12TH ICCRTS
"Adapting C2 to the 21st Century"

Identifying And Assessing Appropriate System Architecture Options for Generic and Specific Mission Requirements

Cognitive and Social Issues / Organizational Issues / C2 Metrics and Assessment

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1 Abstract

The particular focus of this paper is a method for the development of a decision support system that shows how, for a particular instantiation of a Combat Search and Rescue (CSAR) scenario, the requirements for a CSAR mission can be assessed and the available assets measured in order to be able to select a system architecture that meets, at least in capability and attribute terms, what is required by the mission. The method also enables the ongoing assessment of architecture options throughout the mission, so that the system can be commanded to re-structure itself in the event of changing environmental circumstances, the need to re-configure when system assets are damaged or lost, or the mission objectives are changed.

The method adopted in this paper is based upon the use of system attributes which are used to describe required capability, i.e. the so-called 'ilities'. Not only is there no current standard, or even a consensus, on a 'core' set of these system 'ilities' or attributes, many of them are not measurable directly and in this approach are interpreted in terms of other secondary attributes and contributing factors which are more easily measured, in order to generate evaluation techniques for various systems.

2 Introduction

This paper reports on work which considers the selection of assets to perform a Combat Search and Rescue (CSAR) mission. Today's military commanders have to make decisions in very complex circumstances which they may not have experienced previously. It is not acceptable for such decision making agents, whether in the field or at operational headquarters, to be faced with the necessity to make a decision without decision support information: in the absence of decision-support information it is possible that the commander would have to choose from an infinite range of options. On the other hand, network-enabled capability has been seen to often generate information overload which has been found to reduce the capacity of a commander to be able to arrive at a decision in the relevant timescale, particularly when offered a wide spectrum of 'pull-down' information. It is necessary to pre-prepare sets of options which are optimised for particular circumstances and 'push' an appropriate sub-set of these options to the commander to use as decision support aids when particular circumstances are encountered. This research addresses the provision of such a Decision Support System (DSS) which enables decision-making agents to assess mission requirements and available assets in order to provide a set of system architecture options that meet, in capability and attribute terms, what is required by the mission. Many of these relevant factors are for 'soft' issues which are not necessarily measurable but for which rational subjective judgement can be applied. One thread of this work focuses on the impact of 'soft factors' relating to cultural values on communicating and implementing decisions and is described in more detail in Siemieniuch and Sinclair (2006) [8]. The approach does not separate out 'soft' from 'hard' issues – rather it recognises that the various attributes can be affected by factors from across the whole soft/hard spectrum.

The following section considers systems architectures and how they can be applied to this military context.

2.1 Systems Architecting

A system's architecture refers to the structure of a system, much as a civil architecture deals with the structure of the building. It is important to differentiate between a system's architecture and an actual system structure. By way of analogy, a cartographer's map does not represent all topographical features of the terrain but,

rather, is a useful abstraction for the purpose of navigation. A map is not concerned with detail such as individual blades of grass, or the number of windows in a building, rather it abstracts the features of the terrain up to a useful level of information for an observer, where the relative positioning of objects is more important than the physical appearance of them. A system's architecture is often required to deal with the interdependence of the chosen components and the overall functionality of the system, at a level of abstraction that is useful to the architect. As Maier (2000) states, "Architecting deals largely with unmeasureables using non-quantitative tools and guidelines based on practical lessons learned; that is, architecting is an inductive process. At a more detailed level, engineering is concerned with quantifiable costs, architecting with qualitative worth" [4]. *'Qualitative worth'* implies that the level of detail required in individual subsystems is relative to the impact that they will have on the overall system in achieving the objectives and purpose of that system (and therefore ensuring client satisfaction).

From Maier (2000), "Systems architecting is a process driven by a client's purpose or purposes. If a system is to succeed it must satisfy a useful purpose at an affordable cost for an acceptable period of time" [4]. It should be noted, however, that the client's purpose is not quite the same as the operational purpose of the architectured system: nevertheless, an operational success also contributes to the achievement of the client's purpose. But what characteristics of a subsystem are important with respect to the function, cost and timeliness required for success? How should these characteristics be measured? As discussed, at an architectural level it is the functional worth of a system that is important, in the first instance, as opposed to the implementable details of the assets used to realise the system. This research is not trying to establish a single-point mathematically-based optimising methodology. The complexity inherent in systems designs and the high level of uncertainty associated with the system and its environment usually requires robust optimal solutions to be found in most cases, rather than sensitive, single-point solutions. This is founded in the principal that, within the constraints under which the system operates, there is a need to make a "best" decision among alternatives.

2.2 Mission Architectures

A military mission, simplistically, involves achieving some purpose and objectives in an uncertain environment where a friendly force and an enemy force exist (in competition with one another). In equally simplistic terms, mission success for a friendly force could be thought of as requiring it to meet and exceed the capabilities of the enemy force and, in so doing, meet the mission's objectives. This "positioning for capability superiority" is similar in concept to the positioning for information superiority model proposed by Alberts, Garstka, and Stein [1], as shown in Figure 1.

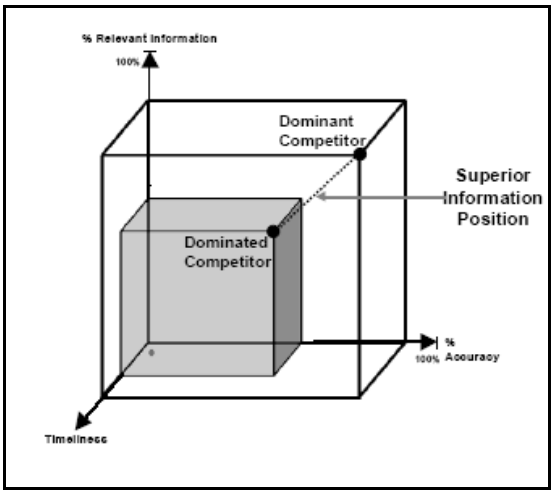

Figure 1: Positioning for Information Superiority

This model deals with gaining information superiority over an adversary, with three key metrics proposed: relevancy of information, accuracy of information and timeliness of information. In simplistic terms, by outperforming the enemy for each of these metrics, information superiority is achieved. However, in the context of military operations, the mission has to be assessed in terms of numerous criteria. Similarly, the system constructed to carry out the mission has to be judged in terms of the capability which it needs for superiority over the enemy forces. This capability, in terms of system attributes, is described later in this paper and often requires a complex high-order multi-dimensional analysis.

The concept of capability superiority fits with Rechtin (1999), who defines such competition in architectural terms as, “an attempt by one system or organisation to equal or surpass others to gain something of value” [5]. In terms of this research the “something of value” would be defined in the mission’s objectives. This positioning for capability superiority is shown in Figure 2, where the system’s capability signature envelops the mission demand’s capability signature, hence achieving capability superiority. More rigorously, the comparison requires an investigation of a feasible trade space. This multi-dimensional space is difficult to represent in two dimensions, but the spider diagram format of Figure 2 helps to interpret the comparison.

