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ANALYSIS OF SUPPLY DISTRIBUTION MODEL - NORTH ATLANTIC TREATY ORGANISATION LOGISTIC INFORMATION SYSTEM

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Abstract:
This paper describes and analyzes Supply Distribution Model (SDM) - module of a North Atlantic Treaty Organisation (NATO) Logistics Functional Area Services (LOGFAS) Infomation system which is used for supply chain modeling and simulation. SDM typically works with certain constraints and restrictions. Aim of this article is to outline solutions which may improve SDM's explanatory power and practical use of output information. The proposal comes out of effective use of a supply unit (e.g. platoon) carrying out a supply job for more subjects. Bringing proposed mathematical methods into SDM may contribute to deal with current deficiencies.

Key words: LOGFAS, information system, SDM, supply, supply chain, distribution, mathematics programing, transportation problem.

1. Introduction

Supply Distribution Model (SDM) represents a fully integrated part of NATO LOGFAS logistic information system. Figure 1 depicts its particular subsystems. SDM is designed to support supply chain decision-making

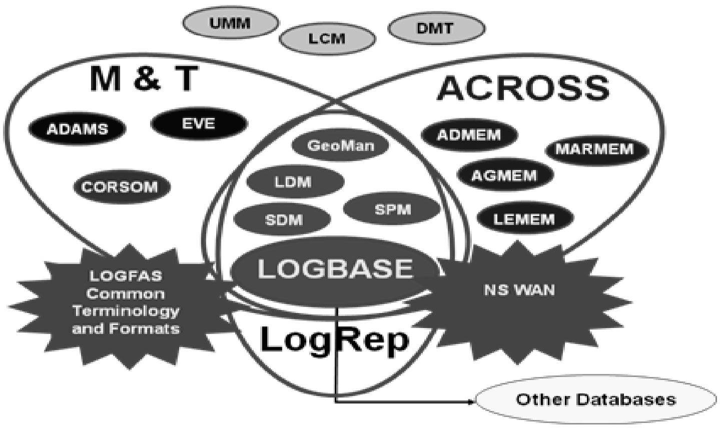


Fig. 1 LOGFAS Information system subsystems

SDM allows users to test and simulate inventory replenishment systems under certain scenarios, identify bottlenecks and other problems in the supply chain and subsequently analyze them. SDM uses data from GEOMAN, LDM and SPM LOGBASE modules (Figure 1).

Before beginning to set up a SDM scenario, the following data is required [1]:

- In the LDM, a Force Profile and Holding file complete with:
  - The Forces in the required command hierarchy;
  - The Holdings for each force, including the required quantity for commodities.
- In the LDM, a Force Resupply Profile to represent the re-supply hierarchy for each supply class;
- In the SPM, the National Parameter Set(s) containing:
  - A complete set of consumption rates for all consumer / commodity combinations;
  - A complete set of modification factors;
  - A complete set of packaging options.
- In the SPM, a Planning Situation, defining:
  - Scenario duration;

Operational & environmental factors;

  - Consumption rate options.
- The SPM Scenario, defining:
  - Planning Situation;
  - Operational Sustainment packaging sets.

SDM extends the SPM analysis focused on the calculation of reserves and adds a flow of supplies simulation to the unit. During the ongoing simulation SDM evaluates the utility of vehicles.

