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Team 5: Impact of Network Enabled Capabilities on Logistics Operations

TEAM 5 MEMBERS

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INTRODUCTION

Several joint and service concepts, logistics studies and analyses, as well as government sponsored studies recognize that the current distribution system is characterized by deficient in-transit visibility (ITV), networked communications, and information system that provide network-wide visibility of node and mode status in a shared logistics common operating picture (LCOP). These deficiencies jeopardize the ability to build a sustainment system that ensures that the right supplies and services will arrive on time and location when needed.

Because the current communications network does not support current force requirements, individual units and commands have supplemented their units with a myriad of commercial wireless technologies procured in an ad hoc manner with operational, discretionary, and supplemental dollars, to augment or replace tactical networks, despite interoperability, security, and spectrum issues. In fact, those commercial wireless technologies serve as systems and as network enablers to fill current network-enabled capability needs. Recent studies, anecdotal evidence obtained from operational needs, integrated priority lists, and collected operational lessons suggest that seamless integration of individual soldier-level wireless tactical networking devices prevalent in support operations areas require a comprehensive independent analysis. Consequently, TRAC-Monterey is conducting a Capability Based Assessment (CBA) to identify network-enabled capability gaps for CSS soldiers and to identify potential solutions to fill those gaps.

IDFW 16 OBJECTIVES

This working group's overall objective for IDFW 16 was to use the Logistics Battle Command (LBC) model, a new battle command simulation developed by TRAC-Monterey, and experimental design techniques to assess the impact that soldier level network-enabled capabilities have on cargo operations at a truck terminal node within a sustainment base supporting a joint force.

Particularly, the specific objectives of Team 5 sessions during IDFW 16 included:

1. Represent the different network structures and distribution of enablers in LBC.
2. Develop measures of effectiveness (MOE) and confirm that LBC can produce required MOEs.
3. Develop experimental design to examine factors of interest to issues of analysis.
4. Explore network-enabled capabilities and distribution of enablers through experimental design.
5. Run DOE for model on the cluster to determine how network-enabled capabilities affect performance.

LBC MODEL

The LBC model is a low-resolution, object oriented, stochastic, and discrete event model programmed in Java and incorporates Simkit. LBC functionality includes planning and decision support features to enable a simulated sustainment decision maker to monitor the LCOP, forecast demand for most classes of supply, and initiate and adjust missions to distribute supplies and perform sustainment functions. LBC model uses network architectures to represent the distribution pipeline to summon sustainment planning and execution representing the end-to-end flow of resources from supplier to point of consumption.

The LBC model uses nodes and arcs to represent the different networks of the distribution system. The LBC model accomplishes this through three layers of network representation: the transportation, communications, and planning networks. First, the transportation network links LBC model to the physical area of operations representing the geographical distribution of supplies, and allows for dynamic route planning. Second, the communications network represents an arbitrary complex communications network of the distribution system linking leaders and soldiers to all applicable stakeholders including the LCOP. Last, the planning network represents the data of the distribution system information network.

SCENARIO

The scenario selected focuses on operations at a terminal node of the theater distribution system: namely, a Centralized Receiving Shipping Point (CRSP). A CRSP is dock to dock distribution center, within an area of operations where cargo is delivered, sorted, shipped, and backhaul cargo is picked up 24/7. The objective is to continuously move cargo quickly and efficiently using regular sustainment deliveries from theater to a CRSP, employing the familiar "hub and spoke" concept. Typically, Army Transportation Soldiers operate the CRSP.

The scenario concentrates on Transportation Soldiers operating the CRSP different sections, especially the container lane, pallet lane, rolling stock lane, and the operations center to process cargo received from regular sustainment convoys composed of thirty trucks with different commodities.

Network Structures

Representing network structures on LBC is the first objective the workgroup addressed. The scenario built was designed to assess three network structures and the ability to accomplish the mission in the assigned scenario. Incorporating network-enabled capabilities in the scenario involves connecting various lanes as nodes in the communications network providing timely and accurate information. The three network structures implemented in LBC to explore network-enabled capability are Hierarchical, Star, and Fully Connected network structures.

First, the Hierarchical network structure represents a topology which outlines the interconnection of five network-enabled nodes through four communication channels in a hierarchical manner. Second, the star network structure delineates a topology in which each of the four nodes of the network within the terminal node are connected to the network central node, with a point-to-point link through four communications channels in a hub and spoke fashion. Finally, the Fully Connected network structure represents a type of network topology in which each of the five nodes of the network are connected to each of the other nodes in the network with a point-to-point link through seven communications channels or arcs making it possible for data to be simultaneously transmitted from any single node to all of the other nodes.

