Abstract. Cmore is a collaborative tool for information management for defence and peace operations. It enables and supports real-time decision-making and responses during operations. However, it has the potential to expand into safety and security industries as well. The technology adoption chasm between the RD&I and sustainable operationalisation of the Cmore software system must be closed. This paper presents the results of a desktop study on the integrated logistics support (ILS) for C-More as a product system (systems hierarchy level 5) and provides a basis for requirements analysis in using a systems engineering approach for developing the engineering logistics management for Cmore’s operationalisation. Specifically, this paper focuses on maintenance and support facilities and utilities; computer resources; maintenance support logistics personnel; and training and training support.

Introduction

The CSIR, constituted by an Act of Parliament in 1945 as a science council, is a leading research, development and implementation organisation of technological innovation as well as scientific and industrial developments in Africa over the past 70 years. The CSIR provides services and solutions to science and technology stakeholders of both private and public sectors to improve commercial and social benefit to enhancing South African citizen’s quality of life. The CSIR supports innovation in South Africa by identifying scientific and technology gaps and further development to close these gaps for improving the nation’s global competitiveness; it is also a shareholder in the Parliament of South Africa (CSIR, 2015).

The CSIR has multiple research areas, including: Built Environment; Biosciences; Defence, Peace, Safety and Security; Information and Communications; Materials Science and Manufacturing; Laser Technology; Natural Resources and the Environment; Mining Innovation and Modelling and Digital Science (CSIR, 2015).

Cmore is a command and control application developed by the CSIR as a part of the organisations’ value contribution that will improve the Department of Defence’s capability to make informed management decisions and support the improvement of their operations and infrastructure. Cmore has also been deployed for safety and security purposes in a large South African wildlife conservation area as a part of boarder protection and control. It is developed by the Defence, Peace, Safety and Security (DPSS) business unit. DPSS is responsible for the CSIR’s role in the National Defence Science, Engineering and Technology (SET) capability and as the main research and development
agency that operates as a strategic in-house technology capability for the South Africa’s safety and security (DPSS, 2015).

The Cmore software application is web-based and facilitates the sharing of information across multiple boundaries to support collaboration between stakeholders. Cmore facilitates planning and supports the co-creation of situational awareness during operational missions based on external and internal information sources (Helfrich, 2013). It allows real-time decisions making through live updates that are received instantaneously, thus enabling the tracking and managing of incidents as they occur in the field. Cmore has also augmented reality and geo-spatial features (Le Roux, 2013) accessible from desktop computers and mobile devices such as cellphones, tablets and notebook computers. Cmore is versatile and allows operations positions to be observed in real-time, the sending and receiving of instant messaging, recording and display of map positions and image sharing between personnel in remote locations. It has special features, including the support for video conferencing and whiteboard collaboration to enable strategic planning (Le Roux, 2013). Reaction units and observers can be dispatched to locations via the system and entities of interest can be tracked, and this includes blue force tracking. Group chats and one-on-one chats are recorded to allow for later reviewing.

This paper uses a desk study to scan the literature for possible treatment of engineering logistics of personnel and computer resources for Cmore. This paper is based on two undergraduate final years engineering projects in Industrial Engineering at University of Pretoria.

**The context of Cmore**

Cmore is versatile and its application in a number of different industries could be beneficial, especially in the context of the Smart City that includes, amongst others, the following:

- **Health Care** – Ambulances can be dispatched into the field by a central control room, where they can be tracked and respond to calls closest to them. Ambulances can then send media and describe the scene and request backup if necessary; thus shortening response time and making the process more efficient.
- **South African Police Service** – Tactical planning and response planning to calls in the field can be dispatched by the central control room, improving the efficiency and effectiveness of the police force.
- **Town Planning** – The use of Cmore’s collaborative geo-spatial planning can be used to plan and build infrastructure in remote areas and report real-time feedback.
- **Sport and Recreation** – Cmore can be used for real-time athlete tracking in races, as well as used by organisers to plan race routes, respond to sport related incidents and react accordingly by dispatching the necessary services.
- **Municipalities** – Services can be dispatched to areas that require attention such as repairing of burst water pipes, stolen electricity cables and pothole repair.

However many challenges are present with the implementation of new technologies, but no matter how big these challenges may present themselves to be; they are worth overcoming due to the many benefits. The challenges versus the benefits will be discussed in making the technology operational. Definitions of Logistics, Integrated
Logistics Support, Systems Engineering and Support are be presented and defined for the purpose of this desk study.