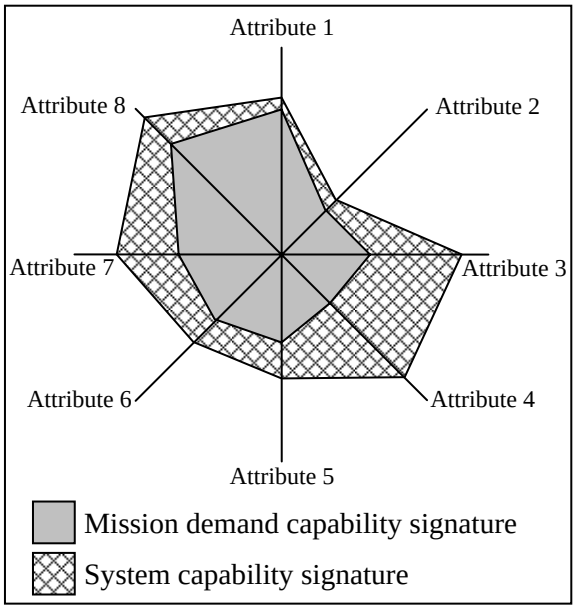

Figure 2: Positioning for Capability Superiority

The idea that mission success could be enabled (as opposed to guaranteed) by considering competitive architectures, in terms of qualitative capabilities, is also lent credence by Rechtin (1999). On the subject of competitive systems, Rechtin (1999) states, “Like economies and the art of war, it is primarily about relative levels between the competitors’ capabilities rather than about their absolute values, sizable and important as the latter may be” [5]. This, in the context of military missions, would indicate that a higher level of abstraction will suffice, initially, for comparing competing systems, or comparing systems in the application of “what we need” against ”what we’ve got”.

3 Overview Of The Approach

To consider the issue of the provision of a Decision Support System that provides systems architecture options a number of steps are required. These are shown in Figure 3.

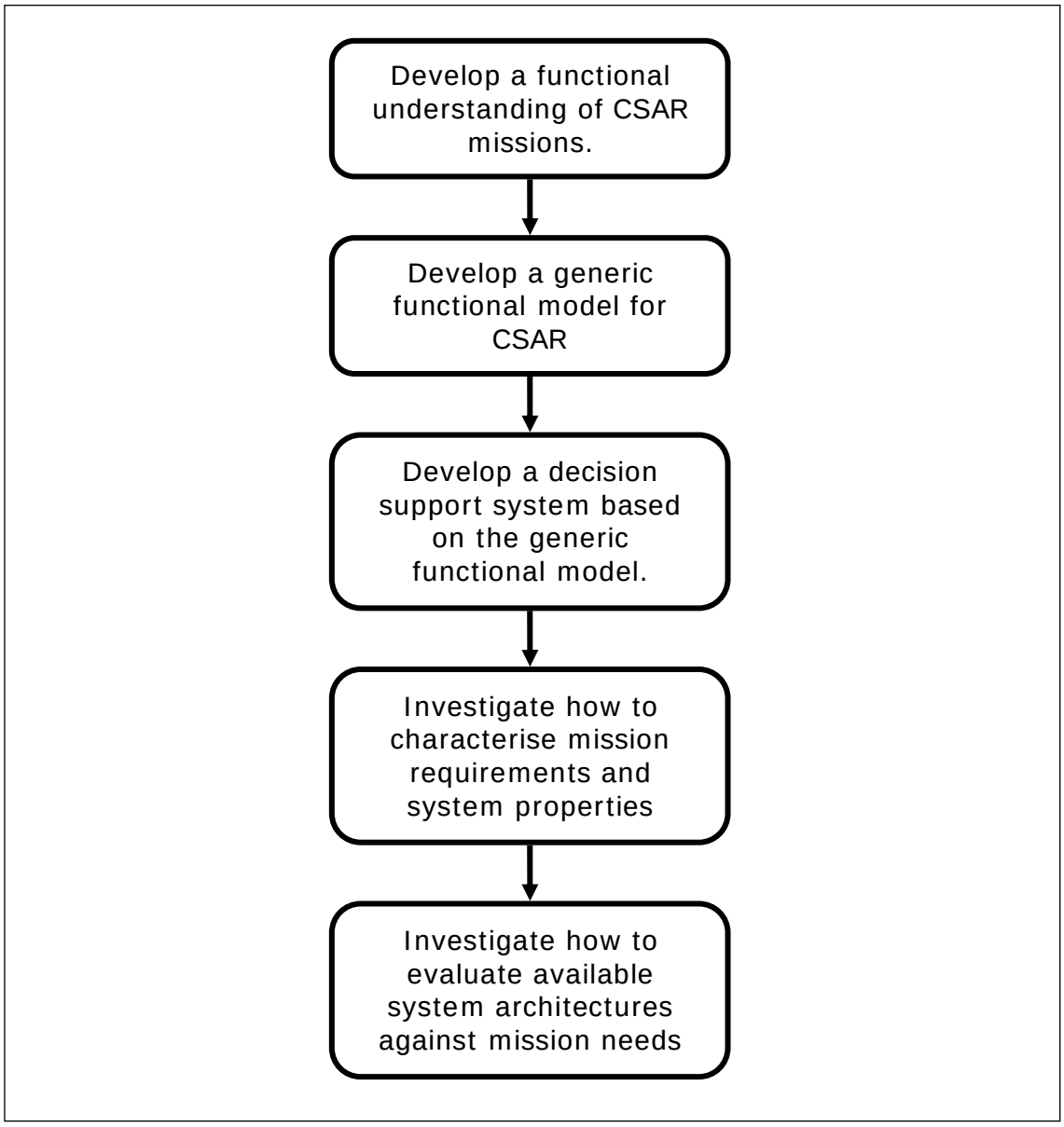

Figure 3: Overview Of Approach

This approach moves from gaining a functional understanding of a CSAR mission through to addressing how a particular mission and system can be characterised for evaluation purposes. A functional understanding is gained because it is solution independent and places an emphasis on required capabilities rather than platforms. The route followed to gaining this functional understanding, which is captured in a generic functional model, is shown in Figure 4.

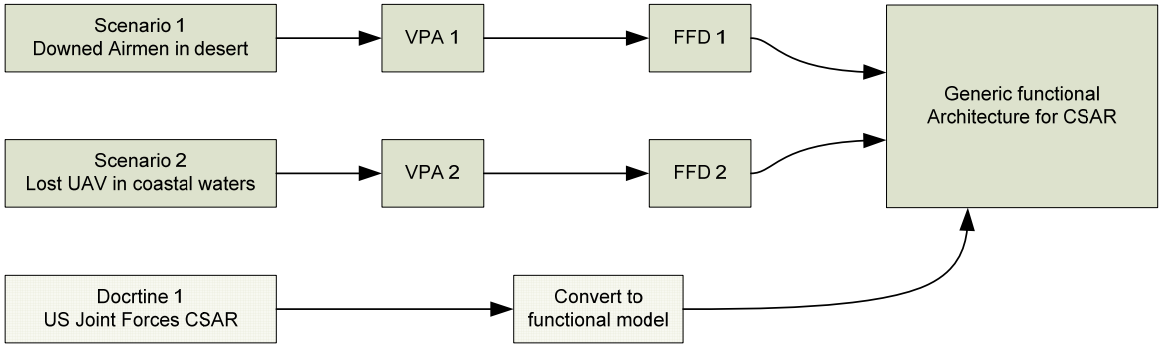

Figure 4: Approach Followed To Developing A Generic Functional Model

With a Generic Functional Model (GFM) for CSAR missions the next consideration is how to support the making of the decision as to which architecture to use for a particular mission. The conclusion reached is that the best way to support this decision is to develop a decision support system that could present to the decision maker a number of architectural options which are functionally and characteristically suitable to conduct the mission. This in turn requires a methodology to assess available architectures against mission requirements, as shown in Figure 5.

