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THE FUTURE OF C2

COMMAND AND CONTROL (C2) EXPERIMENTATION FOR COMBAT SERVICE SUPPORT

Lessons Learnt

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Title: Command And Control (C2) Experimentation For Combat Service Support

Abstract:

Networked centric warfare or networked enabled operations are increasingly featured with prominence in defence planning and implementation strategies of leading defense forces around the world. Central to these concepts is network–enabled, knowledge-based war fighting that will enable armed forces achieve greater force optimisation, self-synchronisation, greater flexibility and efficiency of action as well as enhanced speed and quality of decision making.

An integral component of network centric operations is an adaptive and agile logistics capability that will allow combat service support (CSS) elements to project and sustain combat power with greater speed, accuracy and flexibility and to effectively meet the changing logistics demands in the network centric battlefield. As such, there is a need to transform from the previous mass logistics model based on just in-case planning to one with sense and response capability that can deliver logistics on-demand and to provide the necessary congruency between combatants and their logistics supply system.

The Singapore Armed Forces (SAF) conducted an experimentation initiative on information-based logistics. It premised on information centric technology to spin the OODA decision cycle at a faster rate and also to network all distribution entities for a responsive, robust and survivable system. Three key hypotheses were validated: (1) with network centric supply operation, a hierarchical and stovepipe logistics network can be de-layered and configured into a responsive distribution network (2) with asset visibility information readily available, the combatants' needs can be met with customised combat configured load to facilitate a shift in operating concept from a "just in case" paradigm to a "just-right" paradigm and (3) with logistics information pervasively available to all levels of command, the network centric supply model can reduce the OODA decision cycle time with less inaccuracies and errors as well as enhance the span of command and control.

The key performance parameters that were tracked during the experimentation included the demand visibility to facilitate the logistics planning, in-transit visibility of supply units and the nodal assets visibility which are necessary to plan and meet the logistics demands of combatants in a timely manner.

This paper will share the concepts of the experimentation, the strategies of information reach and richness to the various command levels, the observations made during the deployment of knowledge centric logistics system that is integral to network centric operations.

Introduction

An integral component of network centric operations is an adaptive and agile logistics capability that allow combat service support (CSS) elements to project and sustain combat power with greater speed, accuracy and flexibility and to effectively meet the changing logistics demands in the network centric battlefield.

As such, there is a need to transform from the previous mass logistics model based on just in-case planning to one with sense and response (S&R) capability that can deliver logistics on-demand. The S&R capability translate to superior command and control over the entire logistics supply chain from warehouse to foxhole. Survivability of logistics forces is improved with a reduction of deployment footprint brought about by a shift from Just-In-Case to a Just-Right operational paradigm.

Trial Hypotheses

The Singapore Armed Forces (SAF) conducted an experimentation initiative on information-based logistics. It premised on information centric technology to spin the OODA decision cycle at a faster rate and also to network all distribution entities for a responsive, robust and survivable system. Three key hypotheses were expounded for validation during the conduct of experimentation. (Refer to Annex A for more details) These were:

(1) with network centric supply operation, a hierarchical and stovepipe logistics network can be de-layered and configured into a responsive distribution network

(2) with asset visibility information readily available, the combatants' needs can be met with customised combat configured load to facilitate a shift in operating concept from a "just in case" paradigm to a "just-right" paradigm and

(3) with logistics information pervasively available to all levels of command, the network centric supply operation reduces the OODA decision cycle time with less inaccuracies and errors as well as enhance the span of command and control.

Concepts of Experimentation

The current supply chain operation works in an inflexible, unresponsive and sub-optimal environment due to a lack of timely information. In the modern battlefield that is characterised with speed and precision, the current supply system is too slow and too unresponsive to meet the fast pace and dynamic demand of our combatants (see Annex B). With the advent network centric operations, supply elements need to be highly configurable in size and force as well in order to survive. In response to the new operating environment, there is a need to acquire sense and response logistics capabilities for the "To- Be" supply chain which has enhanced flexibility and responsiveness to configure supply operations based on terrain, ground situation and demands vis-a-vis supply picture.