**OODA Loop**

The observe, orientate, decide and act (OODA) loop can be seen as a learning system or a method of dealing with complexity and uncertainty, a strategy for beating ones competitors. Boyd stated that we live in a world of uncertainty, thus when ones circumstances change one continues to see the world as one thinks it should be due to the failure to shift ones perspective (Mc Kay & Mc Kay, 2014). However to face the new reality one needs to shift ones paradigm. A diagram of the OODA loop is depicted in Figure 1.

The OODA loop can be defined as (Mc Kay & Mc Kay, 2014):

- **Observe** – this incorporates taking into account new information and changes in the environment. Once this happens one’s mind becomes an open system and it becomes easier to gain more knowledge and understanding.
- **Orientate** – this is the most important phase of the OODA loop as this forms the mental models of how one will react to ones environment, decisions that are made, actions that are taken which all influence ones future orientation.
- **Decide**- decisions are made between the various alternatives that were generated in the orientation phase.
- **Act** – this phase is also known as the test phase were one learns from ones actions that have been taken.

![Figure 1. The OODA Loop (Mc Kay & Mc Kay, 2014)](image)

Cmore supports the ‘observe’ phase of the OODA loop in Figure 3 with its ability of helping operators to gather new information from a number of sources such as live feeds, conference calls and instant group messaging as well as helping to detect changes in the environment through sensor feedback in the field which can detect movement and shapes.
Cmore also supports the ‘orient’ phase as it helps to orientate operators through augmented reality and geo-spatial visualisation through its ability to integrate large amounts of data and present it in graphical form.

Further, Cmore supports ‘decide’ phase by making the various alternative actions clearer to the operator as well as support the communication between various operators in the decision making process.

Cmore’s integration of various communication channels supports the ‘act’ phase in making sure that the right signal or command reach the field operators in the right place on the right time.

**Systems Hierarchy and POSTEDFIT**

De Waal and Buys (2007) describes the systems hierarchy levels as shown in Table 1 by defining the levels of interoperability, compatibility, interchangeability and commonality, that are necessary for operation in the defence sector. The authors further explain the need for interoperability for levels 9 to 10, which are the strategic levels, at level 7 and 8, this is where there is a need for compatibility between forces, at level 6 interchangeability is required and finally; commonality spans level 1 to 5 where humans do not form a part of the elements.

Table 1: The system hierarchy levels (De Waal & Buys, 2007)

<table>
<thead>
<tr>
<th>Material</th>
<th>L1</th>
<th>Raw Material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L2</td>
<td>Component</td>
</tr>
<tr>
<td></td>
<td>L3</td>
<td>Product Sub-Assembly</td>
</tr>
<tr>
<td></td>
<td>L4</td>
<td>Product</td>
</tr>
<tr>
<td></td>
<td>L5</td>
<td>Products System</td>
</tr>
<tr>
<td></td>
<td>L7</td>
<td>Operational System (Use Capability)</td>
</tr>
<tr>
<td></td>
<td>L8</td>
<td>Joint Higher Order Military System</td>
</tr>
<tr>
<td></td>
<td>L9</td>
<td>Government Multi-Department System</td>
</tr>
<tr>
<td></td>
<td>L10</td>
<td>International/ Multi National Systems</td>
</tr>
<tr>
<td>Core and Non-core Support</td>
<td>L6</td>
<td>Core System (Core Capability)</td>
</tr>
<tr>
<td>Virtual Systems</td>
<td>L5</td>
<td>Pseudo Capability</td>
</tr>
<tr>
<td>Additional Levels</td>
<td>L8</td>
<td>Department of Defense Other Government Departments</td>
</tr>
<tr>
<td>VIRTUAL SYSTEMS</td>
<td>L9</td>
<td>Department of Defense Other Government Departments</td>
</tr>
</tbody>
</table>
| Govt and Non-core Support | L4 | Role ...
| d |
| Table 1: The system hierarchy levels (De Waal & Buys, 2007) |
| L1 | Raw Material |
| L2 | Component |
| L3 | Product Sub-Assembly |
| L4 | Product |
| L5 | Pseudo Capability |
| L6 | Core System (Core Capability) |
| L7 | Operational System (Use Capability) |
| L8 | Joint Higher Order Military System |
| L9 | Government Multi-Department System |
| L10 | International/ Multi National Systems |
| Systems Hierarchy and POSTEDFIT |

De Waal and Buys (2007) describes the systems hierarchy levels as shown in Table 1 by defining the levels of interoperability, compatibility, interchangeability and commonality, that are necessary for operation in the defence sector. The authors further explain the need for interoperability for levels 9 to 10, which are the strategic levels, at level 7 and 8, this is where there is a need for compatibility between forces, at level 6 interchangeability is required and finally; commonality spans level 1 to 5 where humans do not form a part of the elements.

