Multi-Method synergies empower complex capability development

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Abstract. DSTO conducted a capability development exploratory activity for the Philippine Coast Watch South initiative. The purpose was to help the participants to understand, analyse and evaluate their user requirements and the current status of their capability design. We brought together three complementary methods to explore the problem space: an Engle-Matrix Game, a C4ISR architecture workshop and a simulation-based wargame. The approach was beneficial for all participants. It enhanced their understanding of operational complexity and capability development issues. It also equipped them with the ability to ask the right questions and tackle the challenges themselves. This paper describes the exploratory activity, the three methods, the synergies experienced in applying the methods and the effect experienced by the Philippine delegation and by DSTO.

Introduction

The Australian Defence Science and Technology Organisation (DSTO) conducted a capability development activity to assist the Philippines in the establishment of their Coast Watch South (CWS) initiative. The activity was conducted at the Joint Decision Support and Simulation Centre (JDSSC) [ADM] in Canberra 23-27 June 2008. It resulted from a request by the Australian Defence International Policy Division to provide assistance under the Defence Cooperation Program. A US Coast Guard representative also attended.

The establishment of an effective CWS capability in the southern Philippines is an imperative to counter the very real threats to law and order and national security in this region. The activity aimed to assist the Philippine delegation in understanding the complex issues associated with establishing such a capability and the approaches that could be used to address the challenges.

The DSTO team's approach was to engage different sorts of people and to view the problem space from different perspectives. The aim was for the activity to be a “discovery experiment” [Albert and Hayes]. The activity was also to be participative for the Philippine delegation.

First the rationale and composition of the exploratory activity are discussed. This is followed by a description of the activity preparation, the three core methods and a discussion of their results and their synergies. The paper concludes with a summary of the benefits of the exploratory activity.

Overview of the Exploratory Activity

The CWS capability will be a complex sociotechnical system, a System of Systems (SoS) [Maier] that has to fit into a larger national security system. It is an open system that has to operate within a changing context comprising national and international organisations both military and civilian.

With such a challenge, it is appropriate and necessary to apply methods that are suitable for exploiting and bringing together multi-disciplinary domain knowledge. The methods need to bring together the domain expertise of clients, operators and scientists/engineers [Jakobsson, 2002]. As illustrated in Figure 1, a two-way knowledge transfer is required to successfully address both cultural values and structure to achieve a successful capability design [Kline, p 140].

Kline describes that in the human design process we need to iterate between finding structure and finding values in order to find an acceptable and possibly successful design. Further, he shows that a multi-disciplinary approach is necessary when dealing with sociotechnical systems for which a single discipline struggles to supply adequate systems representations. The methods and other elements combined during the exploratory activity were selected for their utility in engaging people at different levels of thinking and from different disciplines.

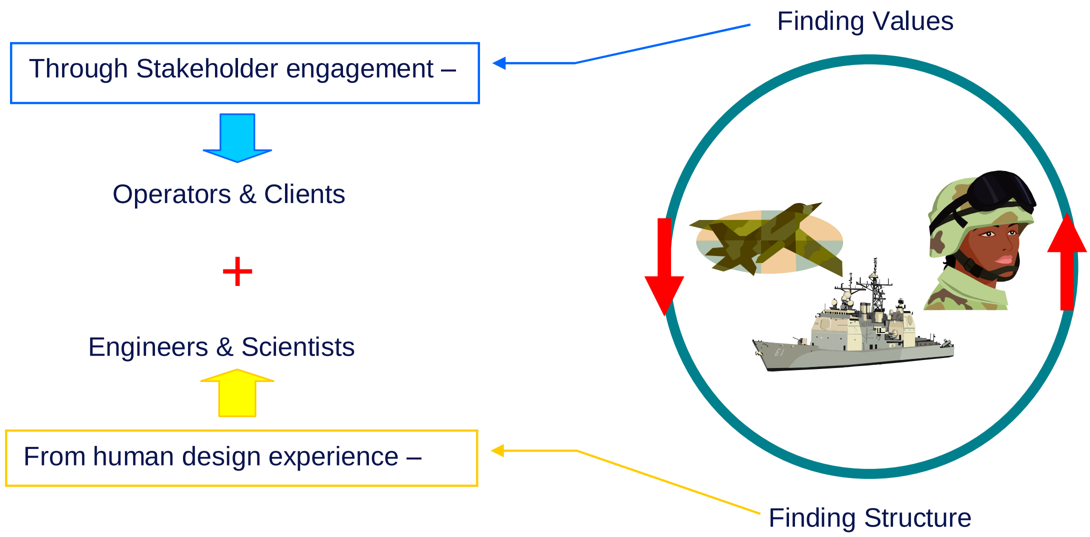

Figure 1 Interactions in the human design process.

The core methods of the activity program were:

- an Engle-Matrix Game, a freeform role-playing session [Engle] ;
- a C4ISR[1] architecture workshop, the structured capturing of the relationships between units, activities and information [DODAF]; and
- an exploratory simulation-based wargame, a computer simulation with first-person control and visualisation of units.