To serve the combatants effectively, the experimentation system was developed to provide a near real time Total Asset Visibility (TAV) of supply, transport and demand picture from warehouse to tactical units. The trial system was extended to different levels in the logistics command chain and provided visibility of the entire supply chain status to enable shorter decision making cycle. Logistics commanders were able to receive coherent information on the status and health of logistics supply under them.

Experimentation Design

The experiment was designed to understand the performance of the transformed supply chain to provide visibility of assets and to collate information to aid decision making. The scope of the experimentation is as follows:

a. Asset Tracking for Operations. The trial system was deployed with the intent to understand the performance and effectiveness of the system to capture and disseminate data in a timely manner. The need for information timeliness in terms of supply status and demand request to meet supply-planning cycle is examined.

b. Asset Tracking for High Tempo Operations. The ability of the trial system to provide for a coherent supply and demand status picture for commander to facilitate better planning and decision making.

Total asset visibility (TAV) capability comprises of three key sub-component capabilities:

a. Demand Visibility – Capture the real time unit consumption during operations to allow for proactive planning for the re-supply before the next mission.

b. In-Transit Visibility – Exchange of information between command centres and supply convoys for the capture of supply convoy status (including on-board stocks) and location. Logistics commanders can command and control the supply convoy to fulfil its primary tasks or to re-direct (in real time) the convoy to meet critical demands as events unfold. Furthermore, commanders can disseminate relevant information (e.g. terrain, plans, etc) to allow supply convoy commanders to make tactical decision to fulfil mission order and to enhance survival rate.

c. Nodal Asset Visibility - Capture of supply status at the nodes, supply units and combat units.

Key enablers identified for the trials are:

Automatic Identification Technology (AIT) – Appropriate AIT such as bar-codes, passive and active Radio Frequency Identification (RFID) are deployed to allow for efficient capture of logistics supply information on the ground

Communication sub-system - A range of communication means are explored to bridge the wide distribution of logistics elements within the area of operations. Tactical VHF radios, satellite communication and general packet radio service (GPRS) are used to communicate between the tactical forces back to the various command levels depending on the area of operation. A communication server is deployed to allow for the routing of information between the various elements

Information System – The system allows for the aggregation of information and allows commanders at various echelons to plan and collaborate on the logistics requirements.

A glimpse of the Asset Tracking System deployed for the experiments is given in Annex C.

Observations/Benefits

Validation of Hypothesis

The trial ATS was able to network the entire supply operation from the strategic level to the tactical levels and allow for the supply chain to be transformed from a stovepipe dedicated supply chain into a one that supported network centric supply operation. All supply entities are inter-connected to provide for a robust, highly survivable supply network that allows for combat configured loads to be delivered to tactical units in a responsive manner.

Command and Control

The in-transit visibility provides logisticians with real time monitoring. Together with two way data communications, logisticians can command and control supply convoys to fulfill its primary tasks or to re-direct them to meet critical demands as events unfold. Logistics planners can share relevant information such as combat service support (CSS) plans, situation picture to allow ground logistics commanders to make good tactical decision to fulfill mission objectives and to enhance survivability. The sharing of in-transit visibility information to commanders vertically and laterally in a network centric manner allows for effective collaboration during the execution of a mission.

Performance Metrics

Improvements derived for some of the end-to-end logistics supply processes are encouraging. Some of the quantifiable improvements includes:

a. Reduction of stocks in the supply chain and a corresponding reduction of supply convoys size and logistics footprint by 30%
b. Reduction of break bulk activities by 60% due to the use of combat configured loads
c. Enhance efficiency by 70%.
d. Increased the reach of dissemination by 40%

Lessons Learnt

One of the crucial components for effective command and control is communications. In order to extend the information reach, an intelligent communications server was deployed to receive messages from the originating consoles, caches and sends the messages to the appropriate recipients. The communication server manages an adaptive point-to-point communication system that leverages on a multitude of communication means (VHF, Satellite communication, and commercial GSM/GPRS services to relay information. This server monitors statuses of the consoles and ensures that no message gets lost, initiates resends as appropriate if a recipient currently not on-line subsequent joins the network. However, the centralised communication server is a potential single point of failure.

