IRIMEE JOURNAL 2021

November Edition

FROM THE DEAN'S DESK

It gives me immense satisfaction to note that 2021 Edition of IRIMEE Journal containing articles encompassing many facets of changing technology has been put together in current issue. Indian Railways is witnessing a major structural change both at organizational and technological Levels. In order to keep pace with changing times we should be aware of latest technological and organizational changes. IRSME has always maintained highest standards in adopting new technologies and delivering Steller performance in changing times. As a Central training Institute, it is our responsibility to collect best knowledge from the field and disseminate the same to all the working officers in the field. Publication of this journal is an effort in that direction.

As expounded in Rig Veda *"आ नो भद्राः क्रतवो यन्तु विश्वतः।।"* i.e. Let the noble thoughts come from all sides . we firmly believe in this thought and encourage our faculty and Trainees, many of them working officers, to pen down their works of explorations into Technology and Management or best practices either done in person or to which they have been witness .Publication of journal is an effort in disseminating the knowledge for the benefit of Indian Railways and society at large.

The issue contains articles about diverse set of articles, such as Enterprise Architecture in Indian Railways, Eco friendly cold chain technology, Automated spray painting of wagons, Artificial Intelligence in Railways world over. Article related to best practices followed in Rajendra nagar coaching depot, ECR on prevention of shortcuts in axle mounted brake system of LHB coaches. Research oriented articles such as Pooled bid evaluation for allocation of minor units to optimize non-farebox revenues in IR have also been included in this issue.

While all attempts have been made to accommodate original views of the authors, errors inadvertent or otherwise are regretted in advance. Keeping in view the CORONA-19 restrictions, this journal is being published in digital format.AI hope that Readers will find the contents useful. Readers are requested to share their feedback for further improvement in quality

Anil Kumar Dwivedi
Dean & SP/RST

FROM THE EDITOR'S DESK

IRIMEE, Jamalpur is the Centralized Training Institute for all training related to mechanical department of Indian Railway. As the seat of all knowledge related to Rolling stock technology, it is the prime responsibility of IRIMEE to disseminate information about upcoming technologies and innovations in this field. The IRIMEE journal is a step taken in this direction. The journal aims to bring out articles related to focused research done in specific areas of Indian Railways and innovations/best practices followed by various units.

The issue contains articles about diverse set of articles, such as Enterprise Architecture in Indian Railways, Eco friendly cold chain technology, Automated spray painting of wagons, Artificial Intelligence in Railways world over and more. Research oriented articles such as Pooled bid evaluation for allocation of minor units to optimize non- farebox revenues in IR have also been included in this issue.

The Journal is being published in digital format keeping in view the restrictions imposed by Covid 19 pandemic.

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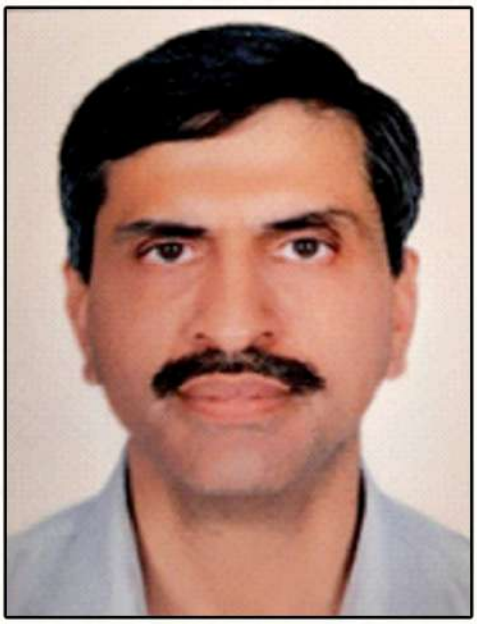

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Enterprise Architecture in Indian Railways

Enterprise Architecture in Indian Railways

Abstract

This article gives a historical background of Information Technology in the Indian Railways and explains briefly the need for developing its Enterprise Architecture (EA), primarily to provide an integrated IT platform for IR. The paper briefly describes the basics of EA, and the standards to which it adheres. The paper also describes the steps taken so far to develop the EA through Project Vistar, and the further steps to be taken to ensure that a workable, sustainable EA is developed.

Historical Background of IT in the Indian Railways

Indian Railways has a long history of 53 years of Information Technology. Initially, systems were necessarily decentralized because networking and data communication was not developed. Over the years, centralized applications became the norm, to ensure that the processes were replicable across the organization. On the back of better data communication, centralization through a body like CRIS (Centre for Railway Information Systems) made the IT applications sustainable.

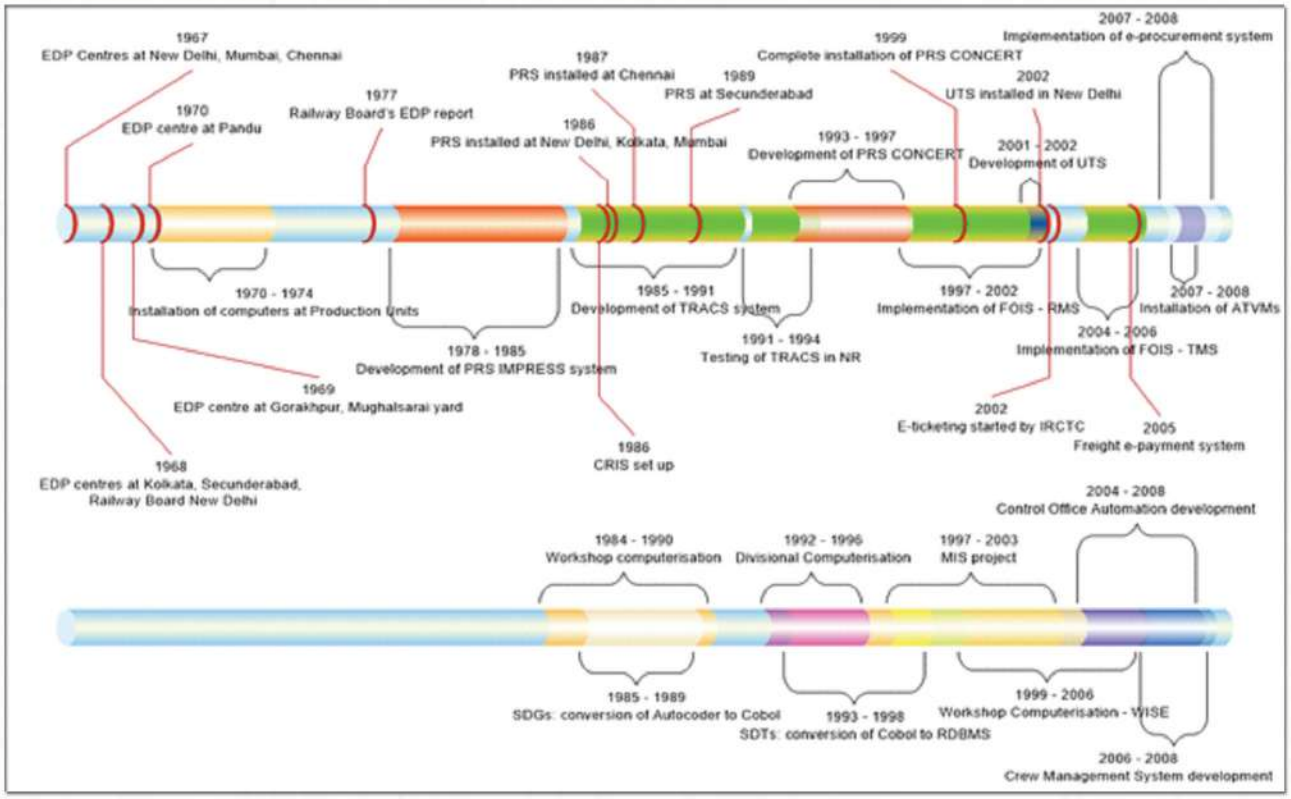


Figure 1. Evolution of IT in Indian Railways (up to 2008)

With centralized applications being developed for nearly all functions of Indian Railways, the need is to develop an integrated IT platform by providing seamless integration amongst the applications, along with standardized access methods for the information.

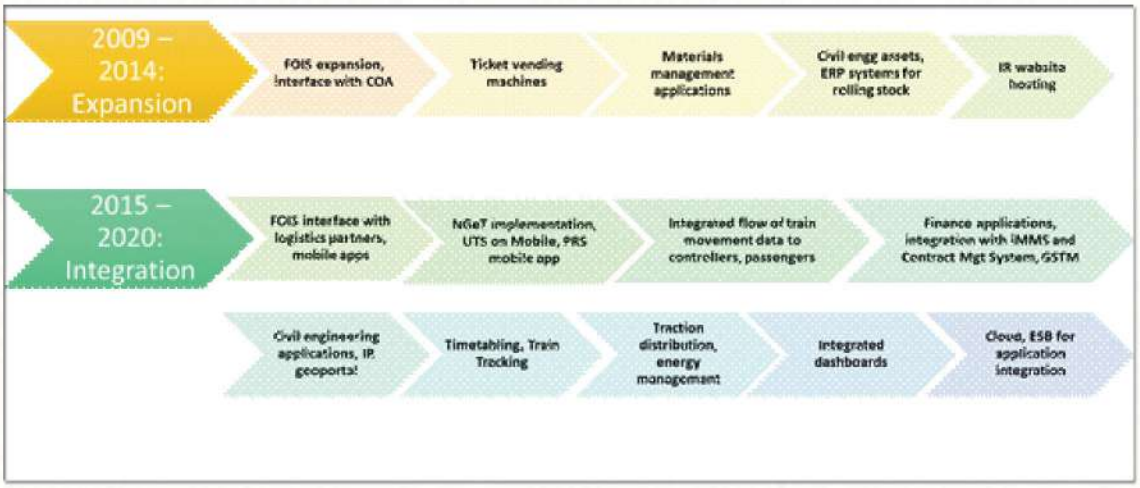


Figure 2. Evolution of IT in Indian Railways (2009 onwards)

Enterprise Architecture – definition and need

An organization can be described in many ways – by the physical assets it owns; by its personnel, their roles and authorities; or by its functions and departments. None of these descriptions is complete in itself; some of them are static and unable to factor in today's dynamic business environment.

One way to describe an organization is by its capabilities – the enablers for the services that it can provide to its customers. In this view, an organization is composed of a set of capabilities that enable it to provide services to its customers and other stakeholders. To create an accurate description of the organization from this viewpoint, the first step is to identify the organization's customers, then identify the services that these customers have demanded from the organization. The organization's capabilities, that enable it to deliver these services satisfactorily, can then be identified.

As time passes, customers' and stakeholders' demands change. The organization should then respond by developing the capabilities needed to meet these demands, and shedding the capabilities that are no longer relevant. The advantage of the capability-based view of the organization is that its dynamic nature is built into the description.

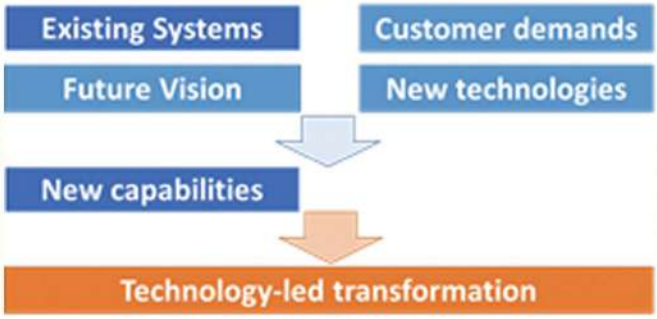
Today, any service to be offered by an organization depends greatly on Information Technology. An organization's Enterprise Architecture (EA) is a combination of its current Blueprint and future Roadmap. The focus is on the flow of information within the organization, and with its customers and other stakeholders. The purpose of building the EA of an organization is to help it to give the required agile response to its changing environment.

Railways are inherently information-driven – each train needs to be guided at every point of its path. All operations depend on a continuous flow of information from the various parts of the organization, to make a series of decisions regarding the movement of trains, their maintenance, and maintenance of the underlying infrastructure, etc. Sound decisions can only be made if relevant and accurate information is available across the organization. Similarly, information has to be provided continuously to its stakeholders, i.e., its passengers and freight customers, suppliers, contractors, other ministries, etc. The focus of Indian Railways' Enterprise Architecture is therefore on the information flowing across the organization and to its stakeholders. That is, the focus is firmly on IR's IT systems.

IR's priorities

Indian Railways is in the throes of change today. The emergence of competing modes of transport, heightened expectations of customers, rise of e-commerce, and lately the vagaries of the Covid pandemic, have placed IR in a highly uncertain environment. A laid down Enterprise Architecture in such times can provide the basis for strategic decision making.

The need is for an organizational transformation in IR. This is best done through a focused program of digitalization of IR's operations. With an EA Blueprint and Roadmap in place, effective digitalization will be much easier to accomplish.



Enterprise Architecture layered structure

The Enterprise Architecture of an organization consists of the following layers and reference models (as per IndEA Framework, a standard developed by MeITy, Government of India. IndEAF is in turn based on TOGAF, a standard internationally accepted EA framework from The Open Group.)

- Business Architecture - Organization, process, people
- Application Architecture - Applications, interfaces
- Data Architecture - Data entities, definitions, attributes, relationships
- Technology Architecture - Hardware, software, networks, datacentres
- Security Reference Model - Ensuring access to authorized, authenticated users
- Integration Reference Model - Integrating all the components
- Performance Reference Model - Measuring effectiveness of operations
- Governance Reference Model - Keeping the architecture updated

IndEAF follows TOGAF's standard Architecture Development Method, which lays down the steps to be followed to develop the EA. The standard also mandates the creation of an Architectural Repository, to store all the artifacts created as part of the Architecture.

