Simulation of Container Terminal Model (SimCon-T) for Mahuva Intermodal for Better Development of Logistic Management System

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Abstract— Intermodal transportation is the transportation between two modes like road and rail. It also known as combined transportation system. The aim of this study is to develop a model called SimConT model, or simulation container terminal model for intermodal transportation system. Two modes i.e., rail and road mode is considered to develop this model. The model can also be used as a tool to calculate the costs and environmental effects of a given transport system. The potential of intermodal road-rail transport was determined using the SimConT model. An input data set was developed based on the collected data from Mahuva port. The output data of this SimConT model is compared with the data of Mundra port. By using this intermodal transportation model business economic costs and social economic costs can be lowered, as well as harmful environmental effects can be controlled. SimConT model can be better used for identification optimal route for delivery of goods, optimization of the use of resources, for improvement of existing model or database system.

Key words: Intermodal Transportation, SimconT, Business Cost, Combined Transport and Environmental Effect

I. Introduction

Ports play an important role in facilitating trade and act as a significant interface between marine and land based transportation system. It is estimated that there are more than 4,936 ports in 196 countries around the world. It is believed that India has been facing galloping growth in international trade over past few years.

Container terminals one of the most important logistic networks. It required and efficient and hassle free mode of transport like rail, truck and, ship. The growth of an industry depends on development of the container terminals.

Now a day's container terminals facing different optimization issues like handling of container, segregation, import and export of containers. These problems leads to improper handling of containers, which moves towards lesser efficient of terminal port.

Efficient planning of container terminals required for increasing the output or turnover of the terminal. With the help of better transport infrastructure like road and rail networks the overall efficiency of the container terminal can be increased.

The main aim of our research is to minimize the loss of the container terminal handling port and increase the efficiency.

The simulation container terminal is concepts which help to the potential users for efficient planning of Mahuva container terminal.

Mahuva is located in Bhavnagar district of Gujarat and connected to other areas of Gujarat like Ahmedabad (170 km), Vadodara (280 km), Jamnagar (266 km), Surat (447 km), Rajkot (178 km), Ankleshwar (364 km), Vapi (514 km), Gandhinagar (228 km) and Mehsana (274 km). Different products like salts, onions, oil cakes, scrap, rape seed and clay. The government of Gujarat also handling different products like steel, coal, iron plates, iron ores and automobiles by the help of this port.

II. Methodology

In the methodology of this study, a model named Simulation Container Terminal (SimConT) is created in response to a problem and is closely connected to the problem it is created to solve.

The primary focus of the current model is on the physical flows, it also going to focus on the system between road transport and combined transport. As stated earlier, the model is not intended to model the actual competition in the market, since the focus is on the potential in the market. However, it is important to gain the knowledge of the market structure of the system to make model more potential. A more market oriented theory will, therefore, also be used to supplement the systems thinking in understanding the market structure of the system. The obvious choice is to look at the different channel theories, due to the combined transport industries channel structure. Particularly, marketing channels theory may be useful to understand the market structure.

A. Modeling Technique

Goods transport models can vary greatly in size and technology depending on the purpose of the models. Due to the obvious geographical connection to transport modeling, many transport models are encapsulated in a GIS-like map interface with connections to databases for input and output data. Behind the graphical interface, there are three main approaches to develop a goods transport model – optimization, simulation and network modeling, although combinations do exist and the boundaries are not well defined.

Optimization is a process in which an attempt is made to find an optimal solution to a problem. Optimization in real-world industry problems is often referred to as operations research. The optimization, then, tries to find the maximum (or minimum) value of the objective without violating any of the constraints. In a simulation, a, normally graphical, model of the system is designed, where the appropriate causal links and costs are included. The model is intended to mimic the behavior of the real-world system. The simulation does not optimize the system, but only tests its performance with the given input parameters. A network model represents the transport system as a set of nodes, for example, a terminal, connected through a set of links, such as roads or goods transfers. Each type of transport mode and vehicle type is represented by its own link with individual characteristics. The links are connected by transfer links to represent allowed transfers. Each link and node is assigned certain characteristics like, costs and delay functions.