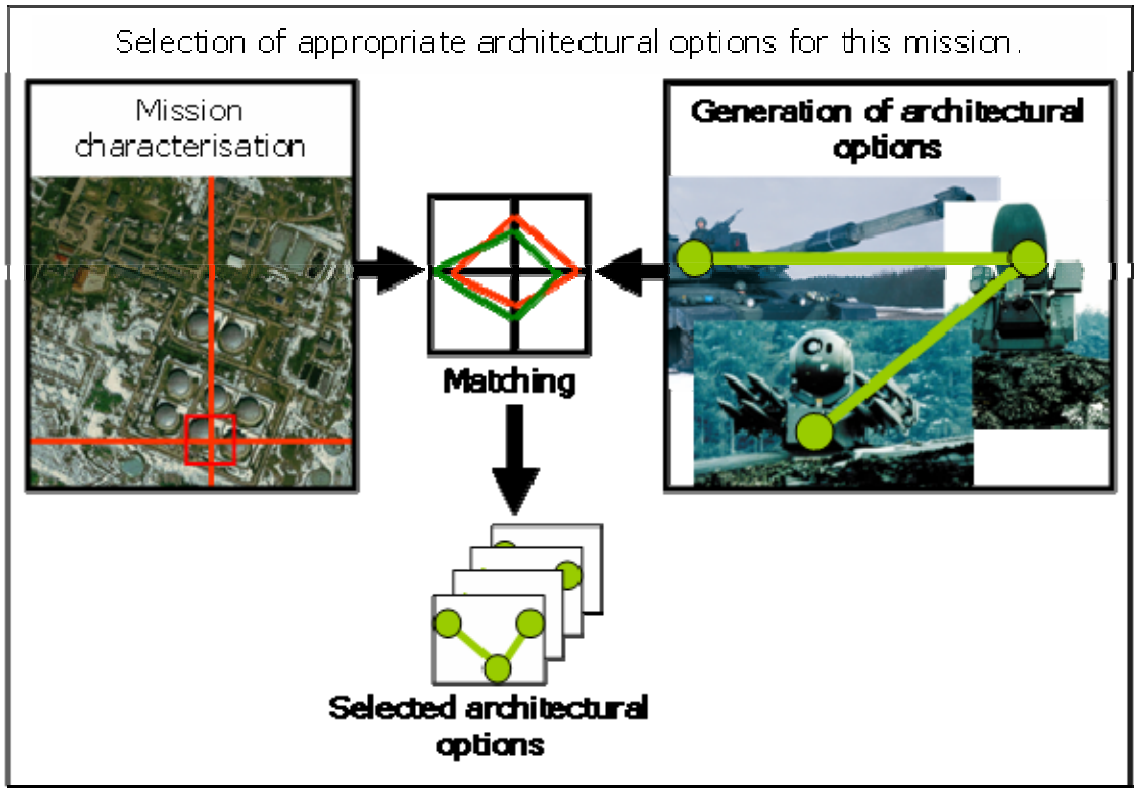

Figure 5: A Decision Support System

4 Development of the CSAR Generic Model

To consider how to support an effective decision-making capability within an architecture a military mission is chosen as a context. The Combat Search And Rescue (CSAR) mission is chosen as the initial context as there is a quantity of literature (including United States military doctrines) available within the public domain. An initial review of this literature indicates that the mission involves decision making in a variety of situations at various levels of authority, making it suitable for this research. Whilst the overall outcome of the research will be focused on CSAR, the less specific outcomes should be valid and applicable to a number of other mission types. There is a variety of CSAR definitions within the available literature, generally varying to some degree; a small selection of definitions is presented in Table 1.

Literature	**CSAR Definition**
Department of Defense Dictionary of Military and Associated Terms [9]	A specific task performed by rescue forces to effect the recovery of distressed personnel during war or military operations other than war (MOOTW).
Joint Doctrine Encyclopedia [12]	
Combat Search and Rescue [14]	CSAR is a specific task performed by rescue forces to effect the recovery of distressed personnel during major theatre war or military operations other than war (MOOTW).
Joint Tactics, Techniques, and Procedures for Combat Search and Rescue [13]	CSAR encompasses reporting, locating, identifying, recovering, and returning isolated personnel to the control of friendly forces in the face of actual or potential resistance.

Table 1: CSAR Definitions

Note that all of these definitions have a human rescue focus. Due to the project focusing on Semi Autonomous / Autonomous Systems, it seems clear that the generic CSAR functional model needs to orchestrate CSAR missions for the recovery of both human and non-human asset targets. Therefore, the following definition is adapted from existing definitions for the context of this CSAR modelling work:

"CSAR is a specific task performed by rescue forces to effect the recovery of assets isolated in hostile territory."

There is also a set of assumptions that accompany the above definition. These are as follows:

- "Hostile territory" refers to an area where opposing forces have the intent and capability to effectively oppose or react to recovery operations and/or threaten the isolated asset.
- The "territory" could include land, sea and littoral domains, but space (as presently considered a demilitarised zone) and air (deemed unlikely) are excluded.
- An "asset" includes, for example, humans, platforms or data.
- "Isolated" refers to an asset when it becomes separated from its operational unit and is in danger of being captured.

4.1 Methodology

The research team has limited previous experience of CSAR operations and so various analysis methods are used to help develop a greater understanding of CSAR. It has been decided early in the project that the team could disregard current literature until a self created generic view of CSAR has been established. This is to ensure that an appreciation of CSAR is gained without being constrained by existing ideas and approaches. It is not until the later stages that literature is used to verify the functional model created through this process.

To understand CSAR various analysis methods are used to build a visual representation of the mission, incorporating functional and non-functional requirements. This is achieved through the process depicted in Figure 6.

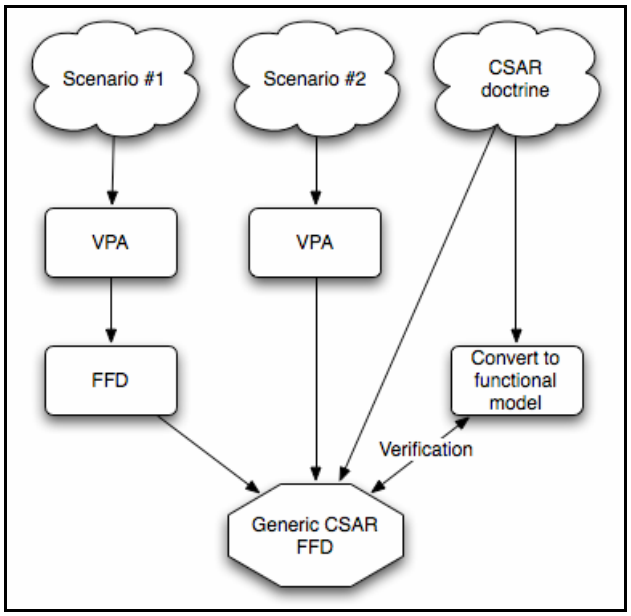

Figure 6: Process to create a Generic Functional Model.

