Logistics Network Simulation Design

Harsh Jagdish Saksena, Abhilash Saksena, Khyati Jain, C. Mallika Parveen

***Abstract* — This paper is an outcome of a simulated project which focused on goods transport planning issues faced by major corporate clients in India. The overall experience proved to be so positive that the model for the project can be used by any corporate client in future years. This paper is based upon necessary inputs commonly available highlighting some of the educational issues which this experience has raised. Of particular interest to prospective clients and educators might be the issues associated with the functioning of some of the departments within the company and the opportunities provided by projects of this nature to establish strong links with industry.**

***Index Terms* —Road Transport, Simulation Design, Logistics Network**

I. INTRODUCTION

TRANSPORT is only one part of logistics and logistics itself is defined as the management of the entire supply chain [1]. Integrated logistics play vital role in the success of any company / industry. It has all the more relevance especially during the recession time wherein the sales are difficult and there is pressure in not only in achieving top line but also maintain, if not improve, the margins.

BRICS countries (Brazil, Russia, India, China and South Africa) and few of the Asia Pacific countries have still managed to withstand the industrial recession which has adversely affected not only the Americas but also Europe. One thing that remains common for BRICS Countries is that they have a large consumption within and hence are not overly dependent upon exports alone. Apart from it there are sufficient internal government related controls to protect the domestic industry. Hence, Integrated Logistics Management (ILM) or the present form of Supply Chain Management plays a very vital role in survival of any company.

ILM does not guarantee low cost of transportation but guarantees overall reduction in per unit cost of transportation by way of optimizing ware-housing and transportation requirements. Transportation can be done by various modes:

1. *Air*- It is the fastest and the costliest mode of transportation.
2. *Rail*- It is the safest and fastest mode for bulk movement of materials- mineral ores, steel, food grains, fertilizers etc.
3. *Road*- This is the ideal mode to arrive at weight to volume optimization as well as improved productivity.
4. *Water ways*- Probably the cheapest mode of transportation- not very developed in most of the countries.
5. *Shipping*- The cheapest mode of transportation from one port to another port both within the country (domestic shipping / coastal shipping) as well as international shipping.

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II. LITERATURE REVIEW

A supply chain can be analyzed as a network made up of the total set of raw materials supply, and several manufacturing and distribution activities [2]. The frameworks currently in use must be extended beyond pure road assessments and must include multi-modal and land-use effects [3]. Great effort is exerted to find an optimal configuration of infrastructure to extensively exploit technical and human resources and to effectively organize technological procedures [4]. To avoid congestion or idle time in the intrabay system, the control of the upper limit or the lower limit on the number of vehicles can be the feasible solution [5]. The synthesis of regional (urban) road transport freight system topological structure enables the assessment of impact exercised by various structural characteristics on the functioning of the system [6]. Flexibility strategy makes the supply chain more resilient to the disturbance [7].

Network rail is an expensive mechanism for channeling public money to private companies and the strength of the neo-liberal ideology [8]. Franchising has generally succeeded in raising rail demand and reducing costs [9]. Optimization algorithms can be used to: minimize the cost of delays; find solutions to recover disturbed scenarios back to the operating timetable; improve railway traffic fluidity on high capacity lines; and improve headway regulation [10]. The time savings due to efficient terminal transshipment can be used effectively only in combination with advanced rail operating forms [11].

If delay propagation is analytically mapped, then it is possible to perform reliable calculations in a short time even for large networks. The low computation times permit a more iterative improvement of timetables than it was previously possible [12]. It is essential for transport network planners and operators to identify sections within the network which, if broken, have a considerable negative impact on the network's performance [13]. The design and scheduling of the network influence directly the quality of service through coverage and directness concerns but also the economic profitability of the system since operational costs are highly dependent on the network structure [14].

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III. INTEGRATED LOGISTICS MANAGEMENT(ILM)

ILM uses more than one mode of transportation for optimizing freight rates depending upon the demand and supply of goods and availability of various modes of transportation.

ILM also combines various units / departments within the company / group companies for arriving at a workable solution- viz. finished product of one company is a raw material for another company, waste product of one company is a raw material for another company, spare parts procurement is co-related to reverse logistics for better volumes and freight management, raw material procurement is co-related to finished product movement for freight optimization etc. Basically ILM helps in forward, backward and lateral integration of manufacturing processes.

