

**LOGISTICS INTRA-THEATER SUPPORT TOOL
FOR COURSE OF ACTION
LOGISTICAL FEASIBILITY ANALYSIS**

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by

Charles M. Macal
Charles N. Van Groningen
Mary Ann Widing
Mary K. Duffy

Environmental Assessment and Information Sciences Division
Argonne National Laboratory
Argonne, IL 60439

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LOGISTICS INTRA-THEATER SUPPORT TOOL FOR COURSE OF ACTION LOGISTICAL FEASIBILITY ANALYSIS*

Charles M. Macal, Charles N. Van Groningen, Mary Ann Widing, Mary K. Duffy

Argonne National Laboratory
Argonne, IL 60439
(708)972-3767

ABSTRACT

The Logistics Intra-theater Support Tool (LIST) is a prototype system that evaluates a course of action for its logistical feasibility. LIST addresses the question of whether a theater's infrastructure and strategic lift allocation are adequate to support the movement of specified ground forces and supplies to a given destination by a specified day. The logistical requirements of a course of action are based on the force units, arrival dates, and other scenario data. Capabilities are estimated by simulating the movement of personnel, equipment, and supplies through the theater's seaports, airports, and road/rail network to the destinations. The system reports conclusions to the user, identifies real and potential bottlenecks, and recommends modifications to the course of action that are likely to improve its feasibility. LIST includes expert systems that select routes and seaports and move personnel, equipment, and supplies through the land network. A user interacts with LIST through menus and a series of map displays. The maps show relevant features and allow the user to access an object-oriented database.

1 INTRODUCTION

The Logistics Intra-theater Support Tool (LIST) is a prototype decision support system for evaluating the logistical feasibility of a course of action (COA). The system assists an analyst in determining whether a course of action is feasible given a theater's infrastructure and strategic sea and air lift allocations. A course of action consists of a requirement for a specified force to be at a specified location by a specified time. Given a course of action, LIST is intended to answer the following questions:

1. Is the course of action logistically feasible?
2. If the course of action is logistically feasible, where are the potential bottlenecks that could cause it to become infeasible?
3. If the course of action is not logistically feasible, where are the bottlenecks that, if relieved, could improve feasibility?

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The system can also provide valuable information on how changing the resources allocated to a theater affects feasibility and how various events and contingencies affect feasibility.

To address these questions, LIST integrates expert systems, a simulation model, and an optimization algorithm. Figure 1 shows the inputs, outputs, and processing capabilities of LIST. LIST focuses on the intra-theater aspects of logistical feasibility. Inter-theater issues such as the allocation of strategic lift assets among theaters and the movement of strategic assets to the theater are not modeled in extensive detail.

2 LOGISTICS ANALYSIS

2.1 Logistics Feasibility

A course of action is specified as part of a scenario. Scenario data consists of force units, the time and location where the units are to be moved, and the resources available for movement within the theater. A course of action is logistically feasible if the following three conditions are met: 1) for each unit, a specified percentage of the unit equipment and a specified percentage of its combat support (CS) unit equipment arrives at the destinations by the required closing day, 2) for each unit, a specified percentage of its combat service support (CSS) unit equipment arrives at the fixed ports by the required closing day, and 3) the specified numbers of days of sustaining supplies are in place at various locations throughout the theater by the required closing day. One course of action is "better" than another if its computed closing day is sooner.

