11th International Command and Control Research and Technology Symposium

"Coalition Command and Control in the Networked Era"

Topics: C2 Concepts and Organizations; Cognitive Domain Issues; C2 Architecture

The SCMILE Services Framework: A Conceptual tool for designing the NCW force

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The SCMILE Services Framework: A Conceptual tool for designing the NCW force

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Abstract

A significant focus of Network Centric Warfare (NCW) has been the information connectivity and exchange, in particular, how information flows enable activity in the major NCW grids. Recently, the attention has turned to the whole decision-making process and the linkage to effects-based operations (EBO), that is, on the reasons the information is being utilised. The concept of *services* (transactions between a providers and a consumers) has been proposed as an approach to examining these wider issues.

In this paper, an approach to services is presented, which moves beyond information relationships only and explicitly defines (as simply but as comprehensively as possible) the set of services that potentially can be exchanged between entities. In this way, it removes the focus from platforms and assets more towards effects. It is a pragmatic approach, building upon established NCW concepts and terminology while still remaining relevant to conventional force design thus providing a universal framework that describes both industrial-age and information-age defence designs.

This paper introduces a conceptual framework, called the SCMILE Services Framework (SSF). It will be compared with other taxonomies and conceptual frameworks and examples of its application and utility will be given.

1 Introduction

A significant proportion of the early activity in the area of Network Centric Warfare (NCW) has been information connectivity and exchange and how networking can enable a more efficient and effective military force [1, 2]. While implicit in some of the discussion of NCW, attention has also turned to the whole decision-making process and the linkage to effects-based operations (EBO) [3, 4].

In the same way, the design of the NCW force initially tended to focus around the information architectures, connectivity and exchange but has also broadened to organisational issues and effects [5]. One aspect that has become more prominent in the design of the future force in the "Information Age" is the relationships between entities (be they people, platforms or systems), especially information flows, but also how they will all meld together (physically, doctrinally, etc) to form an effective force. This issue is amplified when considering the problems associated of integrating new (network-enabled) and legacy systems and preparing for coalition and allied operations.

One of the approaches used to deal with some of these issues has been to utilise the concept of *services*, as used in the idea of a transaction between two parties, one the provider and the other the consumer. This moves the analysis of relationships between capabilities beyond just information to a broader consideration of the nature of interactions. This is in line with the recognition that there is more to interoperability than just the exchange of information [6].

Describing relationships via services have a number of benefits:

- They make explicit the relationship between entities.
- They remove the focus from specific platforms and assets.
- They broaden the focus of relationships from information only
- They potentially make the link between capabilities to effects
- They can describe both "industrial-age" and "network-centric" capabilities in a single conceptual framework
- They can deconstruct capabilities and reconstruct them in different (hopefully better) ways by rearranging the services that normally comprise them.

To our knowledge, there have been only a couple of approaches have been attempted that utilises the concept of services in the military context ([7], [8]). The approach taken here has been a pragmatic one, building upon established NCW concepts and terminology while still remaining relevant to conventional force design.

For the purposes of this paper a simple working definition of a service is proposed:

> A service is a relationship between two entities, one called the provider and the other called the consumer.

The provider creates and supplies the service, which is then utilised by the consumer. In other words, a service is exchanged if one entity provides a service that is consumed by another entity. Usually, this is done so that the consumer gains some benefit from the consumption of this service.

2 Background

2.1 Previous Service models

There appear to have been only a couple of approaches have been attempted that utilises the concept of services in the military context.

As part of their concept of a Network-Based Defence (NBD) [7], the Swedish Armed Forces developed a generic services concept where the service is considered the interface between a provider and a consumer. Entities, acting as both providers and consumers, are linked by their exchange of services, forming chains of activity. Within their concept, they articulated seven services, in two main groupings: Operational Services (which includes C2, Situation Awareness and Engagement) and Infrastructure Services (which includes Interoperability, Net Infrastructure, Transmission, Platform).

Hall et al. [8] recognised that to operationalise the concepts of NCW and EBO, there was a need to broaden the perspective beyond the usual focus on information architectures and exchange. To that end, they introduced the idea of "networked services", seeing at as "a way of describing how a complex network of potential services and providers can be realised to achieve a particular goal." They explore the nature of a services concept, identifying a number of key concepts required to define services and applying their conceptual framework to the military domain.

2.2 Conceptual starting point

In developing the concept of NCW, early proponents introduced the concept of NCW Grids[1] (Information, Engagement, Sensor) [9, 10] and Domains (Physical, Information, Cognitive) [1]. While not intentional, the existence of an information grid and information domain sometimes can cause confusion because people could discuss "information" when they meant "information as in the infrastructure", "information as in the data and bytes", "information as in the words and meaning" or "information as a weapon", sometimes using more than one at the same time.

2.3 From Grids to Services

If one takes the starting point as the four NCW grids, Command & Control (C2), Engagement, Sensor and Information, one can simply ask oneself: what would each of these terms mean as a service (Figure 1)? The first three are reasonably clear:

- A C2 service comprises decision-making, analysis/synthesis, orders
- An engagement service encompasses the production of effects
- A sensing service consists of the gathering of information about the battlespace

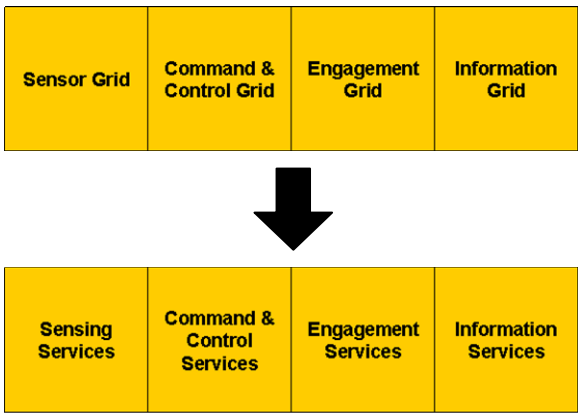

Figure 1 Transforming NCW grids into services

However, "information services" seems to overlap with all of the above, because all of those services involve information in some form or another. The question is whether it is

[1] Other authors have introduced the concept of the Command and Control (C2) grid and this has also been commonly used since.

‘information movement’, ‘information infrastructure’, ‘information warfare’, ‘information as data and bytes’, ‘information as words and meaning’, ‘IT systems’, ‘information storage’ or some other aspect of information? However, if one also considers the three domains, one can recognise that the first three defined services all have aspects in each of these domains. If one absorbs those aspects of information that are relevant into the first three services, what remains to be defined as the information service is the movement of information which has been called here as ‘Information Mobility’ (Figure 2).