Much effort was made to design the Man-Machine Interface (MMI) of the trial system to ensue it remained user-friendly even for the non-technical savvy personnel. Users found the system intuitive, easy to use and learn although feature rich functions were incorporated. The balance of reach and richness continue to be a key design consideration as enhancements are planned. One good feature developed provides logistics elements to correspond via a short message function. This function allows for effective collaboration between commanders/tactical forces and between tactical forces for the finer execution details. During the exercise, tactical forces use the short message capability extensively as it allows plans to be adjusted in real-time when unexpected problems occurred. It complemented the map overlay exchange function well to enhance command and control.

The trial had experimented with basic Sense-and-Response logistics (S&RL) capabilities. The operational concepts with S&RL capabilities incorporated had already shown potential to transform the supply chain to provide agility and responsiveness. The flexibility to practise "Just-in-Case" and "Just-In-Time" supply concepts due to superior situation awareness with lead to greater supply velocity and reduced customer wait time. Higher level logistics commander can deliver supplies before supplies run out or demands are made from the lower level forces as the battlefield scenario changes.

A warehouse-in-the-field capability can be created from the stock status information captured. This Warehouse-In-Field concept allows for small, dispersed and agile logistics supply elements.

Conclusion

The trial system enabled Total Asset Visibility capability as demonstrated during an exercise. With near real time information on assets visibility, the velocity to deliver supply has improved dramatically. The common asset visibility information shared among logistics commanders at various command levels allow for better decisions and shorten OODA loop. On the ground, the transformed supply chain is more agile, responsive and adaptive to meet the changing mission scenario. Total stocks in the supply chain have dropped significantly allowing for reduced operational footprint and consequently ensure better survivability. The experimentation of basic Sense and Response Logistics concept has realised many benefits. The journey to transform the logistics has begun and will continue to derive greater benefits.

Biographies

MAJ Chooi Ker Min is a Army Officer and is the Head of Plans Section, Headquarters Supply and Transport, Singapore Armed Forces. He graduated from the National University of Singapore, majoring in Material Science. He is trained as an Armour officer specialising in the logistics domain. Maj Chooi graduated from Royal Military Academy Sandhurst. He is currently involved in the transformation of Army logistics operations in SAF.

MR LAI YING CHEUNG is the Division Manager of the Joint/Army Tactical C2 Solutions Division in Defence Science & Technology Agency. He graduated from the National University of Singapore, majoring in Communication Engineering. Mr Lai has more than 19 years experience in the area of communication system design, development and project manager. His work experience includes communication system architecture and command and control (C2) information system. He plays an active role in the development of the Army Knowledge Enterprise System (AKES).

MR Joshua Lee is the Programme Manager of Sustenance Command and Control Programme (SUCP). SUCP focuses on tactical logistics business domain and transformational initiatives in the area of Combat Service Support (CSS). Mr Lee has a Masters of Science (Industrial Engineering) and a Bachelor of Engineering from National University of Singapore. He has more than 19 years experience in the area of ground and airborne sensors and Command & Control (C2) Information Systems. He is actively involved in the Army CSS Front End Study and Master Planning and the conduct of experimentation to validate new business processes.

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RESUPPLY PROCESSES AND THE KNOWLEDGE ENABLED LOGISTICS SUPPLY CHAIN

During operations, Supply and Transport (S&T) is responsible to plan and execute all supply and transport support for the Army in the Singapore Armed Forces (SAF). In this role, S&T receives demands from frontline forces, manages the stock level and prepares supplies in warehouses and depots, and allocates transportation resources to deliver these supplies to distribution points. These supplies are subsequently delivered to the lower level forces and ultimately pushed to the frontline troops. Along the supply chain, break bulk activities occur to configure the supply in accordance to the troops' needs.