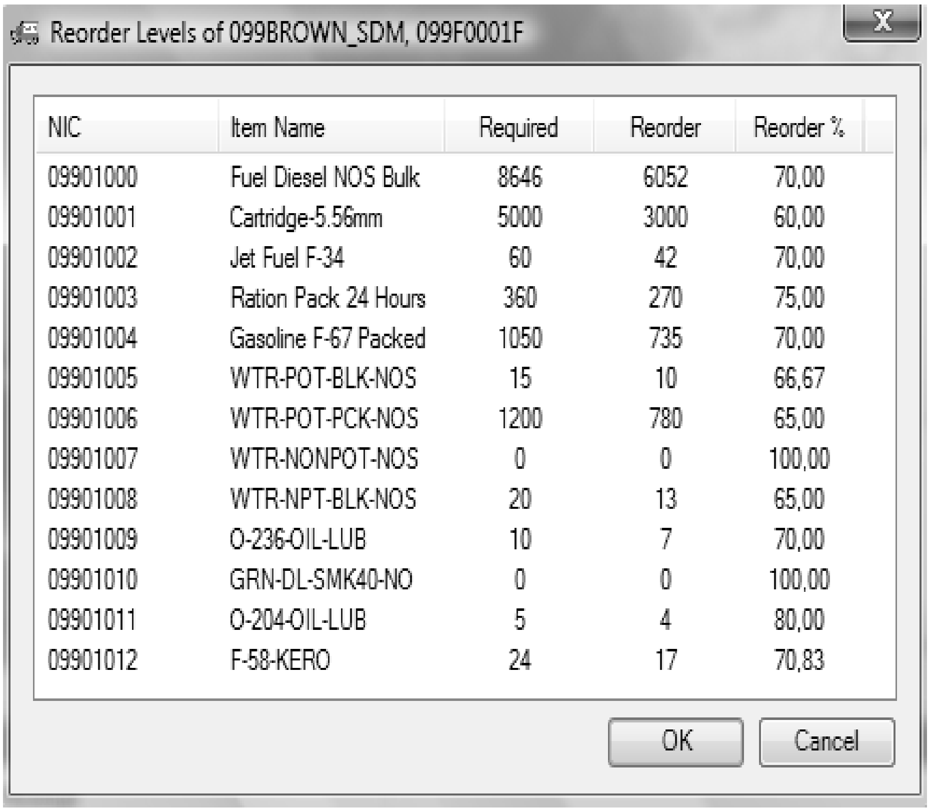
2. Analysis of supply distribution model

Following SDM analysis is focused on SDM's practical analytical deficiencies.

2.1 SDM scenario

For the actual work in the SDM, it is essential to set three basic input parameters "Assets Holding", "Reorder Level" and "Events", which allow actual supply chain modeling. "Assets Holding" represent the number of vehicles and their use in percentage of the supply chain.

SDM uses pull replenishment strategy. Replenishment is required when the "Reorder Level" is reached. Figure 2 shows inventory items and their maximum levels (column "Required") the level at which the replenishment request is made (column "Reorder").



Reorder Levels of 099BROWN_SDM, 099F0001F

NIC	Item Name	Required	Reorder	Reorder %
09901000	Fuel Diesel NOS Bulk	8646	6052	70,00
09901001	Cartridge-5.56mm	5000	3000	60,00
09901002	Jet Fuel F-34	60	42	70,00
09901003	Ration Pack 24 Hours	360	270	75,00
09901004	Gasoline F-67 Packed	1050	735	70,00
09901005	WTR-POT-BLK-NOS	15	10	66,67
09901006	WTR-POT-PCK-NOS	1200	780	65,00
09901007	WTR-NONPOT-NOS	0	0	100,00
09901008	WTR-NPT-BLK-NOS	20	13	65,00
09901009	O-236-OIL-LUB	10	7	70,00
09901010	GRN-DL-SMK40-NO	0	0	100,00
09901011	O-204-OIL-LUB	5	4	80,00
09901012	F-58-KERO	24	17	70,83

OK Cancel

Fig. 2 Reorder Levels window

Section "Events" demon-strates situations which determine stock consumption in the scenario. Example of Events [1]:

- The climate changes: for example to cold on Day 60 at 01:00;
- The operational type changes: for example to Peace Keeping on Day 90 at 19:31;
- Forces rotate: for example Force X rotates with Force Y on Day 30 at 06:00;
- Facility changes: for example Pipeline P begins construction on Day 10 at 09:26.

2.2 SDM deficiencies

1. Generally the SDM module makes it possible to view each materiel class separately. However as shown in Figure 3 it is not possible to identify unit's logistic subordination i.e. it is not possible to locate source and customers.