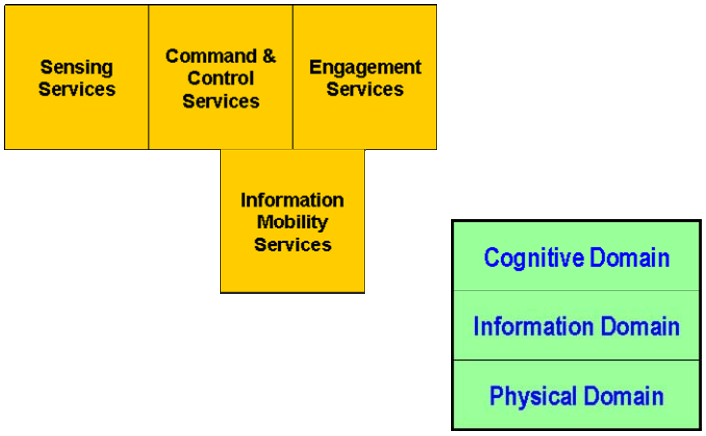

Figure 2 The ‘information service’ is clarified by considering the NCW domains

Once this is done, and again thinking about the domains, the obvious analogue is “Physical Mobility”. Lastly, it is generally recognised there are a number of services to do with logistics, supply, support and training that should be included (the provision of some activity or physical good required for the basic functioning of another entity) resulting in a block diagram shon in Figure 3.

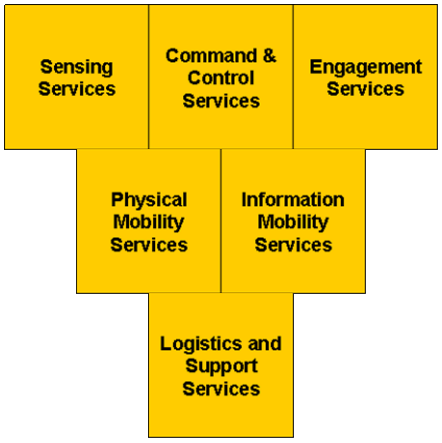

Figure 3 The SCMILE Services Framework Block Diagram

Basic definitions of the services are given in the table shown in Figure 4. The conceptual framework has been called the SCMILE Services Framework (SSF), constructed from the acronym of the Services comprising the framework.

Service	Short Description
Sensing	The provision of information about the battlespace.
Command & Control	The provision of decisions, plans and instructions for agents and analysis of the battlespace (past, present and future).
Engagement	The provision of effects, in and on the battlespace.
Physical Mobility	The provision of locomotive (movement and transport) ability.
Information Mobility	The provision of information storage, manipulation and dissemination infrastructure and processes.
Logistics and Support	The provision of activities and physical materials that enable the normal functioning of an agent.

Figure 4 Brief descriptions of the six services

2.4 Nesting

One of the advantages of taking such a generic approach is that these services can be nested in a variety of ways

2.4.1 'Nested Encapsulation'

The best way to explain this is by way of example.

Take the Joint-Strike Fighter (JSF) as a system (Figure 5). It can be viewed as a collection of services that it can provide (to itself or another entity). For example, it has engagement services (E) that it can provide to itself or another entity. It also has physical mobility services (M), which it only provides to itself. [2] The JSF system also includes its Logistics and Support Services (L), such as basing, maintenance and repair,[3] which it only provides to itself.

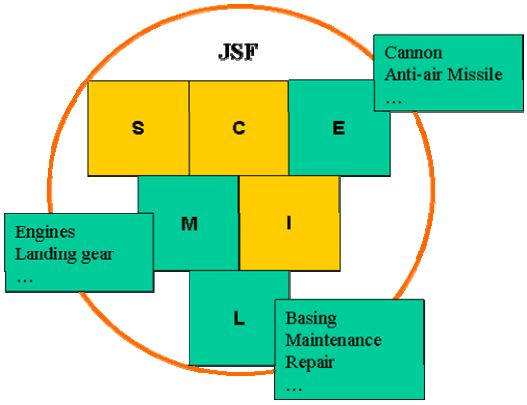

Figure 5 The view of the JSF as a collection of services. Only some examples are identified.

The idea is that you can use this representation to look at any system, sub-system or super-system of your choice using the one conceptual framework. It is one way to try and manage the complexity of systems-of-systems.

So, for example, if one "moves one level higher" and considers a JSF, an Air-to-Air Refueler (AAR) and an Aerospace Early-Warning and Control (AEW&C) aircraft as separate collections of services, one can represent their relationship with each other through the

[2] If the JSF's weapons systems and propulsion systems are considered as separate systems then the engines provide a physical mobility service for the weapons.
[3] The specific designation depends on whether the services are considered internal or external to the JSF system.

services they can exchange (Figure 6(a)). Using this framework the JSF provides engagement services (red) to the AAR and AEW&C, the AAR provides Logistics & Support services (green) to the JSF and AEW&C and the AEW&C provides Sensing services (purple) and C2 services (yellow) to the JSF and AAR.

As a total set of services, the JSF, AAR and AEW&C may be considered collectively as a super-system, perhaps called the Air Domain System (Figure 6(b)). Logically, any services that the individual entities provided can potentially be provided by the super-system as a whole. In addition, at the higher-level of aggregation, other services that the super-system can provide (or requires) may be identified, that perhaps do not exist at the lower level.