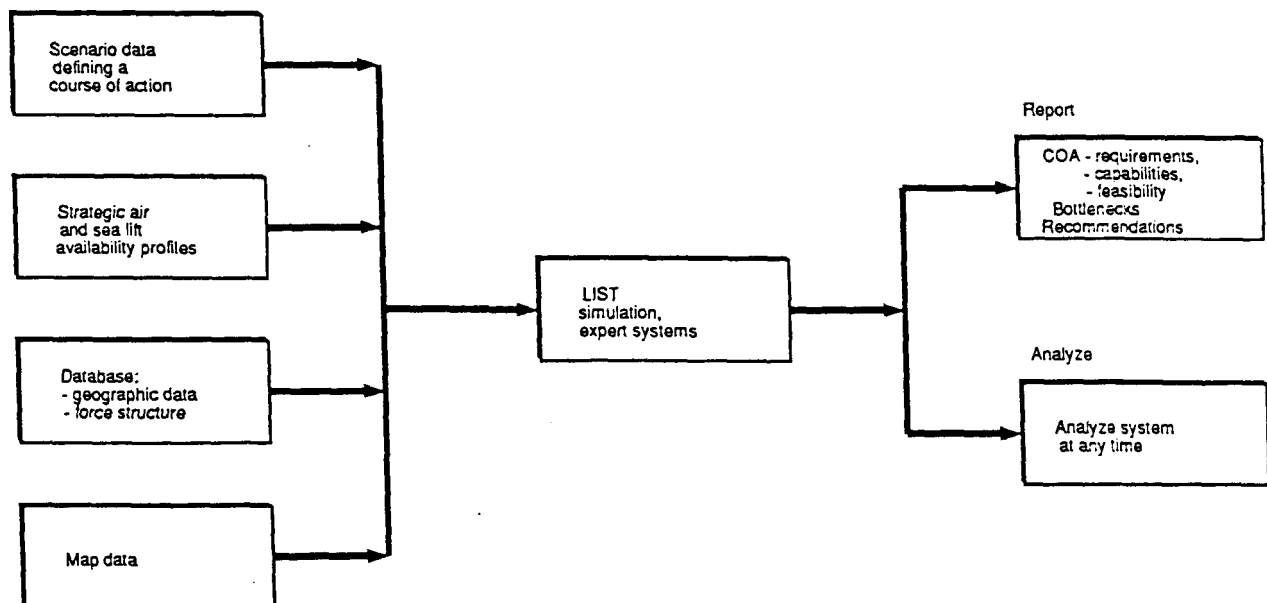


Figure 1 Overview of LIST

Logistical feasibility is based on three factors: 1) logistics requirements to support the force in the specified time frame; 2) logistics capabilities, limited by the constraints of the theater infrastructure and resources allocated for theater operations, and 3) need, which is the difference between requirements and capabilities.

2.2 Analytical Framework

The logistical requirements of a force are based on the assumption that a unit arrives at its port of debarkation at the midpoint between its earliest and latest arrival dates. Heuristic procedures and planning factors are used to estimate requirements for combat, CS, and CSS units and supplies, and sustaining supplies. Logistical capabilities are estimated by simulating the movement of personnel, equipment, and supplies through the theater's seaports, airports, and road/rail network to the destination. Rule-based expert systems are embedded components of LIST that assist the user in route selection, seaport selection, and movement simulation. The scope of LIST is broad and covers several knowledge domains including fixed port operations, aerial port operations, LOTS site selection and operations, and line haul and unit movement by road, rail, and intra-theater air lift. Sources of logistics knowledge include logistics experts and military manuals.

The simulation model includes movement heuristics that decide when items at the network nodes should be moved forward. The capabilities simulation can be run interactively. A user can stop the simulation at any time and introduce an event, such as a reduction of port throughput capacity or the loss of a road, and rerun the simulation from that point onward.

LIST compares logistics capabilities and requirements, determines the need, identifies bottlenecks that limit or have the potential to limit feasibility, and recommends how the plan might be improved. The outputs of LIST consist of text reports, charts, and graphs about the logistical requirements and capabilities of a course of action. Bottlenecks that limit logistical feasibility are highlighted. Different reports present information at different levels of detail to meet the information requirements of various individuals. For example, a summary conclusions report is appropriate for a high level decision maker, while a detailed report on bottlenecks is appropriate for an analyst to understand the factors that limit a plan's feasibility. Examples of reports are shown in Figures 2 and 3.

3 DATABASE

Three general categories of data are included in LIST: 1) the theater infrastructure (transportation network), 2) force structure and planning factors, and 3) maps and geographic features. A transportation network consists of nodes, transport segments connecting the nodes, and features. Nodes consist of fixed ports, airports, LOTS sites, rail heads, road junctions, marshalling areas, and forward operating bases. Transport segments consist of road segments, rail segments, air lanes, and shipping lanes. Features of logistical significance include bridges, tunnels, and mountain passes. The force structure portion of the data base consists of army divisions and brigades by type and planning factors, such as total weight and supply consumption rates. The map database is used to create maps for display with various geographic features, such as country boundaries and rivers. Software linkages to various databases and sources (for example, GEOLOCS, PORTS, APORTS, and TPFDD) are under development.

