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TACTICAL LOGISTICS AND DISTRIBUTION SYSTEMS (TLOADS) SIMULATION

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ABSTRACT

In response to changing threats from opposing forces that often result from use of enhanced technology, U.S. forces must adopt new tactics, employing appropriately upgraded delivery equipment to deliver rations, fuel, ammunition, personnel, and repair parts to forces in forward areas. In the face of sharply reduced R&D budgets, the opportunity to explore new tactics and to test and evaluate new logistics material delivery equipment is correspondingly diminished. In addition, the evaluation of new tactics through trial maneuvers employing seagoing forces and simulated troop landings is often frustrated by non-cooperative weather, the high operational expense of mounting a full-blown sea force and the typically inconclusive nature of the data collected.

However, through the use of simulation, inexpensive, innovative force deployment and positioning schemes are tested. New supply distribution techniques employing a wide variety of equipment combinations both existing and experimental are also tested. The simulation output data is used to grade distribution schemes. This provides ranges of vehicle engineering data which may impact and support subsequent equipment design parameters.

1 INTRODUCTION

The U. S. Navy Engineering Facilities Engineering Services Center provides continuing engineering support to the U. S. Marine Corps. This support focuses on the development of logistics related procedures, equipment and systems that support littoral operations for USMC Expeditionary Forces ashore. Primary development focus is on:

- Transfer And Storage Of Bulk Liquids
- Light Weight, Portable Buildings
- Ocean Anchoring Systems
- Mobile, Self Powered Causeways
- Water Purification Units
- Standardized Shipping Containers

Past doctrinal approaches to logistic support where forward assault forces required initial supply and then periodic re-supply of water, rations, ammunition and fuel, depended on the concept of the "beachhead." The beachhead usually consisted of an operations center that controlled stock requisition communications, stockpile inventory and the transportation of logistics materials from the stockpile to assault elements located inland. In today's environment of technologically enhanced "smart" weapons, the beachhead stockpile is best labeled *a hugely attractive target, easily located and destroyed.*

Notwithstanding recent operations in Iraq, planned near-term requirements for littoral assault and related logistics support has changed focus from the movement of massive numbers of troops, equipment and supplies inland through the beachhead. The focus is now on the placement of small, highly mobile "teams" *Over The Horizon* (OTH) directly into the forward operational areas. These teams would be connected by modern data links to the main force so that location and status are constantly known. The corresponding logistics support and logistics material delivery vision is the same OTH movement of supplies from a sea-based delivery platform directly to forward stocking points or to the actual troop teams is necessary.

During calendar years 1995 - 1997, a series of discrete event models were designed and implemented to examine the impact of doctrinal changes on logistics supply requirements. The models were used to examine the operational efficiency of a variety of supply network schemes using mixes of standard and planned experimental logistics transport vehicles. A model variable was the standoff distance between the ocean-going resupply "Seabase" and the in-country destinations.

As might be imagined, these discrete event models assumed gigantic proportions, with simulation objects approaching tens of thousands. The resulting simulation data proved useful in documenting the likely parameters of modern OTH re-supply scenarios. However, model execution speed and the onerous task of model modification and maintenance forced a reevaluation of the discrete event architecture.

2 MODELING ASSUMPTIONS AND DATA COLLECTION

The purpose of the TLoaDS model is to provide a tool to study the delivery of logistics material to U.S. Marine Expeditionary Forces. Some requirements of the simulation tool were as follows:

- Encompass all elements of the previously built models into one model.
- Allow for easy user modification.
- Increase execution speed significantly.

The simulation was built using Extend™ and SDI Industry® Pro because of the flexibility required to achieve the above requirements (Rivera 1998 and Siprelle 1998). The overview of the model is shown below in Figure 1.

The benefit of this effort is to provide an inexpensive, flexible and practical tool that permits unrestricted and frequent evaluation of new logistics delivery tactics and logistics material transport vehicles through a wide variety of studies. The TLoaDS simulation user is able to define model ***SCENARIOS*** using a highly structured ***LAYDOWN*** process. The laydown process allows the selection and placement of standard force compositions (armored, infantry divisions, battalions, companies, platoons, etc.) comprised of troop, vehicle and weapons types and quantities into an operational area defined and displayed as a standard military Universal Transverse Mercator (UTM) map projection. Each scenario can be saved and reused.