These three methods were linked using a common scenario context. Together, they allowed the problem space to be viewed from a number of different and complementary perspectives. The perspectives included: structured and free-flowing; experiential and conceptual; broad and detailed; technical and social.

Table 1 lists the sessions in the CWS exploratory activity program along with their characteristics and purpose. Figure 2 shows the flow of the activity program. The activity program commenced with a discussion of client challenges, conducted each of the core methods and concluded with a demonstration of various tools applicable to the problem domain and a wrap-up session. The following sections discuss the preparation and exploration activities in detail.

[1] C4ISR: Command Control Computers Communications, Intelligence, Surveillance and Reconnaissance

Table 1: Exploratory Activity Program

Session	Characteristics	Purpose
Client Challenges	Freeform discussion.	Elicit Client needs and expectations of the activity.
Engle-Matrix Game	Facilitated role play. Some structure. Social. Broad.	Set the context and familiarise participants with the domain. Create a “safe” environment.
C4ISR Architecture workshop	Structured enquiry. Rigorous data capture. Conceptual. Broad and detailed. Technical.	Cover the SoS domain of interest. Establish a common language. Verify and document assumptions about the SoS.
Simulation-based wargame	Experiential. Detailed. Technical and social. Initial conditions set.	Test concepts.
Potential Tools & Wrap-up	Technical demonstration. Freeform discussion.	Demonstrate tools suitable for support of further work. Discuss knowledge gained and possible ways forward.

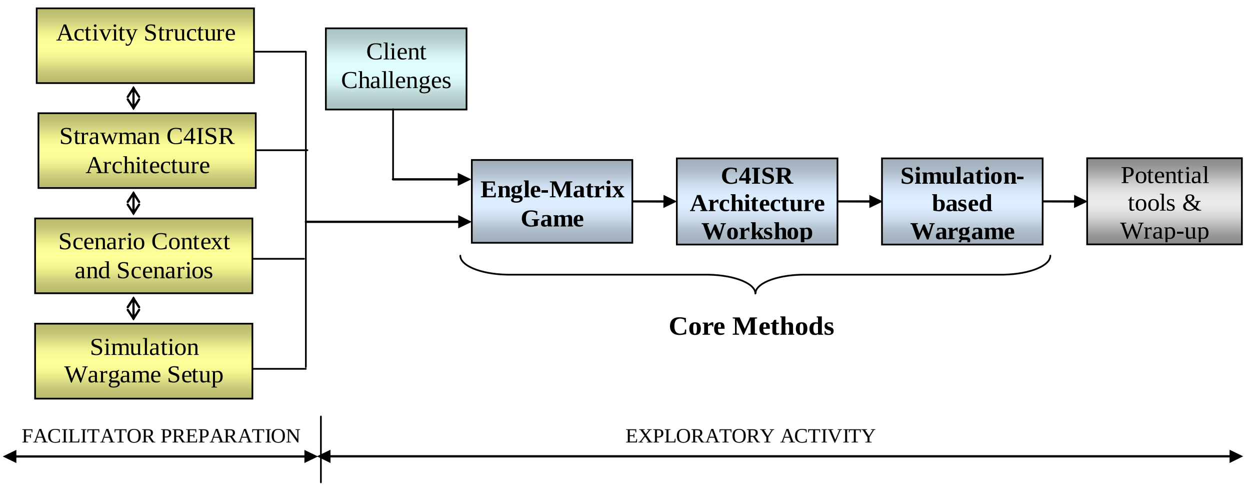

Figure 2 Exploratory Activity Program Flow.

Preparation and Support

The CWS exploratory activity differed to those normally conducted by DSTO in that the participants could not be effectively engaged prior to the activity. Input to the preparation of the activity was limited to an assortment of documentation and a visit to the Philippines by Jamie Watson shortly before the activity was held. However, knowledge of, and experience with Australian Coastwatch operations (now Border Protection Command) was available.

A common framework was developed that consisted of: a scenario context, mission phases, and a strawman C4ISR architecture. This common framework was used to tie together the preparations for the core methods: the Engle-Matrix Game, the C4ISR architecture workshop and the simulation-based wargame. The framework was also used in the development of the tool demonstration. Within this common framework, Figure 3 shows the flow of events used for all of the methods with respect to mission phases and scenario context.