MEASURES OF EFFECTIVENESS

The second objective addressed was the development of MOEs. The three primary MOEs of interest developed are Velocity, Reliability, and Visibility. They were derived directly from the concept specific attributes listed in the Joint Logistics (Distribution) Joint Integrating Capabilities (JIC) (2006) in order to provide the linkage from the specific mission tasks to the estimated operational outcomes for each scenario. This approach clearly provides decision makers with the traceability of capability gaps to required capabilities. Below is a discussion of the MOEs of interest.

- *Velocity* is the speed at which convoys are processed in the terminal node. Convoys must be processed with the right resources at the right speed with reliability. Convoy wait time influences velocity. Wait time is defined, *Service Factor * Utilization Factor * Variation Factor*. As wait time decreased, Velocity increases.
- *Reliability* is the degree of assurance or dependability that cargo terminal operations will consistently meet convoy demands under established conditions to specified standards. Reliability measures the variance of the convoy wait time.
- *Visibility* is the capability to determine the status, location, and direction of flow of materiel. This MOE provide a measure of the impact of network-enabled capabilities. It quantifies the difference between the ground truth stock levels and the LCOP levels.

DESIGN OF EXPERIMENTS

A Nearly Orthogonal Latin Hypercube (NOLH) design was constructed (see Table 1) to develop several experiments based on a range of inputs for seven factors. The decision factors considered are ITV-available, ITV-accuracy, LCOP-update, latency, and probability of communications. These are the parameters that influence network capability for the scenario. The noise factors are resources available, and convoys per hour which allow examining the impact of network capability aspects on a broader base. These factors were derived directly from concept specific attributes listed in the Net-Centric Operational Environment (NCOE) JIC (2006). For simplicity, the factors were considered continuous and integer. Below is a discussion of the factors of interest developed by the workgroup.

- *ITV-Available* represents the probability to which personnel at the terminal node are provided with timely, reliable access to ITV data of cargo.
- *ITV-Accuracy* represents the likelihood of the ITV data of cargo transmitted matches received information given ITV-Available
- *LCOP Update* is the rate in hours at which nodes update the LCOP.
- *Probability of communications* corresponds to the probability of successful communication between nodes given point-to-point link.
- *Latency* refers to the message transmission delay in hours.
- *Resources available* accounts for the amount of materiel handling equipment available for operations at the terminal node.
- *Convoys per hour* are the amount of convoys arriving at the terminal node in an hour interval.

low level	0.2	0.2	0	0.1	0	4	1
high level	0.9	0.9	1	1	0.25	8	3
decimals	3	3	3	3	3	0	0
factor name	ITV-Available	ITV-Accuracy	LCOP Update	P(Comms)	Latency	Resources Available	Convoys per hour
	0.419	0.9	0.813	0.438	0.063	8	2
	0.244	0.375	0.875	0.606	0	5	2
	0.288	0.506	0.063	0.325	0.156	7	3
	0.331	0.638	0.313	1	0.141	5	3
	0.725	0.856	0.438	0.213	0.078	4	3
	0.9	0.419	0.375	0.831	0.016	7	3
	0.638	0.331	1	0.381	0.219	6	3
	0.594	0.813	0.75	0.944	0.203	7	2
	0.55	0.55	0.5	0.55	0.125	6	2
	0.681	0.2	0.188	0.663	0.188	4	2
	0.856	0.725	0.125	0.494	0.25	7	2
	0.813	0.594	0.938	0.775	0.094	5	1
	0.769	0.463	0.688	0.1	0.109	8	2
	0.375	0.244	0.563	0.888	0.172	8	1
	0.2	0.681	0.625	0.269	0.234	5	1
	0.463	0.769	0	0.719	0.031	6	1
	0.506	0.288	0.25	0.156	0.047	6	2

Table 1: NOLH Design

RESULTS

Due to limitations of the current configuration of the LBC simulation, examination of the data sets revealed that additional modifications and improvements were required by the LBC developers to improve model functionality and correct program anomalies.

CONCLUSIONS

The work accomplished throughout IDFW16 was valuable. Team 5 participants developed a scenario, network structures, MOEs, and DOE to measure the impact of network-enabled capability using the LBC model to support TRAC-Monterey's CBA. Further, throughout the working week substantial revisions and expansions of the LBC model were accomplished to improve the functionality and usability of the model as an analysis tool for the operational scenario of interest.

The way ahead is to develop the capability of LBC to handle an experimental design of a large amount of factors to provide analysts with the capability to conduct exploratory studies and develop credible response surfaces. Furthermore, continue to explore additional factors to identify network-enabled capability gaps and identify efficiencies in sustainment operations resulting from network-enabled forces.