The TLoaDS simulation user is able to extract information describing the behavior of the model both while it is running and after a simulation run is completed. Competence with model setup and data recording functions

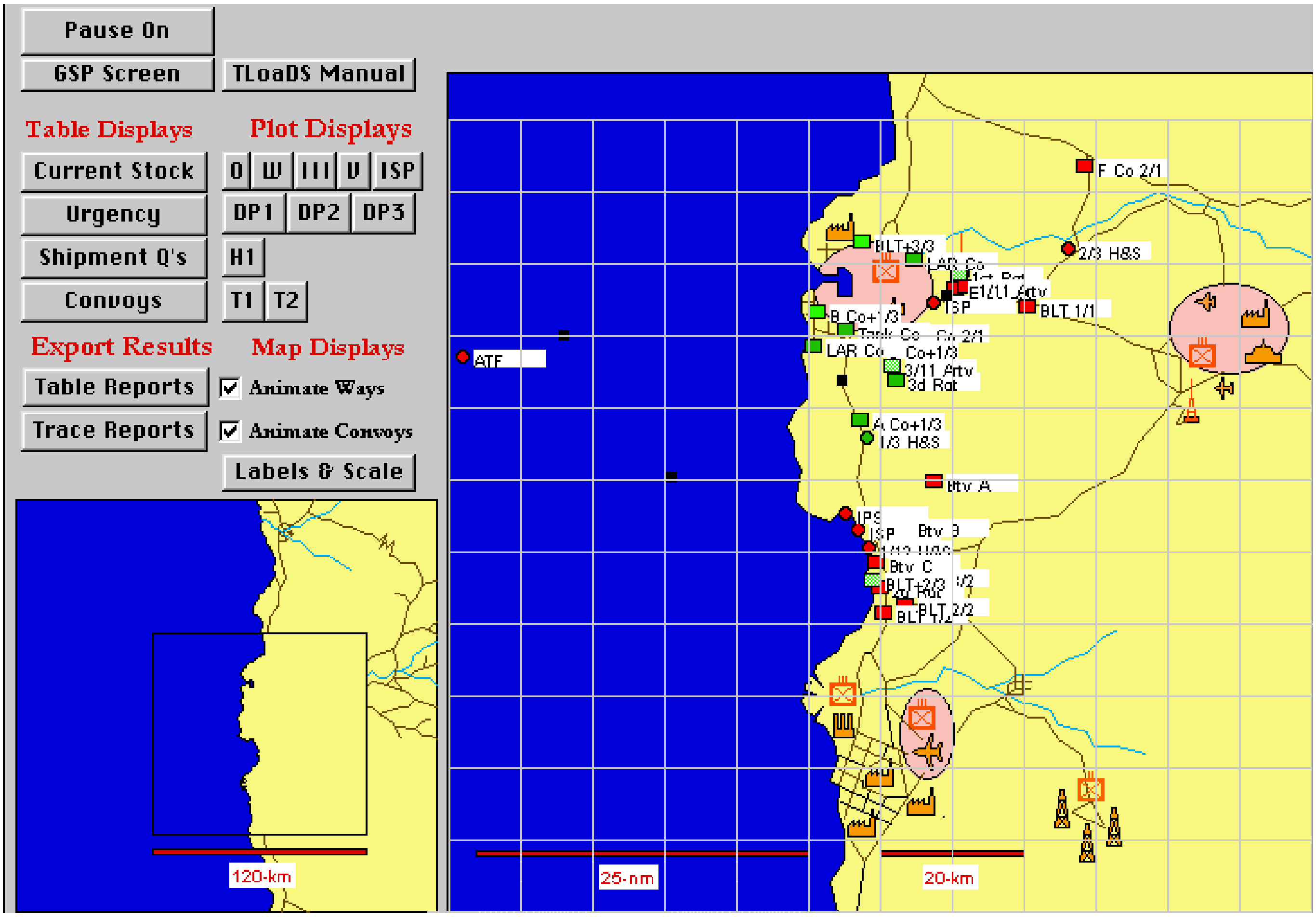

Figure 1: TLoaDS Simulation Overview

allows the user to design that produce and record model responses for variations in input parameters such as:

- Force distribution and placement
- Logistics distribution networks
- Hostile threats
- Weather
- Types and quantities of transport vehicles
- Competition for scarce resources such as transport vehicles and material handling equipment

Basic Model Elements. There are six primary elements that are active variables in the TLoaDS model. These are:

- Materials - the TLoaDS model is fundamentally about the movement of materials from the supplying unit (sea base) to the consumers.
- Vehicles - their types and properties such as day and night speeds, load capacity and maintenance profiles are defined in the Model Context Database. The model user specifies the quantity of each vehicle type assigned to each supplier unit.
- Materials Handling Equipment (MHE such as forklifts, conveyors, cranes, etc.) are recorded in the Model Context Database along with performance and capability profiles which determine the materials that can be handled by each and the rate at which these materials are loaded and unloaded to or from stock piles and/or transport vehicles.
- Containers - the capacity of each container for each material is specified, along with the maximum numbers of each container for each vehicle is recorded in the Model Context Database. In this way, the material capacity of each vehicle by container is determined.
- User Units - are those that do not re-supply other units. Consumption of materials at each unit is determined by the combination of troops, weapons and vehicles (Standard Marine Expeditionary Force Components that are stored in the model database) that are specified when the unit is defined by the model user during the laydown process
- Supplier Units - suppliers have all of the properties of users, but in addition, receive and dispatch materials to other units. Suppliers have MHE and transport vehicles assigned to them.

3 BUILDING THE MODEL

The TloaDS model is comprised of the TLoaDS Logistics Wizard processors, Scenario Laydown processor, TLoaDS Navigator and model Runtime execution processors.

This model design permits the user to build complex tactical scenarios in an orderly and logical manner using the following steps:

- Specify the duration of the operation period (usually in days), the terrain (mountainous, desert, tropical), weather (arid, temperate, tropical), sea state (in numeric stages which determine the load capacity and speed of marine transport vehicles), sunrise and sunset.
- Place Standard (modifiable) Force Units (armored, infantry, artillery battalions, companies, platoons, etc.) at specified coordinates in the operational area which is displayed as a UTM map projection. Assign terrain per unit, unit elevation for helo load calculations and vehicle approach rules (for example, marine craft cannot supply land-bound units).
- Specify operating rules, (e.g. re-supply may occur only during daylight hours with no hostile action) probability of delay due to enemy action, way-points for vehicle transit through hostile areas.
- Specify the material (ammunition, fuel, water, rations) consumption tempo for each unit and material by user specified time periods that together equal within the operation duration.

Database Manager - The database records scenario setup and reference data that is used during model execution. The database can import data from text files that are generated using Microsoft Excel™ or any other application capable of outputting tab delimited ASCII files. Reference databases are created and maintained from the model screen dialogs so that external text files are not required. Database information is "read" from the database and then converted to "Fast Arrays" for high speed use during the model run. This eliminates unnecessary disk references resulting in optimized model runtime. A portion of the database showing some of the tables included is shown in Figure 2 on the following page.

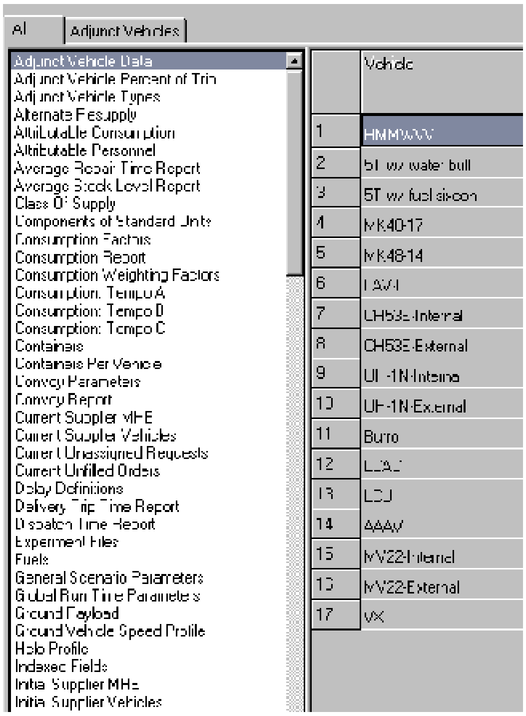

Figure 2: Portion of the Database

The TLoaDS Logistics Wizard - processors designed to be used before model execution. These are custom blocks that allow Database Reference information such as vehicle speed, cargo capacity, etc., to be entered and maintained. There is a wizard for each of the basic model elements so that the characteristics of each element sub-type can be recorded and modified as performance characteristics change. For example, the Vehicle Wizard, shown in Figure 3, allows all vehicle types (5 Ton Truck, Ch-53 Helo, LCAC, etc.) to be recorded along with performance characteristics such as speed, load capacity and maintenance profile.