Table 1: The system hierarchy levels (De Waal & Buys, 2007)
For the purpose of this study, Level 5 of the System Hierarchy will be focused on, as there is an absence of the human element which makes it possible to develop support infrastructure and procedures that are identical for all applications of Cmore. Thus the commonality that spans this level implies the notion that these units are identical in an operational environment allowing system elements (processes or items) to comply with the same specification and be standardised. In this case we can define identical as “the same” or “equal”. Humans add a level of complexity to operations due to a vast number of factors and this is dealt with on systems hierarchy level (SHL) 6.

Various elements need to be taken into consideration in order to integrate a system entirely. Nine elements are identified that should be consider in various situations, defined by POSTEDFIT as shown in Table 2 (SANDF-DMD, 2010). These elements can be grouped to fit each level of the Systems Hierarchy. The elements associated with a SHL 5 system are STEDFIT (Sustainment and Support, Training, Equipment, Doctrine, Facilities, Information, and Technology).

The only STEDFIT elements that are considered during this study are S (Sustainment and Support), T (Training), and F (Facilities) on SHL 5.

<table>
<thead>
<tr>
<th>Element</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>P Personnel</td>
<td>The characteristic of the required human resources that form part of a defence capability, including recruiting (quality, selection criteria), maintaining, staffing levels, career management, development (the identification of knowledge, skills, abilities, and competencies needed to perform a position, job, or task), leadership, the moral dimension, ethos and values.</td>
</tr>
<tr>
<td>O Organisation</td>
<td>The C2 (Command and Control) related characteristics of mission task forces, including task force size and shape, as well as command and support lines. This incorporates actual organisations (order of battle and command structures), organisational characteristics, allocation of responsibilities, command and control, business processes and the allocation of equipment and facilities.</td>
</tr>
<tr>
<td>S Sustainment &amp; Support</td>
<td>The characteristics of the logistics, personnel and financial support and maintenance required, including consumable resources, specialist functional support from service providers and agencies, administrative support and logistics systems.</td>
</tr>
<tr>
<td>T Training</td>
<td>The characteristics of the training required to prepare and qualify human resources and task forces, including individual training (single service), joint and combined training, and training content, training methods, and resources (curricula, standards, equipment, simulators, combat training supplies, funding and time) which ensure that commanders and staff deliver the required performance levels.</td>
</tr>
<tr>
<td>E Equipment</td>
<td>The type, quantity and characteristics of the defence equipment required including acquisition, performance, maintainability, availability, reliability, robustness, flexibility, interoperability and through-life support.</td>
</tr>
<tr>
<td>D Doctrine</td>
<td>The characteristics of doctrine (single service, joint and multi-national doctrine), as well as legal publications, regulations, control aids (e.g. checklists), operating procedures and other directives and standing instructions required, incorporating concepts, policies, strategy (both national and defence strategy), interoperability levels required, tactics, techniques and procedures which govern or guide the way the military forces conduct operations.</td>
</tr>
<tr>
<td>F Facilities</td>
<td>The characteristics of the military facilities required, including administrative, support and training facilities (fixed property, technical support centres, training areas, etc.) incl. DOD infrastructure, national and international infrastructure and facilities.</td>
</tr>
<tr>
<td>I Information</td>
<td>The characteristics of required defence intelligence, information, data and data processing systems, including computer applications, manual information systems, data and information content, timeliness, presentation, format, reliability and validity, data correlation and fusion.</td>
</tr>
<tr>
<td>T Technology</td>
<td>The characteristics of commercial and/or military technologies required, including research and development, technology growth paths, cycles and trends, technology reliability, affordability, cost-effectiveness, technical opportunities and risks.</td>
</tr>
</tbody>
</table>
Defining Systems Engineering and ILS for Cmore

There are multiple definitions for the same term that may vary from each other, because they are dependent on the context they are used in. Therefore a number of definitions have been presented here to illustrate the differences and then define the context according to the support concept for Cmore.

