A Hazardous Materials Distribution Center Location Model

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The purpose of this research is to develop a location and allocation optimization model for use by the Defense Logistics Agency (DLA) in the evaluation of potential sites for hazardous materials distribution centers in the Continental United States (CONUS).

DLA is responsible for the operation of distribution centers and the shipment of supplies to military services. DLA operations include receipt, storage, issue, and transportation of over 25 million orders annually. Over 2 million of these orders are for hazardous materials that are shipped to over 10,000 customers. The main types of hazardous materials include paints, batteries, and petroleum products. Sources of hazardous materials for the military services include the DLA distribution centers, other government agencies, and the private sector.

DLA is evaluating the feasibility of establishing a series of specialty hazardous materials distribution centers for its primary military service customers in the US. The purpose of these centers would be to increase the efficiency of the hazardous materials operations and reduce the waste stream for hazardous materials that comes from the military services. The Joint Environmental Material Management Service (JEMMS) program has been established to determine the feasibility of this concept. The philosophy behind the JEMMS program is to establish a single integrated logistics support service for hazardous materials.

An initial test of the JEMMS program is currently underway at US military facilities in Okinawa. A single integration contractor has taken over the hazardous materials distribution and returns of unneeded hazardous materials operations for the US military services on the island. This allows a single focal point for distribution operations and the return of surplus hazardous materials. A major advantage of this program is the ability of the single distribution center to distribute the material that has been returned for reuse by other customers. This reduces the amount of money spent purchasing hazardous materials and reduces the amount of hazardous materials going into the waste stream.

Now that the test is underway in Okinawa, DLA is evaluating the possibility of extending this concept to the United States. The question that must be addressed is How can JEMMS be efficiently implemented for military facilities in the continental United States? The objective to answer this question is to develop a mathematical model to locate potential JEMMS Distribution Centers (DCs) for DLA hazardous material being distributed to military facilities in the United States that will serve as many customers as possible and minimize transportation costs.

The following assumptions are made for the model:

The maximum service distance for each DC is a set distance.
Aggregate military customer sites to a geographic center of zip code regions.
Only the top 50 customers are considered as potential DC locations
Up to a maximum of 20 DC sites are evaluated.
The DC must be able support its operations without subsidy

The formulation for the model is as follows:

The objective function maximizes the total profit (revenue transportation cost).
Constraint 1 ensures that each customer will not be over supplied.
Constraint 2 ensures that customer j will be supplied by DC i only if DC i is open.
Constraint 3 sets the limit on the number of DCs.
The capacity for each DC is unlimited (a large number M).

$$\max \sum_{i \in I} \sum_{j \in J} \delta_{ij} x_{ij} (r_j - t d_{ij})$$

$s,t,$

$$\sum_{i \in I} x_{ij} \le D_j \qquad \forall j \qquad (1)$$

$$\sum_{j \in J} x_{ij} - M y_i \le 0 \quad \forall i \qquad (2)$$

$$\sum_{i \in I} y_i = N \qquad (3)$$

where

I : *potential DCs*

i : *DC at i*

J : *customers*

j : *customer at location j*

r_j : *revenue at customer j*

t : *transportation cost per ton per mile* ($0.30)

x_{ij} : *tons shipped from DC i to customer j*

$y_i : \{0,1\}$

  $y_i = 1$ *if* y_i *DC is open, otherwise is* 0

D_j : *Demand at customer j*

d_{ij} : *distance between DC i to Customer j*

$\delta_{ij} : \{0,1\}$

  $\delta_{ij} = 1$ *if* $d_{ij} < Distance$ *, otherwise is* 0

Distance : *maximum servering distance*

M : *a large number*

N : *Number of DCs*

The model was programmed in Java. Delivery distances were calculated using ORNL Highway Network Database. Solutions were obtained using the ILOG CPLEX integer programming solver. Results are displayed using ESRI ArcGIS 8.2 software.

The results of the analysis found that as the customer service areas expand (i.e. 50, 75, 175 miles), more customers are served and profits increase, but at a decreasing rate of return. No more than 7-8 distribution centers should be established in order to ensure profitable operations. This would provide service for about 1/3 of the hazardous materials shipments. As the customer service area expands (i.e. 50, 75, 175 miles), some of the distribution center site locations may change. This result will impact the implementation process. Multiple military service locations should be given higher priority to ensure increased shared resources and better use of hazardous material returns.