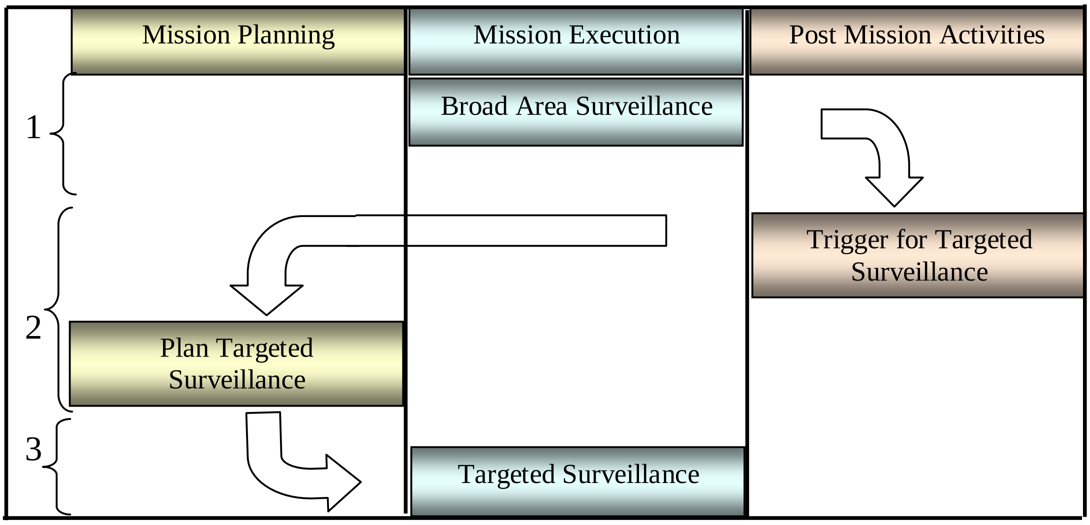

Figure 3 Scenario Context and Mission Phases flow diagram.

Scenario context. The development of the scenario context and the scenarios provided a shared understanding of CWS operations amongst the DSTO team. Their development was based on the CWS documentation provided by the Philippines. The understanding of scenario context proved an important feature, as the details of the scenarios changed during the exploratory activity. The details changed as a consequence of participant input and to facilitate the exploration of subjects-of-interest identified during the activity. The scenario context established the common theme that tied the exploratory activity together and provided a focus for the preparation.

The scenario context followed the mission phases discussed below, and commences with a broad area surveillance mission within an archipelago in the CWS area of operations. Suspicious vessels are detected during routine patrolling over a large area, and this provides the trigger for the next part. The trigger prompts the planning for a mission to conduct targeted surveillance and interception of the suspicious vessels and the plan is then executed. The broad area surveillance and the targeted surveillance were selected to exercise different types of operational activities and roles.

Mission Phases. The identified mission phases were mission planning, mission execution and a post-mission activity phase. The identification and selection of these mission phases were based on experiences from development of an air combat centric Australian C4ISR model for the Joint Strike Fighter C4ISR study [Jakobsson and Vencel, 2005]. The mission planning and mission execution phases are useful for categorising the operational nodes, the activities and the operational information that are required to realise the purpose of the SoS. Sequencing mission execution first, followed by mission planning and then mission execution again elicits motivation and enthusiasm. The participants are immediately immersed in action, the mission planning is provided with a clear goal and a personal context. The second mission execution allows repetition and greater depth.

Strawman C4ISR Architecture. As part of the preparation for the activity, a strawman C4ISR architecture model was developed. The DSTO team internalised CWS domain knowledge through developing the model. However, the strawman was not directly used during the C4ISR architecture workshop. Instead, it provided an anchor for the facilitators during the architectures workshop. It ensured that questions were asked that covered a broad spectrum of the relationships and information flows of the CWS C4ISR architecture. It also ensured that the assumptions about the C4ISR architecture were identified, clarified, socialised and verified during the workshop [Jakobsson, 2005].

The strawman included a substantial representation of the operational node connectivity, the operational activity model and the operational information flow. The depth and extent of the model were realised through extensive reuse of C4ISR domain knowledge acquired during the development of the previously mentioned air combat C4ISR model. Further, the CWS C4ISR model was based on concept projections of the roles, relationships and operational information previously developed for this air combat centric C4ISR Model. This reuse of knowledge from a related domain enabled a detailed strawman to be developed with a relatively modest effort.

The top layer operational node connectivity diagram (OV-2) is shown in Figure 4. The top-level nodes represent the generic role types.