The modern battlefield is characterized by speed and precision and hence the need for a knowledge enabled logistics supply chain that is based on an adaptive, responsive support networks that is robust, scalable, self-synchronizing and dynamic – Sense and Response Logistics. The trial system was developed to allow S&T to experiment with Sense and Response Logistics. It provided a timely, analysed operational and supply situational picture to facilitate decision making and supply support planning through seamless, instrumented Total Asset Visibility as well as information and communications technology components supporting adaptive force structures, information analysis and knowledge management/dissemination. Logistics commanders have stated their desire for the knowledge enable logistics supply chain. Their needs have been articulated as follows:

a. Near real time situational awareness of supply status within area of operations and the elimination of information blackout window
b. Minimise errors due to man-in-the-loop processing.
c. Near real time update of supply runs to facilitate subsequent planning and execution.
d. En-route loss information should be available to allow for adjustment of supply plans between warehouse to tactical units
e. Ability to configure supply runs for a balance of "Just-In-Case" and "Just-Right" concept.
f. Supply operations can be configured for network centric operations with the capability to provide cross sector support flexibility
g. Reduce supply operation footprint to improve survivability
h. Supply operation should have flexibility to scale and configured for responsiveness depending on demands.
i. Supply operations and planning should be demand driven
j. Customer wait time should be reduced and reliable
k. Demands should be closed looped with Advance Shipping Notification (ASN) to prevent repeated demands
l. Reduce the need to break bulk as it is tedious and time-consuming.

TRIAL HYPOTHESISES FOR VALIDATION

Hypothesis #1:: Networked Centric Supply Operation. With information, the layered and stovepipe nature of current supply operation can be de-layered and be connected into a responsive distribution network to provide effective logistics support.

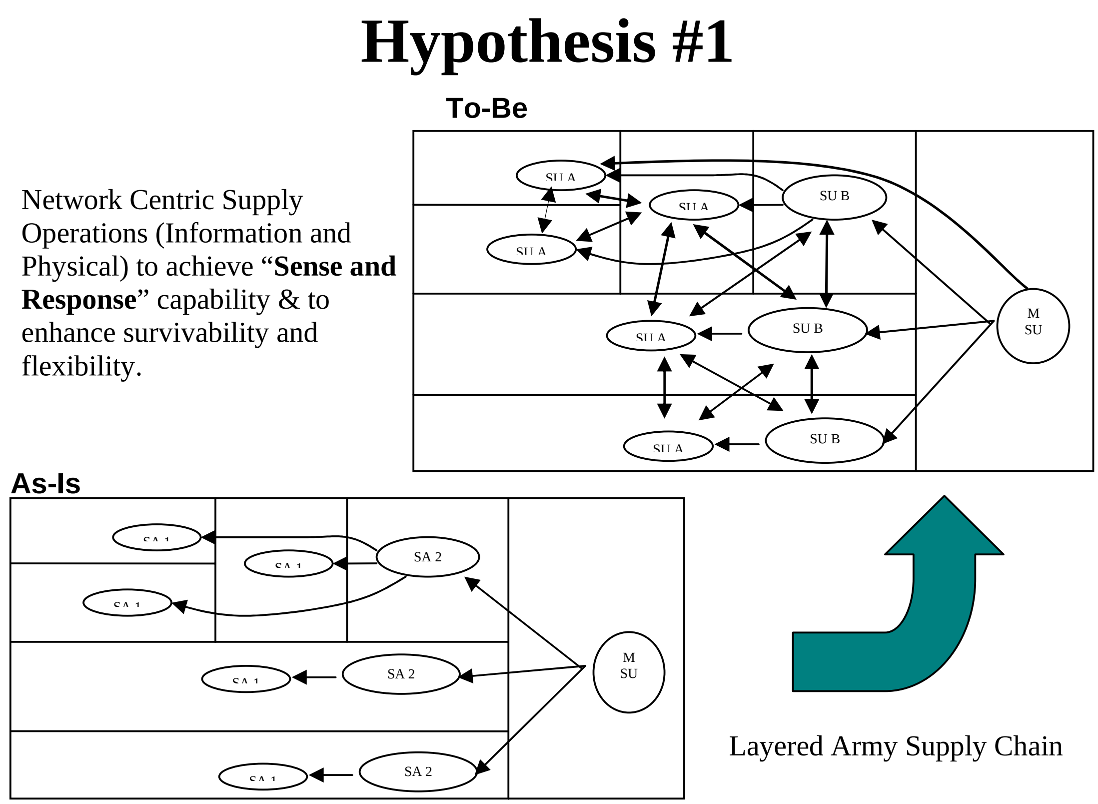

Figure 1: Enhanced Army Supply Chain

Trial Results. During the exercise, all units, who were wired up, were able to provide real time visibility of their own locations and their stock status throughout the entire exercise. Combat units communicated via data communication about their next requirement and when and where to activate the re-supply operation. At the supply units' end, they were able to link up with combat units easily, even when there was a change of locations. Through the trial system, ATS, higher logistics HQ demonstrated the ability to re-route their supply units when required. New overlays were sent to the supply unit, who was on the move, to re-direct it to meet new demands at another location.

