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Integrated Freight Terminal and Automated Freight Management System: A theoretical approach

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Abstract

The author proposes the use of customized conveyor belts for handling goods like cement, fertilizers, grains and other packaged commodities. These terminals will allow efficient running of multi-point trains and facilitate train-to-train transfer. At commercially viable places facilities for handling other traffic like containers, perishable products, and automobiles can be integrated. Common facilities will help to decrease the unit costs for the customers and increase the revenue earning potential for the transporter and terminal operator. Value added services like consolidation and breaking up of cargo, packaging, labelling, bar coding, reverse logistics, customs processing etc.; it will enable many customers to dispense with their own supply and forwarding warehouses. Such terminals at Dedicated Freight Corridors can capture the emerging fast moving consumer goods and e-commerce traffic. This will simplify supply chains and aid in the reduction of the prices of goods. This is particularly important for India where logistics occupies 13% to 15% of the GDP. Railways having a greater freight market share mean significant environmental benefits. Also the proposed concept will reduce the fleet of trucks and highway congestion. Integrated Freight Terminals (IFT) aided by Automated Freight Management System (AFMS) with automated loading/unloading systems, on-site sorting, storage and transshipment facilities will transform the way commodities are transported by railways. Moreover, faster freight service means faster turnover, payment and return on investment.

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Keywords: Material handling; conveyors;logistics,;automated terminals; rail cargo management; rail cargo handling; freight terminals; multimodal logistics; Indian Railways; rail freight

1. Introduction

Globalization and ever increasing population have led to increasing volume, complexity and sophistication of production around the world. Not only more goods have to move around, but these have to move faster. Logistics

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and supply chain management are needed by developing nations in order to accelerate the growth of their manufacturing sector, trading and improve the standards of living of its citizens. Logistics involves the planning and implementation of the transfer of goods, services and related information from origin to recipient. It comprises of transport management, materials management, physical distribution, information management and warehouse management.

Actual logistic systems are unsustainable economically, environmentally and socially:

- The way goods are transported and stored is extremely **costly**, accounting for a significant fraction of the gross national product for many countries. For example, transportation in U.S. represents about 10% of the U.S. Gross Domestic Product, more than $1.4 trillion.
- From an **environmental** perspective, the stakes are also high. For example, in France, freight transportation generates 14% of the greenhouse gas emissions. From 1990 to 2006, these last have grown by an annual rate of +23%, the fastest pace of all sectors.
- **Social** perspective; Continental transport is dominated by road based transportation, leading to a high demand for truck drivers. Many truckers are nearly always on the road, with bad repercussions on their family life and on their health. In the U.S.A., 58% of the accidents concerning truckers were due to fatigue and sleep deprivation Montreuil (2011). India has many other social problems associated with transportation and supply chains.

Railways are considered **environment-friendly** and **economical**, especially for the transport of bulk goods. In India, rail consumes 75% to 90% less energy for freight traffic compared to roadways. Increasing the share of railways in freight traffic leads to a decrease in health damage costs of Rs. 3.57 million per day Singh (2015). In India, the overall share of freight of Indian Railways (IR) has come down from 86% in 1950–51 to 30% in 2015–16. Around 60% of IR's revenue comes from freight traffic. While the railways retain their relative advantage mainly in natural resources and intermediary goods markets in which there are large volume movements and relatively low value-to-weight ratios, they tend to lose it in the case of items with high and increasing value-to-weight ratios. In recent years, the changing composition of Indian manufacturing sector has lent greater weight to the second category of freight traffic, and the relative decline in the demand for railway services Chadha (2009.)

India's share of logistics in its GDP is **13% to 15%**, which is significantly higher share than what the developed countries spend on their logistics domain. The number one reason for this is the inefficiency in the transportation system, with the country being plagued with bad roads, railways with capacity constraints, traffic bottlenecks, and inadequate transport hubs and warehousing.

The terminal is the **focal point** between road and rail and can combine the advantages of railways (mass efficiency), trucks (flexibility) and regional storages (buffering) and even distribution and value-added services. The paper aims to an efficient terminal management strategy and increase the freight market share of railways, particularly for India. The author proposes the optimum use of conveyors for handling goods transported in covered wagons and parcel vans.

2. Methodology

Field observations of freight terminals were undertaken. Official documents of Indian Railways were carefully analyzed especially those pertaining to terminal detention. Besides research papers of various journals and conference proceedings, reports and studies of various government, private and academic institutions were analyzed. The author also tried to understand the freight terminals and automated freight/cargo handling mechanisms in different parts of the world. Problems faced by Indian Railways' customers were studied. The bottlenecks of Indian Railways' freight services and its evolution since 1950s were analyzed. The advantages offered by roadways and airways were viewed. The prospects of railways gaining competitive advantage over other modes and its combination for a multimodal logistics system were analyzed; which would give social, environmental and economic benefits. The time gained by using conveyor belts in the proposed concept was arrived after comparing existing facilities using conveyor belts.

3. The Indian scenario

In India along with the tertiary sector, the primary and secondary sectors are also growing because of renewed efforts of the government. Thus, ensuring an uninterrupted supply-chain, spread over the entire fabric of the economy, is an indispensable prerequisite for sustaining a higher pace and pattern of growth. Indeed, a typical Indian manufacturing unit of tomorrow has to be markedly different from its predecessor of yesterday, in terms of the speed and the form in which it receives the production wherewithal and dispatches its finished products to consuming destinations. Rapid agro-industrialization is encompassing rural areas no less than their urban counterparts. The transport-content of agricultural raw material going to agro-processing units as well as of semi-processed and processed products moving out to various commercial outlets and consumption centres would be fairly high, because the haulage would have to cover wide-spread rural production points. Today, speedier movement of goods is of much greater significance, compared with yesterday; tomorrow, it is bound to be far more so.

The operation of goods train in India depends largely on following aspects:

- Adequate availability of desired railway locos, wagons, crews and appropriate paths for movement of goods trains
- Upkeep of the locos and wagons in good condition by facilitating timely repair and maintenance,
- Ensuring optimum utilization of locos/wagons by achieving reduction in turnaround time.

Ready availability of wagons, their optimum utilization with minimum detentions and reduction in empty haulage of wagon stock are crucial for profitable operation of goods trains. The growth of passenger and freight traffic on IR has been much faster than the growth of network and loading & unloading terminals CAG, India (2013).

Fig. 1 Loading at Kakinada port, Andhra Pradesh, India

3.1 Turn round time

Turnaround is defined as the time that elapses between two successive loadings. It has two components: (i) transit (running) time, and (ii) terminal detention. It has always been the railways' prime effort to reduce the transit time by increasing the average speed of goods trains. However, notwithstanding colossal investments made for the upgradation of tracks and rolling stock, including the induction of high capacity locomotives, there are inherent systemic operational limitations in this regard. On the Indian Railways' (IR) network, both freight and passenger trains use the same tracks. This means that, at any given time, there is a **mixed traffic** regime. As things stand, the goods trains are generally not allowed to take precedence over even the slowest moving passenger trains. In view of this limitation, the only other way to reduce the wagon turnaround is to minimize the terminal detention (loading/ unloading) of wagons Dastidar (2009). Not only the common user facilities of IR like goods sheds but, more importantly, the private sidings of most of the major industries, which depend largely on rail transport, such as steel plants, collieries, iron ore mines, cement factories and ports have not received much investments to improve the terminal efficiency. This neglect, both by the Railways and the industries, has resulted in substantial losses in transport output, productivity and earning potential. Efficient terminal management plays an important role in the optimization of assets, particularly rolling stock, as well as for service reliability and consequently the reduction in the unit cost of transportation. From the customers' point of view, it also reduces the inventory cost Brahma (2009).

Table 1. Wagon turn round time

Year	Wagon Turn Round (in days)
2010-11	4.97
2011-12	5.08
2012-13	5.18
2013-14	5.13
2014-15	4.98

Source: Ministry of Railways, Government of India

The following reasons can be attributed to detention of rakes in terminals:

- Non availability of labour for handling the cargo
- Poor clearance by loading/unloading parties
- Environmental phenomenon like rains
- Inadequate infrastructure including warehousing leading to damage of goods
- Non availability of permission of movement of heavy vehicles in case the terminals are located inside the city limits.

Automated systems in public terminals are minimal or absent, hugely affecting essential goods like grains, fertilizers, sugar, etc. Many large cement and factories use conveyor systems for wagon loading (mostly one at a time) but no such system exist at the destination terminals. The current ways of goods handling operations at railway terminals also increases the fatigue level of workers.

Table 2. Terminal detention due to loading & unloading

Year	Loading Detention (in hours)	Unloading Detention (in hours)
2014-15	16:31	18:28
2015-16	16:08	18:07

Source: Ministry of Railways, Government of India

3.2 Issues at stake

India's archaic **warehousing** system has been detrimental to the growth of almost all sectors, especially sectors like food and food-processing that requires modern warehouses and investments in cold chains and allied machinery Shukla (2009). **Roadways** have the advantage of providing **door-to-door services** and in moving **heterogeneous goods.** For IR to gain additional market share it has to capture the emerging e-commerce traffic from airways. Cement and food grains which were considered exclusive goods for railways are now slowly moving to roadways. Inland waterways are also getting importance in recent years. Customers are seeking better inventory management and desire smaller parcel size and in this context, IR needs to encourage multi point loading/unloading in covered wagons.