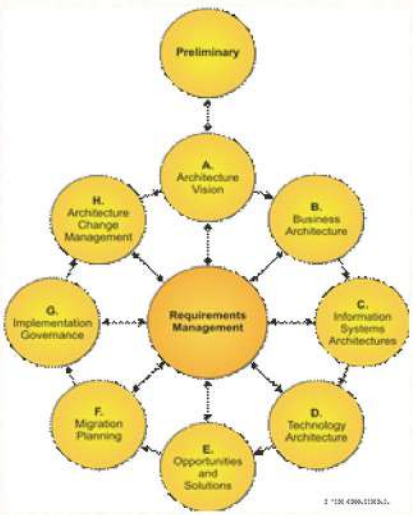


Fig 4. Architecture Development Method of TOGAF

The IREA Project - Vistar

The Indian Railways Enterprise Architecture project was sanctioned in the Pink Book in 2017-18. In November 2017, it was transferred to CRIS from Railway Board. In February 2019, the Detailed Estimate for the project, now named Vistar (Visionary Integrated and Sustainable Enterprise Architecture for Railways) were sanctioned.

Fig 5. Vistar logo

Vistar's deliverables will be:

- A set of blueprints of existing and proposed systems, describing the current and target architecture to meet the organisation's vision
- A roadmap with transition states to reach the target state showing the gaps identified
- Principles and rules to ensure consistency
- A set of enabling technologies and solutions to follow the roadmap
- A governance structure to ensure that
    - the envisaged EA implementation stays on track
    - the EA remains responsive to organisational needs

Sub-projects to procure the tools to realize the architecture, i.e. implement the designed features, have also been sanctioned along with the main project. These components of the IREA project are:

1	Application Portfolio Management	Implemented
2	Enterprise Open API Management	Under implementation
3	Enterprise Integrated IT Applications Monitoring	RFP being prepared
4	Enterprise Architecture Governance	Consultant on board
5	Enterprise Data Dictionary	Being explored
6	Enterprise Integration Platform	Tools to supplement ESB being explored
7	Enterprise BPM Services	Being explored
8	Governance, Strategic Control Framework	Being set up
9	Centralized Command and Control Centre	Being set up
10	Enterprise Information Security Mgt System	In place

EA for the Rolling Stock vertical

As part of the ongoing exercise, a preliminary high-level EA was prepared for the Rolling Stock vertical.

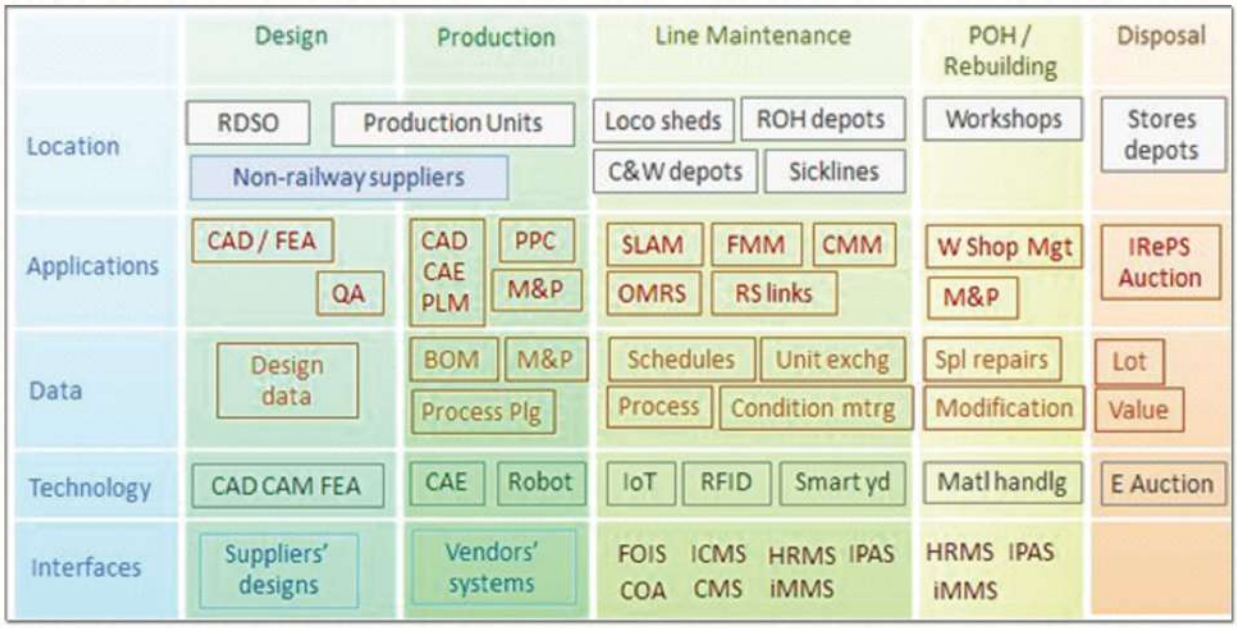


Fig 5. Enterprise Architecture in Rolling Stock management

The following insights were obtained from the exercise:

- for a holistic view, the entire lifecycle of the rolling stock should be considered
- The underlying data has to be unified, that is, common definitions of the data and under standing of their attributes and relationships has to be developed
- Different IT applications need to interchange information among themselves
- A central repository of design data that can be accessed by the different applications needs to be created
- IoT and sensor-based applications need special handling. They generate a lot of data that has to be transported with minimum latency to the central computer infrastructure. A large number of IoT / sensor-based systems have been initiated for which a unified view has to be taken and common infrastructure developed
- Analytics, use of artificial intelligence etc. can help to analyze the data and help to achieve predictive maintenance practices. But the analytics systems have to be designed now, concurrently with the IoT systems.
- Data governance is necessary to ensure that high quality data is available for analysis.

Target Architecture

The interim target architecture is shown below. This interim target architectures would be developed along with the final target architecture, for which a horizon of 5 years is envisaged.

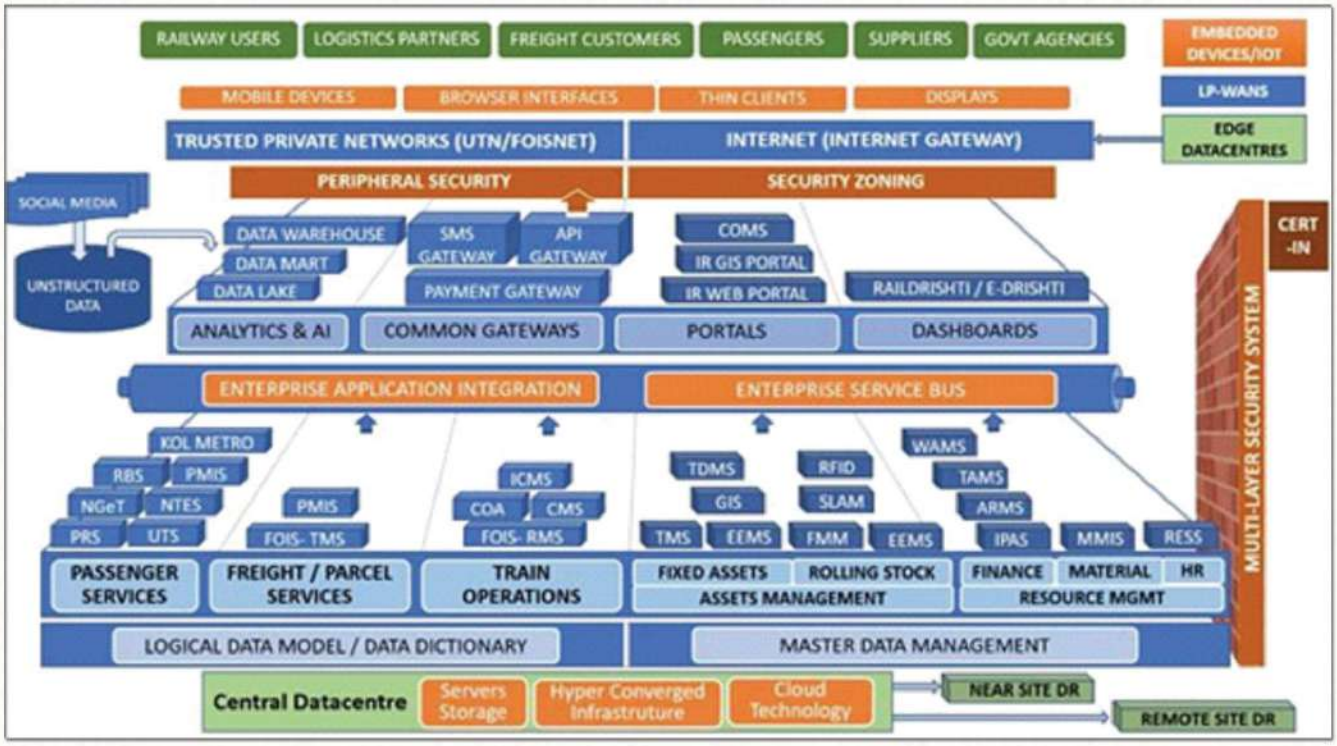


Figure 6 – Interim Target Architecture for IR

Conclusion

The Indian Railways need to keep pace with the development of technologies worldwide. The huge amount of data and information that Indian Railways possess should be utilized for increasing capabilities and better service delivery. The Enterprise Architecture is a tool that allows a vast organization like Indian Railways to optimize its processes and increase efficiency by integrating all the processes presently working in silos. EA provides a directional approach incorporating vision, mission, processes, security and capability of the organization.

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Can we innovate and make the cold chain Eco-friendly

Can We Innovate and Make the Cold Chain Eco-Friendly?

Abstract:

The article highlights the current status of the Cold Chain and its future prospects. It looks at the role of Railways in this logistics sector especially in the transport of vaccines for the COVID-19 pandemic. It looks at ways how DFC can pro-actively participate and provide value added services to the customers thereby, making the chain more efficient. It also looks at alternative and more eco-friendly ways of powering the reefer containers which are being transported by rail.

Keywords:

Cold Chain, Railways, Reefer Containers, eco-friendly

It has been shown that the development of cold chain logistics is positively co-related with GDP growth and improvement in standard of living of consumers (Wang, 2016). According to Crisil Research, the Indian cold chain industry is growing at a 13-15 per cent CAGR and is set to reach ₹47,000 crore by 2022 because of the need to reduce wastage. Cold chain logistics is the safe transport of temperature sensitive products from the supplier to the customer or end user. There is a fine line between temperature and perishability and the whole technology is about optimization of the same. This is used for transporting perishable products like seafood, dairy products and pharmaceuticals (Mohan, et al., 2017). In olden days, as early as 1700s, ice slabs were used by the British to transport perishables. This cold chain is an integral part of the international trade. This chain consists of cold storage, cold transport, cold processing and cold distribution. In order to maintain the goods at the prescribe temperatures, gel packs, Dry ice, Liquid nitrogen, Eutectic plates, Reefers and insulated Quilts have been used depending on the commodity being transported. As far as rail and road transport are concerned, reefers or temperature-controlled, insulated van, truck or standard ISO containers which allow for temperature-controlled air circulation are mostly used. Within the container itself, innovative rack system that allow double stacking of pallets, are adjustable and light weight can be used (Sowinski, 2014).

Now a day's road-railers are also used. Communication units are installed in these vehicles and convey real time temperature data to the data servers and also provide real time location and quality (Zhang, et al., 2018). The management of cold chain requires integration with the distribution network depending on the product properties, performance characteristics and origin – destination (OD) of the product (Brzozowska, et al., 2016).

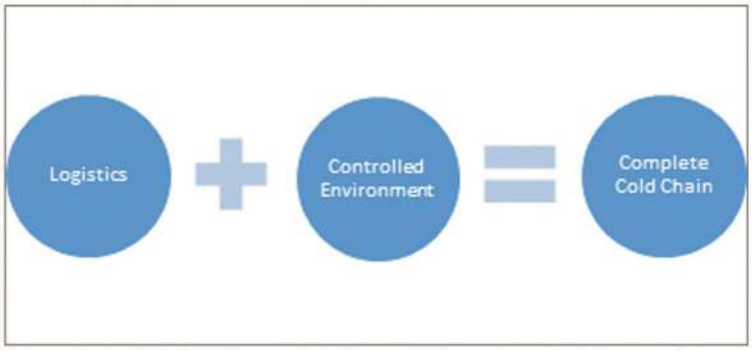

Figure 1 Cold Chain Infrastructure

In Indian railways the transport is governed by the commercial circulars which stipulate the packaging conditions as can be seen below, a copy from the circular of 2006-

"RECOMMENDATION OF THE COMMERCIAL COMMITTEE Res. 5915. The Commercial Committee recommends that "Dry Fish" when booked, as parcels should be packed in "Sound Gunny bags" and internally packed in 'WATER PROOF MATERIAL'. The weight of each bag should be 50 kgs or less".

Cold chain technology is time sensitive and so the role of the transporter is very important. As far as the loading agency is concerned it has to comply with regulations pertaining to Product stability, Packaging, Transportation, Monitoring and Temperature minimums. Apart from this there are regulations and limitations set by the shipping lines, railways and other concerned institutions. More than 60% of the cold storage capacity is in West Bengal, Bihar and UP mostly on account of storage of potatoes. The facilities in Maharashtra and Gujarat as well as the southern states of Andhra Pradesh and Telangana are for dairy products, sea food, fruits etc. However, as the markets develop these facilities are becoming multi-purpose. These states contribute to 77% of the storage capacity.

Predicted loss of fresh food storage				
Food product Storage	At optimum cold temperature	Optimum temperature + 10°C	Optimum Temperature +20°C	Optimum Temperature + 30°C
Fresh Fish	10 days at 0°C	4-5 days at 10°C	1-2 days at 20°C	A few hours at 30°C
Milk	2 Weeks at 0°C	7 days at 10°C	2-3 days at 20°C	A few hours at 30°C
Fresh Green Vegetables	1Month at 0°C	2 weeks at 10°C	1 week at 20°C	Less than 2 days at 30°C
Potatoes	5-10 months at 4-12°C	Less than 2 months at 22°C	Less than 1 month at 32°C	Less than 2 weeks at 42°C
Mangoes	2-3 weeks at 13°C	1 week at 23°C	4 days at 33°C	2 days at 43°C
Apple	3-6 months at - 1°C	2 months at 10°C	1 month at 20°C	A few weeks at 30°C

Figure 2 - Temperature Sensitivity of Cargo (Jain, 2019)

Globally the highest food loss and waste at 45% is in the Fruit and Vegetable chain. Due to inadequate cold chains, there is sustained demand of certain vegetables in large cities while the same may be discarded along the farms. The most perishable commodities are often the most nutritional food and comprise the high value agriculture. To help farmers grow these and improve their income potential, there is a need to develop cross geographical flow of these fresh farm produce by using multi modal transport. This will help in balancing the demand and supply. The supply side is uncertain however, the demand and volumetric consumption can be assessed from surveys and past trends of consumption. DFCCIL should plan scheduled fixed route services to promote large volumes along identified freight corridors. Apart from assured income it will be a service to the nation and also help in up-gradation of the skills of the workforce involved in the chain leading to organizational learning. Since, receiving ends may not have infrastructure to handle large train loads, DFCCIL can conceptualize partial rake loads having compartmentalized wagons or containers attached to existing rakes. A container or reefer is ideal as it is a small unit load and multiple commodities can be loaded in it and this can happen in advance before the arrival of the train. As per the total transport study by the planning commission about 97% volume of fruits and vegetables is carried by road. Also the average lead of these products is far higher on road than on rail (Kohli, 2017).