The foundation of this process is the consideration of two very different CSAR mission scenarios, described in the following sections. These scenarios are analysed in turn using Viewpoint Analysis (VPA) to identify stakeholders, identify key mission requirements (functional and non-functional requirements) and to create a functional, asset independent view of the mission activities for each scenario. The first scenario's functions, generated by the VPA, are then associated with each other to form a functional structure using Functional Flow Diagrams (FFD). This approach enables an understanding, through visualisation of the integrated CSAR system in terms of functions and their relationships within the operational context.

The FFD's are synthesised for several levels of functionality until the desired level of detail has been achieved. This creates a layered functional understanding for a CSAR mission with the associated non-functional constraints. From the FFDs for both scenarios a generic CSAR FFD, or Generic Functional Model (GFM), can be developed to be applicable to a variety of CSAR missions. This is achieved by stripping out the mission specific language in each scenario to leave a set of generic stages which cover multiple CSAR mission types. The GFM functionality is then verified using available US CSAR doctrines.

4.1.1 Scenario 1: Downed Airmen Behind Enemy Lines

In this scenario, a fighter aircraft has been hit by a surface to air missile over enemy territory in the desert. The pilot manages to eject and land in a hostile area. It is imperative that the pilot is found before she becomes captured by enemy forces and is used for propaganda purposes. A signal from the ejector seat beacon has been detected, limiting the initial search area to about 10km^2. The area where the ejector seat is detected is quite remote and it is unlikely that there are any enemy forces in the immediate area until enemy troops from nearby bases can respond. This leaves a small time frame to rescue the pilot before the enemy responds. If the enemy does manage to quickly move a forward team into the area, it is likely to consist of lightly armoured vehicles and conscript soldiers. The downed aircraft has sensitive data and equipment on board that needs to be retrieved or destroyed. A diagram of this scenario is shown in Figure 7.

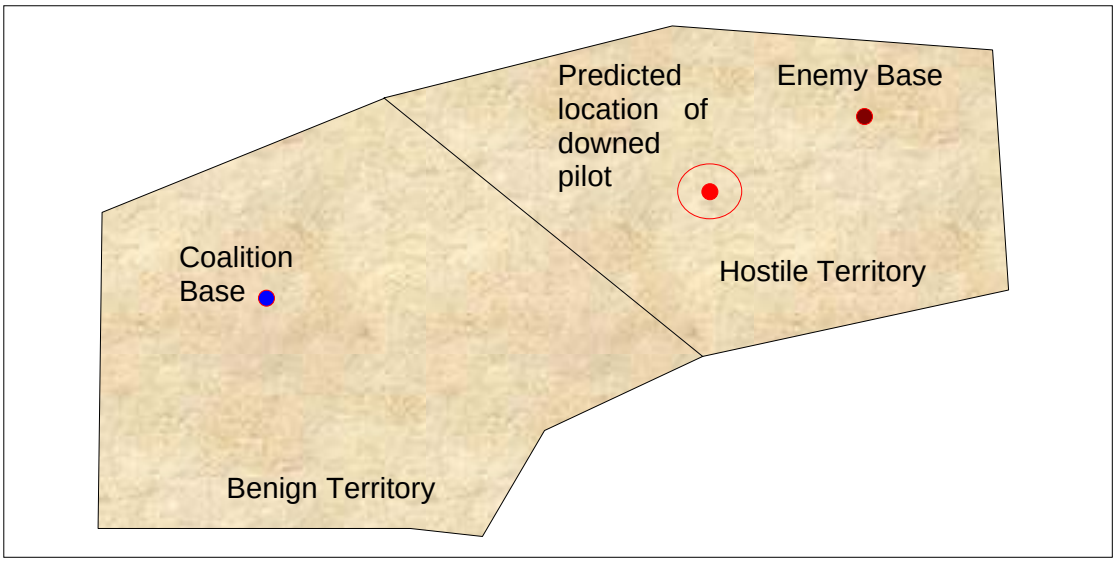

Figure 7: Scenario 1 map.

4.1.2 Scenario 2: Lost Unmanned Autonomous Vehicle

In this scenario communication has been lost with an unmanned, autonomous water borne vehicle in hostile coastal waters. It is presumed that the vehicle has broken down. The vehicle's last recorded position is known, but due to local currents the vehicle may well drift significantly from that position. If the vehicle is found by the enemy it could cause significant political problems, therefore it is important that the vehicle is either recovered or destroyed without being detected by hostile forces. The enemy has significant radar coverage and intelligence indicates that the enemy has coastal patrol boats in the vicinity. A diagram of this scenario is shown in Figure 8.

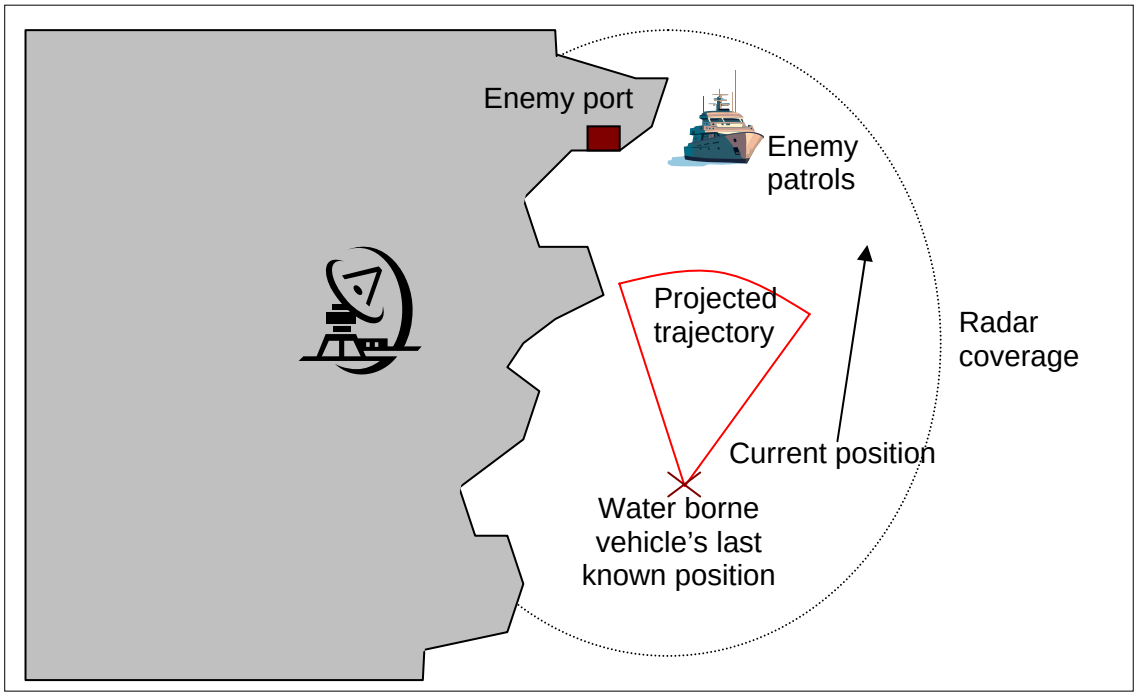

Figure 8: Scenario 2 map.