INFRASTRUCTURE CAPABILITIES VS REQUIREMENTS

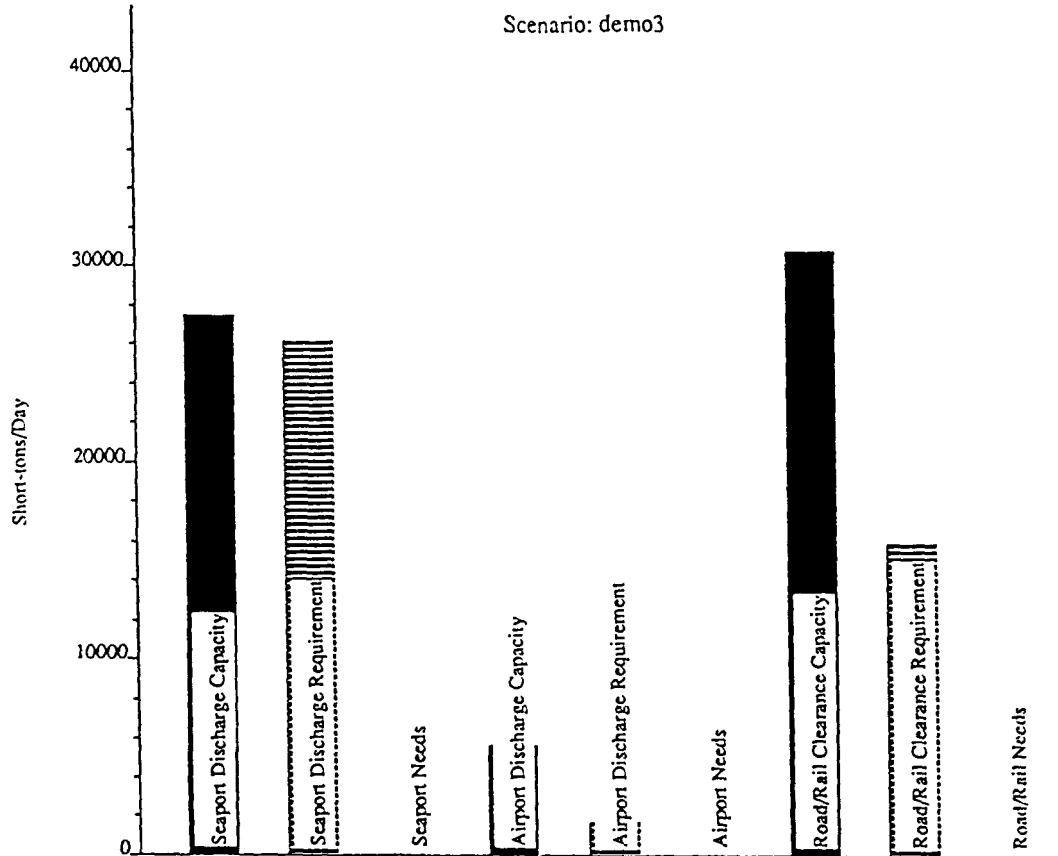


Figure 2 Report on Infrastructure Capabilities and Requirements

CONCLUSIONS REPORT

Scenario: demo3

4-25-89

The course of action is logistically infeasible given the analysis assumptions:

- The unit Armored Brigade (separate)2 has not closed by C+41.
- The unit Armored Cavalry Rgt2 did not close until C+41

Seaport capability needs to be increased by 8.90% to meet scenario requirements, if all units arrive on LAD (worst case).

No choke points exist on the linehaul or unitmove routes.

Berth bla used more than 90% of the available unload days in the scenario.
 Berth cla used more than 90% of the available unload days in the scenario.
 Upgrade the port in order to unload the ships faster.

There are not enough supplies at the FOB on the following days:

- C+17 - 140.25(st)
- C+18 - 140.25(st)

Figure 3 Conclusions Report

Geographic and force data are represented in an object-oriented database. The database consists of objects, relationships among the objects, and attributes for the objects. Hierarchical relationships among the objects allow objects to inherit data values from other objects. For example, all ship berths inherit the geographic coordinates of their seaport.

4 MAP INTERFACE

Capabilities for the generation and display of maps are included in LIST. A user may 1) view the geographic features of an area, 2) create new maps with logistically significant features, 3) display results of the capabilities simulation in a geographic context, and 4) interface with the infrastructure database. Maps can be output to disk files and printers to create hard copy displays or viewgraphs. Two types of map images can be displayed, vector-based and raster-based images. Figure 4 shows a display screen with a vector map of northern Europe, created using World Data Bank II data, with an overlay that shows country names and cities. The map interface also allows a user to import or create icons and overlays of graphic items such as coordinate grids, circles and other geometric figures, and text. The data associated with an icon displayed on a map can be accessed by selecting the icon. For example, a user could display the data on a seaport by selecting the icon that represents the port.

5 IMPLEMENTATION

LIST is written in Prolog and C and runs on a Sun 4 workstation with a color monitor and a minimum of 12 megabytes of memory. The portions of the code written in Prolog consist of the simulation model, the expert systems and inferencing mechanism, the database structure, and the natural language interface. C programs perform the mapping and the windowing functions. The use of Prolog allowed fast prototype development and imposed few constraints on the integration of the various components. A user initiates the main functions of LIST by selecting one of the buttons in the upper window of the main screen (see Figure 4): Modify Database (view or edit the database), Setup Scenario (create or load the specifications for a course of action and compute logistical requirements), Identify Icon (display the data associated with an icon shown on the screen), Execute (determine capabilities through a queueing simulation), Analyze (inspect the status of a simulation at any time), Report (present summary results on feasibility), and Natural Language (interact with the system through natural language instructions and queries).