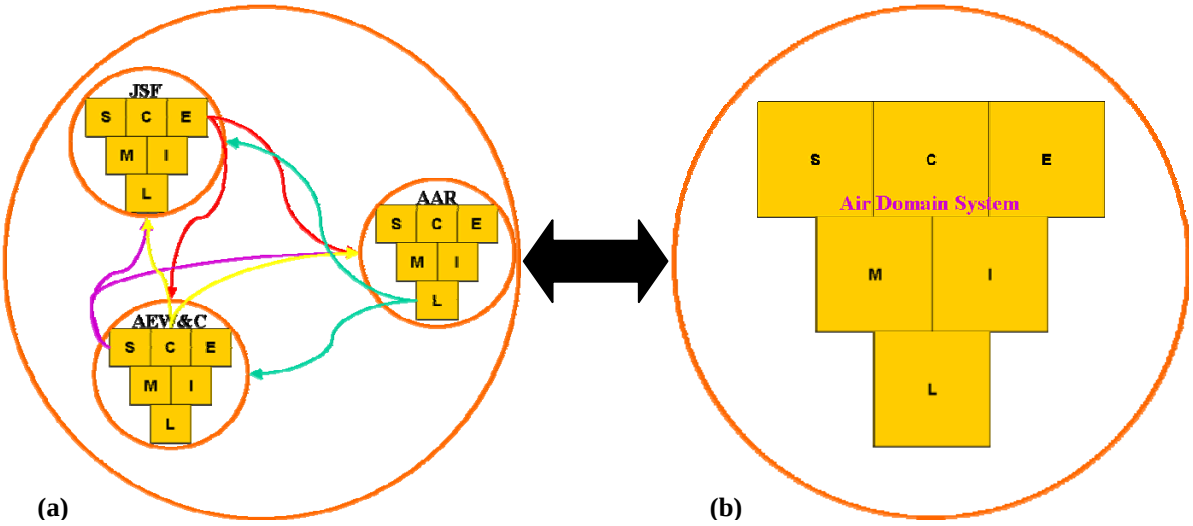

Figure 6 (a) Some of the services exchanged between a JSF, AAR and AEW&C (left). (b) Viewing this collection of platforms as a single system (the Air Domain System) that can potentially provide these services (right). At this higher level of aggregation, the same SCMILE block diagram can be used to represent this system as a collection of services.

2.4.2 Nested Command/Conflict Levels

The services can be applied to any level of command/conflict; they just mean different things at each level (Table 1).[4]

Table 1 Examples of the services at different command levels.

	Command Level		
Service	**Tactical**	**Operational**	**Strategic**
Sensing	Target illumination	Wide Area Surveillance	Intelligence
Command & Control	"Take that hill!"		"Turn full circle"
Engagement		Control the Air	
Physical Mobility	Helicopter transport of Special Forces		Strategic Airlift
Information Mobility	Tactical Data Links		
Logistics & Support			Campaign Logistics and Support

[4] If it is considered useful, the classical three levels of command may be further expanded into five levels be including those in-between i.e. tactical/operational and operational/strategic.

These are just examples of the activities that might occupy each of the categories. Considerable work remains to be done if it is to be filled out in a coherent, consistent and complete manner that is also practically useful to force designers.

Nesting is seen to occur when considering how the services at different command levels are related ()Table 2. Obviously, the service at a lower level contributes significantly to the service of the same name at a higher level. However, this is usually not sufficient to describe the service at the higher level. In reality this service is usually a combination of a number, if not all, services at the lower level.

Table 2 Relationship of services between command levels

	Command Level		
Service	**Tactical**	**Operational**	**Strategic**
Sensing			
Command & Control			
Engagement			
Physical Mobility			
Information Mobility			
Logistics & Support			

This nesting, based upon system boundaries or command/conflict levels, provides the framework with a fractal-like structure reminiscent of natural systems. It allows systems to be described at any level of aggregation using a minimum number of fundamental basis concepts.

However, it should be acknowledged that there is likely to be services at the higher levels that cannot be described (partially or fully) by a combination of services at a lower level. These so-called emergent services are reminiscent of concepts from the field of complexity. An example of this is the creative aspect of C2 where a commander must appreciate all of the activity occuring at the lower level and construct plans and make decisions. This clearly cannot be considered as simply the sum of the activity at the lower level.

2.4.3 The services and the domains

Any service exists in at least one (if not all) of the three domains. These are attributes of every service. For example, as shown in Table 3, there are (at least) two aspects to the sensing service: Firstly, the sensing service (red oval) is primarily about getting information on the physical environment and agents (both physical and information domains) and understanding it (cognitive domain). Secondly, the sensing systems obviously exist physically, we need information on them. Additionally, it can be argued that cognitive processes exist whish are required to understand these items. One could argue that the first encompasses the second and that is not disputed. However, sometimes it can be useful to think about them separately.

Another example is that of *information warfare* (blue oval in Table 3). Primarily it sits in the information domain, but the effect desired lies in the cognitive domain and there are obviously physical processes that are required for its operation. This can be contrasted with standard physical engagement (green oval).

Table 3 The specific nature of the services within each of the domains.

	Domains		
	Physical	**Information**	**Cognitive**
S	Physical Sensing Systems Physical environment & agents	Info on sensing systems Info on environment & agents	Understanding of sensing systems Understanding Sensing Info
C	Physical systems and processes underpinning cognitive processes	Info systems and processes underpinning cognitive processes	Analyse & Understand Decide & Plan Coordinate & Conduct
E	Physical Engagement Systems Physical influence of env & agents	Info on engagement systems Info on physical effects	Understanding engagement systems Understanding physical effects (and producing psychological impact)
	Physical systems & processes underpinning Info Warfare	Influence the information states of agents (and information on this)	Psychological Impact (and understanding it!)
M	Physical Movement	Info on requirements, status and outcomes of physical movement	Understanding of requirements, status and outcomes of physical movement
I	The supporting information architecture The supporting information processes	Info on information storage & dissemination systems	Understanding of information storage & dissemination systems
L	The supporting physical materials and processes	Information on requirements and status of materials and processes	Understanding of requirements and status of materials and processes

3 Comparison with other taxonomies and frameworks

In this section we will compare and contrast the SSF with other taxonomies and frameworks.

3.1 Network-Based Defence

As mentioned in a previous section, the Swedish Armed Forces developed a generic services concept where they articulated seven services, in two main groupings: Operational Services (which includes C2, Situation Awareness and Engagement) and Infrastructure Services (which includes Interoperability, Net Infrastructure, Transmission, Platform) [7]. Figure 7 show the mapping of services between the SSF (ovals) and NBD (blocks) constructs.

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The main points of difference are:

- There is no direct equivalent of the SSF services of Physical Mobility or Logistics & Support in the NBD framework.
- The NBD describes in greater detail the different aspects of information connectivity which is handled within the SSF by using the domains. T
- The NBD model explicitly identifies platforms. This has been deliberately avoided in the SSF because it does not fit within a truly generic framework.

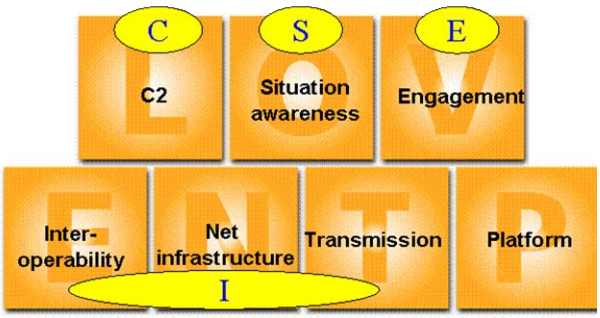

Figure 7 The mapping of services between the SSF and NBD formalisms.