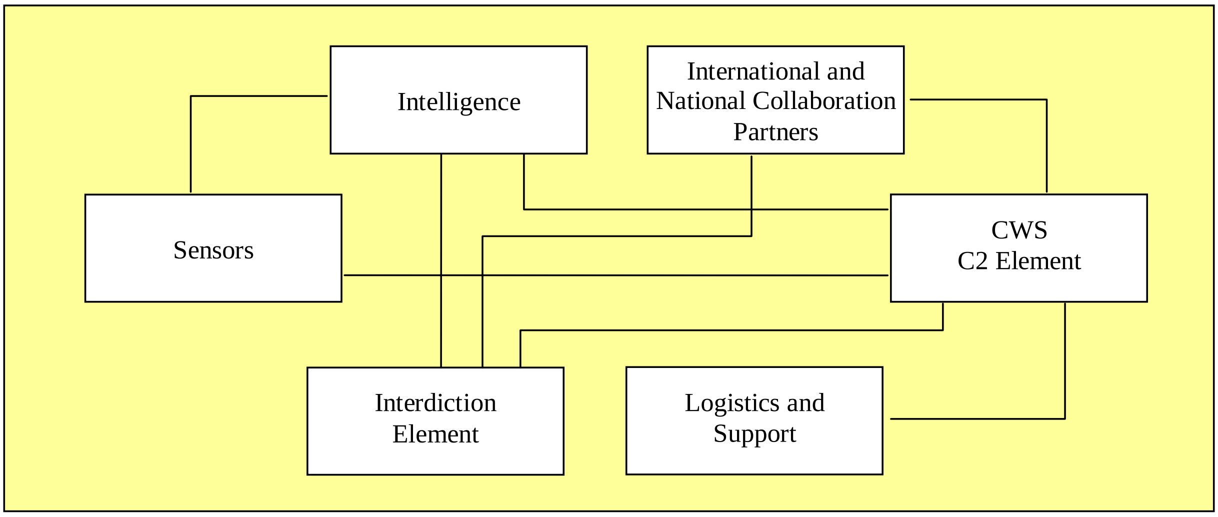

Figure 4 Top-level operational node connectivity diagram.

The CWS operational activity model drew from the mode of modelling (logical functional flow) and the typical military domain Joint Task list [McCarthy et al] that was used in the air combat C4ISR model. To align with the CWS domain the generic top layer of the operational activity model was modified see Figure 5. The activities and their names were mainly sourced from the Philippine's concept of operations document for CWS and from the domain expertise in Australian Coastwatch activities.

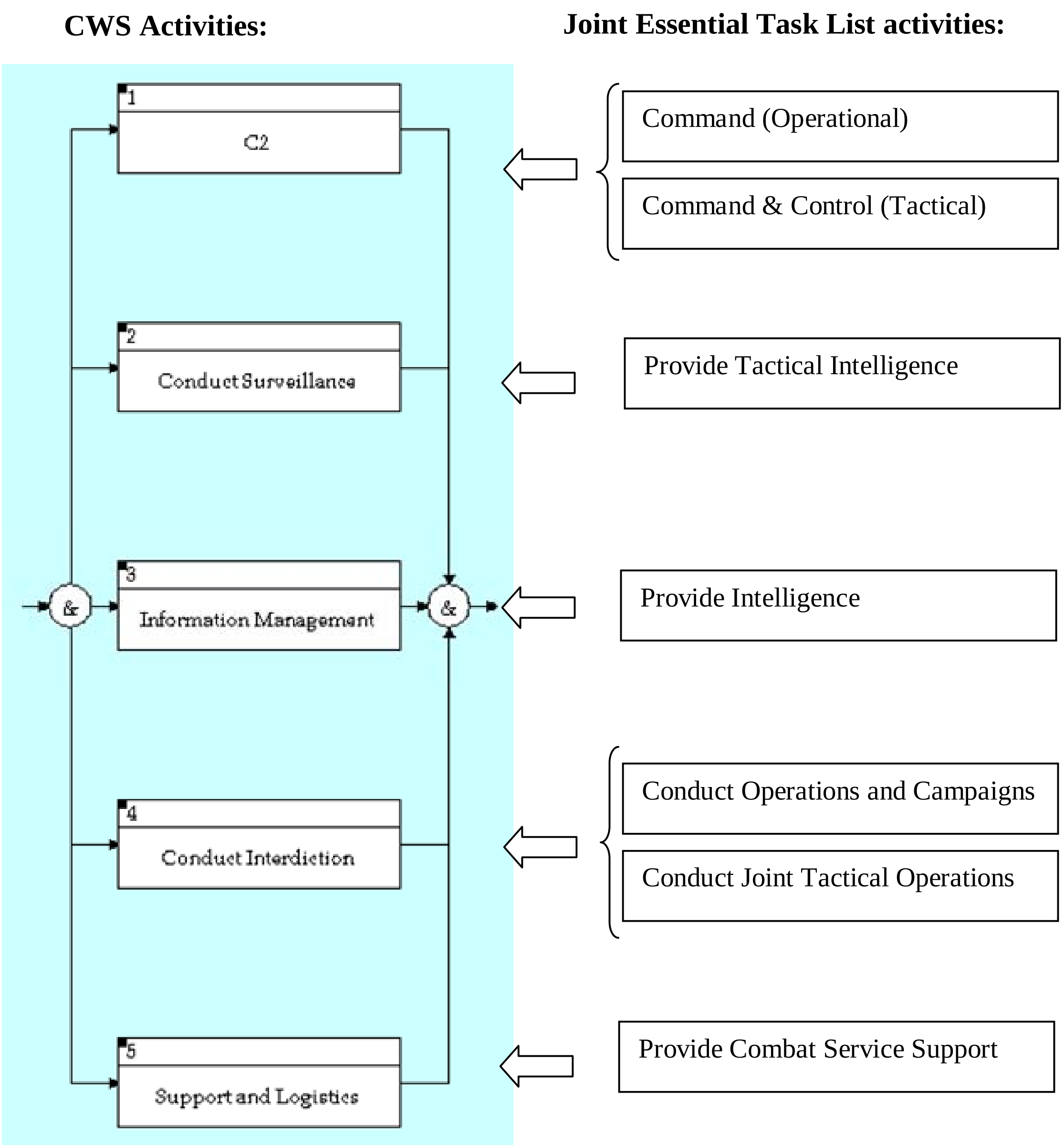

Figure 5 Top-level operational activity model.