Systems Engineering

The International Council on Systems Engineering (INCOSE) defines systems engineering as (Haskins, 2007): “Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem: Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs.”

The NASA’s definition for Systems Engineering is (NASA, 1995): “Systems Engineering is a robust approach to the design, creation and operation of systems. In simple terms, the approach consists of identification and quantification of system goals, creation of alternative system design concepts and performance of design trades and selection and implementation of the best design, verification that the design is properly built and integrated and post implementation assessment of how well the system meets the goals. The approach is usually applied repeatedly and recursively with several increase in resolution of the system baselines.”

The definition for systems engineering prefered by Blanchard (2004) is: “The application of scientific and engineering efforts to: 1) transform an operational need into a description of system performance parameters and a system configuration through the use of an iterative process of definition, synthesis, analysis, design, test and evaluation, and validation; 2) integrate related technical parameters and ensure the compatibility of all physical, functional, and program interfaces, in a manner that optimizes the total definition and design, and 3) integrate reliability, maintainability, usability (human factors), safety, producibility, supportability (serviceability), disposability and other such factors into a total engineering effort to meet cost, schedule and technical performance objectives.”

For the purpose of this desk study, the Blanchard definition is used because it focuses on maintainability, usability, supportability and safety which are essential in making Cmore operational. Cmore is currently being used in a defence and security environment, and many of Blanchard’s definitions are based in the context of this environment.

Logistics

The Business Dictionary (n.d.) defines logistics as: “Planning, execution, and control of the procurement, movement, and stationing of personnel, material, and other resources to achieve the objectives of a campaign, plan, project, or strategy. It may be defined as the ‘management of inventory in motion and at rest.’"
Logistics is defined by Merriam-Webster (n.d.) as: “The things that must be done to plan and organize a complicated activity or event that involves many people.” Furthermore, military logistics is defined as (Merriam-Webster, n.d.): “The aspect of military science dealing with the procurement, maintenance, and transportation of military matériel, facilities, and personnel.”

The military definition for logistics is preferred for the purposes of this desk study as it includes aspects such as maintenance and personnel in a military environment. The logistics that Cmore as a software application needs, does not involve much inventory management.

**Support Infrastructure**

The Business Dictionary (2015) defined support infrastructure as: “Services and supplies needed to sustain an organization in its day to day operations, such as communications, labour, power, transport, water.”

This definition for support infrastructure is appropriate because it incorporates the elements of ILS that will be considered for the development of the Cmore support concept.

**Integrated Logistics Support**

The United States’ (US) Aerospace Industry’s Department of Defence (DOD) knowledge acquisition, describes Integrated Logistics Support as (AcqNotes, n.d.): “...a unified and iterative approach to the management and technical activities needed to influence operational and materiel requirements and design specifications for logistics support. ILS defines the support requirements best related to system design and to each other, develop and acquire the required support, provide required operational support at lowest cost, seek readiness and Life-Cycle Cost (LCC) improvements in the materiel system and support systems during the operational life cycle, and repeatedly examine support requirements throughout the service life of the system.”

Blanchard (2004) states that Logistics in the defence sector evolved into the ‘integrated logistic support’ concept which can be defined as:“...a composite of all support considerations necessary to assure the effective and economical support of a system or equipment at all levels of maintenance for its programmed life cycle. It is an integral part of all other aspects of system acquisition and operation.”

Both definitions are appropriate, because economic considerations, life-cycle costs and maintenance are considered by them. Blanchard (2004) further defines ILS and divides it into ten ILS elements as shown in Figure 2. These various elements interact with one another and thus needs to be fully integrated in the planning, design, and implementation of logistics.

This paper focuses on only four of these ten ILS elements (for Cmore to be fully operational all these ILS elements need to be considered.) The four elements are:

- Computer resources,
- Maintenance and support facilities and utilities,
- Logistics, maintenance, and support personnel, and
- Training and training support.
Due to the nature of two of the four ILS elements that defines the scope of this desk study, these elements involve personnel, Cmore users and training. Thus the needs, processes, equipment and training materials will be defined however the physical involvement of people is excluded.

Figure 2. The ten ILS elements and system requirements (Blanchard, 2004)

The chosen ILS elements for this desk study corresponds to the three POSTEDFIT elements on SHL 5 for:
- Sustainment and Support,
- Training, and
- Facilities.