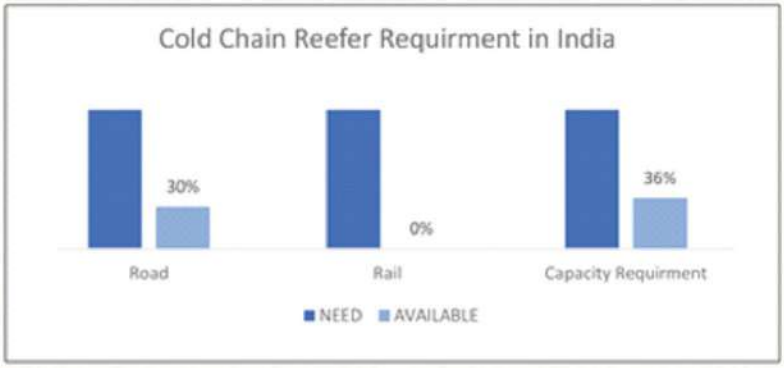

Figure 3 - Cold Chain Reefer Requirement in India (Jain, 2019)

Indian Railways started the initiative of Kisan rail and carried over 12400 tonnes of perishables till November 2020. These Perishables included pomegranate, capsicum, green chilli, ginger, lemon, iced fish and other parcels. These trains are running between Devlali to Muzaffarpur, Nagpur to Adarsh Nagar Delhi and Sangola to Manmad/Secunderabad. For pharma products time tabled parcel trains have been run by Indian railways during Covid times.

The transport of the Covid 19 vaccines when they come will be a big challenge and something for the DFCCIL to look upto. Vaccines are expected to be moved via airfreight, but the reverse chain of replenishment or backfill will be by ocean freight, and this will mean high demand for vaccine transport in the ocean mode. Many Indian logistics companies like Snowman Logistics part of inland logistics leader Gateway Distriparks, Gati Kausar, ColdEX, ColdStar, Bluedart and JWL and Maersk are actively pursuing to be a leader in this chain of transporting the vaccines (Bureau, 2020). It is expected that the vaccine cold chain would need close to 11,500 refrigerated trucks. DFC needs to collaborate with them and ensure fast time tabled trains either Ro-Ro or roadrailers or refrigerated containers and look at their proposed OD to see how we can help speed up their transportation. Since it is a time sensitive commodity even a few hours saved are very helpful. Being part of this value chain will provide tremendous visibility to DFCCIL and also help in building our reputation and brand thereby winning the confidence of our potential customers (Khan, 2020).

The Government is setting up Mega Food Parks or clusters in agri zones whose aim is to link agricultural production to the market thereby bringing the farmers, processors and retailers closer to ensure value addition and capture, reduction in wastage and additional employment opportunities (Jain, 2019). It is expected that this traffic will be in both directions as some other commodity will be available for customers in the other part of the country.

Figure 4 - Refrigerated Indian Railway Container with DG Set (Gazette, 2012)

Refrigerated containers are already operational in Indian Railways and these are accompanied by one BLC wagon carrying a diesel generator set and approximately 3000 liters of diesel. Three operators are generally present who check the temperature in the containers and the working of the gen set especially when the train stops. The operator purchases first class tickets for these three employees. With trains running at 100 Kmph on the DFC there will be some safety concerns in carrying diesel oil and there was a fire incident some years back. The conditions for the escorting staff are poor due to the noise, pollution and heat. This is where DFC can contribute and create a value added service. During COVID times surplus passenger locos have been used for hauling freight trains. We could use HOG, WAP 7 locos with hotel load capability to haul these container trains and the power for these refrigerated containers can be supplied through OHE. Arrangement for cabling etc. will be done by the operator and separate metering would also be done. Railways can charge the unit cost of electricity along with administrative charges and profit. The advantage is that the cost of generating electricity by the diesel gen set is about ₹ 14 per unit and the unit cost for DFC is about ₹ 6-7. Even if DFC charges ₹ 10-14, it will still be useful for the operator as he will not have to incur other costs. Assuming that there are five refrigerated wagons, the average consumption is expected to be about 10 Kwh and so at a ₹ 5 additional cost on a unit the hourly additional earning is ₹ 250/- . For a train journey of about 30 hours from Mumbai to Delhi this would work out to ₹ 67,500/- for the complete train. To ensure reliability, the operator can have his staff at various locations and in case there is any problem they can attend to it. An added advantage is that the haulage of one wagon with gen set is also saved in both directions and in its place another container can be loaded. With HOG, there is flexibility as there may be any number of reefer containers. Another option is that the operator can develop a small transformer and 25 KV supply can be enabled from any loco which can be further stepped down for use. Such a mini dry transformer can be accommodated in the extended portion of approximately 1500 mm of the "A Car". Dwarf double stack refrigerated containers may also be an option. In case shorter length dwarf containers are available, the volumes of the commodities will reduce and these can be easily handled possibly at remote stations. Alternatively, such services can be planned by modifying air conditioned ICF coaches which are likely to be replaced by LHB or by using air conditioned pantry cars. Thus the system also helps in reducing the Carbon foot print and noise and can help better utilization of surplus passenger locos due to reduction in passenger trains because of COVID. This will help DFC fulfill its promise of transforming transportation.

There is a great opportunity for DFC to be part of the cold chain and to make it more eco-friendly and efficient. This will also help in generating additional revenue by providing value added services other than pure transportation. However this would require innovative approaches including training of our own DFC staff and providing reliable and time bound service.

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Pooled bid evaluation for allocation of minor units to optimize non-farebox revenues: application of mathematical modelling for decision making in IR

Pooled bid evaluation for allocation of minor units to optimize non- farebox revenues: application of mathematical modelling for decision making in IR

Abstract

The Indian Railways earns a majority of its revenue through farebox sources. The other sources, called 'non-farebox' form a meagre ~5% of our total earnings. Although multiple initiatives have been undertaken at the board and divisional levels to find newer sources of non-farebox revenue, systemic changes that can bolster them have not yet been explored much. This work discusses one such tweak in the bid evaluation process of minor units on railway stations. We propose that a pooled method of bid evaluation (wherein bids for each unit are pooled and then evaluated together as a group) which also incorporates the impact of synergy (impact of one unit's revenues on the other) on revenue generated by a unit can be helpful in increasing its non-farebox revenues. We maintain the scope of our work to be within the powers of the Divisional Railway Manager, and hence, have not focused on Major Units. To quantify the impact of the proposed change, we develop a non-linear mathematical model of the problem, and solve it using AMPL, a coding language for optimization. Results obtained indicate significant revenue-earning potential of the proposed method of bid evaluation.

Introduction & background

The Indian Railways earns a majority of its revenues from farebox sources or tariff earnings i.e. passenger fares and freight earnings. The other sources of revenue are called as 'non-farebox'(NFR) and these formed only about 5% of the total revenue as of 2017 (Government of India, 2017). This share is extremely low when compared to other nations such as Germany (34%), Japan (30%), Hong Kong (29%), (Government of India, 2017) etc., suggesting a scope for improving the non-farebox revenue earnings. With this thought in mind, the Government of India launched an innovation challenge in the month of February, 2017 (Government of India, 2017) aimed at getting novel ideas to maximize the market potential of non-farebox earnings from monetization of railway assets including land, colonies, trains, etc. Post this, many novel, innovative initiatives have been taken at the divisional level, which have bolstered our NFR from railway stations. These can be broadly classified into the following three types.

1. **Advertisement and promotion:** This includes hunting (looking for grey areas) and farming (increasing coverage of railway assets already used for advertisement).
2. **Licensure for commercial use:** This includes creation and allocation of units on railway premises to vendors.
3. **Reputation restoration:** This includes macro initiatives aimed at increasing foot fall at railway stations by restoring goodwill through initiatives like beautification, landscaping, cleanliness drives, crowd management etc,.

For the scope of this work, we have focused on one railway station as our unit of interest and looked into areas which fall under the schedule of powers of the Divisional Railway Manager (DRM). While advertising & promotion and reputation building seem fairly complete, we feel that there is still some room to explore the improvisation of NFR earned from commercial licensing of units in the station premises. One key observation from exploratory research done for this paper is the correlation between the revenues earned by vendors in the same station. For instance, an ice-cream parlour opened next to an eating joint like Pizza Hut generates comparatively higher revenues as compared to a stand-alone ice-cream parlour. This indicates the presence of "synergy" between different unit-types. Additionally, we find that given a constant number of units and unit types, the process of bid-evaluation and charging of licensure fee from vendors may be further tweaked to increase NFR. This forms the background of this paper.

Research objective

To deep-dive into NFR increase in the direction mentioned above, we have broken down the revenue from licensure as follows.

*Licensure revenue= Avg.rent per unit area*Avg.area per unit*# of units*

Most initiatives currently in place focus on increasing the number of units or the average area per unit. Within those that try to increase the average rent per unit area, the focus is to look for innovations in the nature of businesses (Railway Board, 2018). Despite all these, we feel that the current revenues are not optimum, and there is potential for improvement. We focus on increasing the average rent per unit area while keeping the number of units and unit types constant using our mathematical model. Hence, our objective is:

"To develop a mathematical model for the pooled system of bid evaluation, keeping in mind policy guidelines of allocation , while also including the impact of synergy between revenues generated by different unit types."

Methodology

We followed a full-cycle mixed-methods research approach to answer the problem (Flynn & Chatman, 2005). We started with a rough idea about the direction we wanted inputs on and interviewed vendors and officials on the Sealdah (SDAH) railway station in Kolkata. SDAH was chosen for reasons of proximity keeping the volatile situation of COVID in mind. This primary research indicated the presence of synergy between revenues generated by different units. A sample synergy matrix was developed using the inputs obtained from vendors. Then, we performed secondary research on the current method of bid evaluation and unit allocation to understand where we could incorporate the impact of synergy. Using this, we identified areas that present a potential to optimize NFR within the licensing process. Basis these, we designed a renewed system of bid evaluation and modelled it mathematically. The model so developed was a non-linear model. This was solved after coding on AMPL using the baron solver. Results were recorded and the impact of the proposed model on the NFR evaluated. In this work, we have only considered the evaluation of bids for minor units as it is under the schedule of power of the DRM.

Current method of bid evaluation & pricing

The current system of allocation of minor units in the station premises uses the conventional two packet bidding process (technical followed by financial).The step-wise process followed in the bidding & evaluation of bids for units has been explained in Figure 1.

Based on our interactions with unit owners, and analysis of the process, we feel that there are some systemic drawbacks in the current process of bidding & there is scope to optimize the revenue generated by plugging them. The key issues with the current system are as follows:

1. Applying constraints such as reservation for particular use category or caste limits railway's choices while simultaneously preventing many bidders with relatively better quotes to offer from applying.

2. Our interactions with most vendors indicated a significant impact of the synergy between two shops. For instance, an ice-cream parlour is likely to earn much more if located close to food outlet as compared to in isolation. Similarly, the presence of a shop selling tobacco products is likely to have a negative impact on the revenue of a family shop (family food outlet etc.) Evaluation of each unit is isolation prevents the inclusion of this very important factor into consideration.

3. Having a fixed license fee is an extremely risk-averse strategy and it is possible to link the licensure fee with the revenues generated while still maintaining a relatively small fixed license fee component.

4. Evaluation of bids in isolation and restricting bidders to one single bid only prevents them from being creative & coming up with better offers (by raising a single bid for two or more units, and by raising multiple such bids).

5. The administrative (time) costs associated with forming an independent tender committee for each unit are pretty high and can lead to delays in finalization of the bid as a large number of officials are involved.