4.2 View Point Analysis

View Point Analysis (VPA) is a semi-structured analysis process through which a set of functional and non-functional requirements can be generated [3]. VPA is used initially to brainstorm the key elements of a CSAR missions in terms of their expressed functional and non-functional requirements and, then, to provide an organised structure to fully understand the identified requirements and to recognise additional unexpressed assumed requirements. This approach helps to gain a holistic view of CSAR by considering the perspectives of each of the identified stakeholders in turn. The two CSAR example scenarios, as discussed previously, are used as a basis for the VPA and, due to the diverse nature of the two scenarios, helps to produce a wide set of top level requirements. The two scenarios are intentionally left quite open, lacking the usual detail found in a full military operational planning, to help increase the scope of the top-level requirements. The functional and non-functional requirements produced by the VPA are solution independent, i.e. they do not dictate how the system will be implemented in terms of equipment but, rather, in terms of high-level functions such as 'engage with enemy' or 'detect distress signal'.

A number of key findings are made through undertaking VPA, including:

- A consideration of the wider strategic picture is required for CSAR. A CSAR mission can not be considered in isolation, there are always high-level constraints such as international political agreements.
- Common phases of CSAR are identified for both scenarios (which can be verified against US doctrine). Stripping out the mission specific language in each scenario leaves a set of generic stages which could cover multiple CSAR mission types.
- The scenarios highlight common issues for both human and platform recovery. For example, the requirement to repair the unmanned asset in scenario 2 could trigger an additional requirement to administer first aid to a human asset in scenario 1.

The top functional level of the CSAR mission is shown in Figure 9.

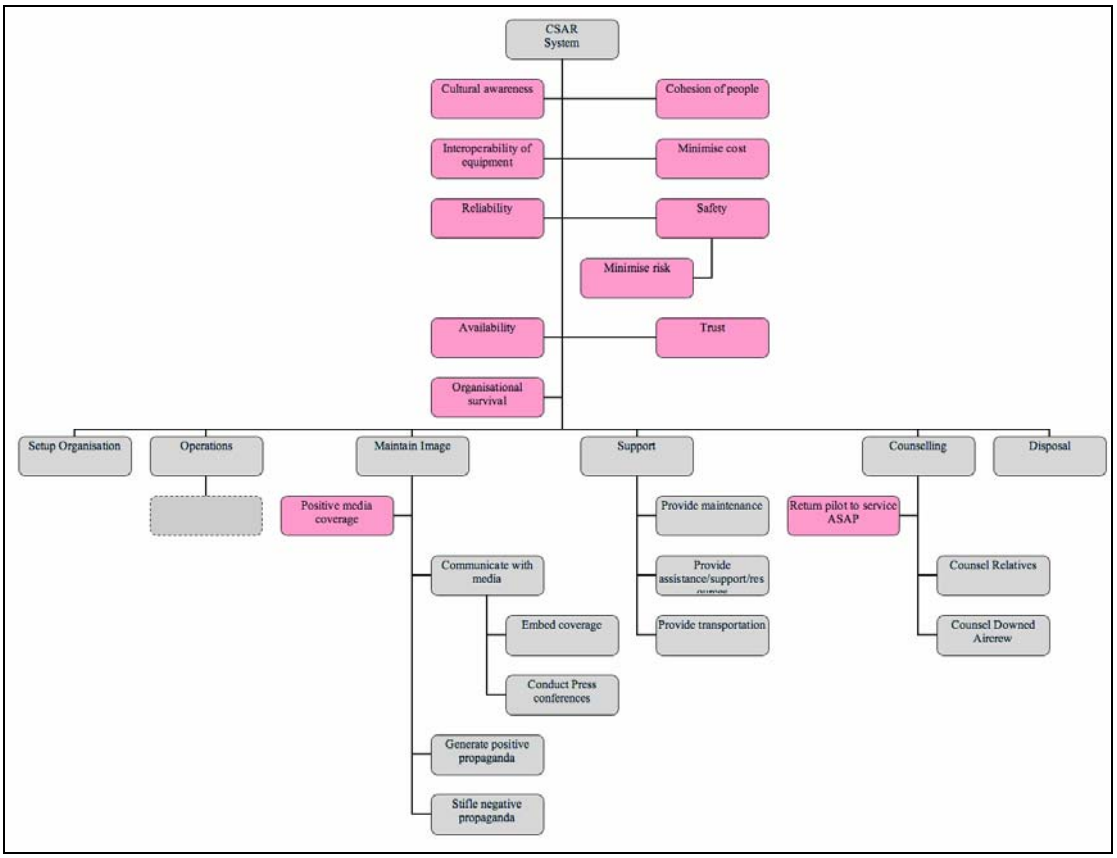

Figure 9: Scenario 1 CSAR mission overview VPA diagram.

Six key functional clusters are identified for undertaking a CSAR mission, these are: Setup Organisation, Operations, Maintain Image, Support, Counselling and Disposal. To provide a focus and some bounding to this work the Operations function is selected for further detailing, as this is the function that actually “performs” the CSAR mission. The VPA diagram for Operations is too large to show in this paper, but provides a functional structure for the Functional Flow Diagrams in the following section.

4.3 Functional Flow Diagrams

Functional Flow Diagrams (FFDs) are the product of a structured functional modelling process and represent a system in terms of functions with inputs and outputs [2]. Producing FFDs allows an understanding, through visualisation, of how the CSAR system fits together in terms of functions and their relationships. An FFD diagrammatically represents functions (from the VPA) as ellipses with interlinking information flows. Each diagram is set at a particular functional level of the system, as determined by the layering developed in the VPA. A functional ellipse can be explored in greater detail by creating a new FFD at a functional level below it. The process of producing layered FFDs helps to ensure consistency in the flows between functions and sub-functions.

Initially the FFD model for the first scenario is produced, based on the VPA for that scenario. This model iteratively evolves over time as the team’s thinking matures, aided by the rapid methodology of FFD synthesis. When this first set of FFDs is produced the team defines the areas of interest within the CSAR system, allowing certain functionality to be drilled down several levels until a desired level of detail has been achieved, sufficient for clarification of what is involved with a particular function. These FFDs along with the second scenario’s model, is then used to produce a FFD model

encompassing both scenarios. An example of one of the FFDs produced is shown in Figure 10.