3.2 Generic C4ISR Model

The Defence Science & Technology Organisation (DSTO) has been conducting a study into the integration of the Joint Stirke Fighter into a coalition C4ISR environment. The study team approached this environment by constructing a Generic C4ISR Model (GC4ISRM), as shown in Figure 8, to establish a common language (at the highest level) for the development of Physical C4ISR Architectures for the various areas of operation and Coalition types [11]. While still examining information exchange, they categorise the information in broad terms based upon their functional purpose.

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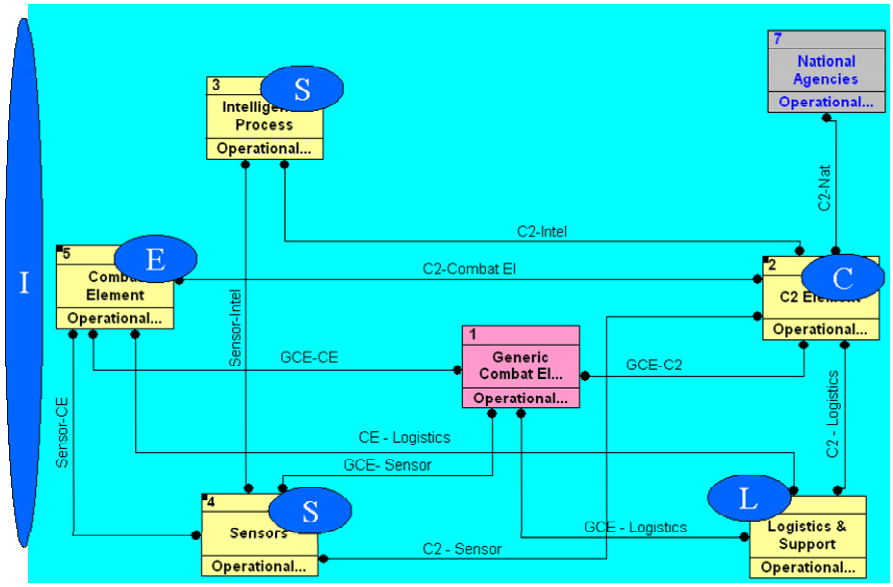

Figure 8 The mapping of SSF services onto the GC4ISRM nodes functions.

A quick examination shows that four of the six services map directly onto individual nodes. The information service broadly maps across the entire architecture since the connections all involve the movement of information, although it does not map perfectly. The only service completely absent is the physical mobility service.

3.3 A distributed networked force

Cares and his colleagues considered the elements of a networked and distributed force [12] and identified six basic functions (Table 4).

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Table 4 The mapping of SSF services onto the functions of elements in a distributed networked force.

Function	Description
Sensing S	Collecting observations of objects within a sphere of competition as well as observations of the environment.
Transport M	Providing mobility for elements that might not have their own locomotion or for elements that in certain cases are more efficiently transported by other elements.
Netting I	Creating the means of information transfer between elements of the system.
Information Fusion and Pattern Recognition	Sharing information among elements for the purpose of collecting observations from sensors, composing informational representations of the battlespace, and determining important patterns within the representations.
Interpretation, Cog C and Decision	Consuming information, deliberating and converting deliberations into decisions.
Influence E	Acting to change physical, informational, or logical states in the battlespace.

In this case, the mapping from service to function is very strong for sensing, physical mobility and engagement. Two services, C2 and information mobility map across the remaining three functions. In this case, the service missing is the logistics & support service.

3.4 Knowledge Analysis Framework (KAF)

Grisogono articulated a framework that linked NCW concepts and EBO [13] (Figure 9). The structure of the KAF is based on layers and transitions, the layers are labelled Effects, Decisions, Knowledge, Information and data (or abbreviated to EDKId), and the significant insight generated by this framework is that C4ISR systems (i.e. Communications, Computing, C2 and ISR) operate in the spaces between the EDKId layers and their roles are to facilitate the transitions. While there are other aspects and systems that play roles as well – eg platforms, weapons and sustainment between D and E, training and experience between I and K, and so on – but what it highlights is where the C4ISR systems are making a difference to effectiveness.

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In examining the KAF in terms of domains and services it can be seen that the KAF cycles progressively through the domains. The transitions between layers map onto four services: C2 information, sensing and engagement. The services missing are physical mobility and logistics & support.

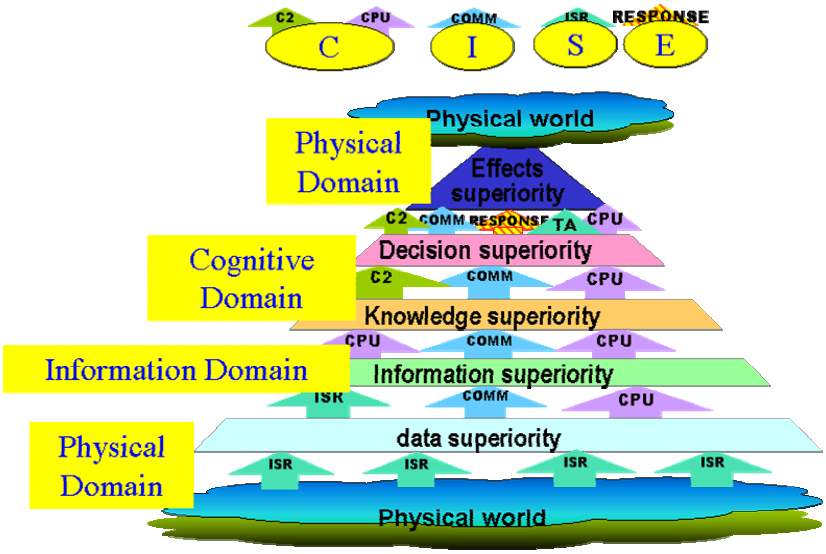

Figure 9 The mapping of SSF services and domains onto the KAF.

3.5 Army Core Skills

In examining concepts Curtis and Dortmans proposed a set of generic and enduring "core skills" that they expect the Army to carry out in achieving their objectives: engagement, information collection, sustainment, communication, protection, movement, and decision making [14] (Figure 10).

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The services map almost perfectly in a one-to-one manner onto the core skill set. Although the specific definitions are somewhat different, there is strong alignment in meaning. The main difference is the added inclusion of protection as one of the army core skills, for which there is no SSF equivalent.

