likelihood of occurrence gives the likelihood of the risk occurring. Table 6 gives the different levels of likelihood and a short description of each.

Level	Descriptor	Description
1	Rare	May occur only in exceptional circumstances
2	Unlikely	Could occur but doubtful
3	Possible	Might occur sometime in the future
4	Likely	Will probably occur in most circumstances
5	Almost Certain	Is expected to occur in most circumstances

Table 6: Levels of Likelihood

5.4 Evaluate Risks

5.4.1 Risk Level Rating and Treatment Plan

The risk analysis matrix shows the different levels of risk and the action plan that needs to be taken for each.

		Consequences				
Likelihood		Negligible	Minor	Moderate	Major	Critical
Rare	1	L	L	L	M	M
Unlikely	2	L	L	M	H	H
Possible	3	L	M	H	E	E
Likely	4	M	M	H	E	E
Almost Certain	5	M	H	E	E	E

Table 7: Risk Analysis Matrix

L = Low risk – Manage by routine procedures

M = Medium risk – Management responsibility must be specified

H = High risk – Senior management attention required

E = Extreme risk – Immediate action required

5.5 Treat the Risks

The risk matrix below shows the risks associated with the digital system, their consequences, their likelihood of occurring and the level of risk that they pose.

Risk	Consequence		Likelihood	Level
Design risk	Inadequate system	4	3	E
Installation risk	Inability to use system	4	2	H
Maintenance risk	System failure	3	2	M
Management & personnel incompetence	Not using the system correctly	3	2	M
Financial risk	Decrease in quality of system	4	1	M

Table 8: Risk Matrix

The different above mentioned risks associated with the digital system may be reduced by executing the proposed treatment plan below.

Design Risk (E)

- Include more detail in the design
- Give more detailed specifications
- Get the design specifications approved by independent design specialists

Installation Risk (H)

- Following the documented installation procedures
- Ensure personnel are adequately trained
- Ensure that installers are accredited

Maintenance Risk (M)

- Ensure that complete maintenance criteria and procedures are documented correctly
- Train personnel
- Ensure that the maintenance personnel are accredited

Management and Personnel Incompetence (M)

- Ensure that management are adequately trained to manage the system
- Ensure that personnel know how to use the system correctly

Financial Risk (M)

- Ensure that the required funds are readily available for use
- Ensure that a system budget is drawn up and followed at all times

5.6 Monitoring the Risks

Risks do not remain constant and therefore constant monitoring is required regularly. Risks should be reassessed periodically (monthly or quarterly) to determine whether their level of importance has changed or whether new risks have developed that should be identified, assessed, ranked and managed.

5.7 Continuous Communication

Risk management plays an important part of any project/system. This is why constant reporting on risk management and the risks themselves needs to be completed and visible throughout the project/system life cycle.

Chapter 6: Implementation

From the CBA study above, if the proposed Digital System turns out to be the best alternative to replace the Film System that is currently in place on the VINTEN RECCE Pod, then the following procurement procedures should be followed to acquire the new system.

5.1 Procurement Process

The procurement department at AFB Makhado is responsible for all the acquisitions ranging from aircraft fuel, maintenance equipment, and uniform to food rations. All these products have their own procurement processes which are regulated by the Military Regulations Instructions (MRI's) from the SAAF Headquarters where the budget and finance allocation procedures are managed.

There are three different procurement processes which were developed based on the Joint Defence Publication (JDP) ACP no 00003/2004/Edition 1 and the Public Finance Management Act (PFMA). The different processes are:

- Short-term Goods Procurement Process (Cash Purchases)
- Government Order (GO) Purchasing Process
- Tender Purchasing Process

5.1.1 Short-term Goods Procurement Process

The process mainly refers to the purchase of food rations. It operates around the element of urgency and not on the quality, price or the value and service delivery, the vendor/supplier is selected according to their ability to deliver fast. These short-term goods purchases are treated as cash purchases and are subdivided into two categories namely:

1. Cash Purchases less than R2 000
2. Cash Purchases between R2 000 and R5 000

Appendix A clearly depicts the logical sequence of events necessary for the successful completion of the two different cash purchasing process.

5.1.2 Government Order (GO) Purchasing Process

GO purchasing process will be used for purchases between R5 000 and R30 000. The main difference between the GO and the Cash Purchase process is that for a GO, the SAAF does not pay using cash to the supplier and Financial Authority is required for the purchase. The supplier must first send an invoice to the procurement section, and then the invoices together with its relevant procurement documentation are sent to the Pay Office which will then pay the supplier electronically. This process will be used for the purchasing of some of the spares that will be required for the maintenance of the Digital System. (**Appendix B** shows the necessary sequence of events to follow in order for a successful GO purchase).