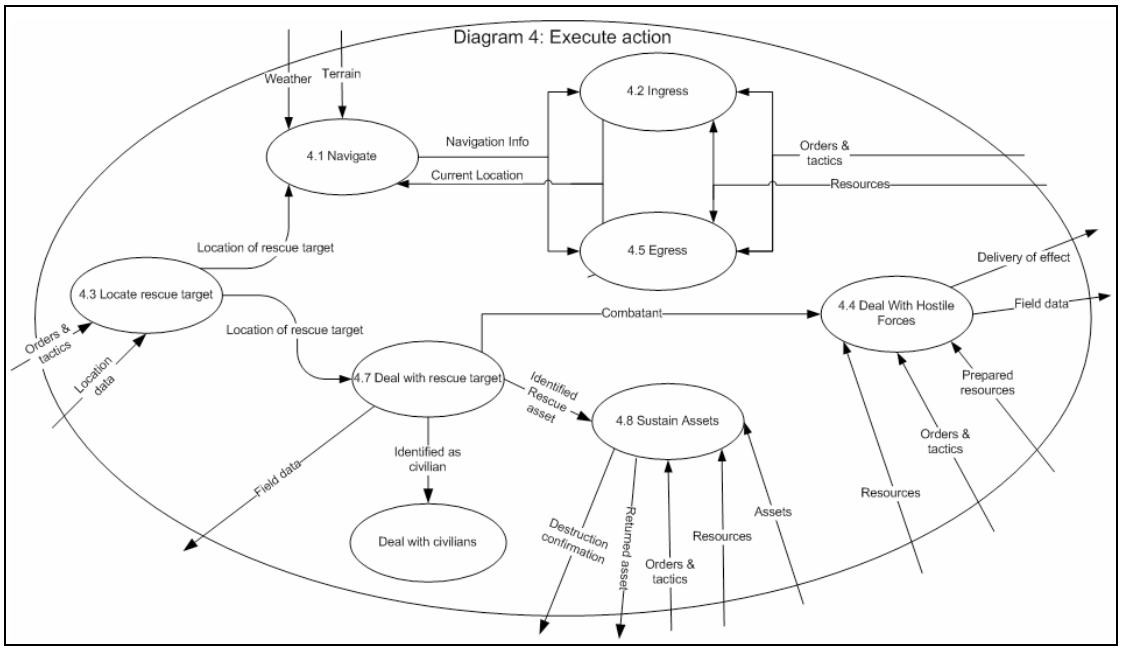

Figure 10: The Execute Action FFD.

The FFD at the highest functional level, Level 0, is called a context diagram, which shows the whole system and its interfaces with the environment. This FFD for both scenarios, showing the overall CSAR system, is shown in Figure 11.

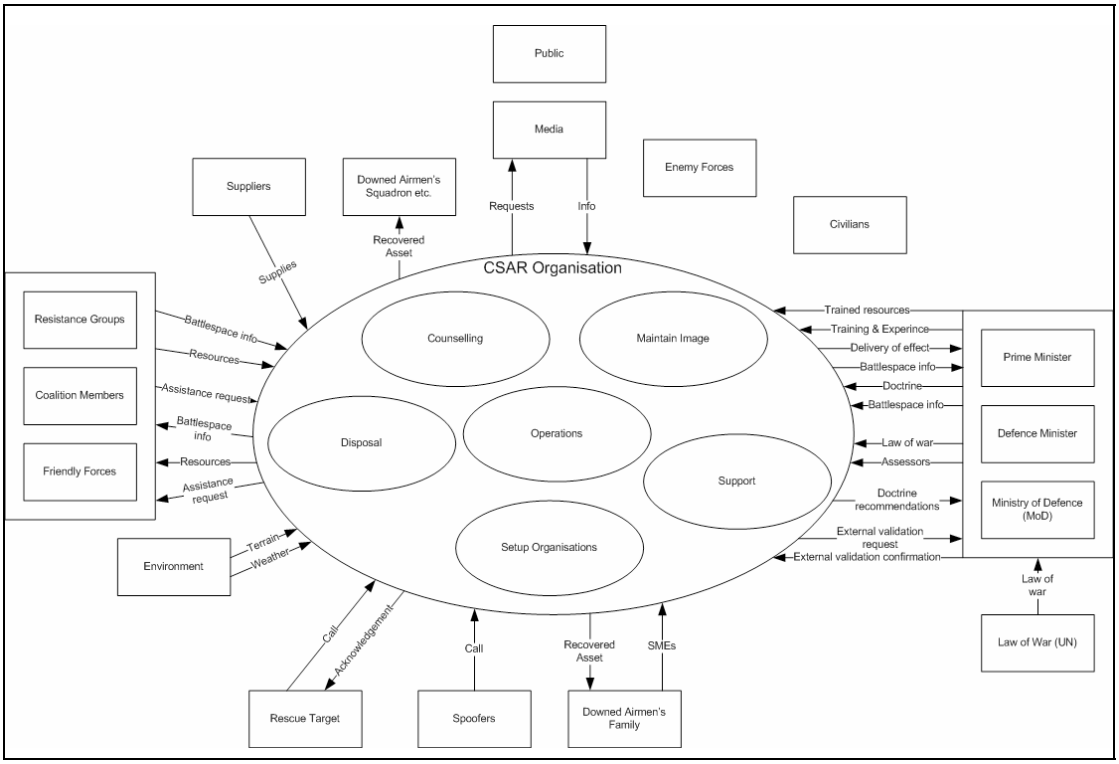

Figure 11: CSAR Context Diagram.

4.4 A Generic Functional Model

By considering the two scenario specific functional models a generic CSAR functional flow diagram or Generic Functional Model (GFM), applicable to a variety of CSAR missions, can be developed. This is achieved by stripping out the mission specific language in each scenario to leave a set of generic stages which cover multiple mission types. The GFM represents a current understanding of CSAR which will continue to mature as the research progresses. Whilst the model is generic at the higher common levels it should be noted that as the model becomes more detailed it becomes more mission specific. The FFDs generated for the different CSAR scenarios show that whilst every CSAR mission is unique at the more detailed levels, there are clear commonalities at higher levels of abstraction. The GFM captures these higher-level commonalities, enabling it to support the majority of CSAR missions and, hence, provides a starting point for the development of the architecture(s) to be used for a particular CSAR mission.

4.4.1 Verification Of The Generic Functional Model

Once the GFM reaches a reasonable level of maturity, it is verified through functional analysis with the available Department of Defense CSAR doctrines: a summary of the key Joint Operations doctrines are discussed below.

Joint Tactics, Techniques, and Procedures for Combat Search and Rescue [13] describes the fundamentals of multinational operations, reviews multinational command relationships, discusses the considerations during the planning and execution of multinational operations and covers operational considerations.

Doctrine for Joint Combat Search and Rescue [10] describes CSAR responsibilities and command relationships, explains CSAR procedures and methods, outlines coordination and planning procedures, defines CSAR intelligence and support requirements and details CSAR capabilities of the services and special operations forces.

Joint Doctrine for Evasion and Recovery [11] provides general evasion and recovery considerations, covers the moral, legal, and operational guidelines for evasion and discusses the philosophy and considerations of recovery.

This verification ensures that the GFM reflects the current military approach to the mission, which incorporates what has been comprehensively tried, tested and learnt in the field. Differences between the GFM and literature are identified and improvements are fused into the GFM to enhance its scope and functionality. This literature based verification will be built on by consultation with appropriate subject matters experts.

5 A Decision Support System

The context of CSAR missions is used to consider decision-making processes for determining architectures appropriate for a particular mission. CSAR missions are recognised as typically reactive missions and are often time sensitive. The functional requirements for conducting the majority of CSAR missions is captured in a Generic Functional Model (GFM). When a CSAR mission is initiated, the GFM can be used to identify the functions required to conduct this particular mission, noting that for a particular scenario, some functions of the GFM may not be active. Understanding the required system functionality may contribute, along with military doctrine, to determining appropriate courses of action based around the purpose and objectives needed to complete a particular mission. Due to the time constraints and immediacy of reactive CSAR operations, it will not be possible to generally predict what assets and

resources will be available. When a mission is initiated it will be necessary to determine what resources (platforms, people, supplies etc.) are available to the CSAR organisation. As stated previously, whilst the GFM provides an initial picture of what is required functionally to complete the mission, it will be necessary to assess and modify this with respect to the probable demands of this particular mission. This can then be interpreted in terms of the superior capability that the CSAR system requires to meet, or exceed, the specific demands of the mission. This leads to a consideration of how to characterise and assess available CSAR system architectures to enable sufficient capability to achieve a successful mission outcome.