Proposed changes to the process

To solve the issues mentioned above, it would be imperative to use a pooled bidding system, in which multiple units are open for bidding to bidders in a single tender, and multiple parties are selected so as to cover all the units open for the bidding process. Additionally, we must include the impact of synergy between units while evaluating bids. Specific recommendations for the process are as follows:

1. No specific use type or caste category is allocated to a unit.

2. A pool of units is opened up for bidding together.

3. Bidders can bid for one or more units and offer a combined quote for the bid.

4. More than one bids (with each bid having a different set of units) are allowed per bidder.

5. Rather than a fixed licensing fee, I.R. gets a fixed percentage commission of the rev-

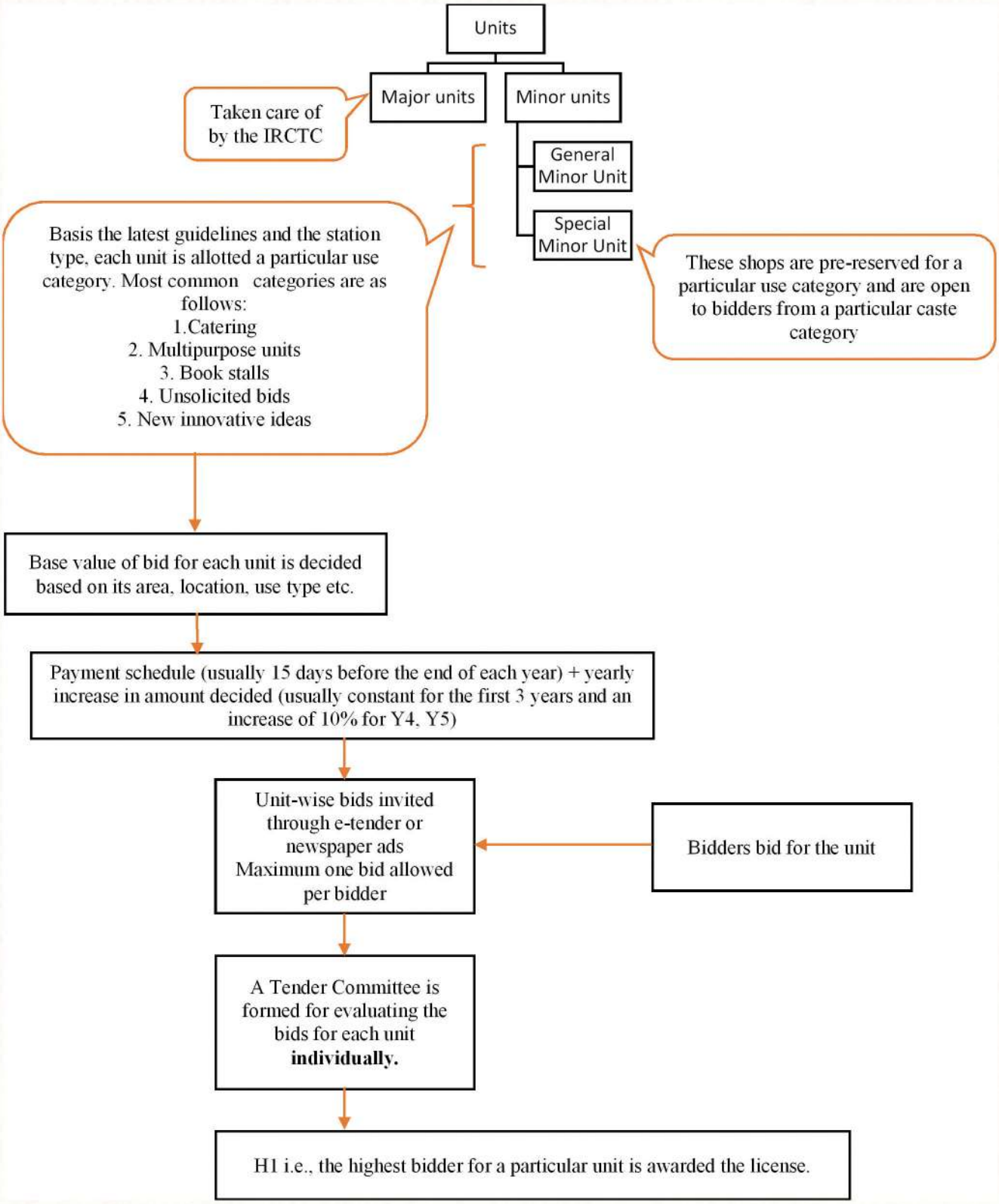

Figure 1: Current process of bidding & tender finalization

6. The quote consists of an estimate of the license fee that the unit is agreeing to pay (basically, an estimate of the revenue the vendor expects to generate from the unit).

7. Synergy factors are calculated and accounted for in the objective function.

8. Evaluation of the bids is done within the pool, and the bids which offer the maximum combined revenue are selected (subject to the conditions regarding specific percentage reservation for a specific use/caste category)

   The same has been explained in Figure 2 below.

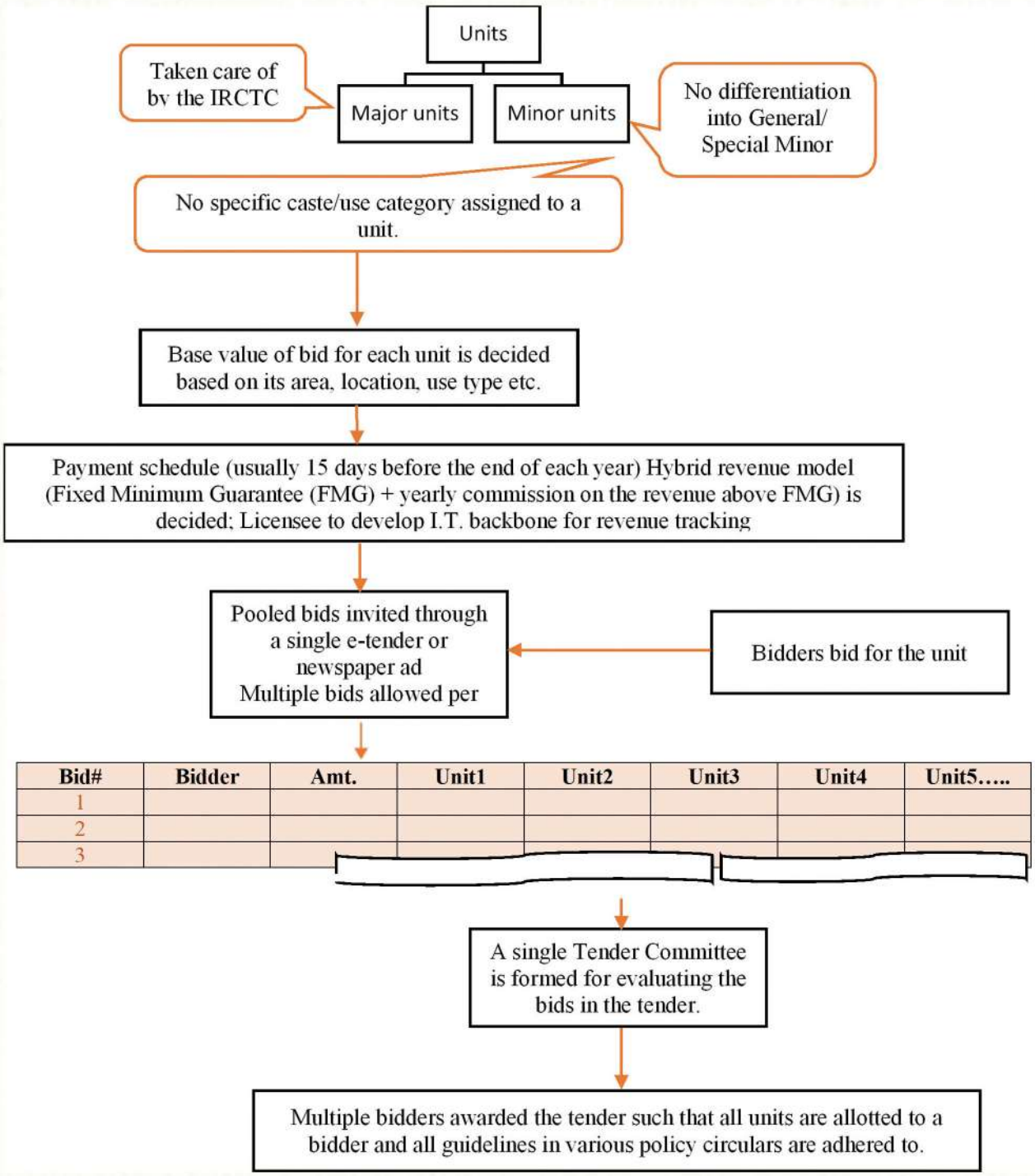

Figure 2: Proposed process of bidding & tender finalization

Mathematical model formulation for the proposed process

We have modelled the modified process proposed above to a mathematical model as shown below. It is assumed that the FMG of each unit is constant, hence, can be ignored in the objective function. The policy circulars guiding each of the constraints framed have been mentioned along with.

Indices:

n, i: set of bids

j: set of units

k: set of unit categories

l: set of bidding firms

Parameters:

Amti = value of FMG quoted in bid i

Coverij = 1 if bid i covers unit j, 0 otherwise

Bidderil =1 if bid i is by bidder l, 0 otherwise

Categoryik = 1 if bid i falls in category k, 0 otherwise

Highin = 1 if synergy between bid i & n is high, 0 otherwise

Medin = 1 if synergy between bid i & n is moderate, 0 otherwise

Lowin = 1 if synergy between bid i & n is low, 0 otherwise

H_factor = 1.3 (measures impact on revenues if synergy between two selected bids is high)

M_factor = 1.15 (measures impact on revenues if synergy between two selected bids is moderate)

L_factor= 1(measures impact on revenues if synergy between two selected bids is low)

Max_catering = 2(Maximum # of catering units that can be allotted to a single vendor as per Railway Board's New Catering Policy 2017)

Commissionk = Commission percent for revenues above FMG for a category k

0.1 for catering (10% in line with Railway Board's New Catering Policy 2017)
.025 for book stalls(2.5% in line with Railway Board's Book Stall Policy 2017 (Circular No. 2010/TG-III/462/1 dtd. 17/10/17))
.12 for multipurpose stalls (12% in line with Railway Board's Multi-Purpose Stall(MPS) Policy 2017 (Circular No. 2015/TG-III/461/2 dtd. 05/09/17))

Is_SCl = 1 if bidder l belongs to Scheduled Caste category, 0 otherwise

Is_STl = 1 if bidder l belongs to Scheduled Tribe category, 0 otherwise

Is_OBCl = 1 if bidder l belongs to Other Backward Caste category, 0 otherwise

Is_womanl = 1 if bidder l is a woman including war widow and widow of a railway employee, 0 otherwise

Is_BPLl = 1 if bidder l belongs to Below Poverty Line category, 0 otherwise

Is_Minl = 1 if bidder l belongs to a minority (Muslims, Christians, Sikhs, Buddhists, Zoroastrians i.e. Parsis and Jain) , 0 otherwise

Is_PHl = 1 if bidder l is physically handicapped, 0 otherwise

Variables:

Xi: a binary variable to indicate whether a bid has been selected or not
(Xi =1 if bid i is selected, 0 otherwise)
Yin: a binary variable to indicate if both bids i & n have been selected or not
(Yin = 1 if both bids i & n have been selected,0 otherwise)
Si: synergy factor for bid i (We have assumed that the FMG quoted will be increased by a factor of (Si+1) due to the synergy between bid i & other selected bids)

Objective function:

The objective function can thus, be framed as follows:

$$Maximize\ (\Sigma_i \llbracket X_i^* \rrbracket \ \llbracket Amt \rrbracket_i + \Sigma_i \llbracket \llbracket (X) \rrbracket_i^* \ \llbracket Amt \rrbracket_i^* S_i^* (\Sigma_k \llbracket \llbracket Category \rrbracket_{ik}^* \llbracket Commission \rrbracket_k)) \rrbracket)$$

Explanation:

The objective of the optimization problem is to maximize the total revenue from the bids we have received. The total revenue has two parts.

1. Fixed Minimum Guarantee (FMG)

This is the value quoted by the bidder in the tender document. This forms the fixed component of the dynamic charging system so designed. Our assumption here is that all bidders are rational and earnest in their desire to obtain the license, and while evaluating the FMG, they have not been overly conservative, so as to have a fair chance at winning the bid.

2. Commission on the revenue generated over & above the FMG

To estimate this, we have introduced the concept of synergy between two categories/ bids. Higher the net impact of the synergy on a bid (represented by Si), higher are the chances of its revenue exceeding the FMG, and thus, higher should be the probability of its selection. The commission percentage that railways can charge on this excess revenue varies across use categories and thus, may influence the net revenue earned by I.R. To incorporate this, the factor $\Sigma_k \llbracket (\llbracket Category \rrbracket_{ik}^* \llbracket Commission \rrbracket_k \rrbracket)$ has been included in the objective function.

Constraints:

The constraints mentioned below are in line with the following governing policy circulars issued by the Railway Board.

- Railway Board's New Catering Policy 2017 (Railway Board, 2017)
- Railway Board's Book Stall Policy 2017 (Circular No. 2010/TG-III/462/1 dtd. 17/10/17) (Railway Board, 2017)
- Railway Board's policy on Unsolicited Non-Fare Revenue Proposals (Circular No. 2017/NFR/20/2 dtd. 10/01/17) (Railway Board, 2017)
- Railway Board's Multi-Purpose Stall(MPS) Policy 2017 (Circular No. 2015/TG-III/461/2 dtd. 05/09/17) (Railway Board, 2017)
- Railway Board's NINFRIS(New & Innovative Non Fare Revenue Ideas Scheme) 2018 (Circular No. 2018/NFR/25/New Innovative Ideas scheme dtd. 21/05/18) (Railway Board, 2018)

The constraints are as follows:

1. Each unit is allocated to exactly one bidder.

   Σ_i▒ ⟦ ⟦ X⟧ _i* ⟦Cover⟧ _ij=1 ? j⟧

2. At least two bidders must be selected to prevent monopoly rule.

   Σ_i▒ ⟦X_i>1 ⟧

3. At least 6% of the catering stalls must be allocated to SCs.

   Σ_(i)▒ ⟦Σ_l▒ ⟦ ⟦ X⟧ _i* ⟦ ⟦Is_SC⟧ _l* ⟦Bidder⟧ _il*Category⟧ _i1 ⟧ ≥0.06*Σ_i▒ ⟦ ⟦ X⟧ _i* ⟦Category⟧ _i1 ⟧ ⟧ (catering is represented by k=1)

4. At least 4% of the catering stalls must be allocated to STs.

   Σ_(i)▒ ⟦Σ_l▒ ⟦ ⟦ X⟧ _i* ⟦ ⟦Is_ST⟧ _l* ⟦Bidder⟧ _il*Category⟧ _i1 ⟧ ≥0.04*Σ_i▒ ⟦ ⟦ X ⟧ _i* ⟦Category⟧ _i1 ⟧ (catering is represented by k=1)

5. At least 3% of the catering stalls must be allocated to bidders belonging to BPL category.

   Σ_(i)▒ ⟦Σ_l▒ ⟦ ⟦ X⟧ _i* ⟦ ⟦Is_BPL⟧ _l* ⟦Bidder⟧ _il*Category⟧ _i1 ⟧ ≥0.03*Σ_i▒ ⟦ ⟦ X ⟧ _i* ⟦Category⟧ _i1 ⟧ ⟧ (catering is represented by k=1)

6. At least 4% of the catering stalls must be allocated to women (including war widows & widows of railway employees).

   Σ_(i)▒ ⟦Σ_l▒ ⟦ ⟦ X⟧ _i* ⟦ ⟦Is_woman⟧ _l* ⟦Bidder⟧ _il*Category⟧ _i1 ⟧ ≥0.04*Σ_i▒ ⟦ ⟦ X⟧ _i* ⟦Category⟧ _i1 ⟧ ⟧ (catering is represented by k=1)

7. At least 3% of the catering stalls must be allocated to OBCs.

   Σ_(i)▒ ⟦Σ_l▒ ⟦ ⟦ X⟧ _i* ⟦ ⟦Is_OBC⟧ _l* ⟦Bidder⟧ _il*Category⟧ _i1 ⟧ ≥0.03*Σ_i▒ ⟦ ⟦ X⟧ _i* ⟦Category⟧ _i1 ⟧ (catering is represented by k=1)

8. At least 3% of the catering stalls must be allocated to minorities (Muslims, Christians, Sikhs, Buddhists, Zoroastrians i.e. Parsis and Jains).