Due to capacity constraints, Indian Railways has been focusing on the core sectors of the economy. This has resulted in the majority of the rail freight basket being confined to a small group of bulk commodities with coal constituting almost 50% of the freight traffic. Further, the need for servicing the core sectors of the economy in spite of severe capacity constraints forced Railways to **accept only train load consignments**. This has led to a drop in the share of Railways freight movement in the country as large proportion of the movement is in less than train load sizes Railway Board (2016). Reducing inventory costs by transportation in smaller parcel sizes can increase the market share of IR.

Restoring short lead traffic concessions to customers who promise long term traffic commitment must be examined. It makes operational sense for the railways to discourage short lead traffic where the production points and the consumption points are located at short distances. But by deploying close circuit rakes and offering competitive tariffs, the railways can increase the size of their freight basket Bandyopadhyay et al. (2016).

IR’s passenger services are highly subsidized and so the onus of revenue earning falls on freight services. Because of it and the above discussed reasons; today IR’s freight rates are almost the highest in the world. Railway’s freight competitors are becoming more competitive not just because of their efficiency, but also because Railways freight rates make them appear better Railway Board (2016).

3.3 Heterogeneous goods

A transportation system is designed to handle a few types of goods, and when it is exposed to goods that differ from the nominal types, cost increases. When faced with heterogeneous goods, the manager of the transportation system can choose between two different approaches:

- Charge for the extra cost the goods generate for being heterogeneous
- Change the system rules so that the goods type is included in the homogeneous definition

In approach 1 the effect is short-term. If there are more occurrences of the same type of heterogeneous goods, however, each short-term effect will be added to the previous thus increasing the total cost. Approach 2 probably has a higher initial cost since the system may need to be redesigned. Once this redesign is finished, the heterogeneous goods are regarded as homogeneous. Arnas (2007). Therefore the author advocates approach 2.

3.3.1 Transportation of grains

Bulk transport systems are usually product specific and designed to handle generic commodities in large volumes. In western countries bulk transport systems have high degrees of automation. Grain is usually cited as an example of bulk cargo. Bulk transportation systems are most economic for large volumes of homogeneous products. Commodities such as coal, potash and sulphur benefit from the economies of size in mechanized handling and shipping. The bulk handling system for grain is now under increasing pressure to change. Grain has ceased to be a homogeneous commodity, or to move in the volumes that are exclusively the domain of bulk handling. The emergence of Identity Preserved (IP) grains has raised new problems Barry E et al (2002). **Hooper wagons** with bottom discharge and top loading is inefficient for meeting this requirement. Demand is growing for a more flexible logistics system that can deliver smaller lots of grain with precise product attributes.

3.4 Issue of containers

Containers have transformed global supply chains, but the author notices some problems associated with containerized inland transportation.

- Containers are more profitable for end-to-end delivery. But certain supply chains necessitates multiple stoppages from origin to destination for loading/unloading, which may be economical for the customers of transport systems.

- Currently intermodal transfer costs are difficult to reduce because of the number of times the container needs to be handled and stored (storage-to-hostler, hostler-to-rail, rail-to-storage, storage-to-truck, and truck-to-distribution centre) Zumerchik et al. (2009). Automation in container handling is slow and direct transfer to/from truck/train needs synchronization and is difficult to achieve.
- Unless container stuffing/de-stuffing takes place within the confines of rail intermodal yards, an additional truck trip is incurred from a yard to distribution centre/warehouse. This is suitable for large companies (who have necessary facilities at their factories/premises) but not when a single container contains goods of multiple customers.

3.5 Interventions by Indian Railways

Freight Operations Information System (FOIS) is a complete management module for freight trains. It tracks and monitors the movement of wagons, locomotives and unit trains and handles the billing and revenue collections as well. It has played a major role in the improved wagon productivity on Indian Railways and the objective is to use the information to further improve productivity, customer service and thus meet the needs of a rapidly growing economy. The Private Freight Terminal (PFT) policy of IR has not brought any noticeable improvement in India's logistics sector.

3.5.1 Dedicated freight corridors

The burgeoning demand in India led to the conception of the dedicated freight corridors (DFC) along the Eastern and Western Routes. The Western DFC covers a distance of 1504 km of double line electric track from JNPT (Mumbai) to Dadri (Uttar Pradesh). The Eastern DFC covers a distance 1318 km from Ludhiana (Punjab) to Dankuni (West Bengal). Dadri will serve as the junction point between the two DFCs. Service Design and Integrated Marketing is the need of the hour. The current delivery processes in marketing , pricing and new product development, service design and implementation needed for each market segment need to be objectively analyzed with reference to their efficacy in fueling the demand for optimal use of the huge capacity being generated on the DFC. This also opens up opportunities for logistic design Kumar (2017). These corridors are predicted to generate huge container, iron ores, coal and other mineral traffic. But the author seeks to justify investments on generating food grains, fertilizers, cement, fast moving consumer goods, e-commerce traffic. This also necessitates the need for handling heterogeneous goods. The benefits of larger and faster traffic volumes can be offset by terminal diseconomies that increase with size Barry E et al. (2002). If leveraged well, Indian Railway could re-invent itself as a giant in the logistic industry of the future.

4. Logistics and supply chains

When a segment of the supply chain becomes unreliable, the whole chain is adversely affected. Rail delays during transfer, which the trucking industry does not have to contend with, include missed connections between railroads, delays in unloading a train, an inability to get the desired unit on the first train out and locating miss-parked commodities at the terminal. Supply chains react to these delays by building an **extra day** and increasing the **cost** of the commodity Zumerchik et al (2009). Presently in most terminals (goods sheds) trains have to wait for the goods to be unloaded into the trucks and vice versa, which leads to overall traffic congestion and also affects passenger train movement.

Drayage cost is important in any logistics system. It can take a considerable amount of time to fully unload/load a truck which has to match the train arrival times. The "stay with" option entails a significant loss of driver productivity associated with waiting while the truck is loading or while the truck is unloading. Distance from the terminal to the distribution centre is another major variable. A basic characteristic of transport economics is the closer the terminals are to where freight originates and terminates, the more efficient railway is, because rail line haul constitutes a greater percentage of the trip. Further, the greater the drayage distance, the greater the inefficiency costs that need to be absorbed (empty trips), which also creates congestion costs for everyone using the transportation system.

5. Proposed operational features

The author particularly focuses on the conveyor layout, but other systems are equally important. Conveyors (CB) can be configured in any number of lanes and levels and can be operated independently or as part of a complete automation system. They can be flexible, custom designed to handle specific commodities and heterogeneous goods, within a certain range of variations. They can be designed to handle uniform packages of cement, grains, fertilizers and non-uniform packages of e-commerce and fast moving consumer goods traffic. The system will be such that when other CBs are not for their designated use they can be used for distributing loads of other CBs in use.

(Diagrams/plan drawings are for representative purpose only and are not proportionate.)