Table 1: Measures (goals bolded) for each skill

	Skill	Measure
E	Engagement	Ability to deliver appropriate and targetted **blue firepower** to disable enemy at an appropriate rate that restricts their ability to operate
S	Information collection	Use of appropriate assets to find and gain **useful information** on the operational environment
L	Sustainment	Maintenance of **operational momentum** through the dynamic use of appropriate assets to distribute resources and maintain capability assets that satisfies operational requirements
I	Communication	Ability to manage and **transfer** information **securely** between units to share **useful information** and enhance the appreciation of the situation
E	Protection	Adoption of strategies to reduce the effect of **potential hazards** to conduct safe military operations in an operational environment
M	Movement	Capacity to relocate units to provide useful **transfer of capability** assets to conduct military actions
C	Decision making	Provision of sufficient wherewithal to make good decisions in the conduct of military operations and thus gain **decision superiority**

Figure 10 The mapping of SSF services onto the identified army core skills

This skill of protection is described is the "Adoption of strategies to reduce the effect of potential hazards to conduct safe military operations in an operational environment" [14]. Under the current formulation of the SSF this is seen as an aspect of engagement (the threat or actuality of engagement protects entities) or an attribute of an entity (armour thickness or stealth technology) where the service cannot easily be extended to another entity.[5]

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It should be noted that the two approaches have been developed for different purposes so it is neither completely useful nor fair to compare them closely. However, the two approaches have several common themes:

- An attempt to use generic terms that are applicable to both the current force and the future force
- A move away from specific platform and asset solutions.
- They capture more than just the information-flow and focus on activities and functions and effects

The conceptual advancements of the SSF over the core-skill set are several:

- They make explicit the relationship between entities
- They are defined and constructed in a manner that allows the aggregation and disaggregation at any scale
- Its connection to NCW concepts is clearer

3.6 Netforce Principles

In an attempt to clarify the debate on Network-Centric Operations (NCO) and Network-Enabled Capability (NEC), Keus developed a modelling framework and introduced "elementary netcentric principles" from which the higher-level NCO and NEC concepts could be constructed and derived [15] (Figure 11). These elementary principles have a striking similarity to the categorisation of information flows posited in the JSF Generic C4ISR model and also have significant commonality with the basic services proposed here.

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Keus has made an attempt to build a very detailed design framework for NCW that categorises the nodes and interactions and goes further to explore the dynamic properties of networked forces (described in the paper as functions and services).

Some common features between the Netforce Reference Model (NFRM) and the SSF are:

[5] While the service of protection does not currently exist in the current formulation of the SSF, there is currently a debate amongst model developers and users whether it could usefully be included.

- The identification of generic elementary building blocks
- A capability to consider both legacy and NCW force elements
- A recognition of the usefulness of nesting in providing a scalable framework

The fundamental conceptual difference between this approach and the SFF is that the NFRM concentrates on actions arising from network information flows. In doing so, it has apparently ignored or diminished the role of physical movement. In addition, the SSF more transparently grounds itself in the NCW concepts of grids and domains. However overall, the Netforce model and the SSF appear to be compatible constructs that can illuminate different aspects of the NCW force design problem.

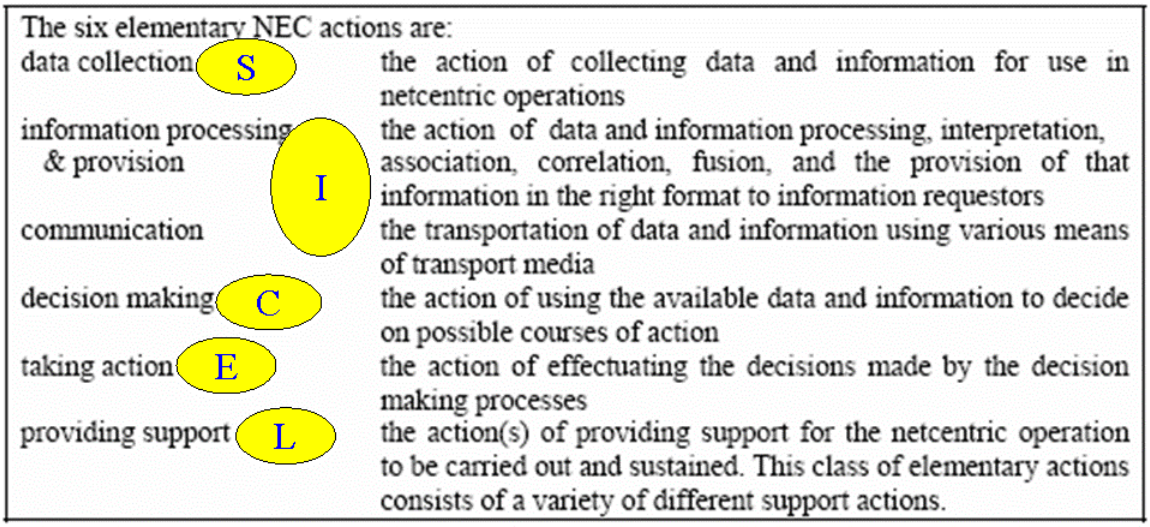

Figure 11 The mapping of SSF services onto the Netforce elementary NEC actions.

3.7 Department of Defence Architecture Framework (DoDAF)

While not directly comparable, it is worthwhile to briefly examine the relationship between an architecture framework (AF) like the DoDAF and the SSF. An AF is a tool used for designing and developing large enterprise systems, typically information systems. The DoDAF uses four views that logically combine to describe an architecture: the Operational (OV), Systems (SV), Technical Standards (TV) and All (AV) views. The framework provides direction on how to describe architectures in great detail. However, it does not provide guidance in how to build or employ a specific architecture or how to develop and acquire systems.

Our perception is that the SSF seems to capture several of the different views simultaneously through a single lens but at a high level of abstraction. It includes aspects of both operational and systems views, and if considered desirable, could include aspects of the technical views. It “expands” the views by looking beyond the focus of IT systems, information and its exchange but also simplifies by utilising a minimal set of concepts. It is done at a high conceptual level but with prescribed standards of description. Furthermore, the SSF is useful in the process of developing systems.

This is not to say that the DoDAF is still important and necessary for good enterprise design. The SSF is an additional tool that both provides a technique to distil the important aspects of relationships between systems and be used by managers at all levels to ensure consistency and coherency in capability development.

4 Application

4.1 Illuminating Provider-Consumer Expectations

The framework is potentially useful in highlighting inconsistencies of expectation between capabilities. This is helpful when managing the coherency of the whole networked force.