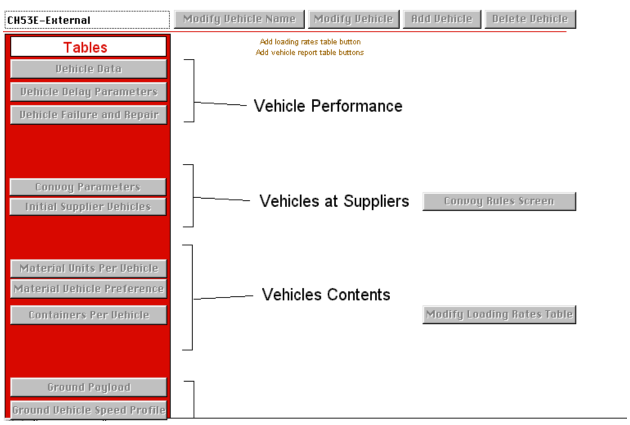

Figure 3: Vehicle Logistics Wizard

The Scenario Laydown processor allows the user to create unique model setup factors such as geographic location depicted as a military UTM map, weather, and sea conditions. The Laydown processor also permits the placement of Organizational Units such as Marine Corps Armored, Infantry, etc., Divisions, Battalions, Companies and Platoons at UTM coordinates in the model geographic area. These organizational units have been previously defined and recorded in the Model Context Database in terms of troops, vehicles and weapons types and quantities assigned. During model run, the total number of troops determines meal and water consumption, whereas the quantities and types of vehicles and weapons determine fuel and ammunition consumption respectively.

As each unit is placed in the model, it is designated as being a User or a Supplier unit and supply links and performance rules with upstream and downstream units are established and recorded in the Model Context Database.

The TLoaDS Navigator, shown in Figure 4, is a set of custom buttons that floats above the model worksheet permitting the user to move by mouse click, directly to any of the wizard dialog screens without having to close and open multiple sequences of hierarchical blocks.

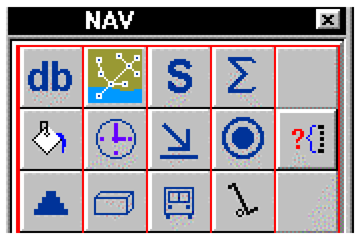

Figure 4: TLoaDS Navigator

The TLoaDS Runtime is a set of custom blocks that uses the data from Scenario Laydown and the reference data from the database to perform material consumption, detection of low supply levels and therefore request re-supply. Simultaneously logistics vehicles deliver logistics materials to the using units, with complete model variable data recorded for post-run evaluation or for graphic display during the model run.

4 VERIFICATION AND VALIDATION

Model Context Database reference data was collected during interviews with Subject Matter Experts, and through analysis of technical reference manual data, empirical material-usage databases and from USMC reference database MAGTF II. These data were cross-correlated and where across the board congruence of data was observed, the data were accepted as reliable. On the other hand, when data variance occurred, the differing data source was not used if the remainder of the data sources were in full agreement. Ambiguous situations were referred to government agencies for final resolution.

Model performance has been validated through the time tested, foolproof approach where fully documented, known, test situations are setup and run. The model output is then compared with the verified correct results and model analysis and adjustments are made to ensure reliable and acceptable operation.

5 RESULTS

According to our customer: "With the U. S. Marines reinventing war-fighting tactics to address the changes in potential hostile threats, novel combat approaches call for reinventing tactical logistics. During a period of severely reduced budgets for live tactical logistics experimentation and virtually no funding for hardware RDTE&A, modeling and simulation's ability to explore conceptual alternatives holds the promise of huge payoffs in saved funding and time, yielding improved system performance, and many lives saved. The novel, paradigm shifting, potentially high payoff, but high risk concepts—the ones program managers would rarely explore with real prototypes or live exercises—become affordable and safe to explore.

In the future, TLoaDS may be enhanced to leverage the investment and meet the needs of many more customers, with the side benefit of being a great training tool to improve tactical logisticians' judgment of the complex system. Further, plans include using it to explore alternative courses of action for an active operation, will provide better assessment of the supportability of combat plans to make better use of scarce resources -- both increasing combat power and the probability of lower men and material attrition."

The TLoaDS model was built using Extend™ and SDI Industry® Pro, both commercially available off-the-shelf software products. The cost of the software was $3495. Significant customization was done within the programming environment of the software to produce the TLoaDS model. The entire project required about 1 man-year of effort split between military personnel and simulation experts. The model runs on a standard PC running Windows 95, 98, or NT. The recommended PC configuration is at minimum a 233 MHz with 64 MB of RAM.

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AUTHOR BIOGRAPHIES

DAVID J. PARSONS is a principal of Simulation Dynamics. His experience with simulation began in 1965 with experiments in the use of natural selection algorithms to evolve architectural designs. During the 1980s he designed, built and operated several dairy-processing plants using simulation of key systems as an integral tool for design, value engineering, and trouble shooting. Mr. Parsons received a B. A. from Harvard College and a Master of Architecture degree from the Harvard School of Design.

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