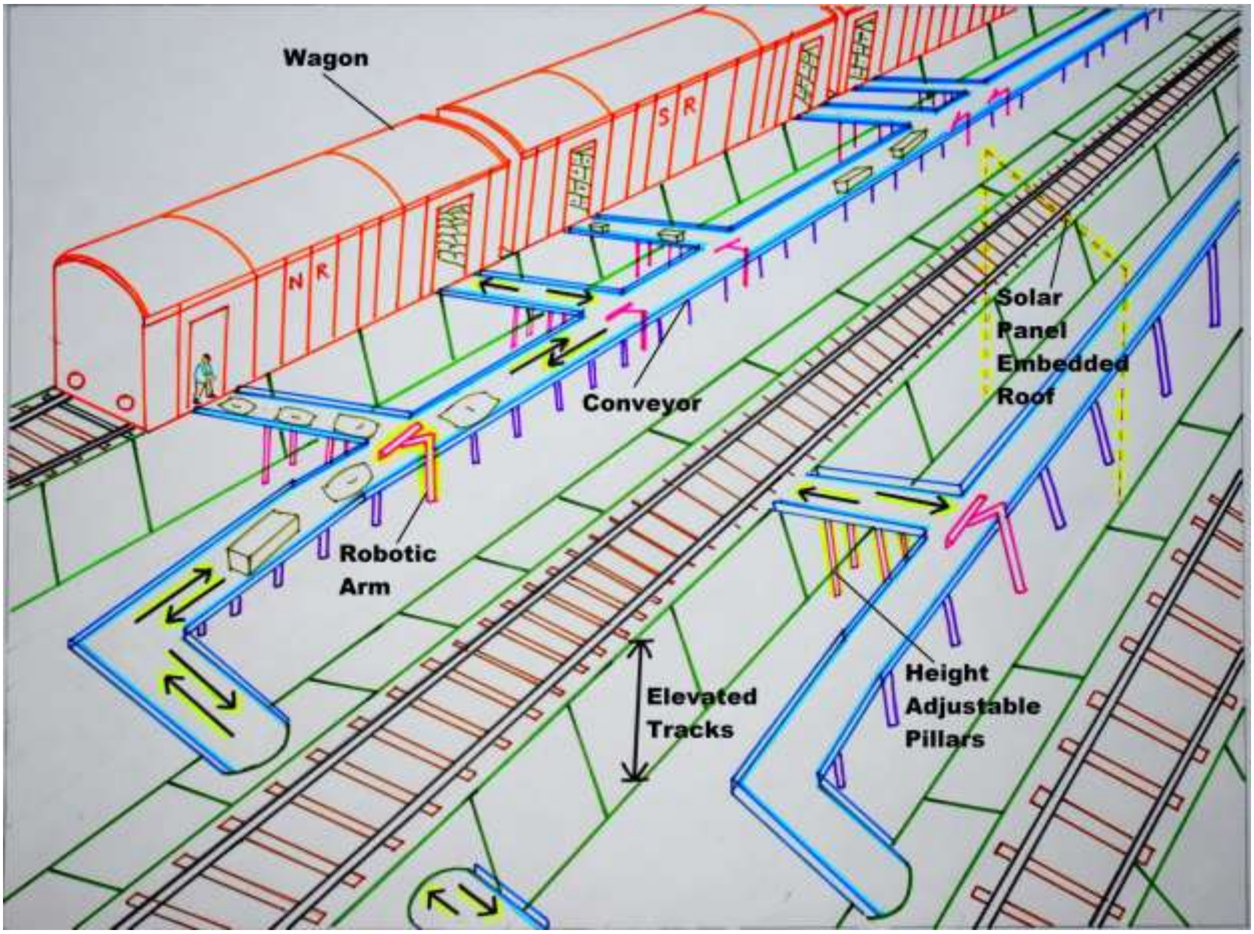

Fig 2. Conveyor illustration of loading/unloading to/from trains

- Loading/Unloading can simultaneously go on to/from multiple wagons.
- There will be such a mechanism which will enable the Robotic Arms to recognize which particular commodity is to be sent to which specific wagon. The Robotic Arm will simply push the commodity to the respective CB of the particular wagon. Usually Optical Character Recognition (OCR) or Radio Frequency Identification (RFID) tags will not be required because of the homogeneous nature of packages (cement/grains/fertilizers). Generally only the carrying capacity of the wagons has to be considered by

AFMS as it does not matter which package is loaded/unloaded to/from which wagon. But AFMS should be designed to handle exceptions efficiently.

- Linking CBs of the wagons from the main CB can be portable, so as to allow exchange, replacement, when necessary.
- There will be posts/pillars (can be hydraulic) for the linking CBs to adjust their height as per the requirement of the specific wagon. The height adjustment may be manual or automatic whichever is cost effective.
- The linking CBs may be gravity driven or powered whichever is found both efficient and cost effective in the long run. This applies to truck loading and unloading also; Fig. 3 and Fig. 4.