Specifically, in the capability development process, it can be used to track the whole-of-force relationships. This is done by individual capability managers listing the services their capability exchanges (provides and consumes) with other capabilities. The result are two tables as shown in Figure 12:

- The provider-only-view table
- The consumer-only-view table

Comparison of these two tables identifies inconsistencies. There are four basic types of comparison:

- Agreed service exchange
- Agreed null service exchange
- Inconsistent service exchange – only identified by the provider
- Inconsistent service exchange – only identified by the consumer

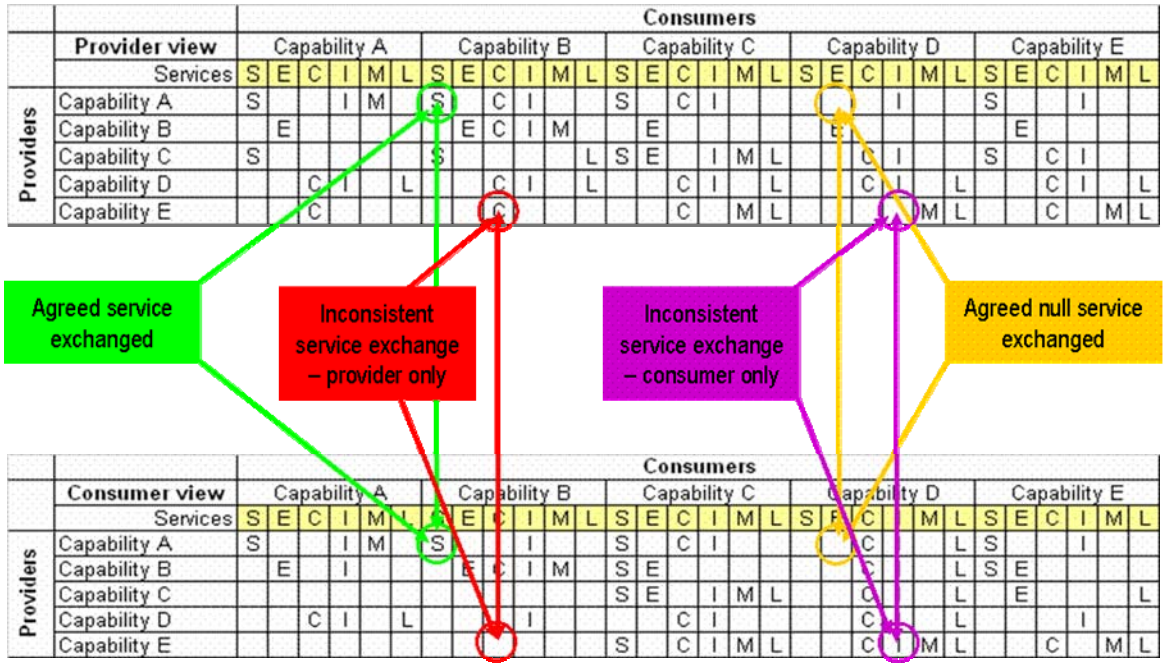

Figure 12 A comparison of the provider-only view and consumer-only view and the inconsistinecies that can arise

These two tables may be merged and the information displayed in a single table (Figure 13).

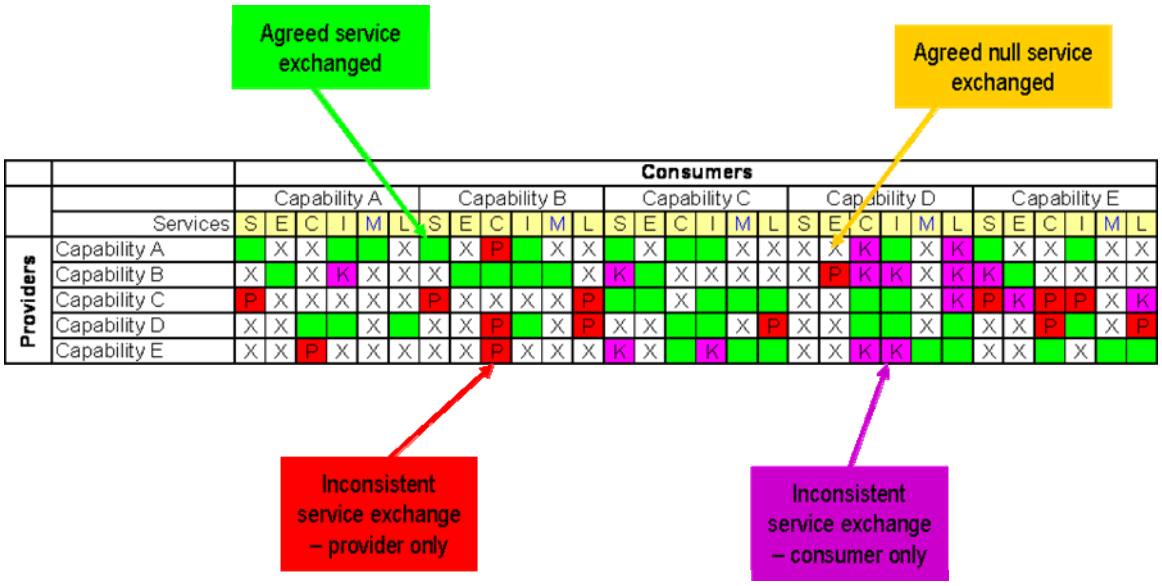

Figure 13 The combined table showing the consistency and inconsistency in expectations of providers and consumers regarding their relationships.

For example, the matrix for the exchange of sensing services may be constructed as shown in Figure 14. This matrix shows only the sensing relationship between 16 capabilities.

Capabilities C&D are similar service providers and consumers, so will be examined in more detail together. From the perspective of Capabilities C&D, they are expected to both provide and consume significant sensing services. However, not all other capabilities agree with the service exchanges indicated. This requires resolution by the capability managers.

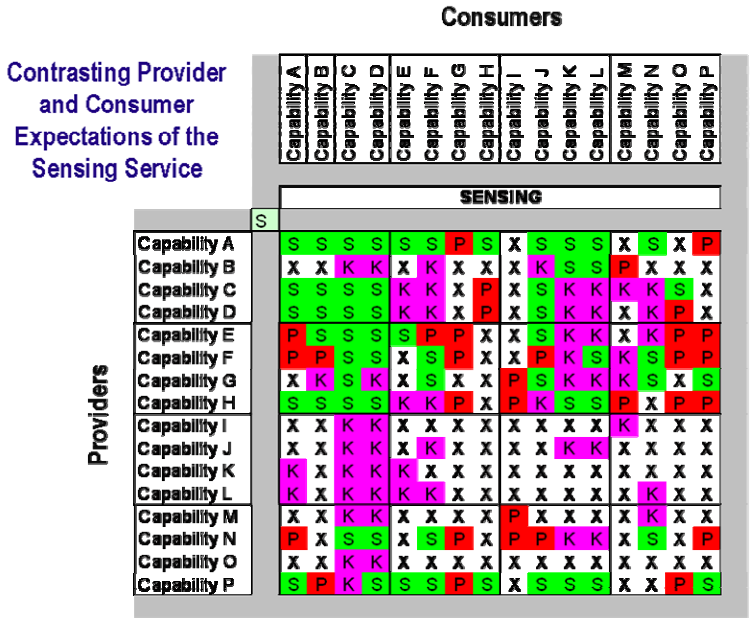

Figure 14 An example of a provider-consumer service exchange expectation table for a sensing service.