Hypothesis #2 : Customised Combat Configured Load. With information, the customers' requirement is better met with customised logistics. It allows a shift of operating concept from "Just in Case" paradigm to "Just Right" paradigm. This, in turn, allows logistics entities to be configurable in size and to be adjustable in route pattern during run to enhance flexibility and survivability. It can also conduct ad hoc re-route if there is an urgent need.

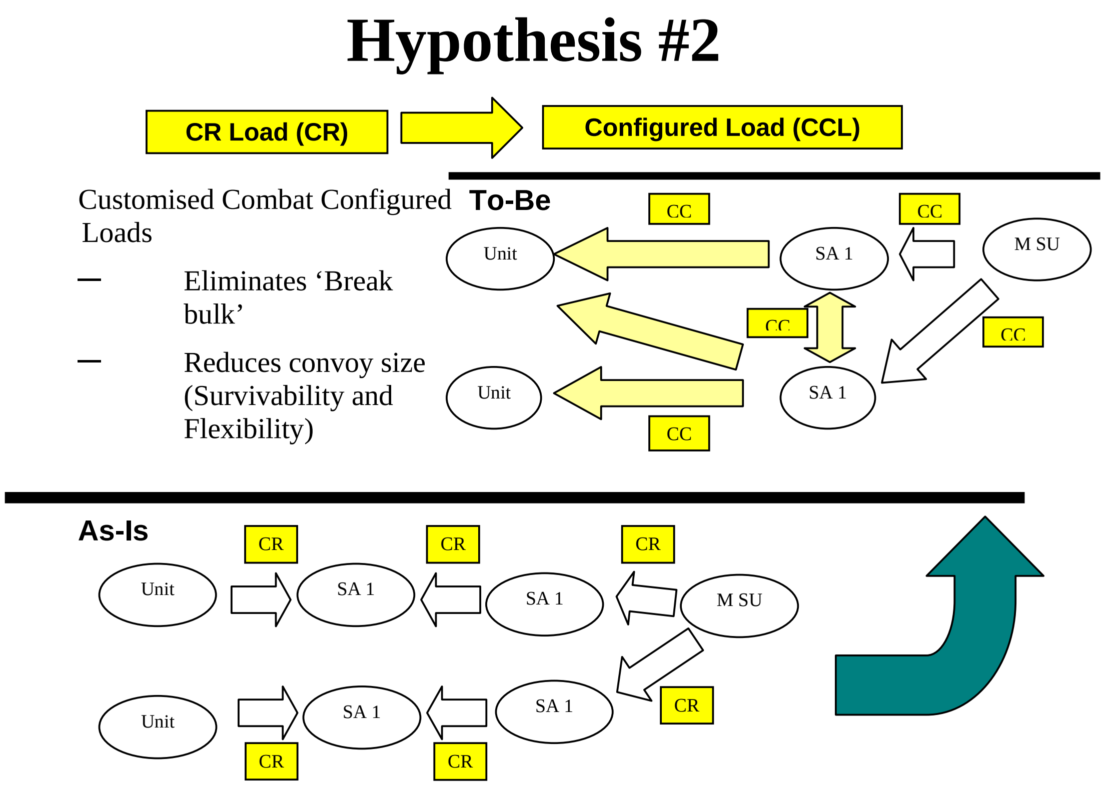

Diagram 2: Combat Configured Load

Trial Results. During the exercise, the unit logistics commander was able to submit his needs for the next 6 hours via ATS. When the logistics commander did not make any request, the higher level logistics commanders were able to monitor the sub-units' requirements and to activate the push promptly. More importantly, the higher level HQ was able to task and configure the load according to the lower level unit needs and pushed it down accordingly. During the supply run, the link-up locations were changed and the information communicated via ATS. The supply unit was able to link up with requesting unit with no difficulty.