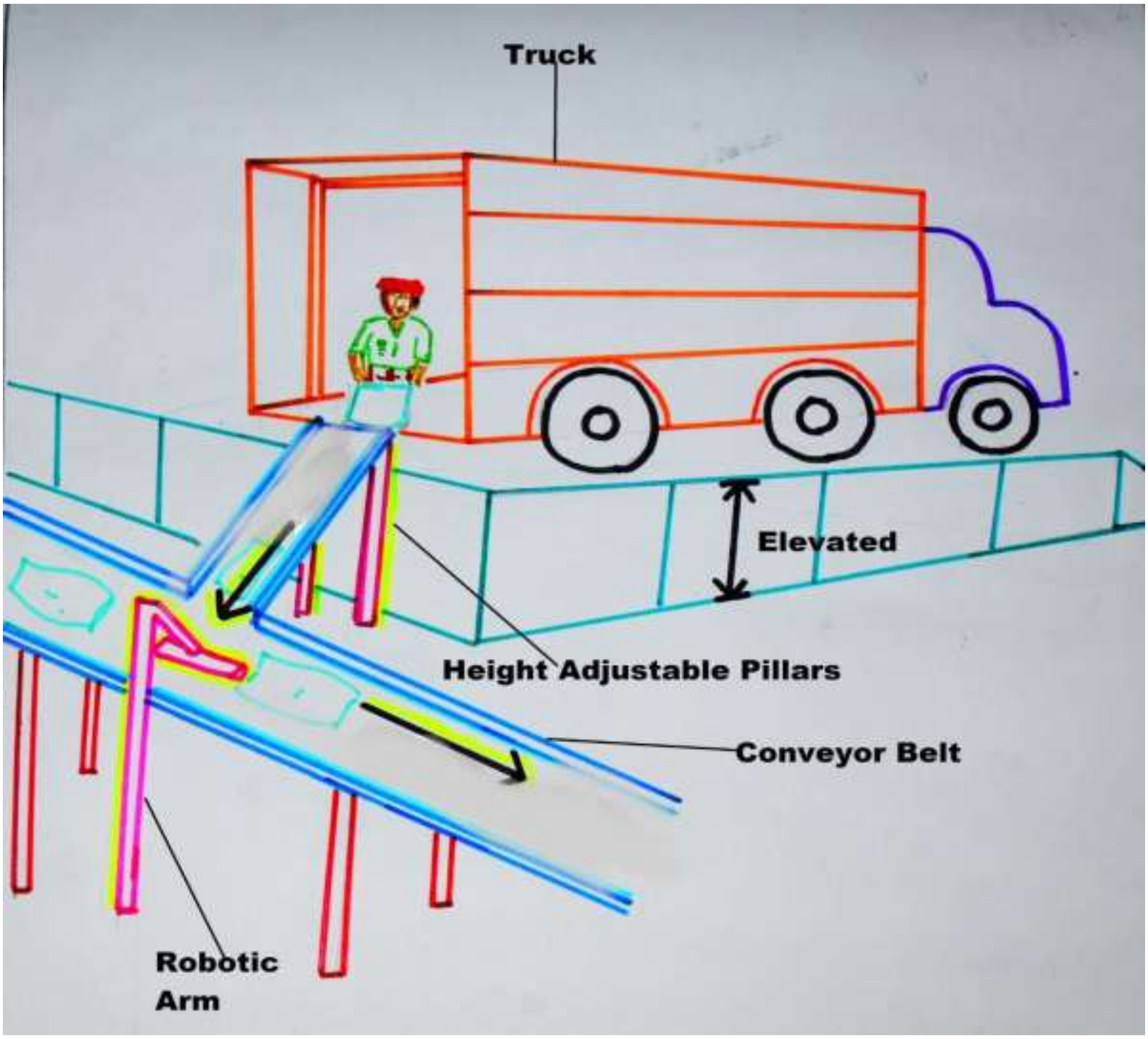

Fig 3. Truck unloading conveyor illustration

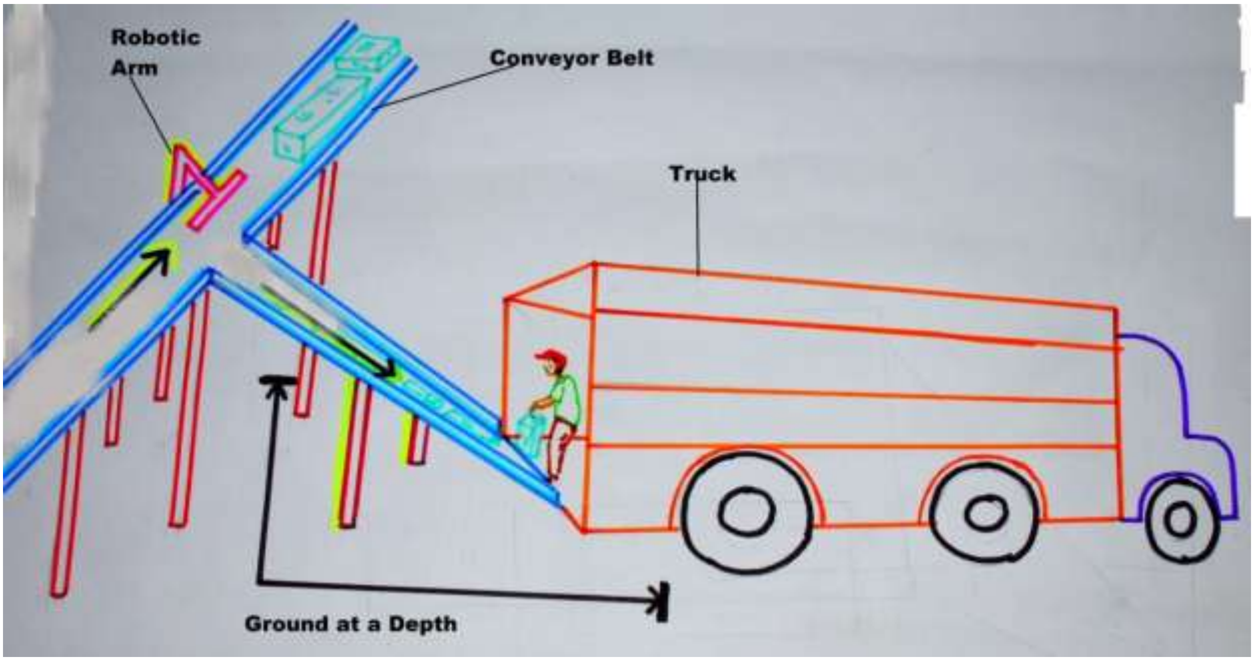

Fig 4. Truck loading conveyor illustration

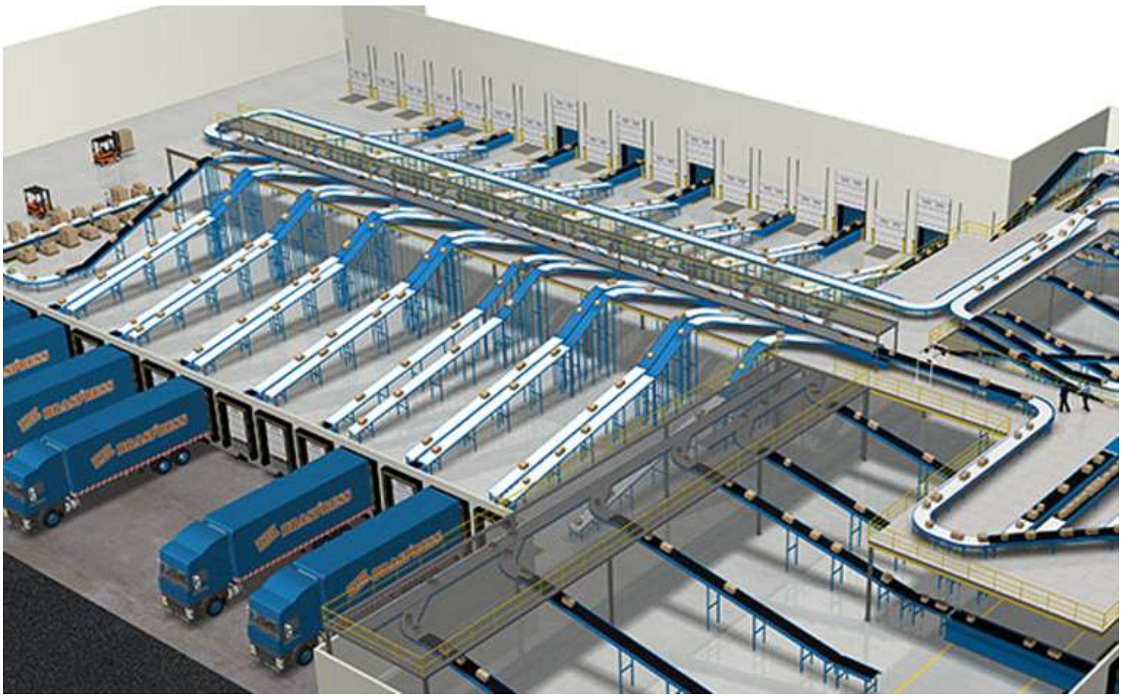

Fig. 5 Typical conveyor aided warehouse truck loading illustration

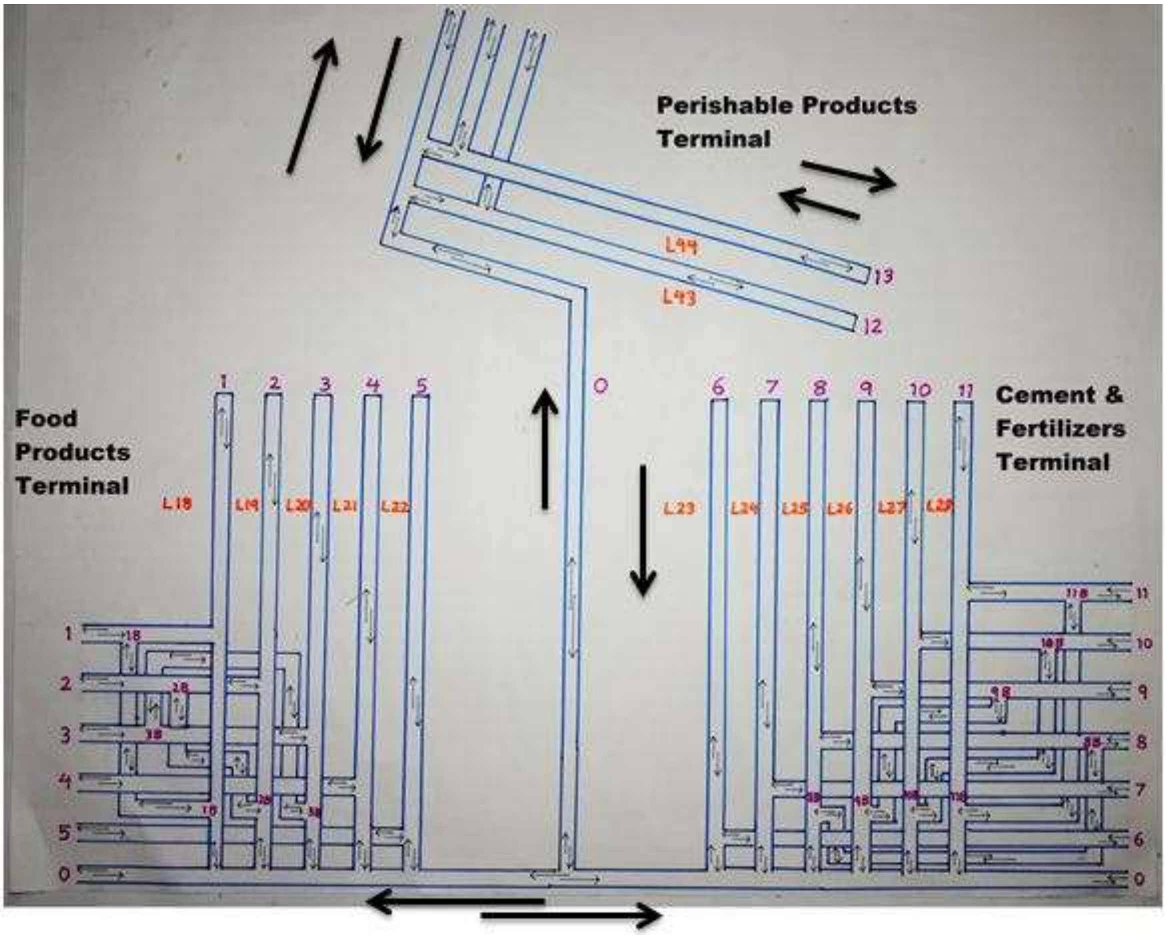

Fig. 6 Trackside conveyor layout (3 terminals shown)

- The letter **B** placed after the CB no. indicates that the CB carries goods which cannot be covered by the main CB (when longer rakes) and links it to the main CB connected to the respective Terminal.
- Each loading/unloading track will be designated a separate CB.
- CB 0 will serve as an interlinking CB between the 3 terminals. This can enable inter-terminal transfer both between trains and warehouses.
- A total of 14 CBs numbered from 0 to 13 has been shown in the representative diagram.
- Goods will be transported via the CB system by an on/off mechanism of CBs, omnidirectional CBs and robotic arms at interchange points, and wherever required.