Hence, a suitable Logistics Network Simulation Design (LNSD) will play a very vital role in success of any company / industry. Logistics network simulations are normally being used for controlling / monitoring in:

A. Passenger Traffic

Bus: Passenger bus, private bus / tourist bus operators.
Train: Local trains, express trains, passenger trains.
Taxi: Licensed taxi, fleet owners, and private taxi.

B. Goods Traffic

Normal Parcel: Parcel can be of any number of pieces. However, each package should not be in excess of 35 kg. Any package greater than 35 kg cannot be easily handled manually and hence might cause damage to materials hence the weight restrictions.

Express Parcel: Normally express parcel is being sent by road / rail depending upon urgency and cost benefit.

Air Shipment: Normally documents / letters are sent by air cargo. However, now, even costly spare parts are being sent by air shipment so as to avoid idling spare part cost. It is more in line with Just-In-Time (JIT) concept.

Road Shipment: Any package which is apparently more than 5 kg is preferred to be sent by road rather than air due to freight charges. Nevertheless, it is integrated with road bridging both for air cargo as well as rail movement.

Full Truck / Trailer Loads: Trucks are of various capacities ranging from 1 MT to 21.5 MT and in few countries up to 27.5 MT. Trailers are available right from 16 MT capacity to 65 MT capacity- depends upon number of axles and horse power of the prime mover.

C. Containerized Movements

20' DVC (Dry Van Cargo) 20' DVC is the most commonly available unit of transportation both domestically as well as internationally- normal dimensions are 20' X 8' X 8'.6". However, high cube DVC containers (normally being used for FMCG / white goods) have height of 9'.6" (all external dimensions as per ISO specifications). Both have carrying capacity of 27.5 MT net cargo weight. 20' containers are normally used for dense cargo.

40' DVC (Dry Van Cargo): 40' DVC is the commonly available unit of transportation internationally- normal dimensions are 40' X 8' X 8'.6". However, high cube DVC containers (normally being used for FMCG / white goods) have height of 9'.6" (All external dimensions as per ISO specifications). Both have carrying capacity of 27.5 MT net cargo weight. 40' containers are normally being used for large items or voluminous cargo.

D. Rail

Private rakes:-
Containerized rakes: One rake consists of 90 TEU (Twenty Equivalent Units- ninety 20' containers or forty five 40' containers or a combination of both). Even though the rakes are owned by private rail operators (thirteen in number- five hold All India License and remaining hold route specific license), the haulage is being done by nationalized railways especially in India.

Specialized rakes / Wagons: Specialized rakes are used for industry specific norms- viz. Cement industry uses bulkers through specialized wagons capable of gravitational bulk loading and pneumatic discharge.

Government rakes:-
Parcel:
VPU [Vehicle (Motor) cum Parcel Van]: It has a capacity to move two vehicles (motors) along with conventional parcels.
SLR (Second Class Luggage rake cum Guard Van / Sitting): It has a carrying capacity to carry 4 MT of parcels / cargo.
Express Train: All express trains invariably have both VPU / SLR. Private parties can either book entire VPU / SLR for a specific period or on trip basis on payment of requisite fees to the railways.
Passenger Train: The cheapest mode amongst the passenger carrying trains.
Partial Loads: Partial loads are normally moved under VPU / SLR and not in rakes.
Wagon Loads: Wagon Loads means stuffing wagon with one type of cargo and the rake can have two or more type of cargo moving together- partial rake movements. However wagon type remains the same for the rake.
BCN Wagons: These are covered wagons with carrying capacity of around 56.73 MT in each wagon. Normally a rake consists of 40 Wagons. Even half rakes are available.
BOX-N Wagons: BOX-N Wagons are open Top wagons normally being used for bulk transportation of mineral ores / steel / coal or any break-bulk cargo. It has a carrying capacity of 58.81 MT. Normally a rake consists of 40 Wagons with carrying capacity of 64 MT.

The reason for low margins in railway movements has been primarily due to severe competition from other modes of transportation, rigid pricing and non-flexibility to changing environment [15].

Full rakes:-
BCN Wagons: 40 Wagons
BOX-N Wagons: 40 Wagons

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Containerized rakes: 45 Flat Rack / 90 TEU's.