5.1.3 Tender Purchasing Process

The process will be used for procuring products/equipment that cost above R30 000. This includes aircraft fuel, aircraft spares for repairs and maintenance and upgrades done on any aircraft system.

This process of procurement is initiated by 5 ASU's Procurement section which prepares the procurement documents which are forwarded to the Central Procurement Service Centre (CPSC) for processing. Once the processing is done and the goods have been delivered to the unit, 5 ASU is then supplied with an invoice. The invoice together with the relevant procurement documentation is forwarded to the CPSC for confirmation before the supplier is paid electronically. (**Appendix C** shows a schematic representation of the step-by-step process of the Tender Procurement Process).

For the installation of the digital system on the VINTEN RECCE Pod, a combination of the GO Purchasing Process and the Tender Purchasing Process must be used to acquire all the necessary equipment and spares.

Conclusion

The report shows how the CBA was conducted with the aid of an excel spreadsheet. The results of this analysis clearly show that the digital system should be implemented. The Risk analysis also shows that the risks associated with the digital system can be reduced by proper management. Both these studies are proof that the digital system will save the SAAF a tremendous amount of money and should therefore be implemented.

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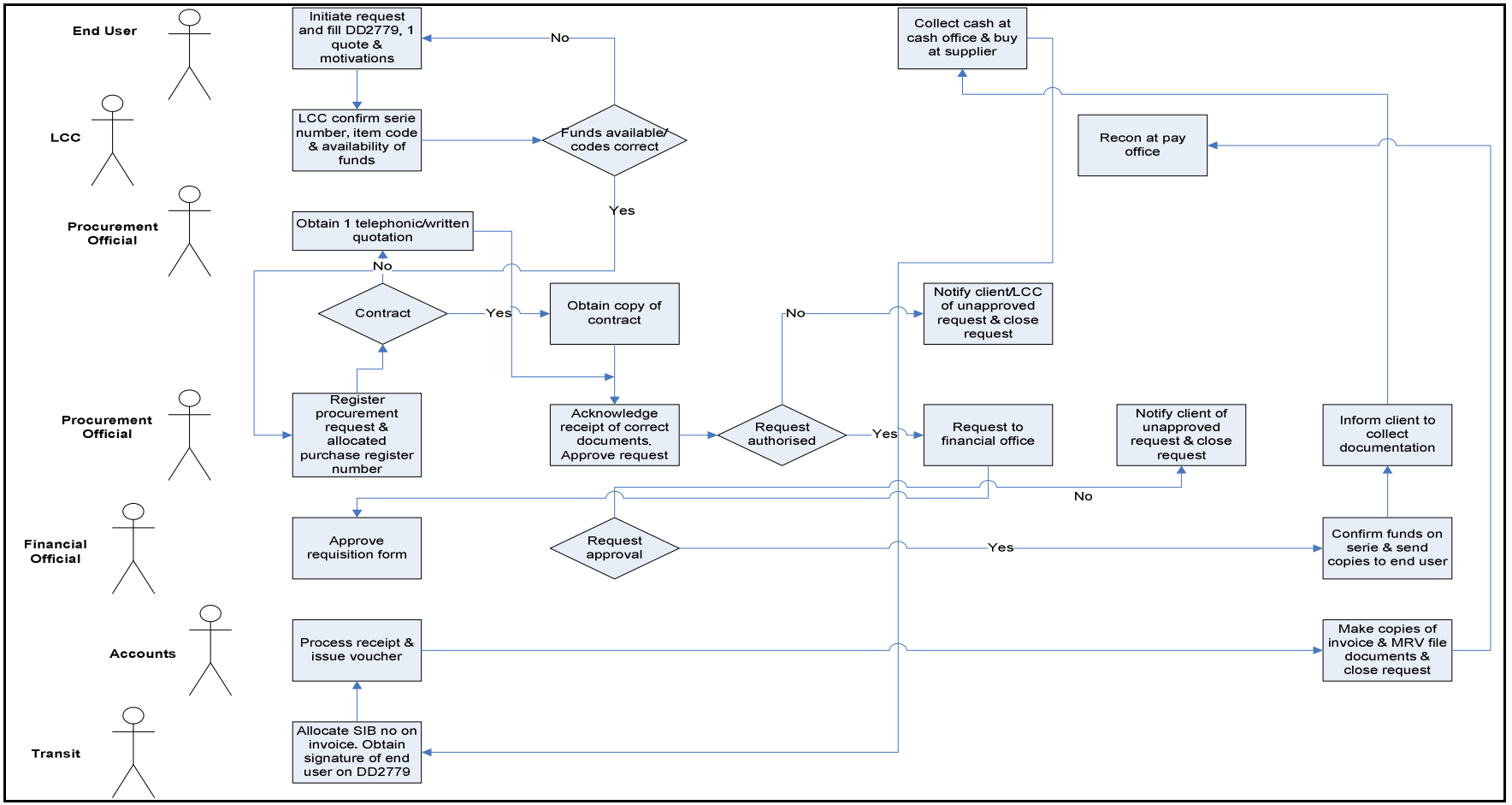
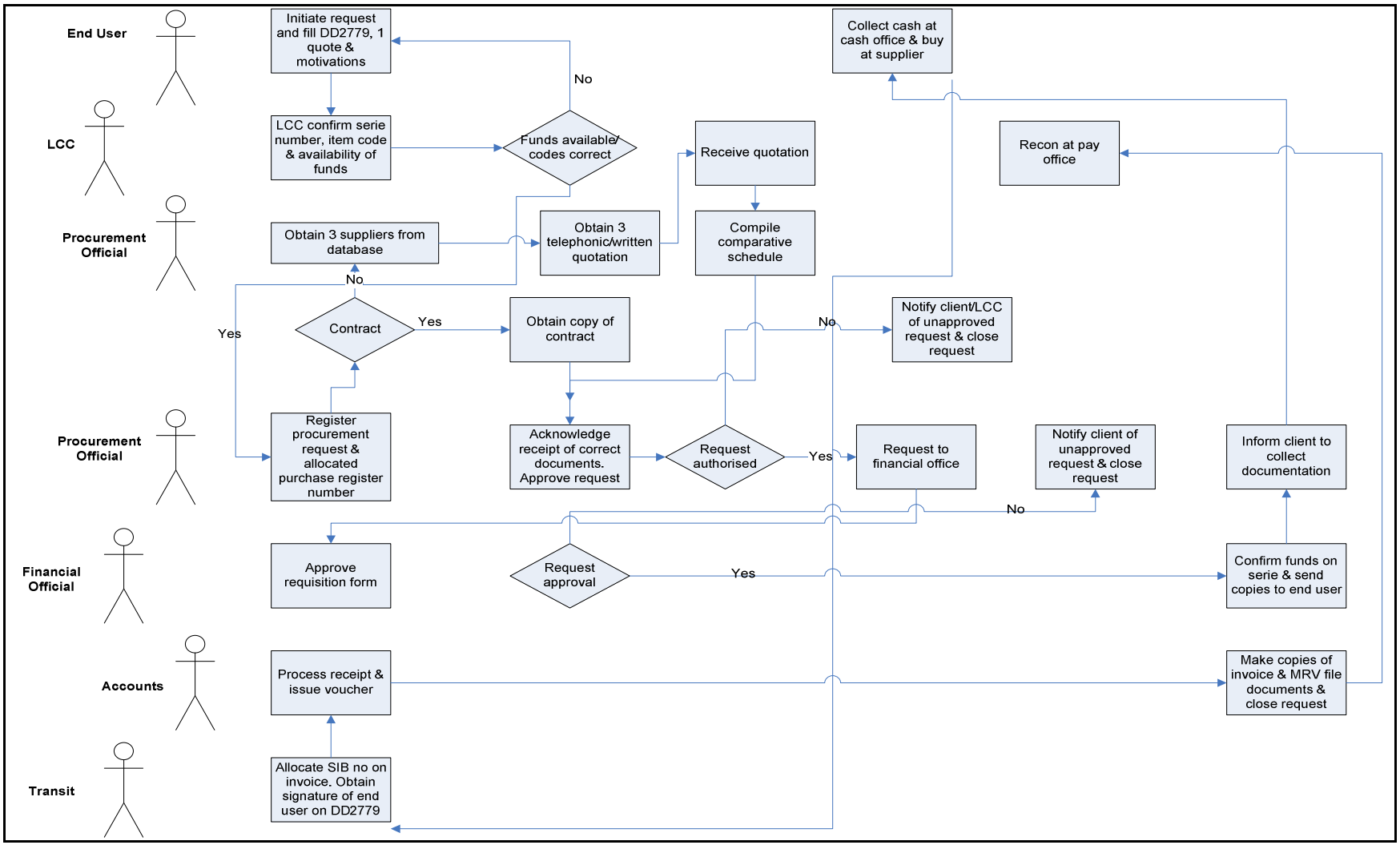
Appendix A