Fig. 7 Typical conveyor aided warehouse

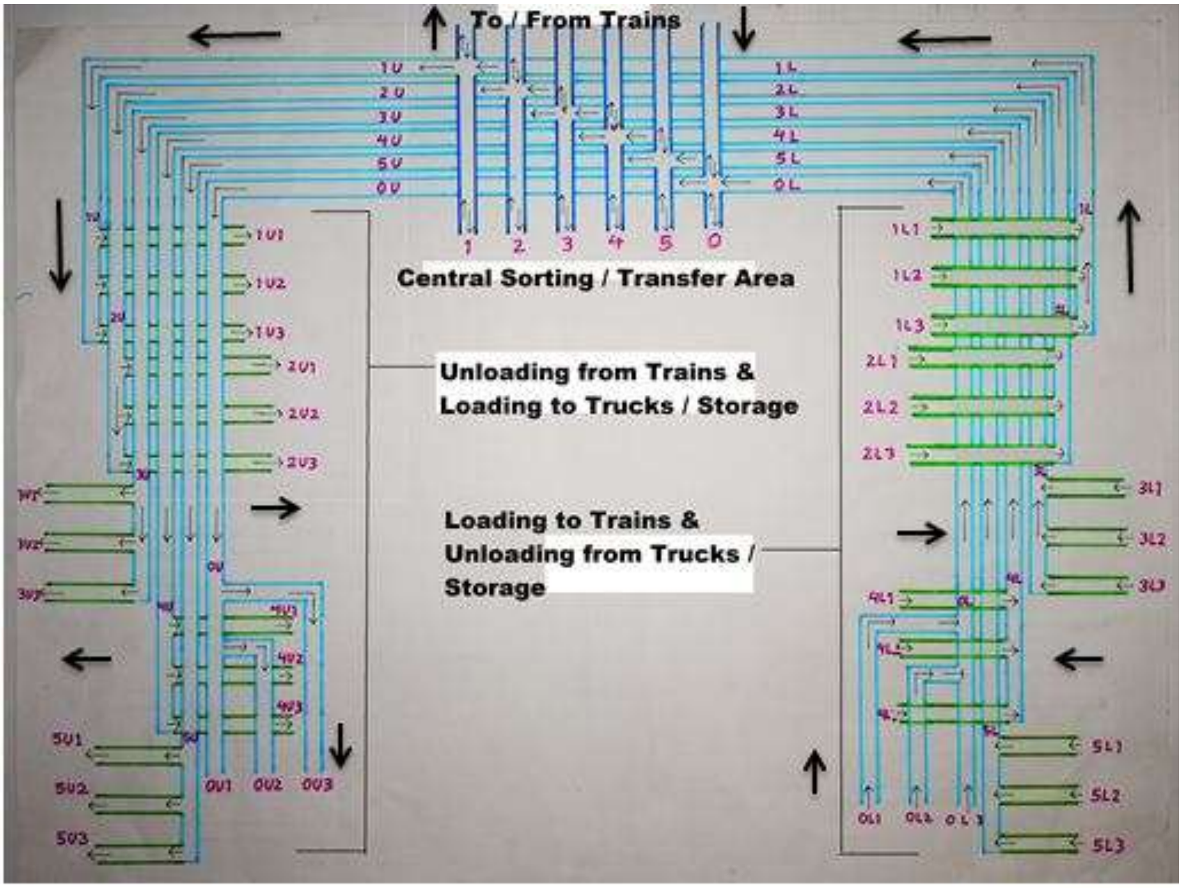

Fig. 8 Warehouse conveyor layout

- The left side linking CBs (marked **U**) will be used for unloading the trains and right side (marked **L**) for loading the trains.
- The linking CBs (green coloured) at unloading side will pass below the main CBs (blue coloured) and will link the respective CBs at respective points by a little elevation. E.g. 1U and 1L from CB 1. (Fig. 10)
- The linking CBs (green coloured) at loading side will pass above the main CBs (blue coloured) and will link the respective CBs at respective points by a little elevation. (Fig. 9)
- There will be 3 loading and unloading point for every CB. E.g. For CB 2U- 2U1, 2U2 and 2U3. This has to be analyzed as per traffic volume requirements.

The main CBs at the center will be used for at the just-in-time loading/unloading to/from trains/trucks. These can be also used for priority/privileged services by a suitable conveyor system, not directly linked to these CBs as space will be required for handling of commodities and movement of warehouse vehicles/equipment. These can be also used for train-to-train transfer with the help of a specially designed mobile conveyor system which can be attached between 2 or more CBs. Train-to-train transfer can also happen by CB 0.
The warehouse may be linked by a conveyor system to a customer’s or terminal operator’s packaging, labelling and other such value added services facility inside the terminal.

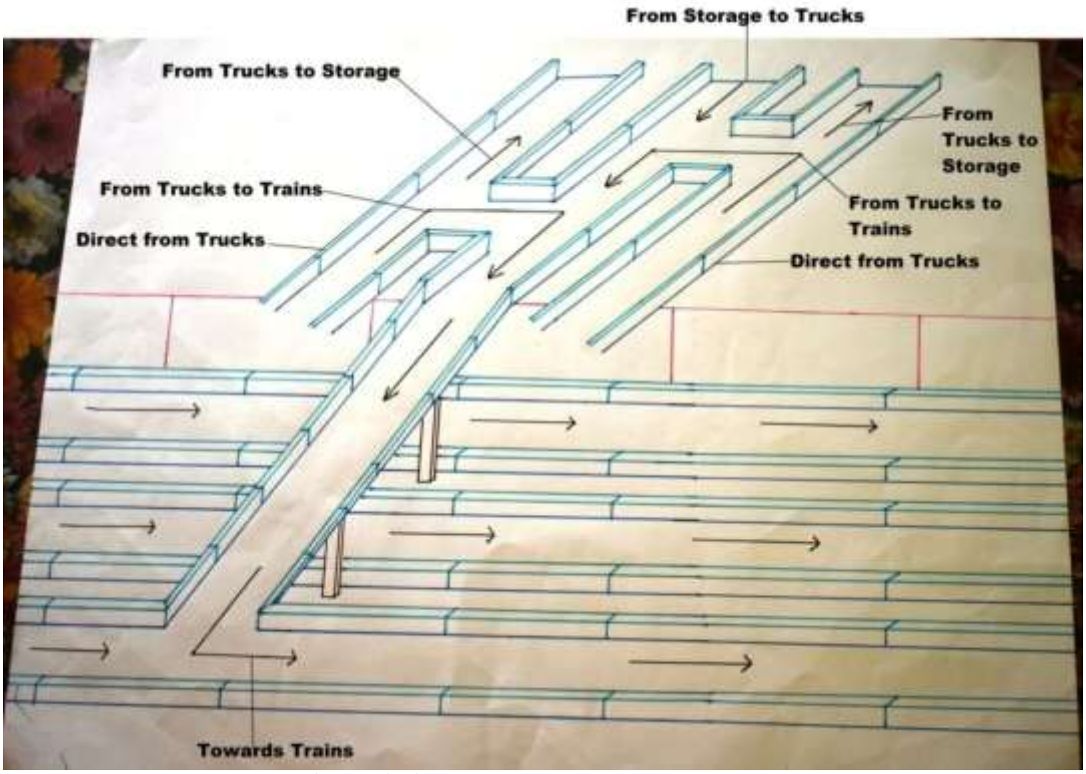

Fig. 9 Conveyor illustration for transfer from trucks/storage to trains

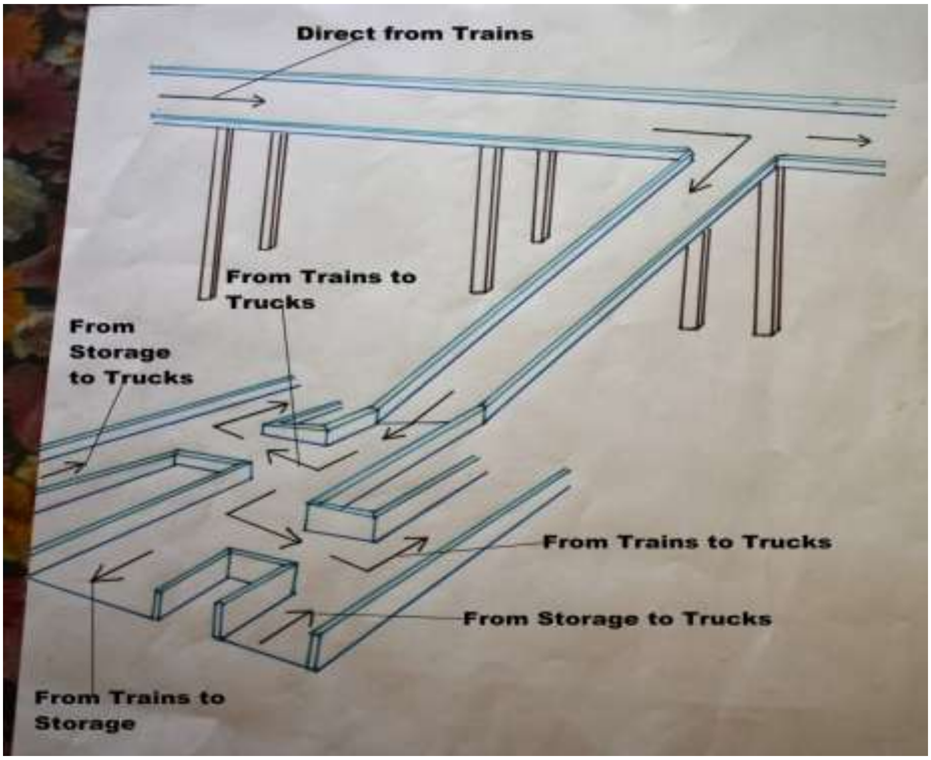

Fig. 10 Conveyor illustration for transfer from trains to trucks/storage

- The loading (from trains, marked U in Fig. 8) CBs will be elevated and the loading CBs (marked L in Fig. 8) will be below ground level. As the unloading CBs will be elevated there will be no problem for the commodities to descend ground wards and as the loading CBs will below the ground level there will be no problem descending the commodities from the ground level to downwards.
- In the unloading side the space below the CBs and in the loading side the **space** above the CBs will be used for **storage/sorting.**
- The system is such that goods from trains can be received for storage/sorting and later transferred to trucks or directly transferred to trucks and vice versa when loading to trains.

The proposed feature of elevated and below the ground level conveyors have to be mathematically analyzed whether it or the ground level CBs will allow optimum space utilization.