For the next level of operational activities, a functional flow block diagram was developed modifying the terminology and the activity diagrams available in the CWS concept of operations documentation. The operational information developed for the air combat C4ISR architecture, related to the Joint Essential Tasks in Figure 5, was mapped as shown in the figure. The operational information was then assessed, modified and utilised as inputs and outputs to the CWS activities. As much as 80% of the operational information was found relevant in the CWS SoS model, with only minor modifications to the operational information definitions. This was significant reuse of previous architectural information from a related domain.

The CORE[2] architecture and systems engineering tool was used to capture the CWS C4ISR architecture .

Potential Tools. To help the Philippine delegation improve their ability to conduct capability development, a demonstration of tools was prepared. The tools were also used to visualise the scenario context and the scenarios and thereby assist in the other preparatory activities. The tools selected support the core methods and the development of a complex SoS and may aid in gaining understanding of complex problems and their representation. The tool demonstration continued to follow the activity framework and presented the tools within context and showed their use in addressing the issues at hand. The tools included a simple range calculator using Google Earth, a Microsoft Excel spreadsheet intercept model, the Falconview Portable Flight Planning Software[3], the General Campaign Analysis Model[4] and CORE[2].

Client Challenges Discussion. As a final preparation for conducting the three core methods and bridging the lack of prior engagement with the Philippine delegation, the exploratory activity commenced with a Client Challenges Discussion. This was used to elicit the challenges faced by the participants. This identified technology and information management challenges. The technology challenges were a dominant topic and focused on sensor and communications requirements. The information management challenges included integrated decision-making, provision of information to decision makers, dispatch of forces, fusion of information, and real-time and long-term information management.

Methods Used and Observations

The methods used during the exploratory activity, the Engle-Matrix Game, the C4ISR architecture workshop and the simulation-based wargame, are described and discussed in this section. We sought to establish that a sophisticated and holistic understanding of the domain was required to develop a complex capability such as the CWS SoS. The use of these three methods was preceded by a Client Challenges Discussion and was followed by a tools demonstration. The flow of the activity program and the use of the methods is as previously described in Figure 2.

The Engle-Matrix Game

The first afternoon was dedicated to the Engle-Matrix Game. The aim of the matrix game was:

- to gain knowledge from the participants based on their experience, intuition, and work to date,
- to help them place their envisaged solutions into an operational context, and
- to introduce the context, the scenarios and some of the roles and activities that comprised the CWS SoS.

The Engle-Matrix Game is a people based method that involves role-play. It is freeform and simple in that it does not require any tools.

Description of method. The technique known as "Engle-Matrix Games" was the basis for the

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[2] Vitech, CORE software, http://www.vitechcorp.com/products/
[3] Falconview, http://www.falconview.org/
[4] GCAM, General Campaign Analysis Model, http://www.spa-inc.net/gcam/

matrix game. Engle-Matrix games are a way of resolving "critical events" in a campaign through the use of "arguments". Each argument consists of an ACTION, a RESULT, and three REASONS. Subsequent arguments in a turn can modify or contradict previously presented arguments. Dice are then rolled to see if a given argument is "IN" or "OUT". In the event that an argument is contradicted or modified by another argument, all the players involved must "roll off" against each other until only one argument remains. Successful arguments are added to the "Matrix" and can form the basis of subsequent arguments. Any player can argue for any side or force within the limits of common sense or the "rules" of the campaign. Other players can modify a previous argument (or its chance of succeeding) in several ways. [Engle]

The Engle-Matrix Game was aided by the use of a map and limited technology. The participants outlined the type of actors within the scenario and were allocated a role for the game. For each turn, the participant playing the role needed to provide information on the argument, evidence and justification, and the outcome of the turn. The facilitator also provided information on how they could continue playing the game and conduct it differently. Note that arguments were resolved by discussion rather than using a dice.

What did the exercise achieve? The Engle-Matrix Game was exploratory in nature and facilitated a greater common understanding between all participants on the nature of CWS operations. The matrix game focused on gaining knowledge from the participants based on their experience, gut feelings and work to date, and helping them place their envisaged solutions into an operational context. The activity created a shared understanding of the domain between the participants and with the facilitators.