IV. METHODOLOGY ADOPTED FOR RESEARCH AND DATA COLLECTION

There is already lot of research being done especially on passenger traffic. However, in this research focuses upon transport network simulation design for goods movements especially by road in India.

Global sourcing, JIT inventory control and the growth of the global marketplace have made inter-modal transport an increasingly important aspect of distribution and logistics [16]. Hence selection of carrier within each mode of transportation is a major business decision [17]. Most of the articles published cater to passenger traffic / vehicular traffic whereas; this article primarily focuses upon goods traffic planning by road in India.

For gathering requisite data for this project, we have taken into consideration:

1. Different readymade software available in market.
2. Existing methodology used in decision making for road transportation.
3. Freight rates by road.

As mentioned above, primarily we can have simulations designed based upon:

1. *Softwares readily available:-*

a. Ware House Management Systems (WMS):
WMS helps in improving in inventory management by way of using FIFO (First-In-First-Out) concept so as to avoid any obsoleteness / dead inventory. Milk run logistics helps in congested urban environments in both developed as well as developing economies [18].

Defective / Damaged / Rejected Products Management: WMS also helps in reverse logistics for managing defective / damaged / rejected products and thus optimizes upon overall productivity.

b. PARAGON: PARAGON is a licensed software which works upon GPS controlled shortest route planning. It helps in devising routing and scheduling through optimal route based upon various inputs.

Cost optimization: Based upon various in-puts fed into the PARAGON system like point of origin/s, various destinations, product mix, quantity required, types of vehicles available- its dimensions and load carrying capacity, number of working shifts etc., one can optimize upon the cost based upon the shortest route and weight to volume optimization. In planning the most ideal distribution network [19] the research has emphasized the importance of overall approach rather than a microscopic view.

(i) Case Study: One of the leading manufacturers of white goods in India who have more than a century experience in manufacturing and is a trusted brand name in India have their plants located at Vikhroli (Mumbai), Ranjangaon (Pune) and Mohali (Chandigarh) manufacturing white goods especially refrigerators (now more than twenty different FMCG products). They have many mother warehouses manned by their own personnel. They were the first to introduce frost free refrigerators in India in 1994 but lost out their first-move advantage to their competitors based out of Faridabad as they were using the traditional logistics tools-demand and supply and material availability. However, when they started using ware house management system in conjunction with Paragon and their in-house modified Enterprise Resource Planning (ERP) they realized the need for re-looking into both their existing production facilities as well as distribution channels. Once the re-designed distribution channel was in place, the growth rate has been un-paralleled and new products have been developed / introduced.

2. *Using Statistical Tools:-*

a. Transport Matrix: Transport matrix helps in identifying goods movement pattern between various cities. We could also use this tool to add on type of vehicles used, products transported so that one could arrive at seamless movement of goods between two cities or cities en-route.

b. Linear Programming Problems (LPP): LPP model can be used to arrive at least cost and freight optimization between two cites. But, this is not essentially a most cost effective and optimal model. It can be used in conjunction with findings under transport matrix.

(ii) Case study: One of the largest manufacturers of polymer products in India have their finished product movement (polymer product) from Hazira (Gujarat) to Hoshiarpur (Punjab) - volumes are large (Approx. 5000 MT P.M.) and hence not practical to move by road alone. Hence, it was thought fit to use multi-modal operations- from Hazira to Surat by road, from Surat to Ludhiana by rail (Containerized mode) and again from Ludhiana to Hoshiarpur by road and simultaneously from Hazira to Hoshiarpur directly by road. This gave the company a relative advantage on idling cost towards inventory gets more than made-up by lower cost of rail transportation and daily dispatch of materials by road a consistent feeder / supply to the manufacturing plant. In return, these very vehicles could bring in polyester yarn to Bhilwara (almost 75% of the transit route) and thus optimize upon the freight rates. This was possible by using statistical tool of transport module- traffic flow. Similarly, multi modal operations was optimized by using LPP model.

c. Customizing customer's specific requirements: ERP is one of the possible solutions wherein different modules are linked to the parent system and real-time position vis-à-vis-production planning to sales forecast and the inventory management are all linked. However, careful consideration has to be made in estimating the inventory holding cost and mechanism for determining capital holding charge [20] while implementing ERP.

d. Customized Software: Many multi-national companies have their own global systems and processes that are linked locally both with their manufacturing units as well as their mother warehouses and distributors. Software like e-MIST (Electronic Management Information System for Transport), IFPS (Integrated Field Processing System), FOURSOFT (ERP) etc. are capable of being modified to suit specific requirements of customer's needs.