B. Data Source

The study is based on the details of primary data collection. It is important to consider the data availability when developing a model. Naturally, it is of no use to develop a model just to find that there is no data of satisfactory quality to input in the model. Data sources can be of two types, primary data sources and secondary data sources. As there are several good primary data sources available and the main purpose of this thesis is model development.

C. Principles of model Validation

To validate a model is a complicated task. There are three parts of a model that need to be validated. First, the underlying conceptual model of the system has to be studied. Second, the model has to be translated into a working computer model and, third, the actual computer model is to be developed. The validation of a computer model consists of three general steps - verification, validation and evaluation.

III. DATA STRUCTURE AND DATA SET

This deals with the data structure and collected data set for model run and analysis. Various input data's are: transport demand, road, rail distance, terminal areas, terminal data, shared fixed costs, train types, all road-lorry types, combined transport lorry types, allowed train loops, allowed lorries, time & control parameters. The output data mainly consists of combined transport, road transport, train loops and aggregated data. The data set consists of time period, demand data, export and import data, forwarder data, combining data.

IV. RESULT ANALYSIS AND DISCUSSION

The model has been run with the data set in a number of different implementations. The run time for the model varied between 10 and 25 minutes depending on the data set. The more complex the input data, e.g. number of demand instances, number of possible train departures, etc., the longer the run times. The model was run on computer system. The modeling period was 60 consecutive working days to reduce any start up effects, and an average daily value was calculated from the output data. It is very important to notice that the data presented in the model is the raw model output and, thus, affected by the assumptions and delimitations made when developing the data set, e.g. that some goods types where excluded from the data set. The raw output data must, therefore, be analyzed and put into perspective. The raw output should be regarded as input into a final analysis. All data is for an average day and the numbers have been rounded. The word optimization is used here to represent the heuristics calculations in the SimConT model.

The input data set was first tested with a number of basic model runs. All possible train loop systems in the input data set was tested, i.e. morning departures, morning and evening departures, lunch departures and evening departures. Each train loop system were tested in all four optimization settings, i.e. lowest cost and train route optimization, lowest cost and system optimization, maximum transfer and train route optimization and, finally, maximum transfer and system optimization. Lowest cost optimization means that the SimConT model finds the transport system that gives the lowest total cost. Maximum transfer optimization means the model finds the system that sends the most goods with combined transport without increasing the total system cost compared with an all-road system. The train route optimizations required several model runs for each tested train system, since the fixed costs in the combined transport system are allocated to train routes already in the input data. The fixed costs allocated to train routes that do not use any combined transport must, thus, be reallocated to other train routes. Since this might affect the modal split, the model needs to be re-run with the new allocation of fixed costs.

	Tones in combined transport	**Total cost combined transport (Rupees)**	**Cost train system incl. Terminals and handling (Rupees)**	**Total cost saving (Rupees)**
Lowest cost system				
Train route optimization				
Morning departures	38,330	67,0000	54, 0000	47,0000
Lunch departures	90,300	147,0000	116,0000	115,0000
Evening departures	39,750	72,0000	58,0000	62,0000
System optimization				
Morning departures	39,300	68,0000	55,0000	49,0000
Lunch departures	90,700	147,0000	117,0000	117,0000
Evening departures	40,400	73,0000	59,0000	64,0000
Maximum transfer system				
Train route optimization				
Morning departures	46,100	81,0000	63,0000	44,0000
Lunch departures	110,300	178,0000	143,0000	103,0000

Evening departures	43,850	83,0000	66,0000	58,0000
System optimization				
Morning departures	57,800	100,0000	76,0000	41,0000
Lunch departures	122,800	205,0000	152,0000	98,0000
Evening departures	48,200	101,0000	81,0000	51,0000

Table 1: Basic Model Runs

As can be seen, the joint timetable produces the best result both for lowest cost optimizations and maximum transfer optimizations. As can be expected, the results are better for the system optimizations, than for the train route optimizations. The lowest cost optimizations determine the lowest cost for the transport system. They can be run with two settings, either train route optimization or system optimization. The system optimizations try to transfer as much goods as possible to combined transport without increasing the total system cost. Theoretically, this would result in a total cost saving of zero, i.e. no change in cost from a system with only all-road transport. However, in the current dataset, there are not enough goods to send by combined transport to reach zero cost saving.