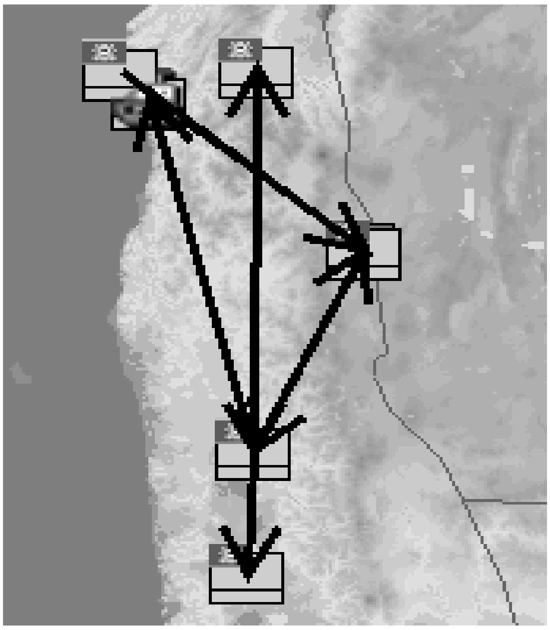


Fig. 3 Supply chain - Material Class V (ammunition)

2. The system allows the user to assign only one materiel class to one means of transport. This fact strongly affects the vehicle's potential.
Practically it is hardly ever possible to calculate the maximum cappacity of a vehicle - trucks are not used effectively. Consequently the entire calculation generates greater vehicle demand.

3. The simulation does not use the road infrastructure. Supply units move directly to their destination and back in a straight line. Therefore it is not possible to determine the actual time shift and time calculations are only tentative. The actual distance is approximate as well.

4. Replenishment is done only for one unit (customer). The supply unit returns to the place of supply (source) and no replenishment with other units among the customer's radius of several kilometers is done. This fact means an excessive time needed to replenish stocks of other units (customers) and also into increased consumption of fuel and lubricants.

Deficiencies mentioned above misrepresent the results of analysis and do not provide a real picture of a supply system.

2.3 Analysis of SDM outputs

Graphs and reports provide an essential basis for analysis of SDM outputs. Graphic design can be displayed for each inventory item, which shows the pattern of consumption and done supplement. Pattern of consumption over time is shown in Figure 4, where the green color shows the level of reserves "Required", "Onhand" blue, and "Re-order" level red.