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(iii) Case Study: One of the leading global logistics company has customized their existing global software to suit the specific requirement of pharmaceutical industry and have named it "O2C" (Order to Cash). Pharmaceutical industry has a very unique requirement wherein each medical representative logs in to place his orders. The orders are normally being processed by the marketing team based upon which necessary instructions for dispatches are being made. Based upon firm orders, production planning is done and then dispatches to retailers- It is a very complex model as O2C is a three month to six month process. Hence this global logistics leader thought it fit to modify their existing WM500i (Ware House Management System) and integrate it with TM300i (Operating System) and simultaneously create a control tower for all on-line order processing / invoice generating / collection of payments from retailers. Today it has been successful with one of the major pharmaceutical companies in India and now the same is being replicated with other large pharmaceutical companies.

V. RESULTS AND DISCUSSIONS

Recommendations: In India, one of the emerging economies, freight rate calculation has been a difficult task as the manufacturing industries are highly skewed towards western India, raw material procurement especially mining materials are in eastern India and the consumption centers are spread all over the country. Apart from it, the surface transport industry is highly un-organized and hence freight rate computation before launch of any new product in India has been very difficult.

Hence, this research tries to incorporate statistical tools to formulate formulas to arrive at basic road freight rate computation which involved not only transportation matrix but also usage of LPP solutions. These rates have been re-verified with weekly freight rates published by leading logistics companies in India and market freight rates quoted by brokers / vendors.

These simulated tools can be used by any corporate client to arrive at basic project costing / freight costing before launch of any new product. Detailed study of projects undertaken can be shared on request.

The result of statistical tools used is furnished in matrix form below for computation of freight rates by different types of vehicles with varying carrying capacity especially in India and are in Indian Rupees (INR) on Per Ton per Km.:

TABLE I
TO CALCULATE FREIGHT RATES BASED UPON MATERIAL LOAD AND DISTANCE

FROM ANY WHERE TO ANYWHERE IN INDIA	RATE PER TON	RATE PER FTL	RATE PER OPEN TRUCK	RATE PER TAURUS TRUCK
		9 TONS	9 TONS	16 TONS
UPTO 250 KMS	4.51	33.37	58.40	61.73
251-500 KMS	3.58	26.47	46.32	48.96
501-1000 KMS	3.30	24.39	42.69	45.13
1001-1500 KMS	3.11	23.01	40.27	42.58
1500 KMS & ABOVE	3.11	23.01	40.27	42.58
ALL INDIA	**3.23**	**23.93**	**41.89**	**45.48**

TABLE II
TO CALCULATE TRAILOR RATES BASED UPON LOAD AND DISTANCE

TRAILOR RATES:	
WEIGHT CATEGORY	**RATE PER TON PER KM**
UPTO 15 MT	3.27
16 MT TO 20 MT	3.52
21 MT TO 30 MT	3.77
31 MT TO 40 MT	4.02
41 MT TO 50 MT	4.27
51 MT TO 60 MT	4.52
61 MT TO 70 MT	5.52
71 MT TO 80 MT	5.77
81 MT TO 90 MT	6.02
91 MT TO 100 MT	6.52

TABLE III
TO CALCULATE RATES FOR OVER DIMENSIONAL CARGO

OVER DIMENSIONAL CHARGES (ODC CHARGES)	NORMAL TRUCK CHARGE EXTRA
LENGTH ABOVE 5.5 MTRS TO 6 MTRS.	10%
LENGTH ABOVE 6 MTRS TO 6.70 MTRS.	20%
HEIGHT ABOVE 2 MTRS. TO 2.5 MTRS.	10%
HEIGHT ABOVE 2.50 MTRS. TO 3 MTRS.	35%
WIDTH ABOVE 2.5 MTRS. TO 3 MTRS.	N.A.
WIDTH ABOVE 3 MTRS. TO 3.5 MTRS.	N.A.

VI. CONCLUSION

By using a combination of readymade easily available licensed software and statistical tools simulation designs suitable for one's specific requirements can be effortlessly developed.

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