   Σ_(i)▒ ⟦Σ_l▒ ⟦ ⟦ X⟧ _i* ⟦ ⟦Is_Min⟧ _l* ⟦Bidder⟧ _il*Category⟧ _i1 ⟧ ≥0.03*Σ_i▒ ⟦ ⟦ X ⟧ _i* ⟦Category⟧ _i1 ⟧ ⟧ (catering is represented by k=1)

9. At least 2% of the catering stalls must be allocated to physically handicapped bidders.

   Σ_(i)▒ ⟦Σ_l▒ ⟦ ⟦ X⟧ _i* ⟦ ⟦Is_PH⟧ _l* ⟦Bidder⟧ _il*Category⟧ _i1 ⟧ ≥0.02*Σ_i▒ ⟦ ⟦ X ⟧ _i* ⟦Category⟧ _i1 ⟧ (catering is represented by k=1)

10. Maximum 2 catering bids for minor units can be accepted from the same bidder for a given station.

    Σ_i▒ ⟦ ⟦ X⟧ _i* ⟦ ⟦Bidder⟧ _il*Category⟧ _i1≤ Max_catering ?⟧ l

11. Linking Yin & Xi

    Y_in= X_i ⟦*X⟧ _n ?i,n

12. Defining synergy factor

    S_i= Σ_n▒ ⟦Y_in*(⟦High⟧ _in ⟧ *H_factor+ ⟦Med⟧ _in*M_factor+Low_in*L_factor-1) ? i

The synergy factor for a bid i is the arithmetic sum of the percentage increase in revenue over & above the FMG due to its synergy with all other selected bids. The synergy factor of a bid not selected is zero.

Coding & outcomes for a small sample data instance

The above model was coded in AMPL and the non-linear model solved for a small sample data instance (Table 1) & synergy matrix (Table 2) using the baron solver. Total solve time for obtaining the optimal solution for the small sample data instance shown in Exhibit 1 came out to be 0.08072 seconds.

Table 1:Sample data instance used to test model developed

Bid	Bidder	Bid category	Shops(Revenue in INR 100k)				
			1	2	3	4	5
1	Haldiram's	1					100
2	Giani's	1				50	
3	Wheeler's Book store	4				20	
4	Souvenir	4			40		
5	GK Pharmacy	3		10			
6	Amul	1		40			
7	Mongini's	1		20			
8	Tea & pan stall	1	20				
9	Pearls & bangles	4			25		
10	Sarees & suits	4					120
11	Utilities store(Amazon)	4	15				
12	Vodafone idea recharge shoppe	4		25			
13	Haldiram's	1			120		
14	Utilities store	2				45	
15	Executive lounge	4				300	

Category:1=Catering, 2= Utilities, 3= Pharmacy, 4=Others

Table 2: Synergy level matrix for the sample data instance

Bid	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	M	H	M	L	H	M	L	H	M	L	H	M	L	H	M
2	L	M	H	M	L	H	M	L	H	M	L	H	M	L	H
3	M	L	M	H	M	L	H	M	L	H	M	L	H	M	L
4	H	M	L	M	H	M	L	H	M	L	H	M	L	H	M
5	L	H	M	L	M	H	M	L	H	M	L	H	M	L	H
6	M	L	H	M	L	M	H	M	L	H	M	L	H	M	L
7	H	M	L	H	M	L	M	H	M	L	H	M	L	H	M
8	L	H	M	L	H	M	L	M	H	M	L	H	M	L	H
9	M	L	H	M	L	H	M	L	M	H	M	L	H	M	L
10	H	M	L	H	M	L	H	M	L	M	H	M	L	H	M
11	L	H	M	L	H	M	L	H	M	L	M	H	M	L	H
12	M	L	H	M	L	H	M	L	H	M	L	M	H	M	L
13	L	M	L	H	M	L	H	M	L	H	M	L	M	H	M
14	L	H	M	L	H	M	L	H	M	L	H	M	L	M	H
15	M	L	H	M	L	H	M	L	H	M	L	H	M	L	M

Assumptions used for solving the sample data instance in AMPL are as follows:

1. Only 5 units and 15 bids by 14 bidders have been considered.
2. Due to the limited number of units, the caste category, BPL and women reservation constraints have been ignored.
3. An average common commission of 10% has been assumed.
4. The relative levels of synergy have been assumed randomly as this is just for illustra tive & checking(that the model works) purposes.
5. All other parameters/ constraints & the objective function remain the same.

- **Output**

The output obtained in AMPL is as shown in Exhibit 12 . The optimum value of the revenue generated is nearly INR 3.42 crores and bids 5,8,10,13,14 have been selected. This is nearly 18% higher than the INR 2.9 crores obtained if each unit type is fixed and bids are evaluated in isolation.

```
objective:   Revenue
Revenue = 341.925

          x [*] :=
          1  0
          2  0
          3  0
          4  0
          5  1
          6  0
          7  0
          8  1
          9  0
          10 1
          11 0
          12 0
          13 1
          14 1
          15 0
```

```
y [*,*]
:   1  2  3  4  5  6  7  8  9  10 11 12 13 14 15  :=
1   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
2   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
3   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
4   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
5   0  0  0  0  1  0  0  1  0  1  0  0  1  1  0
6   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
7   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```

```
8   0  0  0  0  1  0  0  1  0  1  0  0  1  1  0
9   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
10  0  0  0  0  1  0  0  1  0  1  0  0  1  1  0
11  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
12  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
13  0  0  0  0  1  0  0  1  0  1  0  0  1  1  0
14  0  0  0  0  1  0  0  1  0  1  0  0  1  1  0
15  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
;