A. Potential of Model

The potential for combined transport can be measured in a number of ways. It is here defined as the reduced resource consumption from using combined transport compared with all-road transport. This is expressed as the reduced cost by transferring goods from an all-road system to a combined transport system. This measurement has the advantage of being independent of the surrounding system, e.g. demand outside the data set does not affect the potential. However, another interesting measurement is the relative measurement of modal split, i.e. % of the total demand sent by combined transport. This measurement has the advantage of being commonly used when comparing different modes and is also easy to understand. However, it is relative in that it is dependent of what is regarded as the total demand. The modal split presented in the raw output data is limited in that the total demand in the data set only represents a selection of the total demand in India.

B. Cost

The focus in the cost analyses has been on the business economic costs. The SimConT model always calculates both business economic costs and social economic costs, although the optimization only considers one of them.

Transport part	**% of combined transport costs**
Road haulage	20.5 %
Variable terminal costs	25.1 %
Fixed terminal costs	1.1 %
Train haulage	53.3 %
Total	100 %

Table 2: Cost structure of combined transport

The table shows the distribution of the total system cost. Train haulage is, not surprisingly, the largest cost, but also the variable terminal costs represent a fairly large share of the combined transport costs. Terminal operations are an area that is the subject for much research and where the costs also can vary greatly between different terminals. It is, therefore, interesting to see the effects of reduced terminal costs. A data set was run in the SimConT model with the variable terminal costs, i.e. handling costs, reduced by 50%. All other data were the same. This resulted in 10, 9583 tonnes daily being sent by combined transport, or 40 lakh tonnes yearly. The potential for combined transport, thus, increased to 56.2%.

C. Environment

Combined transport also gives a substantial reduction in emissions harmful to the environmental. The environmental savings from using the suggested combined transport system compared with an all-road transport system are shown in Table. Table shows the average emission per tonne-km for the two parts of the modeled transport system.

CO_2	CO	SO_2	NOX	PM	HC	Energy	Cost estimation of emission
53%	49%	25%	53%	48%	53%	31%	53%

Table 3: Environmental savings compared with an all-road system

As can be seen, the environmental effects of using combined transport are substantially lower than those of all-road transport. The only exception is SO_2 where combined transport causes much higher emissions. This is caused by the electricity mix used in this data set. The CO_2 emissions are of particular importance considering the greenhouse effect and climate change. The total CO_2 emissions from heavy traffic (trucks and busses) are 1 million tonnes per year. The reduced emissions in the suggested transport system are 0.5 million tonnes per year compared with an all-road system, or 31% of the total CO_2 emissions from heavy traffic. Although some goods already are sent by combined transport, this shows that combined transport could contribute significantly to reducing CO_2 emissions. A model run was also conducted with an environmental optimization towards the system with the lowest CO_2 emissions. The SimConT model, thus, calculated the transport system giving the lowest CO_2 emissions. This optimization resulted in 45.0 billion tonne-km being sent by combined transport, which is 40 lakh tonnes more than in the original system. This is also more than in the socio-economic optimization. This further shows that combined transport can contribute greatly to reduced CO_2 emissions.

	CO_2 gm	CO gm	SO_2 gm	NO_X gm	PM gm	HC gm	Energy MJ	Cost estimation of emission
Combined transport part	3.28	0.003	0.0024	0.02	0.0004	0.0017	0.18	0.10
All road part	32.21	0.41	0.000057	0.28	0.0046	0.023	0.60	0.086
Total system	15.23	0.018	0.0026	0.11	0.0021	0.0092	0.35	0.034

Table 4: Emission per tonne km for the modeled system

D. Time

The model made some adjustments in departure and delivery times compared with all-road transport. All adjustments were made within the allowed time windows and time gaps. The delivery times, in most cases, were adjusted forward in time. The only occurrences where the delivery time was adjusted backwards in time (14.3%), i.e. earlier delivery compared with all-road, are when the departure times also were moved earlier. No demand has both later departure time and earlier delivery time. As can be seen, 58.7% of the goods weight in combined transport is delivered no later than five hours after all-road transport and 28.8% are delivered no later than two hours after all-road (Figure-1).