6 CONCLUSIONS

The experience of developing the LIST system shows that it is useful to combine expert systems technology and object oriented database structures with traditional methods, such as simulation and optimization modeling. A significant portion of the knowledge engineering work for LIST involved locating and gaining access to the appropriate experts. Some logistical areas involved in course of action feasibility analysis have few experts who have functioned in the particular knowledge domain, for example, running a LOTS operation in combat conditions. In the long term, it may be possible to build a collective and reusable knowledge base of heuristics for logisticians in course of action feasibility analysis.

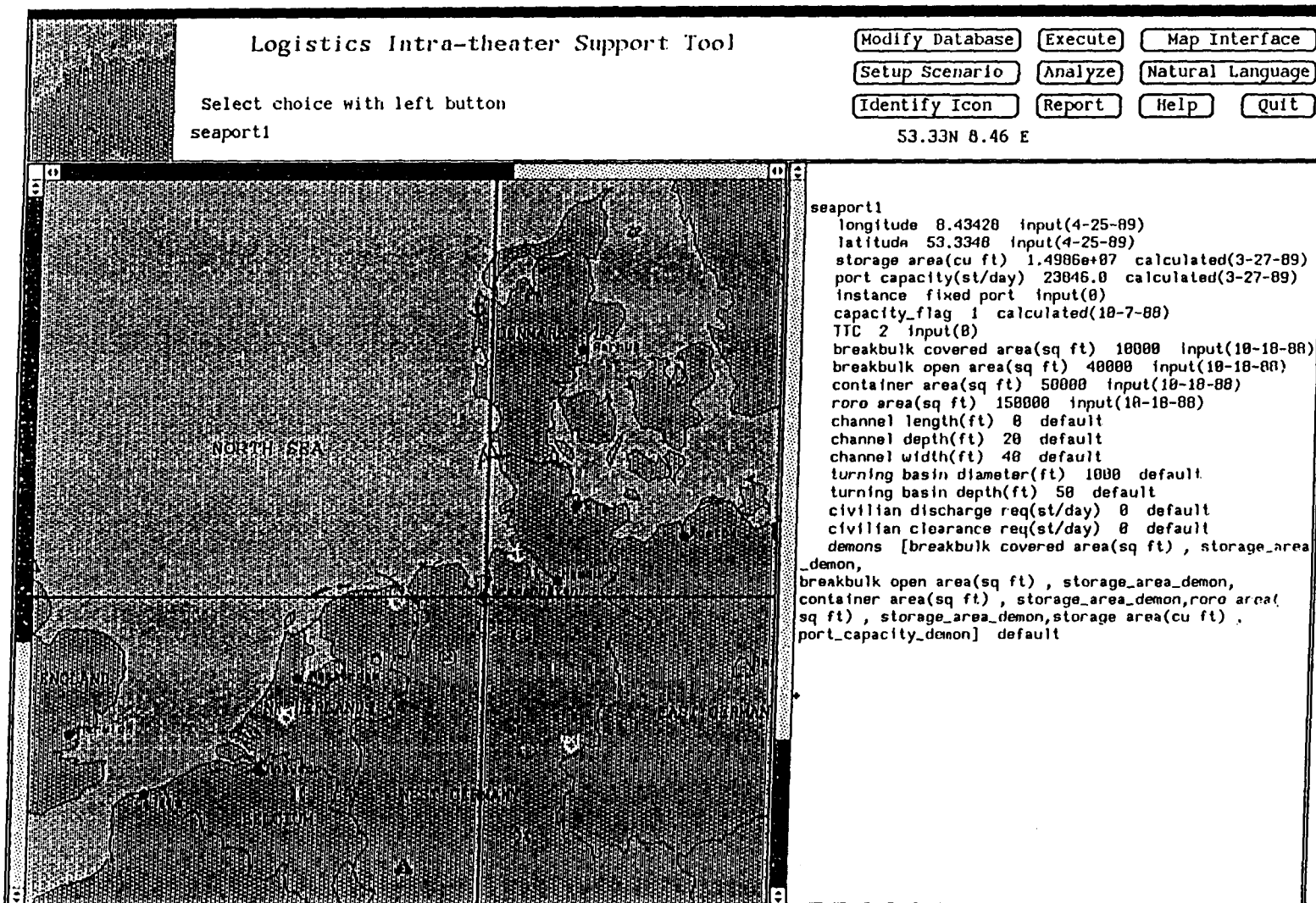


Figure 4 Map Image and Database Access