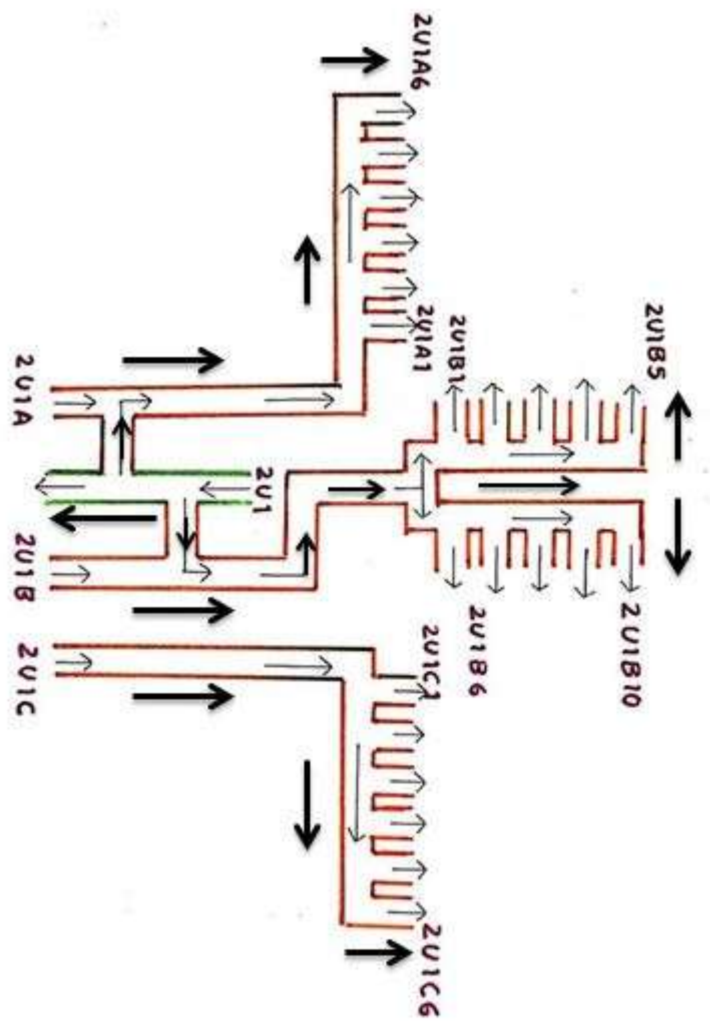

Fig. 11 Truck loading conveyor layout

- In the above drawing, the CB system for loading into trucks has been given. Here only the layout for CB 2U1 is given as an example. The same layout may be also applicable for unloading from trucks in which the CBs will move reverse.
- 2U1A and 2U1B will be used for directly loading into trucks CB 2U1 (green coloured) at points 2U1A1 to 2U1A6 and 2U1B1 to 2U1B10 respectively. But facility (as shown in the drawing) will be also there for

loading from storage area.

- 2U1C will be used for loading into trucks only from storage area at points 2U1C1 to 2U1C6.

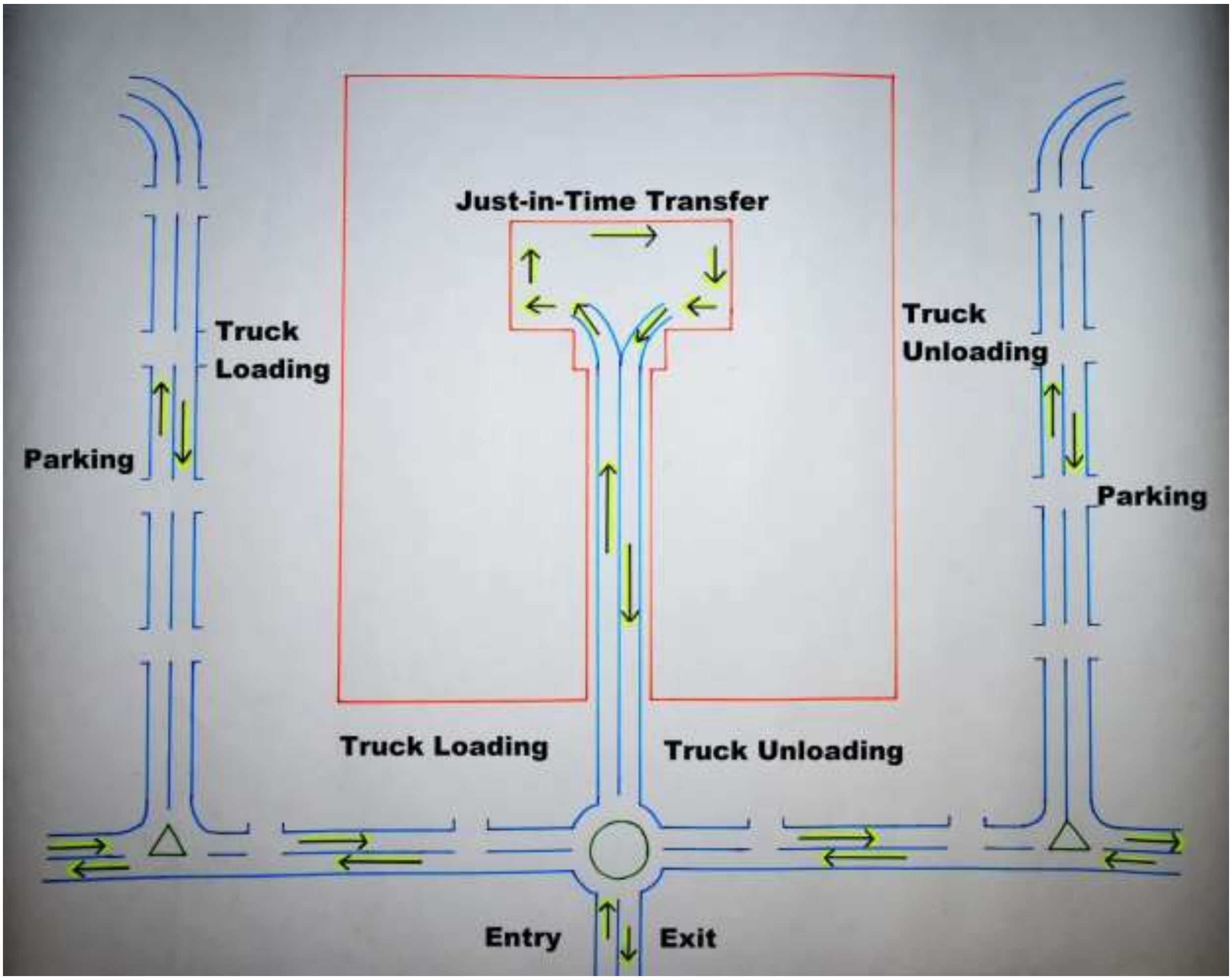

Fig. 12 Warehouse layout

Fig. 13 Typical conveyor aided sorting system

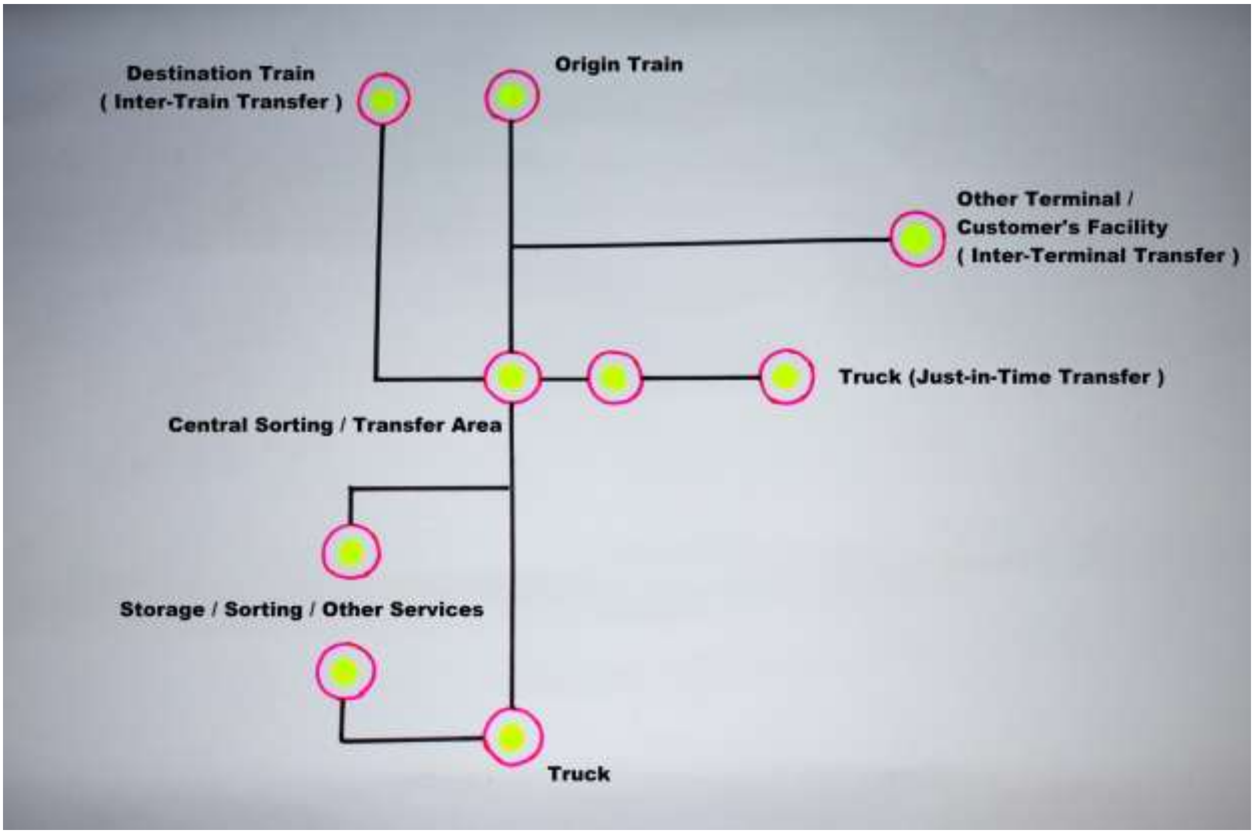

Fig. 14 Proposed bidirectional path of goods movement (conveyor)