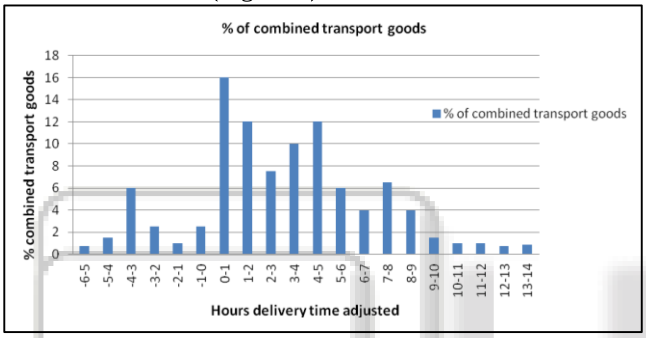

Fig. 1: Adjusted delivery times and share of goods weight in combined transport

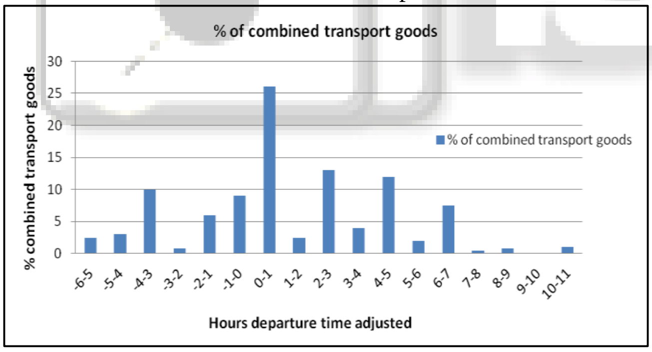

Fig. 2: Adjusted departure times and share of goods weight in combined transport

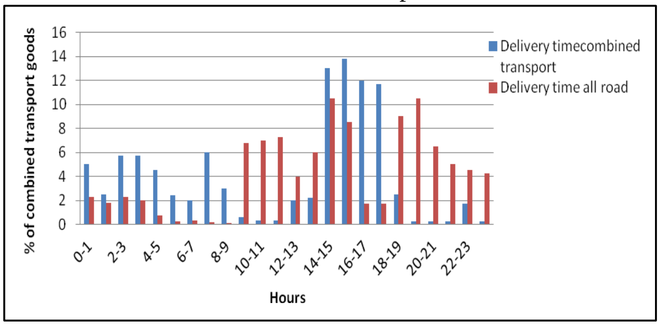

Fig. 3: Delivery times compared between the modes

The departure times were also adjusted. A majority of the demand was adjusted forward in time, i.e. later departure, with only 30.5% of the weight in combined transport being sent earlier. This can be explained by the use of overnight transport, where a large portion of the all-road demand would be delivered during the night. This makes it possible for combined transport to use later departure times and still deliver in the same time period. Figure shows the delivery times by combined transport and if the same demand would have been sent by all-road transport. All-road transport has many deliveries late in the evening (41.1% compared with 5.3% for combined transport between 18-00), while combined transport has more deliveries during the night (35.5% compared with 11.0% between 00- 08). However, both are in the same time period (18-08) and, thus, considered equal (Figure-2 and 3).

E. Collection Area

The collection area is the area around a terminal where combined transport is a competitive alternative. The average transport distance (per transported ton) to or from a terminal is 10 km, i.e. a total road transport of 23 km. The weight distribution can be seen in Figure, which shows the share of combined transport goods distributed by the total road transport distance at both ends (i.e. collection distance plus distribution distance). As can be seen, 50% of the goods (in tonnes) have a total collection and distribution distance of less than 40km. 95% have a road transport distance of less than 140km. This confirms the general belief that the road transport part should be kept as short as possible. The profitable distances, thus, only represent the closest surroundings of the terminal. The large share of goods with a distance less than 10 km is caused by international goods that are aggregated at the border crossing (and at the road transport terminals in the other end) and by domestic goods located in the same municipality as a terminal, thus, with a very short collection distance. Of the total input demand, 31% are located less than 10km total (collection distance + distribution distance) from terminals.