During the game, the participants also started to draw out issues with conducting CWS operations. These included command and control; sources of information; triggers for transition between types of operations; and the timescales for action within the area of operations.

The Engle-Matrix Game can be a bit of fun. This contributed to putting participants at ease.

C4ISR Architecture Workshop

The second day was dedicated to the C4ISR architecture workshop. The objective of this workshop was to elicit the participants' understanding of the nodes, activities, information types, need lines, information flows and dependencies. These elements and their relationships were drawn on a whiteboard as the information was gained from the participants. The aim of the architecture workshop was to give the participants a shared understanding of the fundamental elements of the operational architecture, the roles and the activities performed by the operational nodes and the information flow required to achieve the missions.

The C4ISR architecture workshop combined a soft systems approach with a structured and rigorous data capture. The characteristics of the architecture workshop and its outcomes are:

- Broad context - a holistic view of the capability.
- Structured.
- Rigorous using defined relationships [DODAF].
- Expressed into known reference frameworks (eg DODAF products).

The development of architectures requires abstract thinking from the participants.

Description of method. The C4ISR architecture workshop is a facilitated development of the operational node connectivity diagram (OV-2), identification of activities carried out by operational nodes for a particular mission type and the information required in the course of conducting the activities (OV-5). The workshop used three mission phases as context: mission planning, mission execution, and post mission activities. These were further contextualised with the scenario context into three sessions, see Figure 3.

Each session builds on the previous session and the data is collected through the use of an electronic white board and regular print-outs from the white board. Although the workshop starts with a blank sheet, the facilitators have the concepts and categories of understanding from the development of the strawman to provide informed prompting of the participants.

Session 1: Mission execution for a broad area surveillance mission type within the area of operation. In the first session, the focus is to establish the operational nodes that are active within the context of the mission type. In this process the facilitator guides the participants to consider what type of nodes there are, to promote a level of abstraction into roles. For example, the Command and Control roles (CWS HQ), sensor role (fixed radar site or surveillance aircraft), interdiction role (ship). Some activities and information exchanges are identified in this session, but the main output are the operational nodes active during mission execution and their needlines.

Session 2: Post-mission activities and mission planning for a targeted surveillance and intercept mission type. The second session shifts the focus to the post-mission activities and the mission planning. Many of the nodes previously identified are also valid for this context. However, a number of additional nodes are added to the architecture due to the shift of focus. For example, national agencies that provide requests or input to the tasking of CWS surveillance and intercept activities. In this session more information exchanges are identified and the roles of Command and Control (C2) nodes are further clarified.

Session 3: Mission execution for a targeted surveillance and intercept mission type. By the third session most of the nodes are identified and the focus shifts to articulating the activities associated with the mission execution and the targeted surveillance and post-mission activities resulting from a possible intercept and boarding activity.

What did the exercise achieve? The C4ISR architecture workshop captured concepts, roles and activities explored in freeform during the Engle-Matrix Game as well as continuing to complete a broader context of roles and activities. In this activity information exchange requirements were articulated and discussed. Together with the rigorous and structured data capture, the architecture workshop and the architecture model provided a model for thinking about the CWS SoS as a whole. The workshop socialises the basis for a common understanding about the CWS SoS with respect to both its primary functions (surveillance and interdiction) and its support functions (C2, planning, information management, logistics and support). The resultant architecture data base captured this common understanding of the system in a format that can be further discussed, criticised, socialised and updated. The architecture workshop thus provided the participants with an initial structured understanding of the SoS of interest.

The C4ISR architecture workshop helped the participants to appreciate a variety of issues and perspectives they had not previously considered. The inclusion of the architecture workshop between the Engle-Matrix Game and the simulation wargame had benefits beyond simply producing architecture artefacts. It also facilitated structured thinking about the problem and developed the mindset among participants. This allowed alternatives to be explored and different viewpoints to be considered, and provided for a richer and more focused use of the simulation-based wargame.

After the workshop, the information gained was combined with the strawman C4ISR architecture to produce the next version of the draft architecture. This draft C4ISR architecture was presented as part of the wrap-up on the final day of the exploratory activity.

Simulation-based wargame.

The third day was dedicated to an exploratory experiment conducted in the form of a simulation-based wargame. The experiment continued on from the previous sessions with the same mission phases and scenario context. The objective of the exploratory experiment was to test concepts and constructs discovered or illuminated through the previous work. This included the results of Engle-Matrix Game and the C4ISR architectures workshop as well as the Philippine's prior CWS development. The aim of the simulation-based wargame was to provide an experiential immersion into the problem domain. The experiment allowed the participants to try out their understanding of potential solutions, and to see if and how they worked.

The simulation method provides a focused context and the execution of a scenario in real time. The participants have a personal experience playing a role and carrying out activities identified in the architecture workshop.

Description of method. In the exploratory simulation, the participants were given roles within the scenario being simulated. The participants controlled response vessels as well as shore-based radar stations and the CWS headquarters.