Hypothesis #3 : Faster Decision Cycle With Enhanced Command And Control. The networked centric supply operation is able to provide information pervasively to all levels of command. It reduces the time required to collate data or information and it reduces error and inaccuracy. Similarly, higher command is able to communicate and disseminate information to a wide audience quickly. Overall, this allows logisticians to spend more effort and time on crisis management and command and control to enhance mission success.

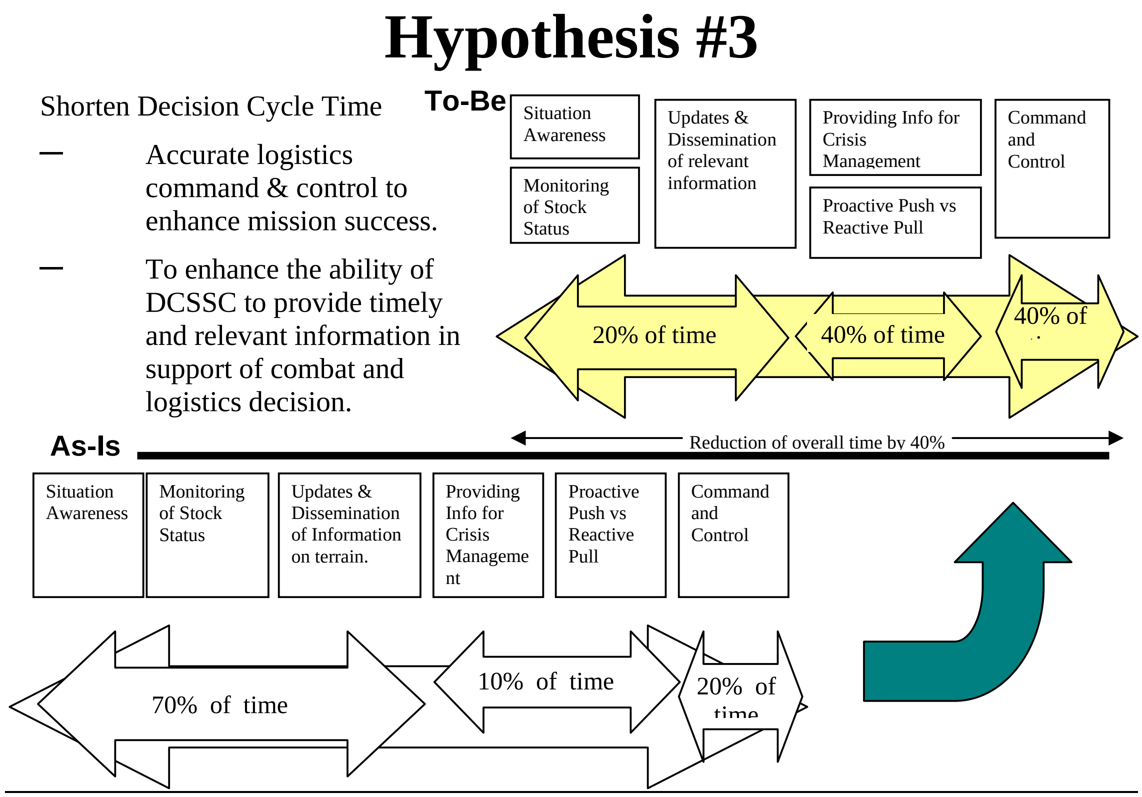

Diagram 3: Shortened Decision Cycle

Trial Results. Higher level logistics HQ was able to collate stock status data instantaneously and were able to disseminate information and updates not only to sub units HQ but sub unit executing arms like Company Commander and Platoon Commander. The process is near real time and it allows logisticians to spend more time on command and control and execution to meet demands. Information obtained facilitated faster decision making for logistics operation to support combat operation. Overall, the entire decision cycle was shortened.

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ASSET TRACKING SYSTEM

The Asset Tracking System (ATS) was developed for the experimentation initiative to explore the concept of network centric logistics operations that allowed combat service support (CSS) elements to project and sustain combat power with greater speed, accuracy and flexibility.