Cash Purchase Less than R2 000

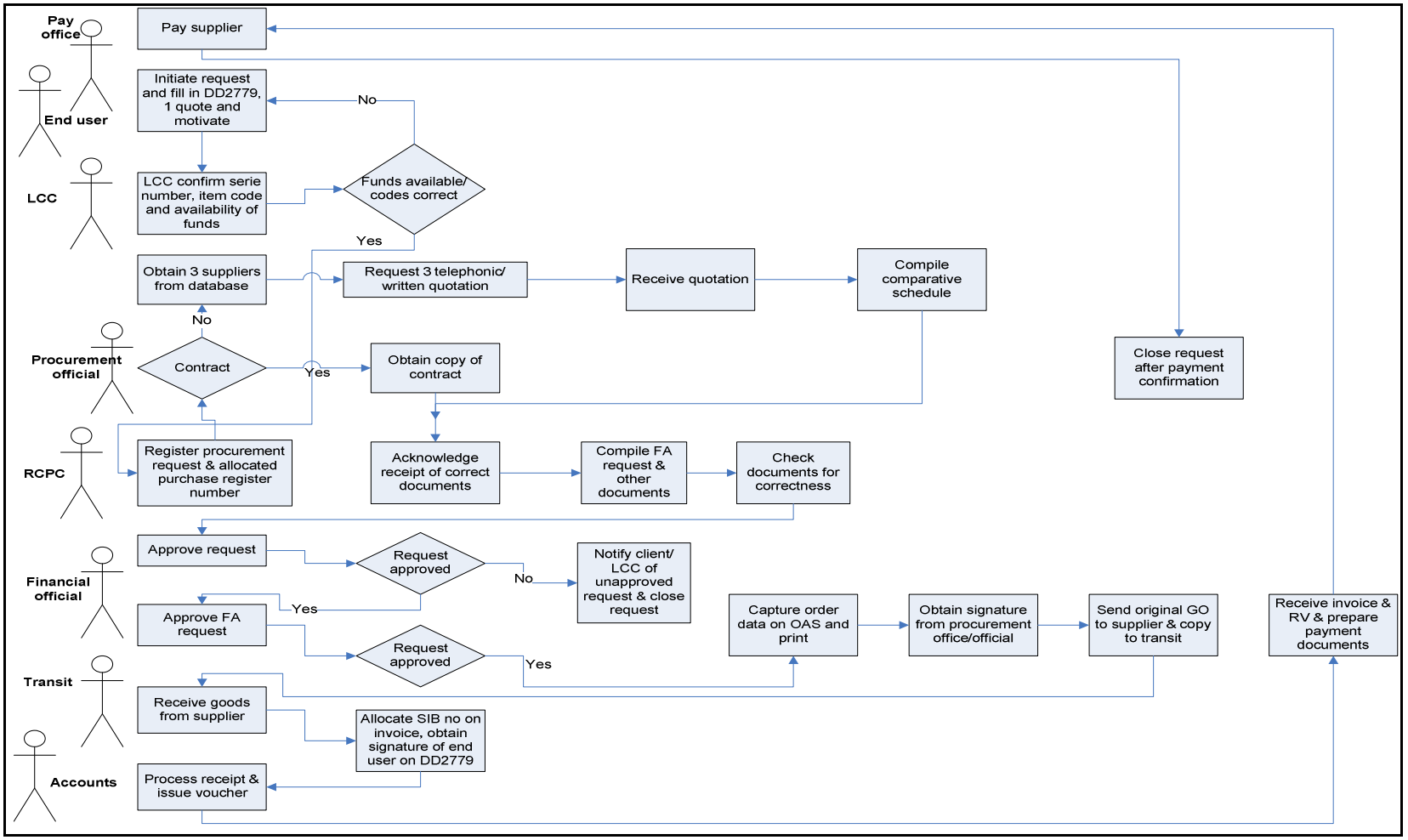


Cash Purchase Between R2 000 and R5 000



Appendix B

Government Order (between R5 000 and R30 000)



Appendix C

Tender Purchasing Process (above R30 000)