Being exploratory, the simulation was not scripted, but was based on providing the starting point of blue force and enemy units, and the route that the enemy units would take. Participants controlled the blue force units, and the game control personnel the enemy units, reacting in response to blue force actions. The simulation software package provided the visualisation of the environment, including simulating and controlling the physics of the situation, such as movement, radar detection, weapon discharge (in response to operator fire control) and weapon damage.

System used. The simulation was conducted using a readily available "hobbyist" maritime simulation software package, Virtual Sailor[5] that allowed participants to control individual vessels from separate networked computers. Another computer on the network provided control of the game. The user community of the maritime simulation software had produced an extensive set of vessel models for use with the software package. This allowed realistic models to be presented for all of the vessels. The scenarios also required fixed shore-based radar stations, and these were achieved by placing vessels on the land masses during game setup.

For the CWS activity four participant workstations were used. Voice communication circuits between the participants were provided to allow them to communicate and interact, using separate software and headsets. Each participant controlled their vessel via the computer keyboard and was presented with a first person 3-D real-time view. A radar display view was also provided, as well as the ability to fire simulated weapons.

What did the exercise achieve? The simulation experiment allowed the participants to apply the concepts explored during the Engle-Matrix Game and the C4ISR Architecture workshop. The participants tested their understanding gained from the previous activities. The simulation-based wargame provided an opportunity for first hand experiential learning.

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[5] Virtual Sailor, Virtual Sailor Nautical Simulation Experience, http://www.hangsim.com/vs/

The experiment quickly demonstrated that there were additional things to consider in the development of a solution. Many issues concerning command and control, roles and responsibilities, situational awareness, communications, doctrine, procedures, tactics and planning were highlighted. The environment meant that the participants themselves recognised the issues and the need to address them. For example, the simulation experiment enabled the participants to identify with clarity the command and control issues and structures they needed to explore further and evaluate in their own experiments. The participants also noted that the first person visual aspects of the simulation provided an awareness of issues related to the physical characteristics and limitations of the proposed platforms.

An important part of the experiment was when the system failed - blue forces were readily and realistically defeated. This event helped crystallise the participants' understanding of the challenges they faced and the need to address them. The consequent understanding expressed was a key event in the activity.

The insights gained fostered the understanding that a solution is about much more than simply listing requirements. The participants also considered that the simulation experiment was an effective tool for explaining the complex issues faced to senior officers and the senior executive, and intended to use it for this purpose.

Results and Discussion

An exploratory activity was conducted, consisting of an Engle-Matrix Game – C4ISR architecture workshop – simulation-based wargame combination and supporting elements as described earlier in Figure 2. It was found to be effective from a number of perspectives. The exploratory activity enabled the Philippine delegation to comprehend the complexity of CWS capability development and equipped them with the knowledge to move forward. It demonstrated to DSTO how different methods can be effectively brought together to facilitate capability development and learning.

Important Outcomes for the Participants. The Philippine delegation provided very positive feedback about the exploratory activity during the wrap-up. They were pleased that they had been afforded the "dignity of letting them do it themselves". They felt empowered to meet the challenges they faced and expressed that they "can't over emphasise the importance" of the activity.

Important results for the participants included:

- an understanding of complexity issues
- an understanding of doctrine and standard operating procedure issues
- an understanding of command and control structure issues
- methods for expressing the issues identified

By combining methods with a common framework, the activity was able to build understanding and ownership by the participants. The participants explored their experience and gut feelings with the Engle-Matrix Game, proceeded to an initial structured understanding via the C4ISR architecture workshop, and then tried it out in the exploratory simulation-based wargame.

This flow of the methods within the activity program had an additional benefit. It meant that when the CWS system was broken during the simulation-based wargame, the participants readily acknowledged the issues, rather than seeking excuses or trying to fault the experiment. The participants understood and accepted that a more sophisticated and structured understanding of the domain was required.

The Philippine delegation felt empowered to develop CWS capability as a result of the exploratory activity. The DSTO facilitators observed that the activity shifted the delegation's thinking from concerns about surveillance equipment specification to concerns about the whole CWS capability. Their consideration turned to how actors such as C2, ISR, and response elements would interact during mission execution activities. The activity also began to establish the actors in mission planning and post mission activities and what information and interaction were necessary during these phases.

Important Outcomes for DSTO. The observation of the authors, who facilitated the exploratory activity, is that DSTO gained an understanding and practical demonstration of how several different methods can be effectively brought together. The authors have experienced an ongoing challenge with explaining complexity to clients. Standard presentations and reports filled with complicated diagrams are often ineffective. In this activity, the immersive appreciation of a situation from several perspectives was demonstrated to be effective for enabling client comprehension of complex issues.

The activity demonstrated how the combination of methods could facilitate multi-disciplinary capability development and enable learning. The activity also demonstrated the benefits of being guided by an underlying framework and remaining flexible in response to emergent factors. The benefits of extensive preparation within a common framework were also evident.