This matrix can also be used for impact analysis. For example, if capabilities C&D were not available, this obviously has an impact on other capabilities (Figure 15). If they are not available as a provider, a number of capabilities need to find alternatives for the service they were expecting. If they are not available as a consumer, a number of capabilities may be allowed to change their requirements since they no longer need to provide that service to those capabilities).

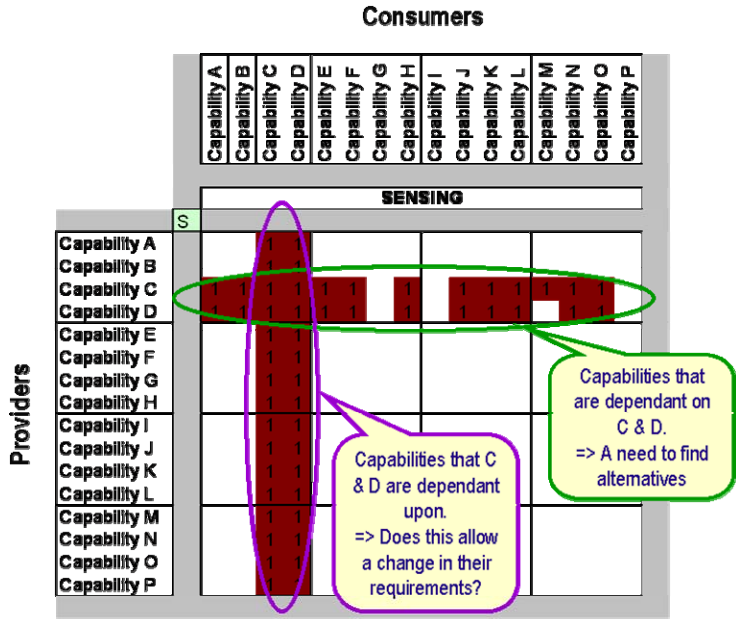

Figure 15 The potential impact of the removal of capabilities C&D

Finally, the framework is potentially useful for finding possible alternatives of service provision. Since we already have the full service exchange matrix, we can quickly look at the other capabilities that provided a similar service (Figure 16). The questions to be asked are:

- Could any of them (or combination of them) provide the same services provided by C&D?
- Could any of them be modified to provide the same services provided by C&D?
- If not, what do we need to introduce to the system?

While this obviously requires a more detailed comparison of the sensing services provided, it is a good starting point.

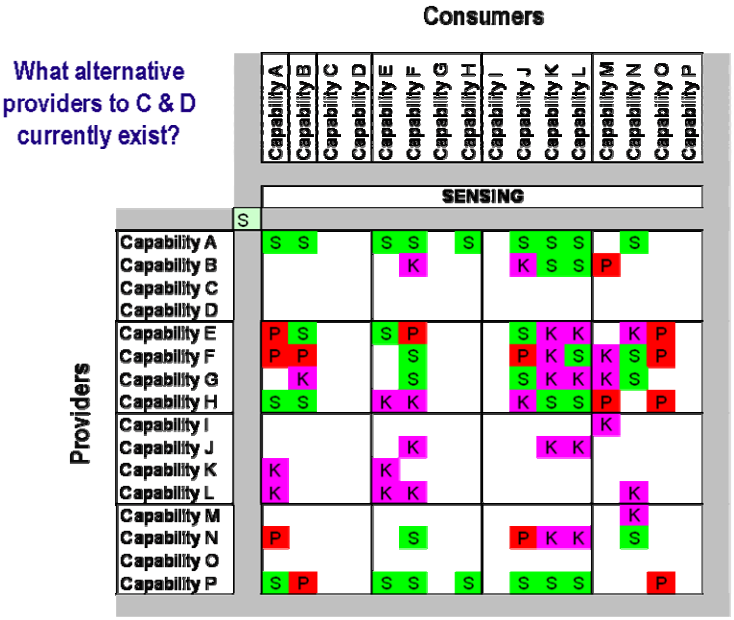

Figure 16 Showing the alternative providers of a sensing service to capabilities C&D. It does not show if the quality of service is the same.

These examples show that this framework has the potential to be a high level tool for decision-makers. Not only is it a tool that permits broad, high-level views of the state of linkages between capabilities, it is useful from the perspective of the local capability manager. The benefit of providing a consistent language for capability relationships is that it potentially enables problems to be solved locally providing a collectively better solution in the manner of the "Wisdom of Crowds". It also means that senior capability managers can concentrate on larger issues of particular importance and the enterprise-wide issues.

4.2 Mission Capability Packages

The importance of the concept of the Mission Capability Package (MCP) is exemplified by the comment in the 2001 Department of Defense Report to Congress on NCW:

> "The notion of a Mission Capability Package (MCP) is central to the development of NCW capabilities." [16]

Deleted:

A MCP is described as consisting of "an operational concept and associated command concepts, doctrine, organizational arrangements, personnel, information flows, systems, materiel, education, training, and logistics; that is, everything needed to make the concept work in an operational setting" [17]. In short, a MCP is composed of a purpose, associated tasks and candidate resources or in other words, all of the requisite entities, linkages and activities required to produce an operational-level effect.

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Often, the starting point is a traditional one: "What are the platforms and assets available that will comprise this MCP?". However, this is only one aspect of the MCP. The SSF enables the consideration of relationships between entities, the entities that contribute to the final operational effect and the activities and resources required to initially field individual entities. It does this at a high-level of abstraction, so the decision-maker doesn't get bogged down in details, at the same time highlighting major gaps and problems.

For example, consider the operational effect of Strike which could be described as 'the neutralisation or deterrence of the use of a key adversary strategic capability'. The candidate list of assets might look something like that given in Table 5 below.

Table 5 List of assets compringing the MCP to conduct Strike.

Sub-surface combatant	Combat Aircraft 1	Tanker
Surface Combatant	Combat Aircraft 2	UAV
Helicopters	Surveillance Aircraft	Missile

Initially, one can consider the whole package simply using a single SCMILE block diagram to represent the MCP and identifying the main contributors of services within the MCP (Figure 17). Already it is exposing the fact that information mobility has not been considered fully and that the entities providing these services need to be identified. It also shows that there are two main capabilities that can provide the operational effect, while the remaining capabilities are primarily involved in enabling that final effect by working together.