The system consists of two main modules, supply tracking module and vehicle tracking module.

Supply Tracking Module (STM)

The supply tracking module consist of the following components:

a. A logistics server to keep track of all assets tracked and transactions carried out together with a logistics status dashboard
b. Lap-tops, In-vehicle units (IVU) and RFID/bar-code handheld to facilitate tracking of assets.

A web-based logistics hosts the asset tracked and transaction databases. The stock transactions from the deployed consoles are forwarded to the server via the communication server. The server application would analyse and correlate the information received and present it in an intuitive and easy to understand manner so that it could assist the commander to better react to change and crisis management. Users would be able to query the database using a browser.

Logistics Status Dashboard

The dashboard was a data fusion engine installed at the logistics server. The main functions were to filter all the reports submitted by the consoles and present the information in a format that was easy to read and understand.

The dashboard shows the current holdings for all mission critical equipment with the allocated quantities concurrently to allow commander to know the unit's ability to sustain the next phase of the mission. With this inherent capability, the commanders are able to allocate more time to derive superior support plans to enhance mission success.

The dashboard fusion engine eliminates the need to manually compile stock status updates from sub-units. Some of the capabilities of the dashboard is figures below:

Figure 1: Demand against Time view

Figure 2: Consumption against Time view

Stock Status Report

Stock Status allows users at the various levels in the supply chain to monitor their stock details and co-ordinates the re-supply run for all the units.

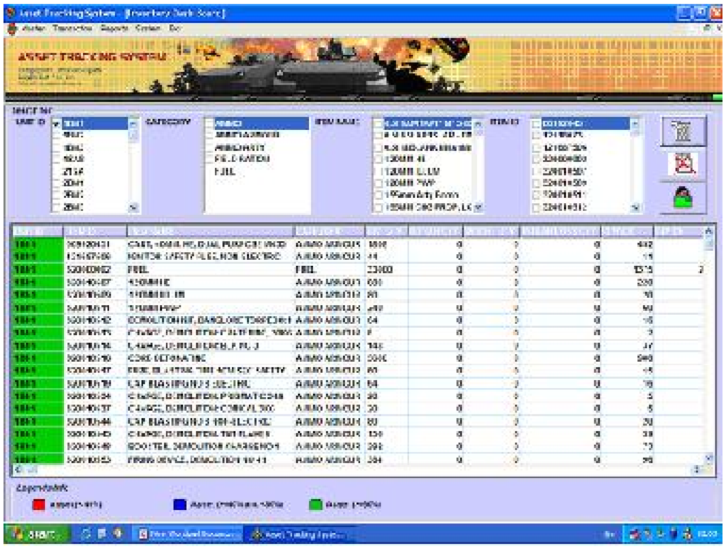

Figure 3: View of the Stock Status report

In-Vehicle Unit (IVU)

An In-Vehicle-Unit (IVU) was a custom designed computer and communication console for installation in the vehicles. It was designed to withstand the vibrations and shock when the supply vehicles travelled in the exercise training terrain. It comprised of a touch-screen LCD monitor, a GPS receiver, an Iridium satellite phone, a GPRS transceiver and a short-range voice radio. Two heavy-duty 12V batteries that could last for about two days power the entire unit. The batteries are designed to be charged by the vehicle when on the move.