                    S [*] :=
                    1  0
                    2  0
                    3  0
                    4  0
                    5  0.45
                    6  0
                    7  0
                    8  0.75
                    9  0
                    10  0.75
                    11  0
                    12  0
                    13  1.05
                    14  0.75
                    15  0
                     ;
                _total_solve_time = 0.08072
```

Exhibit 1: Output after solving for the sample data instance in AMPL

Scope for further research

It must be noted that the unit types used in this data instance are only illustrative and non-exhaustive. There is also scope to further refine the values of the synergy factors by taking a much more sample size for calculation. Additionally, we can include factors such as gender, caste category etc. to bring our data instance closer to real-life situations, but we have ignored that for simplicity.

We are aware that although, the proposed model shows significant efficacy on the sample data instance, to check its real impact (effectiveness) vis-à-vis the current model for allocation of minor units, we need to apply the model on a real-life data instance. This is a future project, as it requires us to implement the model on a fresh pool of units for a station, which *will need changes to existing policy and Railway Board approval.*

Conclusion

This work presents a business case for implementing a pooled method of bid evaluation for minor units on railway stations. It has direct policy implications, keeping in mind the current emphasis laid down by the Indian Railways on optimizing our non-farebox revenue earnings. Refining the calculation of synergy factors and running a pilot programme to assess the impact of the pooled method of unit allocation are potential next-steps. Finally, this work also brings out the potential in overhauling internal processes for NFR optimization, something which has not yet been explored in depth.

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Acknowledgement

The authors wish to thank Sh. Prabhas Dansana (PCOM, South Eastern Railway, ex-DRM, Sealdah division), Sh. H.N. Ganguli (ACM/SDAH), Sh. Shailesh (Sr. DEN/Infra/SDAH), Sh. Hemanta Basak (Sr. DCM/SDAH) and Sh. A.S. Roy (ACM II/SDAH) for their continuous inputs during the research. We also wish to thank vendors on the Sealdah Railway Station for sharing their insights about synergy. Lastly, we thank Prof. Sundaravalli Narayanaswami from IIM, Ahmedabad for her guidance and mentorship during this project.

Akhil Palliwar

AWM/RYPS/SCR

Automated Spray Painting of Wagons

AUTOMATED SPRAY PAINTING OF WAGONS

1. Introduction

Painting of wagons is a crucial activity in the process of overhauling of wagons as it shields the surface metal from corrosion inhibitors. Currently in most of the workshops over Indian Railways, painting is being carried out using manual spray painting or brush painting. These methods have the following drawbacks:

a) Low production rate

b) Non-Uniform Application: The spray thickness and the evenness of coating layer are the major issues in a painting process. Controlling spraying path is an important parameter in achieve uniformity or evenness of coating layer thickness but it is not possible with manual spray system. Over- coating also results in paint bleeding.

c) Hazardous Environment: Vapors of Hydrocarbons in a paint shop are inevi table. These vapors prove to be carcinogenic on prolonged exposures. More over, during spray painting, atomized paint droplets repeatedly mask the surface of safety goggles and overcoat of the technicians. Hence, even per sonal protective gears underperform in such conditions.

An automated painting system can eliminate all of these drawbacks. The following are the tangible benefits enlisted for automated spray painting:

Parameter	Conventional Manual Spray	Automated Spray Painting (Estimated)
Time of Operation	36 min	20 min
Manpower	0.96 per wagon	0.6 per wagon
Health and Environmental Hazard	Extremely High	Low
Coat	Non-Uniform	Uniform

2. Schematic Design of Automated Paint Booth

The painting activity is carried out by atomizing the paint over a nozzle (paint sprayer) connected to a paint pump. The paint sprayers are arranged and movements are configured so as to achieve complete painting of end wall, side wall and roof of a wagon. Figure 1 depicts the general schematic of paint booth.

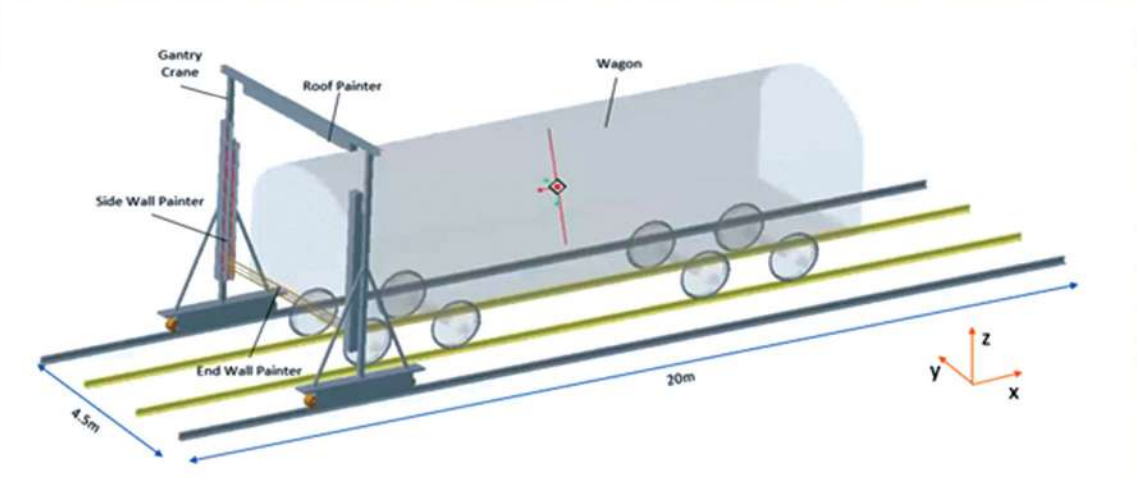


Figure 1: General Schematic of Automated Paint Booth

- All the painting mechanisms are mounted on the gantry crane, that can move along the rails spaced at 4.5m in the longitudinal direction (X direction).
- As shown in the figure, there are four painting mechanisms:
  a) Left Side wall painter (comprising 3 sets of sprayers)
  b) Right Side wall painter (comprising 3 sets of sprayers)
  c) End wall painter (comprising 10 sets of sprayers)
  d) Roof painter (comprising 4 sets of sprayers)
- The movement of these 4 mechanisms are achieved with the help of screw drives as in CNC machines controlled by servo motors for precise position control
- The following is the direction of movement of the mechanisms:
  a) LHS side wall painter- Vertical Reciprocation (Z direction)
  b) RHS side wall painter- Vertical Reciprocation (Z direction)
  c) End wall painter- Vertical Reciprocation (Z direction)
  d) Roof painter- Lateral Reciprocation (Y direction)
- The operation timings and position of various motor and paint sprayers are controlled with help of Arduino microcontroller/PLC.

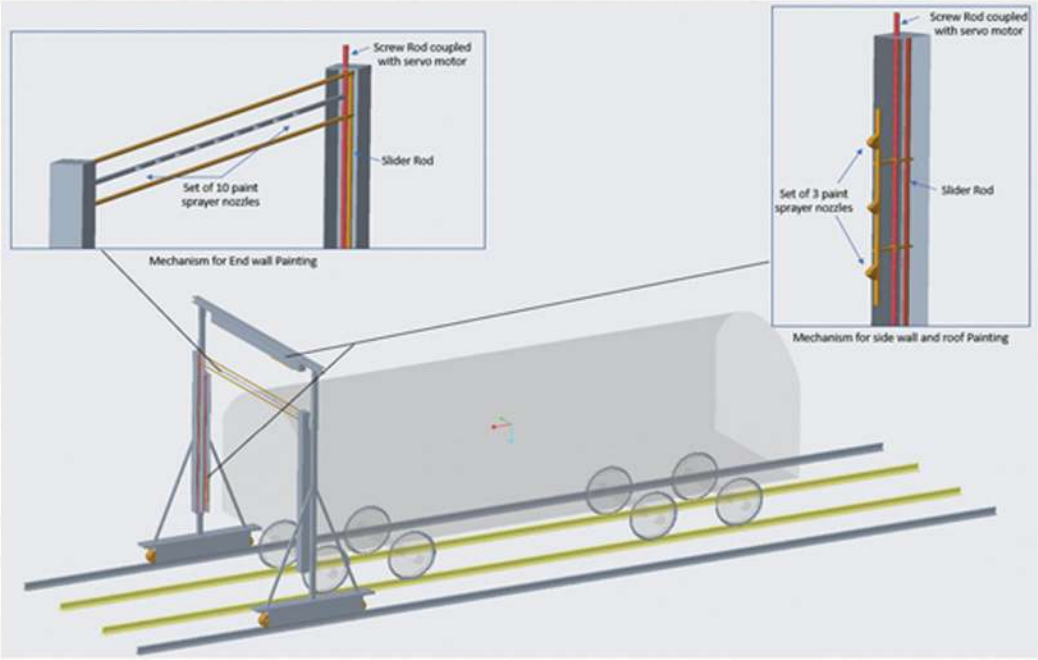


Figure 2: Exploded view of Painting Mechanisms

The entire painting mechanism is enclosed in a civil infrastructure (Figure 3) consisting of:

a) A grated mesh flooring for dripping of excess paint
b) Roofs equipped with paint filters
c) Roof mounted exhaust fans to expunge hydrocarbon fumes within the booth after filtration

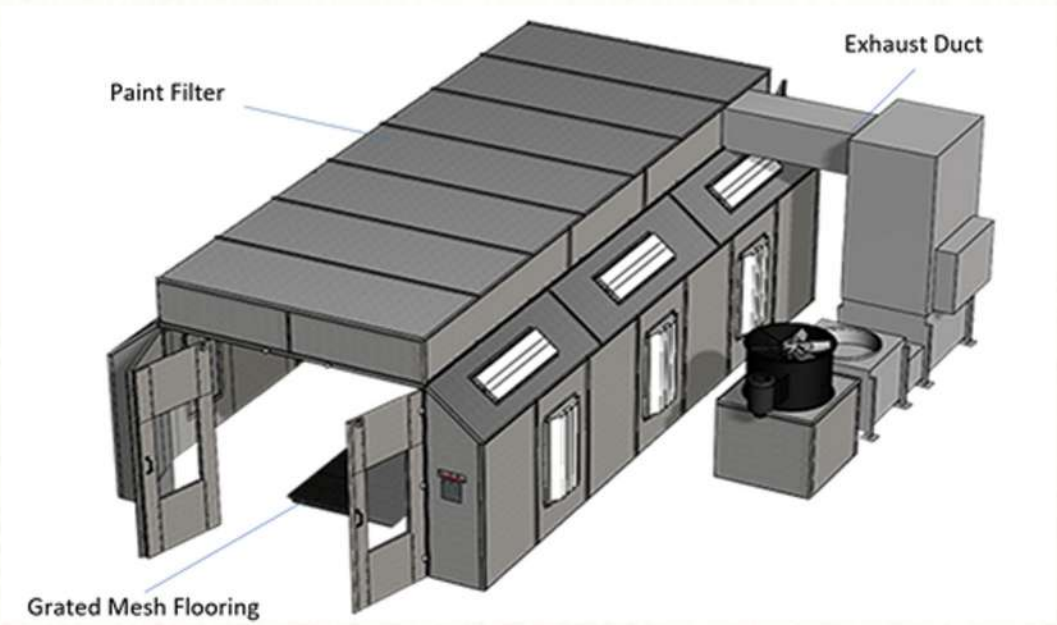


Figure 3: Civil Infrastructure

3. Important Components

Rhino Pump:
This is an airless spray pump. The power source is compressed air. The pump generates hydraulic pressure at the paint side by using the energy from compressed air without intermixing air with paint. The pressure ratio is 1:55 (air: paint) and can deliver up to 6.8 L/min of pressurized paint.

Automatic Airless Spray Gun:
This is a pneumatically actuated spray gun that atomizes pressurized paint into small droplets and sprays up to a distance of 60cm at a fan width of 300 cm.

3 phase AC brake motor:
This motor is used to impart motion to the gantry crane structure. The speed will be controlled using VVF drive. Power:3HP

Stepper Motor:
This motor is used to impart motion to various screw drives. The minimum rotation this motor can achieve is 1.8 degrees.
Holding torque: 85 Kgcm
Step Angle 1.8˚/ pulse
Supply Voltage: 24 V

Arduino Mega Microcontroller or SEIMENS PLC S7-1500:
This is a programmable microcontroller, that receives input from various sensors processes them and gives command to its peripheral output devices

LIDAR Sensor:
This is a distance sensor, that will be used to sense the presence of wagon and the signals will be sent to the microcontroller for necessary commands to be generated to start/stop the spray gun, movement of screw drives and gantry crane.

RMCS 1101:
This is a stepper motor driver. Its function is to amplify the low power control signals from microcontroller to required power levels of the stepper motor.

3/2 Solenoid Valve:
These valves will pick electrical command signals from microcontroller in order to direct air into the automatic airless spray gun, for controlling the spray of nozzles.

Ball Screw Drives:
To actuate the movements of various painting mechanism as discussed before.

Diameter: 25mm
Pitch:10mm/rev

4. Automation Circuit

Automation circuit (Figure 4) is the low power control circuit that is used to receive signal from sensors and command various motors and pumps accordingly. The circuit consists of the following components:

a. Sensors:
   - LIDAR Sensor: This sensor is used to sense the presence of wagon and helps to decide the initiation and halting of painting process.
   - PUSH Buttons: Connected on A0-A10 ports of Arduino Mega. These pins will hold specific programs to paint different types of wagons depending on their structure and size. For ex ample, A0 will execute program to paint BOXN and A2 will execute program to paint BCN.

b. Microcontrollers:
   - Arduino UNO: This microcontroller is used to continuously read data from LIDAR sensors and send interrupt command to Arduino Mega/PLC to start/stop painting process based on presence of wagon.
   - Arduino Mega/PLC: This microcontroller is used to control motion of servo motors, paint pump, gantry crane motors, solenoid valves etc.

c. Actuators:
   - RMCS 1101: This motor driver receives signal from Arduino Mega/PLC and drives the step per motor at preset speeds
   - Relay Module: Relay module receives low power control signals from Arduino Mega/PLC and translates it to high power signals to drive gantry crane motor, Paint pump, spray noz zles and process indicator lights.

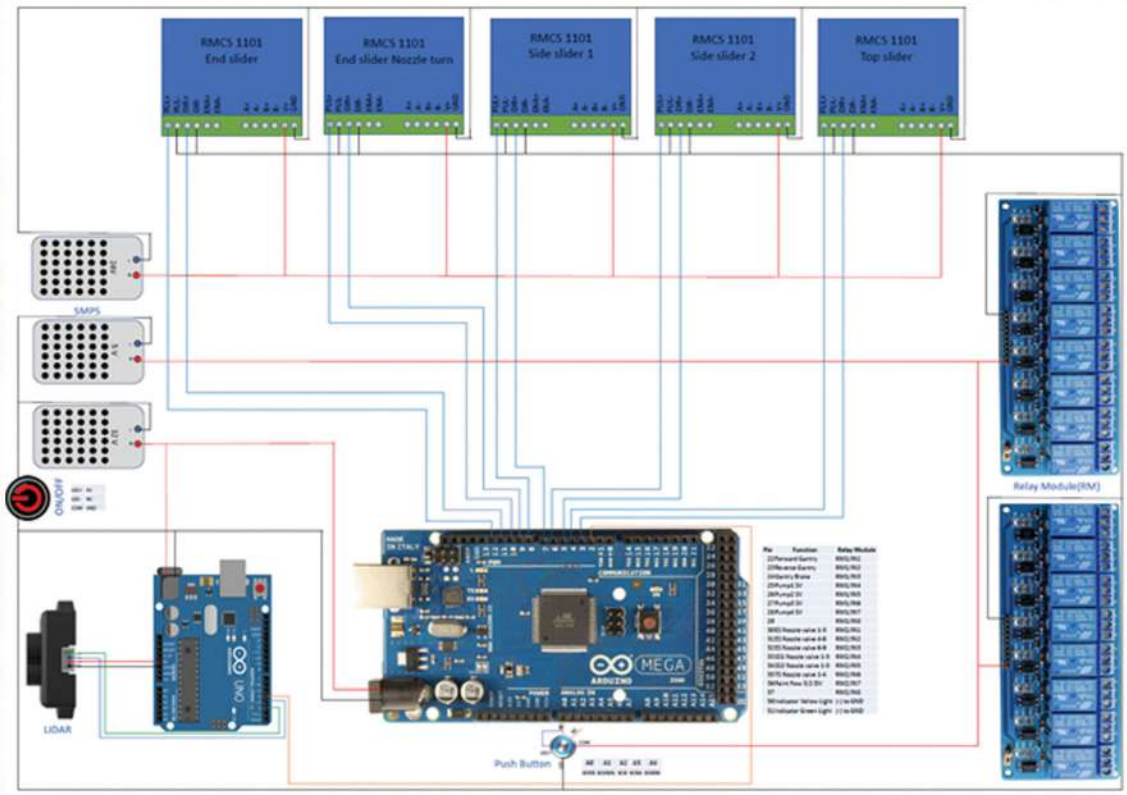
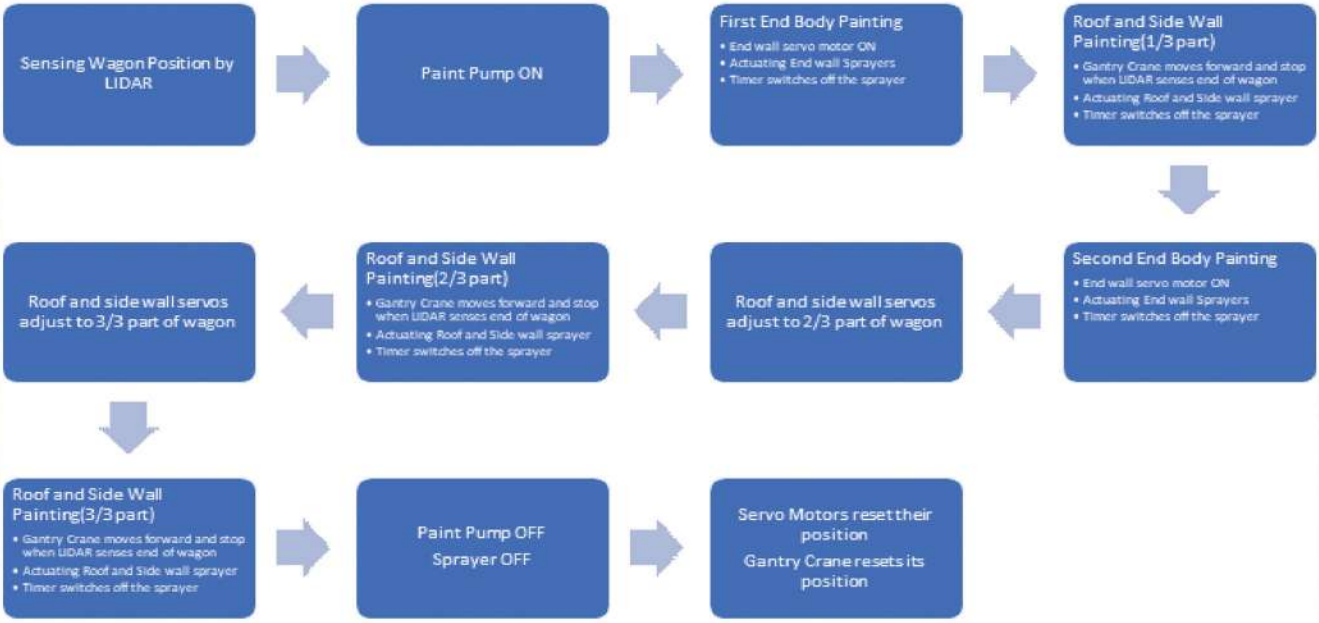
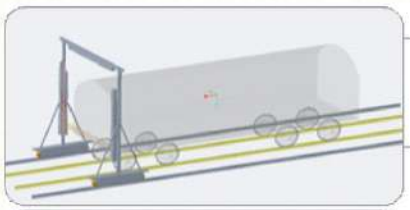


Figure 4: Automation Circuit

5. Programming Logic

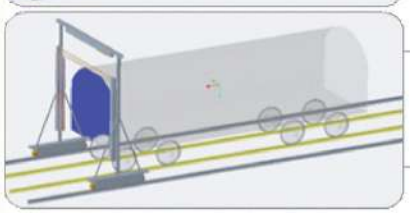


6. Sequence of Operations



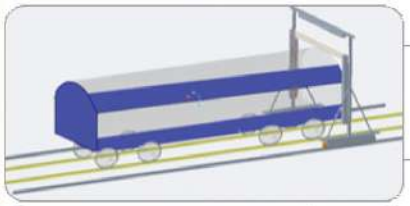
LIDAR Sensor presence of wagon

- End wall painter moves in +Z direction to paint first end wall



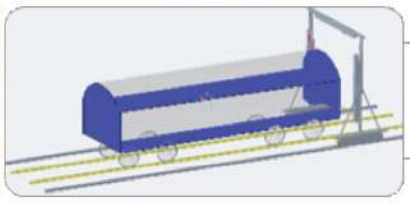
First end wall painted

- Gantry crane moves in +X direction to paint 1/3 part of RH, LH side wall and roof



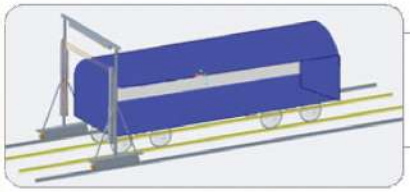
LIDAR senses the position where wagon ends

- End wall painter moves in -Z direction to paint second end wall
- End wall painter moves in +Z direction to clear area for gantry crane movement



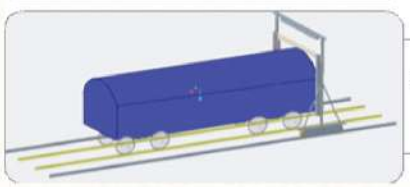
End walls painted and 1/3 side wall and roof

- Servo motor moves Roof and side wall painter in +Y and +Z direction to adjust to 2/3 part of wagon
- Gantry crane moves in -X direction to paint 2/3 part of RH, LH side wall and roof



End walls painted and 2/3 side wall and roof

- Servo motor moves Roof and side wall painter in +Y and +Z direction to adjust to 3/3 part of wagon
- Gantry crane moves in -X direction to paint 3/3 part of RH, LH side wall and roof



Full wagon painting completed

Scan the code to watch the sequence of operations

7. Conclusions