Asset	Engage	Sensing	C2	Info Mob	Phys Mob	Log & Supp
Sub-surface combatant					X	
Surface combatant	XX					
Helicopters					X	
Combat Aircraft 2	X	X	X		X	
Tanker						X
Surveillance Aircraft	X	X	X			
Combat Aircraft 1	X	X	X		X	
Missile	XX					
UAV		X				

XX	Operational Effects
X	Tactical Dependency Effects

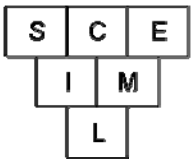

Figure 17 A table showing services that produce tactical effects as well as the services that contribute the majority of the operational effect for the MCP.

If that is insufficient for a decision-maker to fully understand the properties of the MCP, one can go further to explore the explicit relationships between entities. In this case, the specific services exchanged between entities are identified (as shown in Figure 18). This allows a quick understanding of the impact of removing particular entities from the MCP.

Provider-Consumer Table	CONSUMERS: Sub-surface Combatant	Surface Combatant	Helicopters	Combat Aircraft 2	Tanker	Surveillance Aircraft	Combat Aircraft 1	Missile	UAV	Operational Effects
PROVIDERS: Sub-surface Combatant		M								
Surface Combatant										E
Helicopters		M								
Combat Aircraft 2			E		E	E	E	SCM		
Tanker				L			L		L	
Surveillance Aircraft	E	S					S			
Combat Aircraft 1						E		SCM		
Missile										E
UAV		S	S	S	S	S	S			

Figure 18 A table showing the specific tactical service exchanges as well as the services that contribute the majority of the operational effect for the MCP.

This can also be represented by a network diagram as shown in Figure 19. While not simple to use visually, it can be examined using network analysis tools and techniques to identify vulnerabilities and robust features of the network.

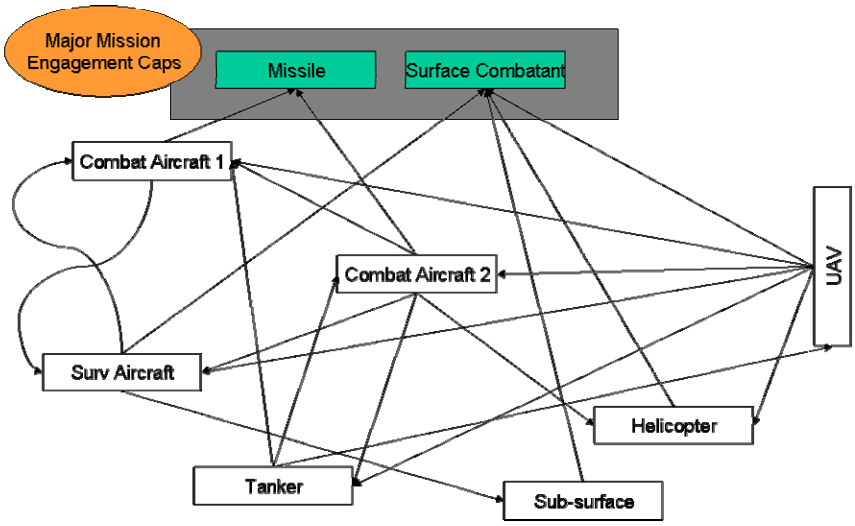

Figure 19 A network model of the service exchanges given in Figure 18.

Additionally, each capability/platform/entity can be described in terms of a SCMILE block diagram (Figure 20). This focuses on internal service provision and the services required to field the capability in addition to the services already articulated as part of the specific MCP.

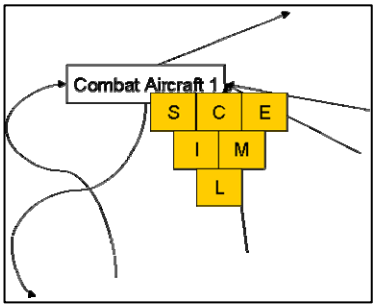

Figure 20 The consideration of the services implicit in fielding a capability to be an element of the MCP

For example, Combat aircraft 1 have physical mobility sub-systems (engines) that need to be maintained, engagement systems for self-protection (weapons) that need to be serviced and operational and C2 systems for analysis and decision-making (pilot, automated systems) that need to be trained and perhaps pre-loaded with information. By considering all of the blocks a high-level but relatively complete picture of a capability can be drawn in generic (leading to specific) terms. This can be done for other individual capabilities if it is warranted for the decision to be made.

In summary, by encompassing all possible relationships between capabilities, the SSF allows the dependencies between capabilities to be explored consistently and coherently. The high-level description can identify major gaps in the MCP. It also provides an auditable and traceable description of the understanding of the composition of an MCP and how its basic operational concept achieves an operational effect.

5 Conclusions

A conceptual framework, called the SCMILE Services Framework (SSF), has been introduced that provides a simple but powerful lens with which to view interoperability and the complex relationships of a networked force. It is generic so that it can equally apply to a legacy force and a future networked force and thus can also be used in transitioning between the two. It removes the focus from assets and platforms only and beyond just information flows. While similar constructs and taxonomies have been developed previously, it is argued that the SSF is a more coherent and complete (while remaining concise) concept with clear

links to the NCW concepts of grids and domains. The utility of the SSF to the design and development of the NCW force has been displayed. In particular, the SSF offers the following benefits:

- It has fractal-like properties to permit scaleable analysis and solutions.
- It provides a high-level construct for viewing enterprise-wide relationship issues in a gestalt fashion and also allow the examination of particular issues.
- It consists of a simple set of relationships that permit first-level problem-solving at the local level.
- It provides a clear link between the elements of a mission-capability group, their relationships and its concept of operations.

5.1 Future Work

While showing some early promise, the development of the SSF is still at a relatively early stage. Additional work needs to be done to refine the concept and apply the framework in further situations to test its robustness and utility.

In particular, the utility of describing services at the next level down or "second level" needs to be investigated to determine whether this level of fidelity adds positively to the framework or the additional detail detracts from the simplicity. As has been mentioned by other researchers (Hall, Keus) the "Quality of Service" (QoS) is an important characteristic to define. It provides the details that may be required to solve problems of a technical nature.

It may be useful to develop a taxonomy of services at all three levels, (Strategic, Operational and Tactical) and the relationship between them. This would permit a deeper understanding of how tactical issues contribute to operational and strategic effects (and how strategic and operational activity can be partially decomposed into lower level activities).

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