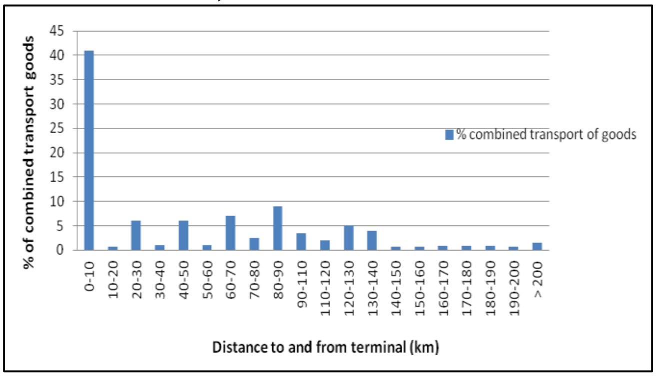

Fig. 4: Collection and distribution distance by share of goods weight in combined transport

In this the total demand has the same sending and receiving terminal and are, thus, always assigned to all-road transport. This share is interesting because it cannot be sent by combined transport without new terminals. However, this should be interpreted with caution, since the demand database used in the data set is not designed for very short distances. Some data from the forwarders were, for example, divided into three parts (to terminal, long-haul and from terminal).

This makes the data set not fully representative on very short distances. Also, the fact that there is a potential train route to use does not necessarily mean that the train route can be made profitable. However, a careful geographical analysis can be made by looking at the share of the total transport demand for a region, where sending and receiving terminals is the same.

F. Comparative analysis of after and before combined transport system

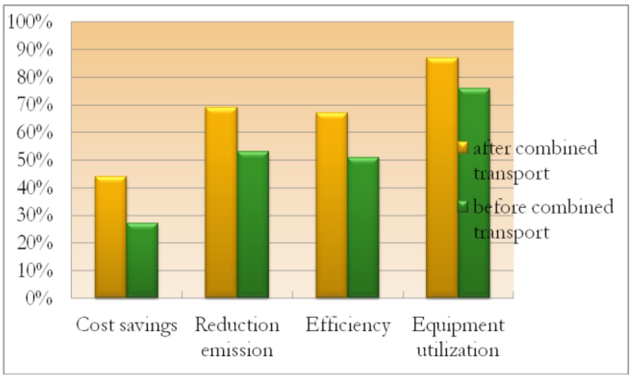

Fig. 5: Comparative analysis of combined transportation system

By using intermodal transportation overall efficiency, cost savings, emission reduction and equipment utilization can be increased.

V. CONCLUSION

The model was developed for SimConT decision support for combined transport in India. As stated in the determination of the potential for combined transport in India, the model is well suited to its purpose.

One goal was to build a flexible model. The model structure does not limit the size or geographical area (for example other countries) of the model. The input and output data can be changed easily processed and analyzed using the Microsoft Access database, without requiring the user advanced computer skills. Not only the large data sets can be performed, but the models can also be used with small data sets, for example, for an individual train route or a single combined transport operator. The model could also be extended to other modes of transport. In particular, the shipment would be interesting to add to the model. From the point of view of modeling, modeling principle is the same. A long-haul transport mode is simply a representation of the loading capacity, costs and transport times, which might as well be a ship or an airplane like a train. Lines are very flexible and versatile and can be used in many different situations.

The SimConT can be used by decision makers to evaluate and examine the possibilities of intermodal transport and also to test the effect of changes to the system, for example, taxes, cost trends, new technologies, new infrastructure, etc. The transportation industry can use the model to develop new transport systems and improving existing systems. The model can also be used as a calculation tool for calculating performance, costs and the environmental impact of a given transmission system.

The scan paths and models made with SimConT model in determining the potential of combined transport in the current system of transporting Indian stressed the importance of being familiar with the model and the assumptions made during the testing and analysis model. Several parts of the output data can be explained by the way the heuristic model works. This shows that a model user must be very well acquainted with a model before attempting to use it. This gives the user the ability to separate the effects of technology on the model of the effects of the studied system.

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