5.1 Characterising Architectures

The decision regarding which architecture to use for a particular CSAR mission is critical, as a poor selection or structuring of the system's architecture could result in the system being unable to meet the demands of the mission. For the majority of CSAR missions, the functional understanding has been captured in the developed GFM. However, the CSAR mission is set in a number of scenarios such that the detailed objectives can vary between different specific missions but can be identified for each application. This leads to an awareness that differing levels of capability can be defined for these specific missions, which requires a system's architecture to be more than just functionally and structurally fit for a particular mission. It also requires the system to have appropriate capability attributes, such as adaptability and interoperability, i.e. the so-called 'ilities'. These 'ilities' are attributes, or characteristics, of systems which are frequently used within the descriptions of non-functional requirements for systems. The 'ilities' have found particular acceptance in defence requirements engineering where they are often specified for military systems. It is necessary to be able to regard 'ilities' as holistic system attributes rather than being attributed to individual functions. Whilst individual functions may be linked with or even dominate a specific attribute, it is still necessary to consider the entire system contribution. This is of particular importance in dealing with emergent properties of the CSAR system.

Various authors identify individual 'ilities' [6] and their importance for Systems Engineering [7]. Whilst the 'ilities' have gained widespread acceptance there is currently no universally accepted list of definitions for them. The 'ilities' are not often useable in their current form for performing an assessment of system architectures or mission requirements in general applications, instead they must be specifically understood for each application. A more structured, coherent and defined set of measurable attributes are required to characterise systems for evaluation purposes. In this research an approach is adopted which enables these characteristics to be assessed in a structured way. This approach moves away, in most cases, from using the 'ilities' directly (since they are usually difficult or impossible to measure directly) and, instead, utilises more measurable secondary attributes and factors to characterise the attributes.

The developed Decision Support System (DSS) characterises the 'demand' side of a mission and, on the "supply side", helps to determine suitable capability systems and the functionally-based architectures which may underpin them. At any time, some given resources or assets are made available to carry out a particular CSAR mission. These assets may or may not have the inherent skills and competencies needed to carry out the specific mission. For a given CSAR mission architecture, various combinations of assets can be brought together to form a system to carry out that mission. In order to assess the suitability of the available system alternatives, they can be assessed in terms of the same attributes, secondary attributes and factors as used above. These attributes and factors may be given priority weightings to recognise their relative importance within specific missions. When matched against the mission 'demand'

requirements, an evaluation can be carried out to assess the suitability of a chosen capability system and to identify appropriate architecture options to integrate available assets for that particular mission. An overview of the DSS is shown in Figure 12.

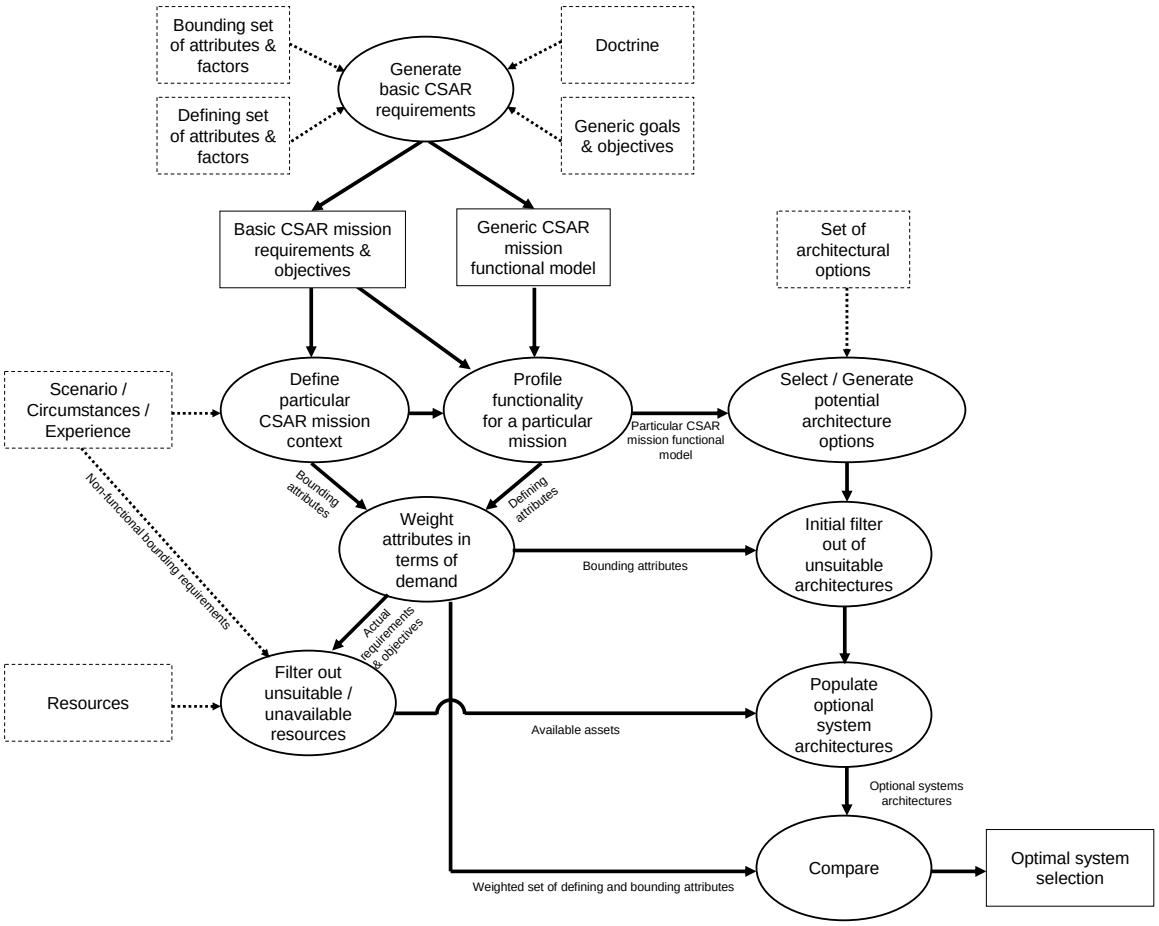

Figure 12: An Overview of the Decision Support System.

Note that this assessment may indicate that the available assets cannot be combined to complete the mission. Whilst this evaluation process will not give a guarantee of success it will show whether an architecture is functionally and characteristically suited to the mission. As discussed previously, the non-functional characteristics will be evaluated using system attributes, secondary attributes and factors, as shown in Figure 13.

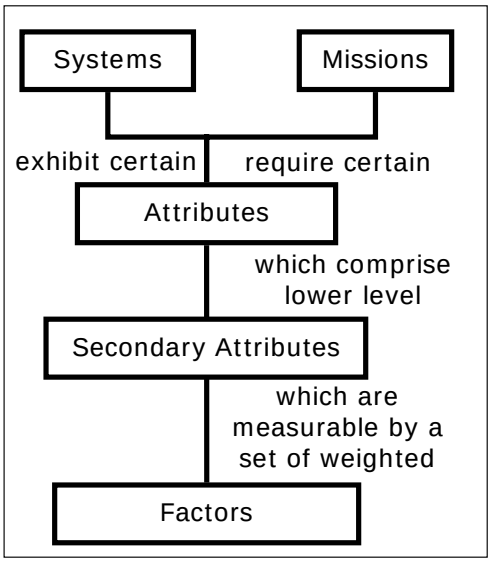

Figure 13: Relationship Of Terms

It is likely that, during a specific mission, circumstances may change or objectives may be altered. The DSS can be used at any stage of the mission, from pre-mission planning to mission completion and post-mission evaluation, to assess the best use of assets, possibly through reconfiguration into alternate architectures, to accommodate changes in circumstances or mission objectives.