Painting of POH'ed wagons in RYPS workshop is been carried out manually. Introduction of automated spray painting of wagons will reduce the time of painting, manpower required with reduced health and environmental hazards thereby increasing the quality of painting for wagons.

The market rate for a paint booth is around ₹ 7.1 crores. This project is very economical as the In-house manufacturing costs only 8-10 % of the Market Rate at an estimated cost of ₹57.67 lakhs. The following is the estimate of the project:

Cost Analysis

Gantry Crane Structure

S No	Description of item	Qty	Spare Qty	Rate	Value	Remarks
1	3 phase brake motor with gear box(3HP)	2	0	₹ 70,000.00	₹ 1,40,000.00	
2	couplings	2	0		₹ 0.00	Available
3	wheels	4	0		₹ 0.00	Available
4	channels -5 meters length	10	0		₹ 0.00	Available
5	Angular beams	4	0		₹ 0.00	Available
6	VVVF Drive	1	0		₹ 0.00	Available
7	3 Core 4 Sq"mm Copper cable	2	0	₹ 14,000.00	₹ 28,000.00	
8	Control Transformer	1	0	₹ 10,000.00	₹ 10,000.00	
9	MCCB	1	0		₹ 0.00	Available
10	Main Contactor	1	0		₹ 0.00	Available
11	Contactors	2	0		₹ 0.00	Available
12	Pendent	1	0		₹ 0.00	Available
13	OLR	1	0		₹ 0.00	Available
14	Energy Chain	15	0	₹ 8,000.00	₹ 1,20,000.00	
15	Aluminium tray	20	0	₹ 5,200.00	₹ 1,04,000.00	
				Total	₹ 4,02,000.00	

End Wall Slider

S No	Description of item	Qty	Spare Qty	Rate	Value
1	Steeper motor, NEMA 34, 85 kgcm torque RHINO MICRO-STEPPING STEPPER MOTOR	2	0	₹ 7,000.00	₹ 14,000.00
2	DRIVE 18-80V 7AMP	2	0	₹ 3,800.00	₹ 7,600.00
3	1 inch dia,10mm pitch,4 meters length ball screw rod with two Nuts	1	0	₹ 30,000.00	₹ 30,000.00
4	End supports BK20 motor side	1	0	₹ 3,500.00	₹ 3,500.00
5	End supports BF20 other end	1	0	₹ 2,500.00	₹ 2,500.00
6	Supporting Steel tube,25mm OD,14mm ID,length 4 meters with surface finish 8 Ra,Roundnees: 0.008 inch,straightness:0.001 inch per foot	1	0	₹ 4,000.00	₹ 4,000.00
7	Linear Axis ball bearing with block ,Model:SC25UU	4	0	₹ 2,834.00	₹ 11,336.00
8	Support Cross beam and Nozzle rotation rod 4.5 m	1	0	₹ 5,000.00	₹ 5,000.00
				Total	₹ 77,936.00

Mechanical System	Civil Infrastructure	Estimated Cost
₹ 27,65,868	₹ 30,02,000	₹ 57,67,868
Market Value		₹7,35,00,000

LHS Slider , RHS Slider, Top Slider

S No	Description of item	Qty	Spare Qty	Rate	Value
1	Stepper motor, NEMA 34,85 kgcm torque RHINO MICRO-STEPPING STEPPER MOTOR	3	1	₹ 7,000.00	₹ 28,000.00
2	DRIVE 18-80V 7AMP	3	1	₹ 3,800.00	₹ 15,200.00
3	1inch dia,10mm pitch,4 meters length ball screw rod with two Nuts	3	1	₹ 30,000.00	₹ 1,20,000.00
4	End supports BK20 motor side	3	1	₹ 3,500.00	₹ 14,000.00
5	End supports BF20 other end	3	1	₹ 2,500.00	₹ 10,000.00
6	Supporting Steel tube,25mm OD,17mm ID,length 4 meters with surface finish 8 Ra,Roundnees: 0.008 inch,straightness:0.001 inch per foot	3	1	₹ 4,000.00	₹ 16,000.00
7	Linear Axis ball bearing with block ,Model:SC25UU	6	2	₹ 2,834.00	₹ 22,672.00
				Total	₹ 2,25,872.00

Paint and Electrical Accessories

S No	Description of item	Qty	Spare Qty	Rate	Value
1	Paint pump,RHINO 55.275	4	0	₹ 2,56,000.00	₹ 10,24,000.00
2	Automatic sparay nozzles	22	0	₹ 18,880.00	₹ 4,15,360.00
3	TC Nozzle 615	22	0	₹ 2,855.00	₹ 62,810.00
4	Pneumatic directional valves	12	0	₹ 1,700.00	₹ 20,400.00
4	3/8 inch Paint hose-20 mtrs	4	0	₹ 6,000.00	₹ 24,000.00
5	1/4 inch paint hose-5 mtrs	15	0	₹ 1,700.00	₹ 25,500.00
6	Manifolds,T joints,Elbows	5	0	₹ 2,000.00	₹ 10,000.00
7	Pneumatic ON /OFF valves	4	0	₹ 1,700.00	₹ 6,800.00
8	Micro-controller-ARDUINO MEGA 2560	2	0	₹ 4,000.00	₹ 8,000.00
9	Micro-controller-ARDUINO UNO R3	2	0	₹ 2,065.00	₹ 4,130.00
10	LIDAR Distance sensor	2	0	₹ 3,399.00	₹ 6,798.00
11	Relay Module 8 channel 5V, 30V DC 10A	4	0	₹ 450.00	₹ 1,800.00
12	Momentary Metal Push Button 5V 2A	10	0	₹ 230.00	₹ 2,300.00
13	Power metal push button 12V 10A 22mm	2	0	₹ 560.00	₹ 1,120.00
14	4 pin Cable connectors IP65	10	0	₹ 698.00	₹ 6,980.00
15	20cm connectors	10	0	₹ 190.00	₹ 1,900.00
16	SMPS 24V, 12V, 5V	3	0	₹ 2,000.00	₹ 6,000.00
17	Wires (Red, Black) Cable 0.3mm2	60	0	₹ 50.00	₹ 3,000.00
18	Wires (Blue Green, Black) Cable 0.3mm2	20	0	₹ 50.00	₹ 1,000.00
19	Pneumatic Pipes	50	0	₹ 55.00	₹ 2,750.00
20	Pneumatic Solenoid valve Fittings	30	0	₹ 50.00	₹ 1,500.00
21	Pneumatic T joint, X joints	20	0	₹ 50.00	₹ 1,000.00
22	Breadboard	2	0	₹ 250.00	₹ 500.00
				Total	₹ 16,37,648.00

Ashok Kumar
Sr.CDO/RNCC/ECR

Prevention of shortcuts in axle mounted disc brake system in LHB coaches

Prevention of Shortcuts in Axle Mounted Disc Brake System in LHB Coaches

Abstract– The maintenance of LHB coaches in the coaching depots of Indian Railways is governed by LHB Maintenance manual. The Axle Mounted Disc Brake System (AMBDS) has been provided in LHB design Mainline Passenger Stock for Indian Railways. The brake system equipment provided on the LHB design coaches meet the requirement for high-speed trains hauled by locomotives and permits the emergency braking for such trains to be within the stipulated limits when brakes are applied on a straight track at a speed of 160 kmph with loco brakes. The maintenance of Air brake system includes periodic schedule maintenance like Quarterly, M-36 & M-72 schedules along with checks during D1, D2, D3 and SS-1 maintenance schedules prescribed therein which are applicable to coaching depots.

Presently, Rajendra Nagar Coaching Complex Depot (RNCC) of East Central Railway has a LHB Coach holding of 750 coaches and as on date AMOC Contracts covering AMBDS of M/s Knorr Bremse India Pvt. Ltd & M/s Faiveley Transport Rail Technologies India Limited are under execution with an annual expenditure of Rs.12 Crores (approx. cost)

The author has conducted audit of the existing maintenance system of AMBDS at RNCC Depot and has detected various insights on the shortcuts being adopted in depot by the departmental as well as staff of OEMs. The purpose of this paper is to share the insights in the preventive measures to be taken for stopping the shortcuts during various maintenance schedules in Depots so that other depot officers can undertake similar audit and prevent malpractices, if any, in their depots. The paper shows root causes behind the failure of different components of Air brake system due to the shortcuts.

He has also proposed to investigate means by which strict control on expenditure on AMBDS system can be ensured with much better maintenance of LHB stock for high-speed operation. The author believes that such a study on LHB AMBDS system is to be done in each coaching depot over Indian Railways and request inputs and insights from all LHB maintainers.

1) **Background –** LHB coaches were introduced on Indian Railways in 2000 and in ECR in 2007 from Rajendra Nagar Coaching Complex (RNCC). Over a period of time, the population of LHB coaches in RNCC has increased to present holding of 750 coaches.

   When some failures were investigated in detail, some shortcuts were noticed at RNCC Depot in Axle Mounted Disc Brake System including WSP system. Effects of these shortcuts were reflected in failures of air brake system e.g. brake binding, hot axle cases, control arm failure, spring failure, wheel defects etc. They have also led to huge expenditure on WSP card & speed sensors failures.

2) The shortcuts - The shortcut methods detected during the audit have been listed below:

a. Release choke of Distributor Valve missing:

Figure -1

Figure-2

Figure-3

The release chokes of DV were found to be have been taken out in several coaches (The red squares in figure-3 depicts the missing choke) so as to have a DV releasing time within permissible range (i.e. 15 - 20 sec)

Case Study no.1: Brake binding occurred in Coach no- EC LWSCN 17237, (POH- LLHM 22.12.20, R/date- 01/24, D2 Sch.-RNCC 20.02.2021, DV make- Knorr) in train no.03201/02 on 09.03.21.

Case Study no.2: Brake binding occurred in Coach no- EC LWS 17505, (POH- LLHM 27.11.20, R/date- 01/24 D2 schedule done- 24.02.2021., DV make- Knorr) in train no.03201/02 on 09.03.21.

In both cases, audit revealed that the release choke of DV was found missing, probably to get permissible release time thereby creating the erroneous impression that the DV was satisfactory.

b. Reduction of brake cylinder pressure:

Few coaches were detected with brake cylinder pressure of less than 3.0 kg/cm2. Pre sumably, this was done surreptitiously to reduce brake releasing time and faster brake-releasing for reducing wheel shelling, when the air brake gang was put under pressure for better maintenance to reduce wheel shelling. However, RDSO has time and again emphasized that no alteration in brake cylinder pressure from the specified value of 3.0 ± 0.1 kg/cm2 has to be done as it has implications on Emergency Braking Dis tance.

Reference: RDSO's Letter No. MC/LHB/Brake; dated:20.04.2018

Figure-4

Figure-5

The above picture show how pliers are used quite easily for adjusting the BC pressure from Control panel.

Case Study: Brake binding occurred in coach no. EC LWLRRM 193286 (DOC-19.05.19, R/D-05/22, SS1-RNCC 06.01.21) in train no. 02310 on 14.01.21. Brake cylinder pressure was found 2.9 kg/cm2.

c. Use of ICF DVs in LHB coaches

In some of the off-POH coaches from Workshop, ICF DVs were found fitted in LHB Coaches which were detected during the pre-commissioning checks at sickline. In LHB DVs maximum Brake cylinder pressure is 3 kg/cm2 whereas in ICF DVs it is 3.8 kg/cm2.

Case Study: Off POH coach no. EC LS 154267 (POH-LLH 04.05.21, R-06/24) received with ICF DV fitted instead of LHB DV.

Figure-6: (ICF DV)

Figure-7: (LHB DV)

d. Clogged Breather plug of Brake Cylinder:

Figure-8

Figure-9

On several occasions the breather plugs of Brake cylinder were found to be fully choked and clogged with dirt. Clogging of breather plug of brake cylinder leads to improper venting of BC pressure and causes shelling subsequently. This activity needs to be ensured in the D2-Sch itself.

Case Study: Brake binding occurred in Coach no. EC LWSN 15239, POH-LLH 28.03.2019, R/D-05/22, M-36- RNCC on 18.10.19). in train no. 02351/52 on 21.10.20. On investigation, the breather plugs of brake cylinder found to be fully choked andclogged with dirt.

e. Shortcuts being adopted in WSP system

Audit of WSP system in existing LHB fleet was conducted and the findings is as:

WSP make	No. of coaches checked	K05 relay valve found defective	Fuse no. 63 & 65 found defective	Pressure switch found with wrong wiring
FTRTIL	321	36	20	20
KNORR	260	24	04	09
ESCORTS	53	04	03	03
TOTAL	634	64	27	32

Table-1

Based on above we can categorize the shortcuts related to WSP system into 04 parts:

Based on above we can categorize the shortcuts related to WSP system into 04 parts:

i. K-05 Relay found defective:

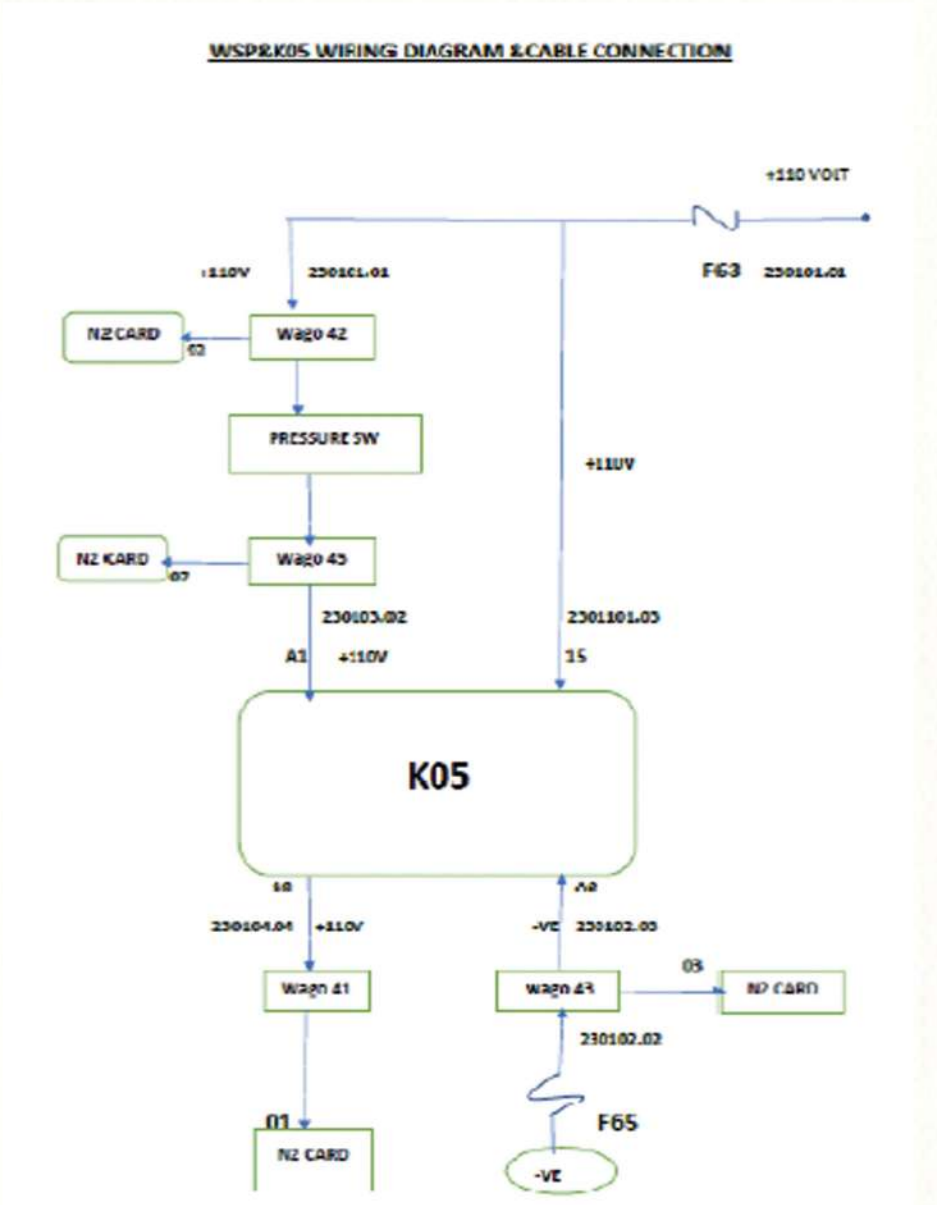
Cases of bypassing K-05 relays were noticed which may be due to:

* Non-working of K05.
* Pressure switch defective (discussed in detail at 5 (c)
* 110 V power supply discontinued due to wrong wiring in the WAGO.

Figure-10

Figure-11

