HUMANITARIAN RESPONSE IN SOUTH AMERICA

(LCDR HUI LEE & LCDR ASHWIN ANUPDEV)

EXECUTIVE SUMMARY

Background

For the past 10 years, there has been a significant increase in complex humanitarian disasters throughout the world. On Dec. 26, 2004, a tsunami from a 9.1 earthquake overran the shores of many countries along the vast rim of the Indian Ocean, killing over 283,000 people died. On Oct. 8, 2005, a magnitude-7.6 earthquake devastated the Kashmir region of Pakistan, killing over 87,000 people. On Jan. 12, 2010, a magnitude-7.0 earthquake devastated the Port-au-Prince region of Haiti, killing over 316,000 people. On Mar. 11, 2011, a tsunami from a 9.0 earthquake devastated the Tohoku region of Japan, killing over 15,000 people.

The US Department of Defense (DOD) is the only organization with the global reach and breadth of capabilities to provide an immediate response to distressed populations wherever and whenever they may occur. During periods of distress, the security and stability of partner nations can be undermined by the lack of capacity to provide or maintain essential services. Regional security and stability can be threatened by the absence of critical services that are enabled by potable water, energy, communications, and medical. Moreover, the lack of appropriate U.S. response may create a national strategy gap and opportunities for potential adversaries. Authority in theater often lacks the capacity to develop or repair essential services in times of crisis.

The analysis in this document will use a disaster scenario in the region of Honduras. An earthquake of magnitude 8.0 hit Honduras and USSOUTHCOM was tasked to provide humanitarian relief support. The Humanitarian Response Network's operation is to deliver water, power generators, communication and medical support as quickly as possible with cost effective. The purpose of this network is to analyze the cost savings and the benefits of the network.

The nodes used in the network are supply, intermediate, and demand nodes. Supply nodes are Fleet Industrial Supply Centers (FISC), Naval Air Station (NAS), US Naval and Coast

Guard ships, Fixed Air wings, Defense Logistic Agencies (DLA), and NPS HFN team (Hastly Formed Network – Nemesis Network Warfare Van, deployable wireless communications). Intermediate nodes are NAS Forth Worth and FISC San Diego. The end node is USSOUTHCOM for reporting of delivery completion. The edges are calculated as (Transfer Cost, 0, Capacity). Limiting factors of this network are the capacities of capacity availability and cost of modes of shipments via trucks, planes, and ships.

Formulation

This project involved solving of two problems; the outer problem is the primal which is an LP. This gives the best min-cost multi commodity flow in the network. The inner problem which is an MIP gives the interdiction plan on either arcs or nodes. Then with that interdiction plan the primal LP is solved again to find the min-cost flow. The formulation of primal problem is given below:-

Objective Function:- $Z = \sum_{ijk} \left(Cijk + d * X_{ij}\right) * Y_{ijk} + \sum_{j,k} nC * U_{jk}$

Constraints:- BALANCE OF FLOW

CAPACITY CONSTRAINTS

FIXING Y - $Y_{ijk} = 0;\ \forall i,j,k\ s.t\ C_{ijk} = 0$

Analysis

At first the interdiction was done on selected arcs to see how it affects the cost. The corresponding operator-resilience curve is given at figure 1 below:-

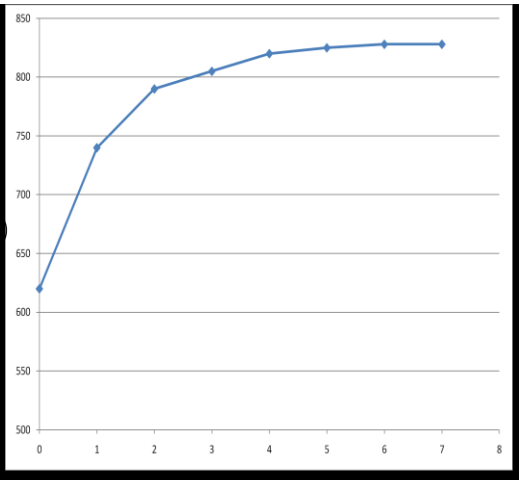


Figure 1

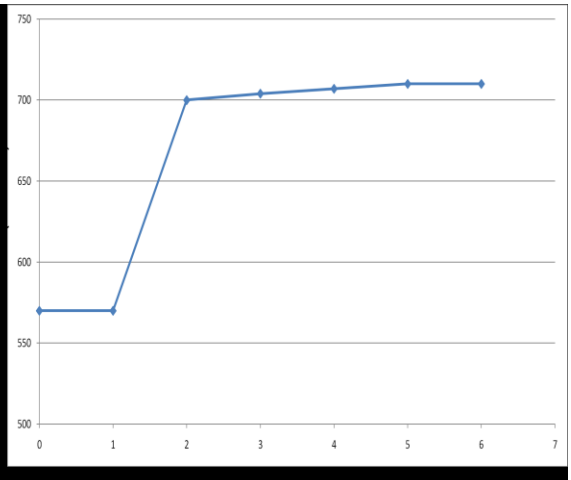


Figure 2

From the curve we can see that the cost jumps at one attack and two attacks. This is because at first the most important and cost efficient arcs are attacked like NortFolk to Jacksonville and Jacksonville to PuertoCortes. Further attacks only increases the cost my small factor and after 6 attacks that cost gets stabilized. This is because flow of supply to demand has to be maintained at a higher cost as the penalty for unsatisfied demand is considered very high in this network. Now when we attack the nodes some interesting facts come out. This can be seen in the operator-resilience curve given at figure 2. For higher number of attacks (attacks>3) the cost does not change too much. This is where the afloat units are attacked. From 0 to 1 attack there is absolutely no change in cost where the node FortWorth is attacked revealing that the network can do fine without this node. But then the importance of this node comes when some other transit nodes like Jacksonville is attacked. With both Jacksonville and FortWorth is attacked the cost just goes up to gigantic proportions as now there is no other way for the flow and the flow is forced through paying the huge penalties.