**Maintenance and support facilities and utilities.** These are the unique facilities required to support the logistic functions and include storage, buildings and warehouses, and maintenance facilities at all levels. Other facilities for consideration includes portable buildings, mobile vans, personal housing structures, maintenance shops, etc. Utilities such as heat, power, energy requirements, environmental controls, communication, and security, are provided as part of a facility (Blanchard, 2004).

**Computer resources (hardware and software).** These are all the computers, software, connecting components, networks, and the various interfaces necessary for day-to-day logistic operations to conduct the scheduling of maintenance activities and implement monitoring programmes for system support diagnostics. Provisions for unscheduled maintenance are also implemented (Blanchard, 2004).

**Logistics, Maintenance and Support Personnel.** This element includes the personnel that performs the system maintenance and logistics activities. These activities include the initial provisioning and procurement of items needed for support, along with
production-related functions, the installation and checkout of the new system and its elements at the operational site, the in-field service, and the sustaining support for the system throughout the systems lifecycle. Personnel at all levels that are directly attributed to the system, from maintenance and mobile teams to operators and maintainers at test facilities (Blanchard, 2004).

Training and Training Support. The training of operational and maintenance personnel is for both initial and followup training. Thus all personnel, equipment, facilities, data and documentation are specified for the training of staff. Training equipment may include simulators or special devices, training manuals, and computer resources and are specified according to the system requirements to support the day-to-day on-site training of personnel (Blanchard, 2004).

Systems Engineering Approach To Cmore Support

The Systems Engineering Method (Kossiakoff, Sweet, Seymour, & Biemer, 2011) will be applied to develop the support necessary for Cmore’s Support, Maintenance and Logistics Personnel along with the training and training support. This approach follows four steps and should be applied throughout the scope of the Cmore development. These steps are (Kossiakoff et. al, 2011):

1. Requirements Analysis – Problem Definition
   This involved organising all requirements, plans, milestones and models and identifying whether or not each one is necessary and sufficient for the system. If the requirements do not fit with the system constraints the inadequacies are corrected and each requirement is quantified.

2. Functional Definition – Functional Analysis and Allocation
   The system requirements are then translated into functions that the system must perform. The interactions between various functional building blocks are then linked and organised in a modular configuration.

3. Physical Definition – Synthesis, Physical Analysis and Allocation
   A number of system component alternatives, which represent different designs, are synthesized with the required functions. The preferred approach is selected by doing a trade-off study. The trading off process will be off a set of predefined and prioritized criteria – Measures of Effectiveness (MOE) in order to obtain the optimal balance between performance, risk, cost and schedule.

4. Design Validation - Verification and Evaluation
   Models are then designed and tested. Simulations and testing may occur and the system solutions may be analysed against environmental models.

The “V” Model in Figure 3 shows a view of the system lifecycle, and how the development of system requirements need to be verified and validated in connection with one another.

Jones (2007) defines supportability to be: “a prediction or measure of the characteristic of an item that facilitate the ability to support and sustain it mission capability within a predefined environment and usage profile.”
Engineering activities such as reliability, maintainability and testability are interwoven with supporting activities (Jones, 2007). Thus in order to produce a system that is supportable, joint efforts are required from a number of different disciplines.

Supportability engineering calls for active participation between systems engineers and system architect’s to balance performance, cost and support by influencing the design process and overall decreasing the cost of ownership (Jones, 2007).

The mission statement of the overall system is required in order to understand what the system is required to do. Based on the mission statement, requirements are developed for the supporting activities, based on measures of effectiveness (MOE).

**Phase 1: Systems Engineering Approach**

Phase 1 of the project consists of obtaining information from a number of interviews with Cmore staff. These interviews will be conducted with a questionnaire, consisting of open ended questions, for guidance. The point of the interviews is to obtain information from the Cmore staff as there is very little to no documentation available on Cmore at this stage of development. Thus, Cmore needs and requirements for Integrated Logistics Support will be obtained through the interviewed sources, whom which shall remain anonymous.

**Mission Statement.** Cmore’s mission statement can be stated as: “Smart systems for integrative collaborative and distributive awareness” (Le Roux, 2013).

**Context Diagram.** A context diagram for Cmore is shown in Figure 4. This preliminary context diagram will be update and refined as more insight is gained into Cmore.