The exploratory activity iterated between structure and values (see Figure 1) and engaged clients, operators, scientists and engineers. The basis for the structure was the strawman C4ISR architecture development. Importantly, this preparation established concepts and categories of understanding for the facilitators that allowed them to guide the participants through a broad *and* detailed examination of the CWS SoS.

DSTO staff also learned a significant amount about the CWS operational domain in a very short time-span, reflecting the two-way nature of the activity.

Participant Engagement. Effective participant engagement was a key contributor to the success of the activity. Important aspects were:

- The enthusiasm of the participants, their interest, open-mindedness, and willingness to learn.
- Establishing trust, which also promoted resilience in the rough patches.
- Providing the participants with ownership of the problem space and also the solution space.
- Providing the participants with an appreciation of different perspectives.
- Empowering the participants with the means to tackle the issues they faced.
- Listening to the participants and understanding their concerns and points of view.

Also of note is that the activity readily overcame language and cultural barriers. There were surprisingly few misunderstandings.

Conclusion and Future Work

DSTO conducted an exploratory capability development activity together with Philippine and US Coastguard representatives. Multiple methods were successfully brought together to address a complex problem. There was a significant shift in the thinking of the Philippine delegation in the matters that were important to the CWS capability. They were shown many different aspects of their problem and felt empowered to face the challenges themselves.

The three methods, an Engle-Matrix Game, a C4ISR architecture workshop, and an exploratory simulation-based wargame, were amenable to being used together in a common framework in the exploratory activity. This enabled the exploratory activity to meet all three aspects of successful learning, namely intellectual quality, significance and a quality learning environment.

The methods were shown to be synergistic and demonstrated the value of:

- a multi-method approach
- an iterative approach with ever increasing levels of fidelity
- architectures as a tool to frame and structure experimentation
- architectures as a means to broaden the perspective of an experimentation activity.
- structured workshops.

The activity made explicit and captured domain expertise from:

- the Australian C4ISR domain
- the Philippine CWS operational domain
- four different cultures

The exploratory activity as a whole expanded our knowledge about methods and how to apply them to complex capability development in order to successfully engage clients, operators and scientists.

Future work. DSTO is planning to use this multi-method combination in a small number of studies engaged in the joint coordination of tactical activities and in the space capability domain. A number of concepts and subsets of stakeholders will be identified for each study and an exploratory activity of 2-3 days duration will be held for each concept / stakeholder group. The intent is to further test this multi-disciplinary combination of methods to explore new concepts in the Australian Defence context.

An important result for DSTO was the learning effect of the combination of methods. The Quality Teaching Framework [NSW Department of Education and Training] presents the characteristics of successful learning: Intellectual Quality, Significance and a Quality Learning Environment. The three methods and the exploratory activity as a whole appeared to exhibit many of the characteristics. Future studies will need to anchor the methods in a learning framework.

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BIOGRAPHY

Åse Jakobsson graduated from Chalmers University of Technology, Gothenburg, Sweden in 1984 with a M.Sc. in the school of Electrical and Electronic Engineering. She worked for Ericsson Radar Systems AB, Sweden, for 10 years including a 3 year posting at DSTO, Australia. Her work included engineering microwave antennas and phased arrays. She worked for AWA Defence Industries from 1994 to 1997 engineering radar warning receivers and defining standard procedures for systems engineering. In 1997 Åse joined DSTO, and has since worked with radar systems, multi-sensor integration, science policy and organisational change, and C4ISR integration. Her research interests are development of complex systems and SoS design and integration.

Gary Bulluss is a DSTO scientist with 25 years of experience providing scientific and professional support to the Australian Defence Organisation. Gary now specialises in bringing together disparate systems to form more effective integrated capabilities. From 1983 to 1995 Gary provided software support for naval tactical systems, and then spent three years in intelligence. Since moving across to DSTO in 1998 Gary has conducted research into systems of systems and architecture practice, as well as undertaking secondments as the DSTO Scientific Adviser to Coastwatch and the DSTO Representative to the joint defence-industry RPDE program. Gary has a B.Sc. from the University of Sydney and a M.Sc. by research from the University of New South Wales.

Jamie Watson joined the Royal Australian Navy in 1988 as a midshipman at the Australian

Defence Force Academy. After graduating with an honours degree in engineering from the School of Civil and Maritime Engineering he proceeded to sea where he served in a number of ships before qualifying as a Principal Warfare Officer. Upon joining DSTO in 1998 he contributed to the research of amphibious operations and was later appointed as the first lead analyst of the Maritime Operational Analysis Centre, during which time he completed a Masters of Technology in Information Systems and Management. In 2007 he set about establishing the Joint Decision Support and Simulation Centre (JDSSC) in Canberra. Jamie maintains a strong advocacy for relevant and informed operations research and has deployed in direct support to operations to both Timor-Leste and Iraq.