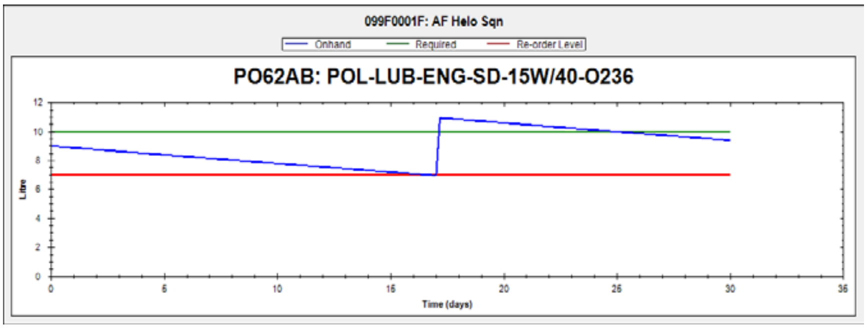


Fig. 4 Consumption progress

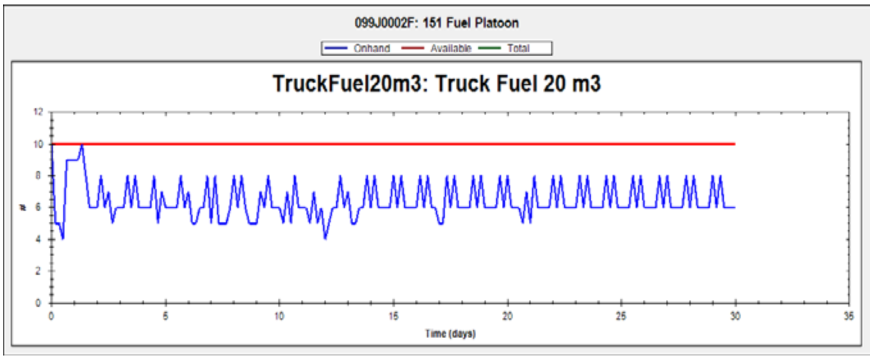


Fig. 5 Vehicle utility

Graphic representation of vehicle utility is shown in Figure 5, where blue indicates onhand transportation assets (i.e. those not currently in a convoy) and red colour available transportation assets.

There are two types of scenario report provided by the SDM [1]:

- Commodities Shortfall Report;
- Transportation Asset Utilization Report.

Commodities Shortfall Report (Figure 6) shows the percentage of the time when the unit (customer) had an inventory item below Reorder Level (at zero level). Transportation Asset Utilization Report (Figure 7) provides information on the employment of vehicles, the percentage utilization and percentage of full capacity utilization of means of transport. E.g. "Fuel Truck 20 m3" has been used 36% of the time of the supply chain. This vehicle's capacity has not been fully used though.

ForceID	ForceName		% Below Reorder	% At Zero
PO62AB	**POL-LUB-ENG-SD-15W/40-O23 6**			
099A0001L	Brownland Regt		5.0	0.0
099A0005S	Ammo Coy		0.0	0.0
099A0101I	1 Mech Infantry Bn		3.9	0.0
099A0102T	3 Transport Bn		7.2	0.0
099A0103T	1 Recce Bn		1.1	0.0
099F0001F	AF Helo Sqn		1.7	0.0
099J0001S	Supply Regt		0.0	93.4
099J0002F	151 Fuel Platoon		60.8	0.0
099J0002P	15 Port Sqn		0.6	0.0
099J0006S	Fuel Coy		2.2	0.0
099T0002T	Recovery and Repair Company		0.0	0.0
		PO62AB	**7,48**	**8,49**

Fig. 6 Commodities Shortfall Report

ForceID	AssetID	AssetDescription	PercentUtilisa	PercentFullyUti
099A0005S	AA TRUCK 5T	5 TON TRUCK	0,00	0,00
099A0102T	AA TRUCK 10T	10 TON TRUCK	0,00	0,00
099A0102T	AA TRUCK 5T	5 TON TRUCK	0,00	0,00
099J0001S	AA TRUCK 10T	10 TON TRUCK	0,00	0,00
099J0001S	AA TRUCK 5T	5 TON TRUCK	0,00	0,00
099J0002F	AA TRUCK 5T	5 TON TRUCK	0,00	0,00
099J0002F	TruckFuel20m3	Truck Fuel 20 m3	0,36	0,00
099J0002P	AA TRUCK 10T	10 TON TRUCK	0,00	0,00
099J0002P	AA TRUCK 5T	5 TON TRUCK	0,00	0,00
099J0006S	AA TRUCK 5T	5 TON TRUCK	0,00	0,00
099J0006S	TruckFuel20m3	Truck Fuel 20 m3	0,59	0,20

Fig. 7 Transportation Asset Utilization Report

3. SDM improvement proposal

This chapter focuses on the improvement proposal to deal with deficiencies referred to in point 4 of Chapter 2.2.
Finding the optimal sequence to deliver the required supplies with regard to transportation costs is the application of operations research

- the Traveling Salesman problem (TSP) and transportation problems (TP). In order to optimize certain supply chain tasks or just their parts (deployment of procedures) it is essential to employ the TSP method. TSP method sets the order of the traveling salesman path, so that the total distance was minimal with regard to the fact that each site was visited only once. An example is given in Figure 8.