**Requirements Engineering.** This is the process where user requirements for the system are discovered along with the constraints of the system (Sommerville, 2011). Requirements are descriptions of the services and constraints that are generated through the requirements engineering process. There are two main types of requirements:
- User requirements – High level abstract requirements stating the services the system is required to provide the system user as well as the operating constraints.
- System requirements – This is a detailed description of what the system should do under service and operating constraints.

Figure 4: A context diagram for Cmore Software.

Furthermore these requirements can be broken down into Functional Requirements and Non-Functional Requirements (Kossiakoff, Sweet, Seymour, & Biemer, 2011). Functional requirements are statements containing the services that the system should provide; how the system reacts to inputs and the systems behaviour under certain conditions. The non-functional requirements are constraints that the system is placed under, and may apply to the system as a whole or on functions of the systems or on components in the system. These constraints may include, amongst others, reliability, response time, safety and maintainability. (Sommerville, 2011).

Requirements specification is the process of writing down the user and system requirements in a requirements document. The requirements should state what the system should do and the design should show how it does this (Sommerville, 2011). This however, is an outdated approach as the IEEE Std 1233 (1998) standard prescribes that due to the complexity of many systems a single document is no longer sufficient, thus a database containing containing a system's model: the definition of the need, the operational concept, and the systems analysis task should be used (IEEE Std 1233, 1998).

For the purpose of this project, interviews can be conducted, the system and user requirements will be obtained which will then be generated into functional and non-functional requirements in a requirements specification document.

Requirements will then be validated, as errors in requirements may increase costs and waste time. Thus factors such as validity, consistency verifiability, traceability, completeness and comprehensibility are important (Alexander & Stevens, 2002; IEEE Std 1233, 1998).
**Requirements Development Context.** The context in which requirements are developed is essential as it will determine the success of the system in terms of it meeting customer requirements and conforming to the environmental constraints while still being technically correct. Figure 5 below illustrates the context in which requirements are developed.

![Context Diagram](image)

Figure 5: The context in which requirements are developed (IEEE Std 1233, 1998)

**Model Based Systems Engineering (MBSE).** A student licence can be acquired from Vitech (2014) for CORE (a systems engineering tool), the requirements and functions will be placed into the tool in order to improve traceability. There are several model based systems engineering approaches however Vitech (2014) is preferred due to its ease in linking requirements, functions and components. Figure 6 illustrates the MBSE concept implemented in CORE and the links between the modelling elements.

![MBSE Diagram](image)

Figure 6: Model Based Systems Engineering Approach (Erasmus, 2015)

Another important aspect is to understand the system interfaces. The various interfaces that the product has, not only between hardware and software components, but also between users and the environment as these will influence decisions made for the support concept. Thus it is vital to understand how components fit together and how the system operates in order to provide the system with a comprehensive ILS concept that covers all bases and that will help to make Cmore operational in the future.

**Phase 2: Development of a Support Concept**

The development of a support concept can be considered another phase of the project, however the two phases, requirements development and the development of a support concept, run parallel to one another as development proceeds. Support concept development incorporates the various methods and tools available in order to develop the most effective concept. These methods and tools are presented here and will provide an outline of how the project’s objectives will be met.
**Supportability Analysis.** Amongst other activities, various analytical techniques are combined to develop an efficient and effective logistic support infrastructure capability which also satisfies the system requirements (Blanchard, 2004). A Supportability analysis Life Cycle Framework (Dalosta & Simcik, 2012) is shown in Figure 7 and illustrates the various stages of the lifecycle when designing for support together with three distinctive but integrated approaches, i.e. design for support, design the support, and support the design. Design for support starts at the earliest stages of the system’s lifecycle, where the user’s needs are identified, and the systems priorities are determined and defined. Design the support refers to the output of what the support processes need, such as spare parts, equipment, maintenance training. The product supportability analysis refers to the support that is needed by the various elements for the overall operation and integration of the system.

Based on the Supportability analysis Life Cycle Framework in Figure 7, this within the scope of this desk study, the following product support analyses should be performed:

- Manpower and personnel.
- Computer resources.
- Facilities and infrastructure.
- Training and training support.

![Supportability analysis Life Cycle Framework](image)

**Figure 7:** Supportability analysis Life Cycle Framework (Dalosta & Simcik, 2012).

Blanchard (2004) describes the approach to supportability analysis as depicted in Figure 8. A number of steps is included that should be followed when developing a support concept. This supportability analysis approach will be followed as closely as possible in order to produce a support concept that is of a high standard and that may be implemented in the future.
Figure 8: Supportability Analysis Approach (Blanchard, 2004).