5.2 Attributes and Factors

A proposed set of system attributes is shown in Table 2.

Table 2: A Proposed Attribute Set

Attribute Name	Attribute Description
Adaptability	The ability of a system to change how it functions (allocation of functions) and what it does (what functions it executes) in response to the environment.
Availability	The ability to provide a particular functional level for the majority of time.
Co-operability	The ability to engage in co-operative behaviour in a team, e.g. by information sharing and mutual support.
Credibility	The impression created by a system of its intent to follow through on its actions.
Decision Making Superiority	The ability to make the right decision at the right time.
Deployability	A measure of what is required to get "on station" at the required functional level.

Attribute Name	Attribute Description
Effectiveness	To do something effectively and properly, to deliver the required effect.
Flexibility	The variable allocation of task within a system.
Interoperability	The ability to operate in synergy in the execution of assigned tasks.
Orientability	The ability to comprehend the environment and assess current status.
Survivability	The ability to function during and after a natural or man-made disturbance.
Sustainability	The ability to deliver a level of performance despite any interference.

An attribute is a high-level system characteristic. As stated above, an attribute is not normally measurable directly. These attributes are, therefore, to be represented in terms of a set of relevant secondary attributes and, consequently, can be measured through the interpretation of appropriate secondary attributes and their contributing factors. This relationship between an attribute and the relevant secondary attributes and factors is shown in Figure 14.

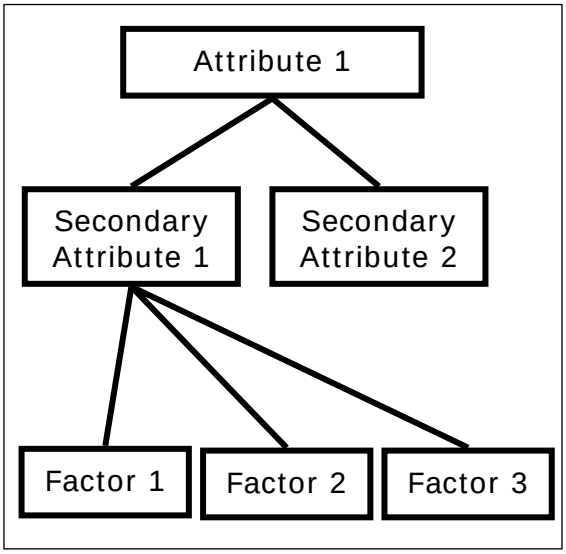

Figure 14: Representation of an Attribute

An example set of proposed secondary attributes for the Effectiveness attribute is shown in Table 3.

Table 3: Some Proposed Secondary Attributes for Effectiveness

Secondary Attribute Name	**Secondary Attribute Description**
Accessibility	The quality of being at hand when needed.
Configurability	The ability of a system to change its functionality through the rearrangement of its parts.
Dependability	A measure of how worthy the system is of reliance or trust by other systems.
Integrity	The wholeness of the system, everything within the system has a role or purpose and all inputs and outputs have somewhere to go - no unmanageable internal conflicts.
Lethality	The ability to deliver a lethal effect for a sufficient period of time.
Mobility	The ability of a system to adjust its position in order to deliver an effect/output against a moving target or a choice of targets; or to avoid the enemy effect
Predictability	The ability of a system to consistently produce the same expected results.
Timeliness	The ability to functionally achieve something within a predetermined or favourable timeframe.
Usability	How usable the system is by the humans within it or external to it (who are likely to be trained specialists), including recovery from errors. This does not imply simplicity.
Processing capability	The ability to process incoming knowledge, information/data effectively, efficiently and in a timely manner, to reach conclusions regardless of the state of the information/data.

It is proposed to evaluate these secondary attributes through the interpretation of measurable hard and soft factors which are defined for the purposes of this research as lower-level characteristics or properties of a system.

A number of factors can be considered to contribute to a representation of an attribute, as shown again in Figure 14. Many of these relevant factors (particularly in this research) relate to ‘soft’ issues which are not necessarily objectively measurable but for which rational subjective judgement can be applied using the Soft Factors Modelling Tool being developed within this research programme. However it should be emphasised that this approach does not differentiate ‘soft’ from ‘hard’ issues – rather, it recognises that the various attributes can be affected by factors from across the whole soft/hard spectrum. Each factor can contribute, of course, to the interpretation of a number of secondary attributes. A small sample of proposed factors is shown below:

Commonality - How much the system has in common with other systems to enable them to work together (protocols, communications, etc)

Durability - A measure of how long lasting the system is in its normal operating environment.

Redundancy - Duplication of critical functions to enable continuation in case of subsystem failure.

Supportability - A measure of how easy a system is to support (i.e. the extent, complexity and size of its reach-back architecture).

Testability - How easily / comprehensively the system can be tested, either by an external party or by self test.

6 Future Work

When an initial set of attributes, secondary attributes and factors has been developed, the next stage will be to agree the draft attribute set with subject matter experts. An important part of this initial draft set will be to understand and define the links between the factors and the secondary attributes up to attribute level. As a factor can influence many secondary attributes, which in turn can influence attributes, defining this hierarchy of relationships is of significant importance.

7 Conclusions

In this research, a method is being developed to evaluate appropriate system architecture options for CSAR missions, in order to provide support to the decision regarding which capability system to use. This is a decision that may have to be updated as the mission progresses and changes occur. Hence, there is a need to establish a repeatable, dependable evaluation process, suitable for use throughout the mission, from planning through mission execution to post-mission assessment.

A Generic Functional Model (GFM) for Combat Search and Rescue (CSAR) missions has been developed. This model has been used to consider how architecture options can be evaluated against a particular mission's capability requirements. This has necessitated an investigation of how best to describe and measure capability through the use of a selected set of system attributes which relate directly to mission capability requirements. These attributes have been recognised as being complex and difficult to measure directly and so secondary attributes and factors have been introduced to better describe these attributes and allow the measurement of them through interpretation. The aim of this is to obtain a comprehensive set of attributes, secondary attributes and factors. These will not be chosen just because they are measurable, but because they capture the key characteristics that influence mission success or failure. Defining a comprehensive baseline set of characteristics and their relationships from attribute down to factor level, which can satisfy the requirements of subject matter experts from various domains, is the ongoing work in progress.

This work provides a major step forward in the delivery of a Decision Support System to enhance the capability of military commanders to make decisions when faced with very complex circumstances which they may not have experienced previously. It is necessary to provide sets of options based on prescribed system architectures which are optimised for particular circumstances and 'push' an appropriate sub-set of these options to the commander to use as decision support aids.

Whilst based upon the challenges faced by military commanders, it is clear that this work will contribute to improvements in decision-making under extreme pressure for leaders in various operational domains

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