06-21-2011	From Node	Connect To	Distance/Cost		From Node	Connect To	Distance/Cost
1	Node2	Node1	15	7	Node7	Node6	5
2	Node1	Node11	16	8	Node6	Node5	6
3	Node11	Node8	6	9	Node5	Node3	8
4	Node8	Node10	10	10	Node3	Node4	5
5	Node10	Node9	9	11	Node4	Node2	8
6	Node9	Node7	10				
	Total	Minimal	Traveling	Distance	or Cost	=	98
	(Result	from	Two-way	Exchange	Improvement	Heuristic)	

Fig. 8 Sequence table of routes to reach the minimal distance

N1 is considered a starting point. Optimal sequence of replenishment is as follows: N1 -> N11 -> N8 -> N10 -> N9 -> N7 -> N6 -> N5 -> N3 -> N4 -> back to N2 and N1. The total distance for this optimal sequence is 98 km.

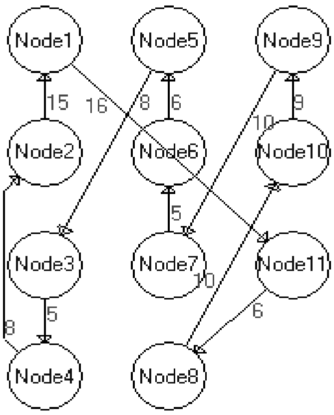


Fig. 9 Graphic solution of TSP

In the transportation problem there are typically defined suppliers with restraint cappacity (the amount that the supplier is able to deliver in a time period) and the number of destinations (customers) with specified requirements (the amount that the customer demands in a time period). The relationship of each pair source-destination is quantified (i.e. a calculated transportation cost per unit of goods between source and destination, or mileage distance between source and destination. [2]

The standard TP tends to be more complex and involves the calculation of indicators.

The general problem of the TP can be defined and represented by a network shown in Figure 10. [3]

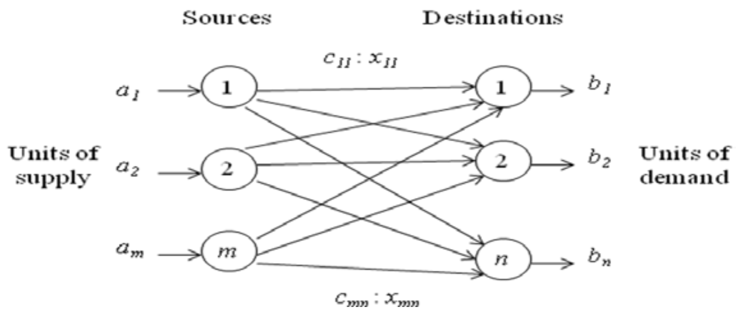


Fig. 10 Representation of the transportation model with nodes and arcs

TP methods of solution [3], [4]:

- North-West corner method
- Indexing method
- Vogel´s Approximation Method

The last mentioned method is considered most successful in finding optimal solution [4]. (Figure 11).

4. Conclusion

In order to mitigate the deficiencies listed in point 4 Chapter 2.2 the authors suggest to implement an intelligent algorithm, procedure or heuristics based on operations research methods. This implementation may significantly increase the explanatory power of simulations and serve as a reliable tool for modeling in SDM module.

At a time when economy and efficiency are the buzzwords and the armed forces are constantly pressed to watch the budget the need for optimal solutions in supply chain comes into play.

References:

[1] *Logistic functional area services*: Supply distribution model (SDM), version 6.0. Document Version 1.1. April 2010.
[2] *Dopravní problém*. Metody oper. výzkumu II. [on-line]. 2011-10-28. WWW: http://www1.osu.cz/studium/ mopv2/ doprav/#Reseni
[3] FARNALSKIY, D. *Applications of linear programming,* Case study, minimizing the costs of transportation problem. 2006. Degree Thesis. International Business. Supervisor Badal Karis Durbo.
[4] GROS, I. *Matematické modely pro manažerské rozhodování*. Praha: VŠCHT, 2009. 282 s. ISBN: 978-80-7080-709-5