Conclusion

It can be seen from the analysis that some of the nodes and arcs are important to keep the cost minimal. So pre-positioning the equipment and supplies at required places will help movement at lesser cost. Shorter response distance and time will result less total overall cost. This is a basic model created on the given situation. Further improvements can be done to make it more realistic and the analysis more fruitful:-

(1) Time element – along with the cost, time can be considered as a factor to be minimized as time is an important parameter in relief operations like the one we have considered here.

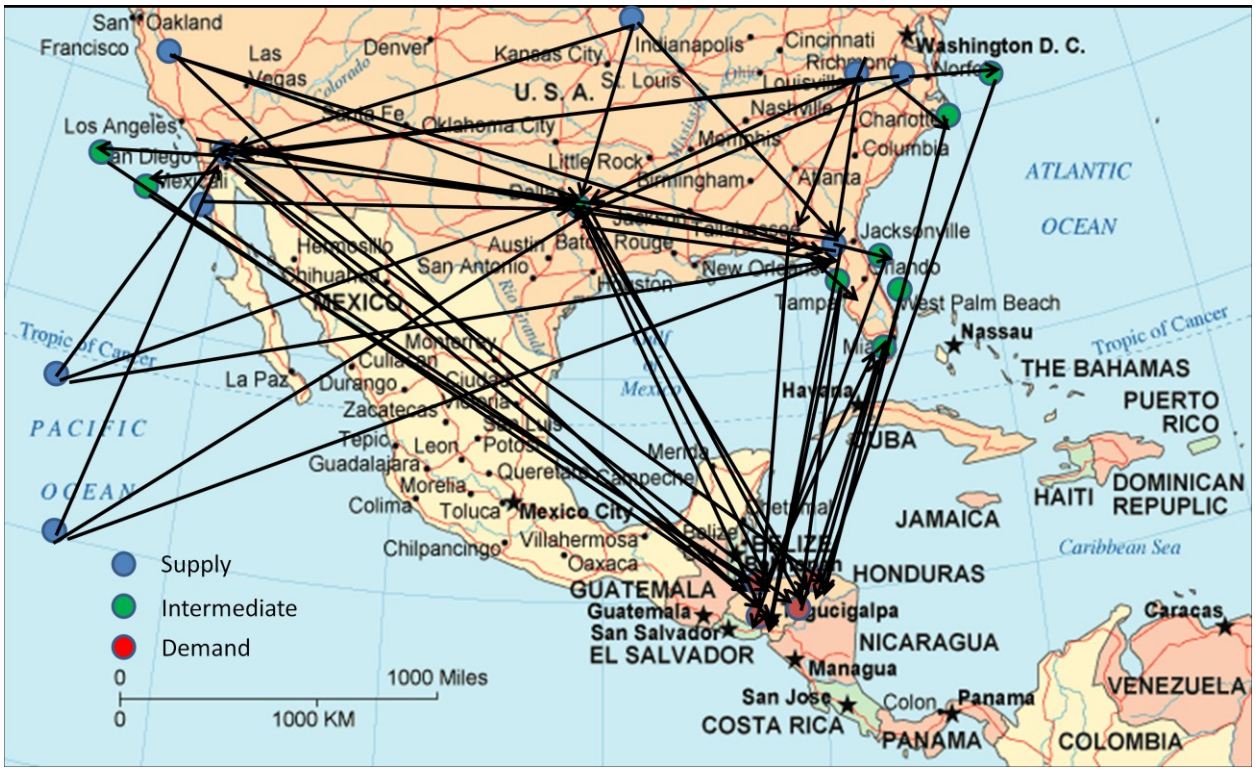
(2) stochastic element – Instead of considering the arcs and nodes getting eliminated completely, we can provide stochastic elements on the arcs or nodes to say that with a certain probability the arc/node gets interdicted and the cost doubles.

(3) Cost – In this model the cost is considered per unit volume of shipment, which may not be the case in most realistic situations. The model can be improved to consider fixed cost in certain shipment locations.

(4) Complex network – This model can be improved to accommodate more nodes and arcs to represent more complex situations and interesting facts can be revealed through analysis.

Appendix

NETWORK MAP



Nodes Set

1.FiscNorfolk
2.FiscSanDiego
3.FiscPearlHarbor
4.FiscYokosuka
5.UssVinson
6.UssNassau
7.UssReagan
8.UssBoxer
9.DlaRichmond
10.DlaColumbus
11.UssMercy
12.NpsHfnteam
13.NasForthWorth
14.FiscJacksonville
15.UscgcAlligator
16.UscgcDolphin
17.Vr58Fleetlogsupsqn
18.SotoCanoAirBaseHonduras
19.PuertoCortesHonduras
20.PuertoCastillaHonduras
21.TegucigalphHonduras
22.CholutecaHoduras
23.UsSouthCom