Weighment of goods will be done **online** at the conveyor itself. There will be **signal lights** at each loading/unloading point of the conveyor belts along the tracks and trucks to direct the flow of goods to the personnel handling them. **Omni-directional** conveyor belts can be used wherever required. Technologies are available for using robotic arms and OCR and RFID devices and sensors for efficient handling of goods. As the CBs will traverse long distances, there will be junctions at appropriate places to allow efficient maintenance/repairing. Also, it will enable to switch off the CBs which are not needed at a particular time to save energy. Conveyor belts will be crucial in the operations of the proposed system and they should be constantly maintained both in a reactive manner (e.g., curative maintenance after breakdowns) and predictive manner. Conveyor belts at loading/unloading truck bays may be controlled in a decentralized way near the bays, coordinated by the Central Control Centre. Automatic stackers can be used for same sized packages. Installation of asset protection and monitoring equipment like hot box detector, bearing acoustic detector, hanging part detector, etc. will be crucial in reducing terminal detention. The AFMS including movement of conveyor belts, trains, trucks, warehouse vehicles, and equipment, staff, and customer services will be controlled in an integrated manner by the Central Control Centre, aided by Information Technology, Internet of Things & Artificial Intelligence can be used in the later stage. AFMS should include services like inventory management, analytical tools, predictions for customers and the terminal operator.

Automated real-time communication and better collaboration through the AFMS between railways, terminal operator, truck line operators and consignees can be effective in reducing drayage cost. Gate communication can be improved if the AFMS instructs the gate as to what goods are waiting at the warehouse for pickup, the real time tracking of the inbound/outbound trains, goods awaiting arrival at the warehouse or the incoming train. Further smartphone applications can be used for truck drivers to schedule appointments to pickup or drop goods. At any given time, the AFMS can communicate with the truck line carriers, courier companies, railways and the consignee (and thus be a component of their inventory management system).

In addition to rail/road, storage, the Integrated Freight Terminals will act as distribution hubs when adjusted to the needs of the customer, can provide a multitude of logistical services. They need to have space for the offices and facilities of courier companies and other customers, so that they can perform **value added services** like packaging, labelling at the IFT itself. Courier companies and small scale traders can perform all their storage and distribution functions at the terminal itself. IFTs should have **flexible local infrastructure**, to handle different kinds of goods, whether packed or unpacked, solid or liquid, in pallets or loose. For this purpose, appropriate equipment is made available for use according to the respective requirements ranging from reach stackers, forklifts to conveyer belts, earthmovers up to portal cranes for the handling of containers and heavy duty components Albernsmann (2009). Location specific terminals in the IFT like terminals for perishable products, containers, cement, food grains may be set up. Those using conveyor belts should be able to handle heterogeneous goods within a certain range of variations.

Artificial Intelligence applications like Artificial Neural Networks (simulation) and Genetic Algorithms, Fuzzy Logic, Game Theory (optimization), which if used in planning and optimizing the operation of the IFT, will make the system much more efficient and reliable. Many AI methods are flexible with adaptive learning capabilities enabling smooth functioning for the complex and dynamic requirements of AFMS. Integration of both real time and historical data will lead to best optimal operational predictions for running the Conveyor Belt system in the IFT, adjusting it to train timings, delivery timings, etc. AI’s capability to detect errors and improve accuracy will lead to energy savings, suitable timings; make the operation of the IFT efficient and at the same time profit making solutions for the transporter, terminal operator and customers.

5.1 Ownership structure

The ownership structure of the IFT should be as per the situation demands and profitability. But it is important that the management is entrusted to a single terminal operator, especially loading and unloading of trucks and trains. Otherwise, detention owing to mixed loads will be high. Also, valuable space at the terminal will be sub-optimally used.

6. Discussion

The conveyor belt loading/unloading operations will allow efficient running of **multi-point trains, train to train transfer** thereby bringing a paradigm shift in the freight operations of Indian Railways. Suppose a train travels from terminal A to terminal B and en-route it passes through terminal C. Cargo (consider less than wagon load) is to be transported from terminal A to terminal D. Another train travels from terminal C to terminal D. With synchronization of train timings such inter-train transfer can be made at a very short time in terminal C.

Table 3. Comparison of time gained by proposed concept

Current Free Time for Loading & Unloading	No. of Wagons	Labour Required (16 per wagon)	Estimated Maximum Time for Loading/Unloading	Labour Required (6 per wagon, incl. 2 per truck)
10:00	20	320	2:00	120
14:00	30	480	2:30	180
18:00	46	736	3:00	276
22:00	58	928	3:30	348

BCNHL wagons with direct transfer to/from trucks, both loading and unloading at one cycle considered; only loading & unloading can happen in half the given time

The great advantage of adding AFMS enabled IFT is that it allows **trucks and trains to operate independently** and lowers truck turn time by offering immediate selection. After experiencing the AFMS immediate selection advantage, few trucks are likely to arrive at the terminal without an appointment, and thereby eliminating “waiting truck” terminal congestion and diesel emissions problems. The drayage driver servicing AFMS enabled IFTs will have an advantage over his counterparts because of more efficient pick up and deliveries—drop off of one truck load, followed by a pickup of another truck load. There also will be significant air quality benefits from a reduction in **truck idling and roadway congestion**. If governments mandate off-hour (6 PM to 6 AM) deliveries, business will be able to accept deliveries to AFMS-equipped facilities 24/7 without having to add labour.

And unlike conventional terminals, the marginal cost of each additional equipment, labour will not increase as **volumes increase**. That is because the AFMS enabled conveyor interface between the modes ensures the a **minimal amount of handling** occurs regardless of the traffic volume Zumerchik et. al. (2009). The IFT can bundle up mass flows, and buffer and allocate them according to the demand. In this way, one can consolidate large volumes and high frequency truck transport and deliver according to the **wishes of the customers**, which, in turn, bring about a reduction in the truck traffic. Thus has a positive effect on the road infrastructure and on the people living in the vicinity.

The AFMS enabled conveyor belt system will be able to **make up time** at this stage of the operation. Trains that arrive late can be unloaded and loaded in order that they then leave again on time. This kind of flexibility ensures that both up and down the supply chain, logistics partners are not adversely affected by a delay to rail running times either inbound or outbound to an IFT. Faster turn round time of wagons and automated transfer ensures trucks and wagons are back on the road and rail in a timely fashion, reducing the total number required in the fleet and aiding operational efficiency.

As has been discussed (Sec. 3.2 para. 2), wagon loads and small consignments are not encouraged in IR but in the IFT's strategy (proposed in this paper) efforts can be made to engage in long term agreements with cooperatives (farmers, traders etc.), small-scale factories, wholesalers, and courier companies so that IR is sure that even if the full train is not leased to a particular company, the train will earn full revenue. Customers prefer to have their own private sheds. But if IR is able to attract its customers to the IFTs with attractive offers, then they will able to understand that it will be more profitable for them to operate from IFTs as there will be common resources and facilities provided by IR. Whereas in the private sidings, everybody have to pay separately for their needs like rake maintenance, etc. In places where it is commercially viable terminals for **varied traffic** like cement, fertilizers, grains, perishable products (with cold storage), containers or even petroleum products terminals can be set up in an IFT. Customized services and infrastructure can be set up in an IFT with long term agreements with customers. This will allow services like locomotive sheds, wagon repairing to be exclusively set up for an IFT which will further **add to operational efficiency.** At the same time IR will earn bumper profit as it will invest only in one common facility but multiple customers will use the same facility and pay separately to IR.

The traditional concept of establishing warehouses in the proximity of manufacturing facilities and raw material sourcing centres is also undergoing a transformation. In addition to production centres IFTs need to be set up near consumer markets. IFT will allow the role of a terminal to transform from a conventional terminal to an inventory management set-up with greater emphasis on value-added services. IFT should provide additional services like consolidation and breaking up of cargo, packaging, labelling, bar coding, reverse logistics, customs processing etc. Many customers can dispense with their own supply and forwarding warehouses, at least in parts. In such a way, the fixed costs on the customer's side can be reduced to a minimum. It can emerge as a critical growth driver.

It often requires a truck carrying goods from a yard or siding to sort out the goods in a warehouses, which is again further distributed and vice versa while being loaded to trains. But in the IFT, **distribution chain will become simpler** as the goods to and from trains/trucks will be sorted there itself. The IFT can serve as distribution centres for courier companies. IR may sign agreements with India Post and courier companies to provide end-to-end logistics solutions. This will in turn reduce the costs of the essential commodities, as there will be in-house sorting, storage and transshipment facilities. As IR is state owned, it may consider services at reduced rates for farmers and provide them complete end-to-end transportation (elimination 3rd party logistics companies and middlemen) so that their income increases. The IFT may also be built near a port, established or emerging industrial hub, in order to tap their logistics needs. Decreasing logistics cost will also the promote **entrepreneurship and local business expansion**.