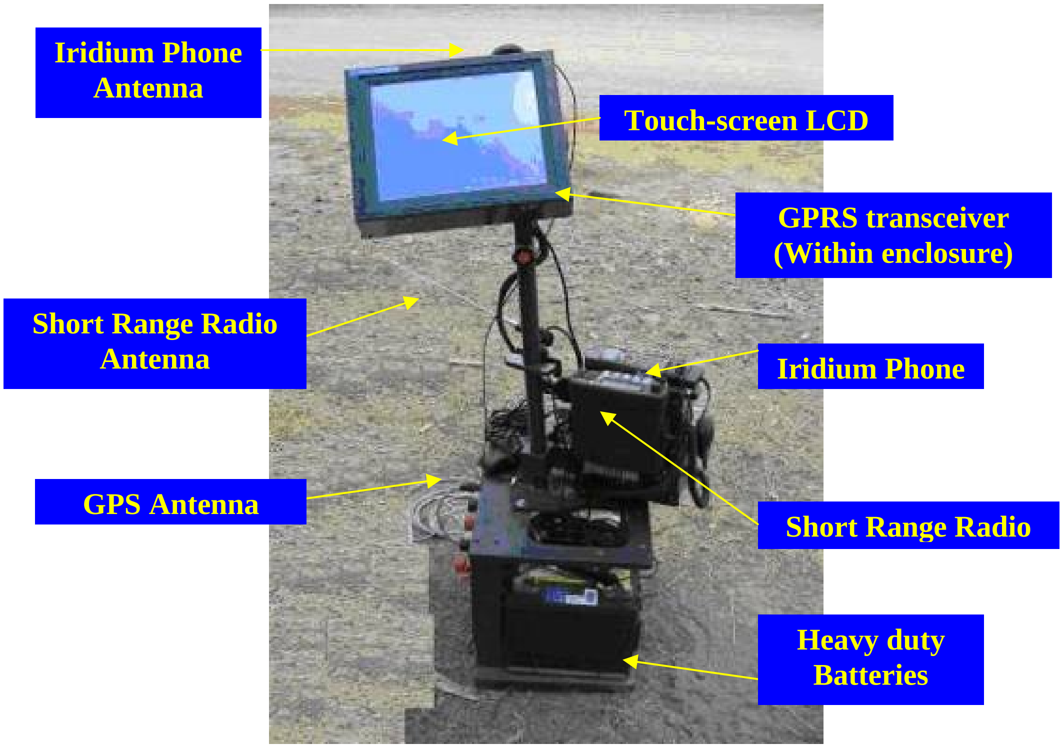

Figure 4: In-Vehicle-Unit (IVU)

Figure 5: IVU installed in Landrover

Handheld

Figure 6: Handheld Terminal

For the trial, handheld terminals were deployed for the users to scan the barcode associated with the supplies received. The handheld could withstand 1.2 metre (4 foot) drop on concrete floor and was sealed to IP54 standards against water and dust. The rugged housing protects the terminal against the harsh working environment often encountered by the mobile users in the field.

When RFID and/or barcode information are captured, the information is transferred back to higher HQ via the communication network/server.

Vehicle Tracking Module (VTM)

The VTM software was installed both on the In-Vehicle-Unit (IVU) and the ATS consoles. The main functions of the software were as follow:

a. Route Planning module to allow the users to draw the CSS plan and send to the supply convoy

b. Integrated with the GPS to assist the user to obtain own location and navigate to the destinations,

c. Short messaging capability to facilitate to users to communicate among themselves,

d. File Transfer Utility to enable users to send reports and overlays,

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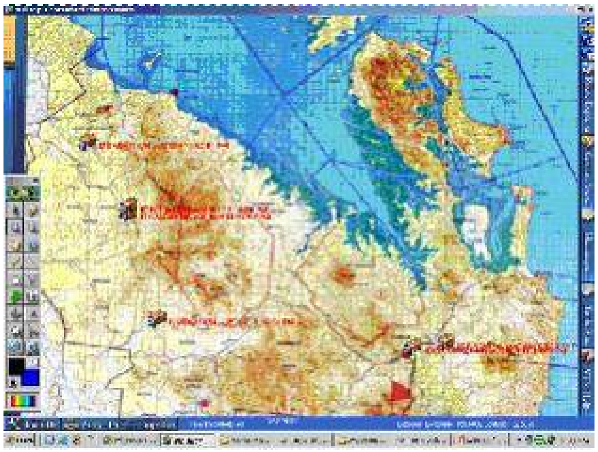

Figure 7: All Unit Location View

Figure 8: File Transfer to send reports and overlays

Seamless Communication

A range of communication means was explored to bridge the wide distribution of logistics elements within the area of operations. Tactical VHF radios, satellite communication and general packet radio service (GPRS) are used to communicate between the tactical forces back to the various command levels depending on the area of operation

All communications were routed through the communications server. The communication server had the ability to cache the messages at the server when the clients were off-line and pushed it out when they came back online. It enabled the system to be flexible as the clients could join the network as and when they required and still received all the messages intended for them.