Model Selection. There are a number of evaluation techniques that can be used for various support concepts (Clement & Reilly, 2013), however an accounting approach along with engineering economics (Park, 2006) will be used to model the support concept; in order to determine the costs associated with the various training program development, user equipment and training equipment, facilities and infrastructure and computer resources that may be necessary for personnel support. In terms of staffing levels and skills, there may be a need for another evaluation technique. A cost model will be built for the Cmore support structure, if there is an existing model in place it will be used as a basis for the model, however if there is no model for the Cmore support one will be developed. This model will model costs on an Excel spreadsheet, thus making a techno-economic analysis possible.

A value system (Blanchard, 2004) will be used to compare and evaluate the various alternatives and their costs for the support concept. By building a model, repeatability is obtained, thus if Cmore is used in different applications; the support concept may differ in cost and quantity; and thus can be modelled accordingly. Therefore the model that is built is the most important output and not the actual calculations for the purpose of this assessment.

Logistics Requirements Development. In order to successfully conduct a supportability analysis; detailed system requirements and multiple ILS elements need to
be analysed (Blanchard, 2004), this will determine the quality of the output: Effective Maintenance and Support Infrastructure. In Figure 9 this concept is demonstrated, the two elements that will be focused on as previously mentioned will be “Personnel Training Requirements”, “Operator Task Analysis” and “Facility/Utility Analysis”. These three factors will be evaluated at great depth, however due to the beginning stages of the systems development, data may be limited, thus the analysis will depend on various estimations, assumptions, intuitions, and the use of similar systems to generate concepts; the status of each parameter value will be indicated accordingly. These assumptions will later be validated and verified when the system is up and running.

![Diagram of System Requirements and Supportability Analysis](image)

Figure 10: A supportability analysis and supplemental (Blanchard, 2004)

Logistics requirements can be formulated by applying the supportability analysis.

The logistic requirements for the various Cmore personnel may include factors such as: quantity of personnel, personnel skill level and location of personnel. Furthermore, training and training support requirements may be developed to include: operator and maintenance training programs, training equipment, aids, simulators and devices, training facilities and data.

The logistic requirements for computer resource requirements could include: hardware such as mobile devices as well as computers, screens, servers; as well as software
including operating systems and the Cmore application, amongst others. Maintenance and support facilities and utilities may include: housing, structures, maintenance facilities, air conditioning, and electrical or other power to name a few.

**Methods and Tools.** There exist a number of analytical techniques and methods which include Blanchard (2004):
- Life-Cycle Cost Analysis (LCCA)
- Failure mode, Effects and Criticality Analysis (FMECA)
- Fault-Tree Analysis (FTA)
- Maintenance Task Analysis (MTA)
- Reliability-Centred Maintenance (RCM)
- Level-of-Repair Analysis (LORA)
- Evaluation of Design Alternatives

The methods that will be used are LCCA, MTA and the Evaluation of Design Alternatives.

LCCA involves the determination of the life cycle cost in terms of the maintenance and support costs, factors such as high-cost contributors and potential risk areas are evaluated, cause-and-effect relationships may also be determined in order to identify areas of improvement. The MTA method will be used to evaluate maintenance functions that are allocated to humans. Factors such as skill levels and personnel quantities shall be identified. Lastly, the Evaluation of Design Alternatives will be configured using multiple criteria, and weighted factors to establish the ‘best’ alternative (Blanchard, 2004).

Lastly a cost break-down structure will be formed to illustrate how the costs are broken down and where the costs functions are allocated. This will then form a part of Cmore’s business model as these costs fall under the costs required for the system as can be seen in figure 5. The business model however does not fall within the scope of this project; it is purely mentioned to illustrate the greater purpose of this study.

**Conclusion**

Cmore has a vast potential when used under the correct circumstances. It has the ability to support defence, security services and primary healthcare providers to improve their reaction time and service quality to citizens’ needs, which may in turn save lives and reduce crime in South Africa. Due to South Africa’s high crime and death rates serious action needs to be taken and the implementation of the Cmore application can be a piece of the puzzle which may help solve these problems and make a difference in South African’s lives. By using a Systems Engineering approach to develop the various requirements for the four elements of ILS for the Cmore application, it seems feasible that engineers will be able to take these requirements and develop them into physical outputs for implementation in industry.

**References**