Through the bundling of services with multiple customers and incentives to attract cooperatives, trader, construction of IFTs in low sales region is also possible. In spite of it such heavy investment cannot be made at small wayside stations where there are negligible prospects of revenue generation. But this new concept will allow the traditional method of direct loading/unloading to/from trains/trucks to continue. Scurrying for solutions to fight the toxic air pollution, the government is planning to transport **coal in covered rail wagons** and trucks across the country. This will also help to reduce the **Empty Run of Wagons** as packaged goods can be safely transported in the return journey. This policy will be commercially viable for the proposed concept.

These new generation freight terminals will enable to completely do away with the **demurrage regime**, since railways always lose more revenue by way of demurrage collected when compared to what they would have earned otherwise from productive utilization of the rake Ghosh (2009). Train turn time savings currently come in small increments, or are too inconsistent, to depend on in developing accelerated schedules, but when the **terminal turn time** is reduced in a **reliable and predictable** manner, the reduction can be captured and result in **accelerated schedules.**

India's dream of becoming a manufacturing hub to the world may well remain a dream if the logistics infrastructure does not keep pace with the growth in other sectors in order to enhance the country's existing cost arbitrage. In short, the growth of several industries and their cost-competitiveness rests squarely on the growth and development of the logistics industry. Moreover railways carrying majority freight has significant environmental benefits.

7. Conclusion

A new strategy for optimum use of covered wagons and parcels vans for transporting essential commodities like cement, grains, consumer goods and to capture the lost piecemeal traffic (small consignments), by using conveyor belts and certain ideas has been proposed in this paper. With a multitude of efficient services AFMS enabled IFTs will emerge as regional logistics hubs and can significantly increase the freight market share of IR. AFMS enabled IFTs will be at a competitively advantageous position of a **unique selling proposition** (USP), since some specific services can be offered which can only be copied by the competitors (roadways and airways or other terminal operators) with great difficulty.

Tax incentives and public/private investment will be well warranted for optimally located inland AFMS enabled IFTs, because they provide significant social benefits, such as reduced energy consumption, harmful emissions, accident risk, fatigue level of workers, highway congestion and reduction in the prices of essential commodities. Other public benefits, such as improvements in business output, employment and tax revenue from improved accessibility to markets, would justify even greater public investment. Investment for the highway connectors justifiable for shared terminals supporting complete logistics solutions—would significantly reduce railway capital costs, which, in turn, would further leverage railway capital costs to accelerate AFMS adoption.

With average freight speeds set to more than double on the dedicated freight corridors, Indian Railway stands on the verge of unprecedented opportunities, towards customer service, the likes of which it had never experienced before in its 166-year old history, of serving customers at very high velocities through Automated Freight Management Systems enabled Integrated Freight Terminals. Moreover, faster freight service means faster turnover, payment and return on investment.

8. Future research

The relative advantages of the AFMS enabled IFTs after integration with inland waterways, airways and ports is to be researched in detail. Types of conveyors needed and design of customized conveyors or even other equipment for the discussed needs is an important area for research. The use of Genetic Algorithms in optimizing the layout of the terminal (tracks, warehouses, roads) will be an interesting area to research. Integrating Artificial Intelligence and

Internet-of-Things applications with Information Technology for optimizing logistics systems is to be researched in the Indian context. Quantitative studies can be undertaken to arrive out at the predicted benefits of the proposed system environmentally and socially (reducing the prices of essential commodities and increasing the standard of living). The author has focused on India but it is possible to fully automate (humans only as monitoring agents) the proposed AFMS enabled IFT by integrating with automatic stackers, robots and many such presently available technologies. This can be researched in European and North American context where there is shortage of manpower.

Appendix A. Free time for loading and unloading in Indian Railways

RATES MASTER CIRCULAR DEMURRAGE-WHARFAGE-WAIVER 2016-0

2.2 FREE TIME FOR LOADING/UNLOADING OF WAGONS AT RAILWAY TERMINALS AND PRIVATE/ASSISTED SIDINGS OTHER THAN STEEL PLANTS WHICH DO NOT WORK ON 'ENGINE-ON-LOAD(EOL)' BASIS

2.2(a)	**Type of Wagons**	**Permissible free time** (in hours & minutes)			
		MECHANIZED		MANUAL	
		Loading	Unloading	Loading	Unloading
2.2(a)(i)	**OPEN wagons** like BOXN, BOX, BOY, BOI, BOST, BOXNHA, BOXNHS, NBOY etc.	5:00	7:00	9:00	9:00
2.2(a)(ii)	**HOPPER wagons** like BOBS, NBOBS, BOBR, NBOBR, BOBY, NBOBY etc.	5:00	2:30	N.A.	N.A.
2.2(a)(iii)	**FLAT wagons** like BFR, BRH, BRN, BFK, BFKI, BFNS, CONCORD rakes etc.	6:00	N.A.	8:00	8:00
2.2(a)(iv)	**BCNHL wagons** *(refer Rates Circular No.1 of 2012)*	N.A.	N.A.	5:00 (1 to 20 wagons)	5:00 (1 to 20 wagons)
				7:00 (21 to 30 wagons)	7:00 (21 to 30 wagons)
				9:00 (31 to 45 wagons)	9:00 (31 to 45 wagons)
				11:00 (46 wagons & above)	11:00 (46 wagons & above)
2.2(a)(v)	**Covered wagons other than BCNHL**	N.A.	N.A.	5:00 (1 to 20 wagons)	5:00 (1 to 20 wagons)
				7:00 (21 to 30 wagons)	7:00 (21 to 30 wagons)
				9:00 (31 wagons & above)	9:00 (31 wagons & above)
2.2(a)(vi)	**BCFC** *(refer Rates Circular No.25 of 2015)*	12:00	12:00	N.A.	N.A.
2.2(a)(vii)	**TANK wagons** (in all cases other than those specified as black oil) *(refer Rates Circular No.22 of 2006)*	6:00	6:00 (upto 29 wagons)	N.A.	N.A.
			8:00 (30 wagons & above)		

References

Benoit Montreuil, January 2011, Towards a Physical Internet: Meeting the Global Logistics Sustainability Grand Challenge; Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation, (CIRRELT), and Department of Operations and Decision Systems, Université Laval, Pavillon Palasis-Prince, 2325, de la Terrasse, Québec, Canada

Seema Singh, Research Associate, Green growth and transport in India: The Energy and Resources Institute, New Delhi. 2015

G. K. Chadha, Infrastructural Challenges for India's Future Economic Growth: Hopes from Railways; The Asian Journal, Volume 16, April 2009, Number 1, Journal of Transport and Infrastructure, ISSN 0971-8710

Report of the Comptroller and Auditor General of India, Management of Goods Train in Indian Railways For the year ended March 2013, Union Government (Railways) Report No. 31 of 2014 (Performance Audit)

S. B. Ghosh Dastidar, Terminals on Indian Railways; The Asian Journal, Volume 16, April 2009, Number 1, Journal of Transport and Infrastructure, ISSN 0971-8710

G. D. Brahma, Bulk Freight Terminals on Indian Railways: Evolutions and Options; The Asian Journal, Volume 16, April 2009, Number 1, Journal of Transport and Infrastructure, ISSN 0971-8710

Sankalp Shukla, Freight Terminal Development sine qua non of Logistics Development; The Asian Journal, Volume 16, April 2009, Number 1, Journal of Transport and Infrastructure, ISSN 0971-8710

Ministry of Railways (Railway Board) Government of India 2016, Share of Railway Traffic vis-à-vis Road and Air Transport: An Evaluation, Fifth Report of Railway Convention Committee (2014), Sixteenth Lok Sabha

Dr Saurabh Bandyopadhyay, Dr Palash Baruah, Dr Devendra B. Gupta, Factors Impacting Railway Freight Traffic in India, Report No. 2016–02–1, National Council of Applied Economic Research, 2016

Per Olof Arnas, Heterogeneous Goods in Transportation Systems A study on the uses of an object-oriented approach, ISBN 978-91-7291-944-0, Department of Technology Management and Economics CHALMERS UNIVERSITY OF TECHNOLOGY Göteborg, Sweden 2007

Barry E, Jake Kosior. Prentice Erica Vido, A Mixed Logistics Strategy for Grain: The Competitiveness of Containers Versus Bulk; The Transport Institute 631-181 Freedman Crescent University of Manitoba, October 2002

John Zumerchik, Jean-Paul Rodrigue, and Jack Lanigan, Sr, Automated Transfer Management Systems and the Intermodal Performance of North American Freight Distribution, Journal of the Transportation Research Forum, Volume: 48, Issue Number 3, 2009; ISSN 1046-1469

G.V.L. Satya Kumar Executive Director (Perspective Planning) Railway Board, THE BLUE PRINT FOR INDIAN RAILWAYS, March 31st 2017

Juergen Albersmann, Multimodal Huns for Steel Transportation and Logistics, The Asian Journal, Volume 16, April 2009, Number 1, Journal of Transport and Infrastructure, ISSN 0971-8710

Indra Ghosh, New Management Model for Railway Freight Terminals, The Asian Journal, Volume 16, April 2009, Number 1, Journal of Transport and Infrastructure, ISSN 0971-8710