Figure-12



ii. Fuse no. 63 and 65 defective which leads to failure of N-2/MB/JZP and other WSP Cards

The cases of damaged WSP cards were investigated and it was found that the Glass fuses no 63 & 65 were deficient and bypassed with wires thereby making the WSP system prone to power surge and ultimately damage to WSP cards. WSP cards are one of the costliest items being used in coaching depots. The cost ranges from approx. Rs. 85,000/- to Rs. 2,50,000/-(approx.) per card whereas the fuses costs only Rs.1/- (approx. cost) so it is imperative to prevent damage to WSP cards.

Case Study: JZP Card Escorts make WSP System of Coach no. EC LWLRRM 193700, (DOC-06.08.19, R/D-08/22) found burnt due to defective fuse no.63 and 65 on 24.12.20.

S.No.	Probable Reasons	Preventive Action to be taken
1.	Glass fuse 63 & 65 is replaced by wiring	Checking of Glass Fuses of F-63 (6.3A) in +ve 110 DC and F-65 (6.3A) in -ve 110 DC.
2.	K05 contactor is bypassed	Working condition of K-05 Should be checked by timer for Anti-Skid Device 110 V DC in every monthly schedule.
3.	Working condition of Pressure Switches	Working of pressure switch to be checked in every monthly schedule.
4.	Removal of N2 card without shutting down the power of WSP System	Removal of N2 card without shut down to be stopped.

Table-2

Figure-13

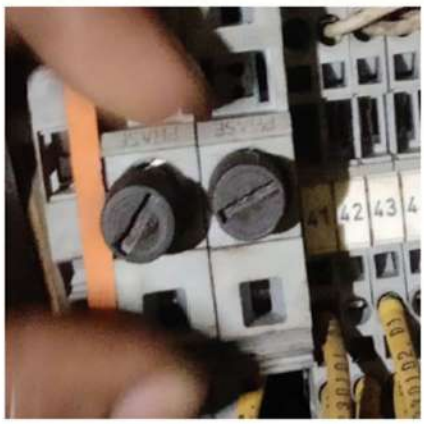


Figure-14

(Glass Fuse no 63 & 65)

iii. Use of defective pressure switch to operate WSP:

The pressure switch is supposed to facilitate energizing of WSP system at 1.7 kg/cm2 feed pipe pressure.

Figure-14 (defective pressure switch)

Figure-15 (new pressure switch)

When the defective pressure switch is not made available by the OEM, the OEM staff or railway staff uses wire to short the electric supply as shown in figure-14. Use of defective pressure switches to operate WSP leads to continuous operation of WSP system and draining of battery supply even when the coaches are lying stabled. WSP system never goes into SLEEP mode thereby unnecessary damage to WSP cards is possible.

Case Study: Brake binding occurred in coach no. EC LWACCN 11108 (LLH 30.01.19 R-03/22 IOH RNCC-07.11.20 D3 RNCC- 09.05.21) in train no.03392 on 13.05.21. On investigation it is found that defective pressure switch is used to operate WSP.

iv. Faulty Speed Sensors:

Speed Sensors on many occasions were found to be interchanged among OEMs and even on the same OEM (Faiveley) the selection of speed sensor was not correct. Speed sensors used in LHB coaches are both Voltage & Current based ones and their characteristics differ substantially between makes.

S. No.	Make	Voltage/Current based	No. of cables (excluding shield/earthing)	Colour coding of speed sensor cable
1	Knorr-Bremse	Current	2	Red – positive White – negative
2	Faiveley	Current	2	Red – positive White – negative
3	Faiveley	Voltage	3	Red – positive Black – negative White – signal
4	Escorts	Current	3	Red – positive Blue – negative White – signal

Several times, lack of continuity in WAGO connectors of speed sensors had been noted. At times, due to incorrect colourcoding of speed sensor supply cables coming from WSP panel and wrong numbering being followed, wrong connections with speed sensor cables were made leading to faults in WSP panel.

Case Study: *Brake binding occurred in coach no. EC LWLRRM 193285 (DOC-23.05.19, R/D-05/22, SS1-RNCC 27.02.21) in train no.02309/10 on 13.01.20. On investigation the speed sensor found faulty (code-71,72). Firm replaced the speed sensor after warranty lodged.*

Figure-16

Figure-17

The speed sensor being a costly item worth Rs. 43,752/- (approx. cost), so its physical damage needs to be avoided and following preventive action needs to be taken to avoid damage:

S. No.	Reason	Preventive Action to be taken
1	Gap of 0.9 to 1.4 mm is not being maintained properly during D-2	Gap should be religiously maintained in D-2. It is to be ensured that sufficient number of feeler gauges are available with each maintenance gang.
2	Damage to sensor head due to rubbing action when fasteners loosen.	Fastener tightness to be checked in every D-1
3	Crimping of sensor end near the junction box	Connection of cable with junction box to be checked in every D-1
4	Cable cut between sensor and junction box	Replace cable between sensor and junction box.

Table-3

3) Recommendations

a. Breather plug of brake cylinder - Substantial correlation of wheel shelling with clogging of breather plug of brake cylinders had been observed in the coaches.

Frequent and periodic cleaning of breather plugs of the brake cylinder should be ensured to prevent wheel shelling.

b. Card Failure – The WSP cards of any OEM are one of the costliest components of air brake system. Therefore, all possible steps should be taken to prevent damage to cards.

i. It has been prescribed in OEM's Manual for WSP Maintenance that at the time of welding anywhere in coach, fuse no 63 and 65 are to be removed. But due to igno rance, this practice is hardly adopted. All the supervisors and welders need to be counselled.

ii. It has been prescribed in OEM's Manual for WSP Maintenance that during removal of card from microprocessor unit, fuse no 63 and 65 are to be removed. All the supervisors and staff of air brake maintenance gang need to be counselled.

c. Fault code 95 - Fault code 95 logged in the system denotes either presence of tran sient faults or presence of such faults which are only detected during dynamic condi tion. In no condition, faults code 95 should be permitted without troubleshooting.

d. WSP Circuitry - Complete wiring of WSP circuitry to be checked during pre commis sioning as well as in case of any card failure.

e. Speed Sensor:

i. Speed sensors should not be interchanged between OEMs.

ii. No visible damage to the face of the speed sensor probe should be permitted.

iii. Speed sensors should be handled therefore with utmost caution.

iv. Speed sensor gap should be kept within 0.9-1.4 mm as prescribed in various guide lines.

v. Several times, lack of continuity in WAGO connectors of speed sensors has been noted.

vi. Continuity of speed sensor cable up to WSP panel should be ensured.

vii. At times, due to incorrect color coding of speed sensor supply cables coming from WSP panel and wrong numbering being followed, wrong connections with speed sensor cables are made leading to faults in WSP panel.

viii. Working of speed sensor cable should be ensured with Moving Metal Test Set up before rejection.

ix. Speed sensor probes should be properly secured during bogie change.

x. At times, speed sensor cables get entrapped between Curve Rollers, it should be secured properly.

f. WSP Display OFF - WSP display should be ON in all conditions of coach running. Cases of Display OFF should be rectified with the following procedure -

i. Ensure FP is charged

ii. Ensure availability of Fuses and Cards

iii. Ensure input supply at F63 and F65

iv. Ensure proper fuse working

v. Ensure supply at wire no. 41 and 43

vi. Ensure continuity in wire no. 41 and 42 to validate working of Pressure Switch

vii. 42 supply will energize Coil of K05 relay, in case of 42 supply not available, Timer
characteristics of K05 relay will kick in.

viii. Ensure power supply at terminal 44

ix. From 44 terminal power supplies will be fed to the power supply card through the connector. Should be checked accordingly.

4) Conclusion – This paper is a practical pointer and intended to be a field guide to the shortcuts being adopted, for whatever reasons, in one of the depots of ECR and the purpose of making this public is to share the experience for the benefit of all Coaching officers and to encourage and invite sharing of similar practices, if any, in their knowledge. The shortcuts, if not detected and stopped, in air brake system will be detrimental to the health of coaches.

Shashwat Gupta
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IRIMEE

Artificial Intelligence (AI) in Railways Around the World

Artificial Intelligence (AI) in Railways Around the World

Introduction: What is AI?

The term "Artificial Intelligence", or AI, itself encompasses a wide range of evolving technologies, making it very difficult to formally define. Broadly, it can refer to any technology, or machine, that mimics traditional human responses to stimuli "given the human capacity for contemplation, judgement and intention" to reach decisions with comparable expertise.

AI machines are designed to make decisions in real-time, adapting intelligently to diverse input data. Naturally, such automated ability comes with wide-ranging applications and ramifications.

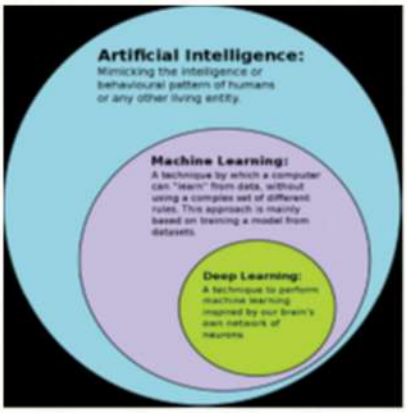
In the form it is mainly used in today, the field of AI can be broadly classified as:

(i) Machine Learning (ML) – It is a subset of AI, where the algorithm can be "taught" on the basis of a pre-determined set of data, and then apply it on other data sets to make predic tions based on what it has "learned". ML has three steps: Training, Validation set, Testing. The higher quality the test data, the better.

(ii) Neural Networks (NN)/ Deep Learning – A form of supervised learning under ML that models the logical system as a hierar chy of weighted nodes, similar to neurons.

(iii) Natural Language Processing (NLP) – The branch of AI and ML dealing with interactions between computers and human language (text-to-speech and vice versa).

(iv) Robotics – Machines working on AI can put computation in motion to perform various daily tasks.



"All models are wrong, but some are useful" – George E.P. Box

Potential Applications of AI in the Railway Transport Sector: UIC's View

In their paper, Artificial Intelligence Case of the Railway Sector: State of Play and Perspectives (March 2021), UIC outlines the following broad areas of application of these technologies to the Railways:

(i) Image recognition for security or antiterrorism – facial recognition from CCTV footage at railway stations, such as in China (at boarding) and Eurostar (at Customs).

(ii) Chatbots & Virtual Assistants – NLP can be deployed to provide chatbots to act as customer service assistants, ticketing staff, helpline staff, public announcers, etc.

(iii) Sales Prediction through ML – based on data from large number of e-tickets sold within any system, passenger behaviour can be monitored and annotated for sales managers to decide sales policy, keeping in mind the twin considerations of operational efficiency and ease-of-use to attract and keep customers.

(iv) Station staff – Robotics in hotels, airports and hospitals can be adapted to Railway stations to cost-effectively improve service quality.

(v) Trains – Cleaning robots on trains for speedy, effective, and inexpensive cleaning.

(vi) Warehouses – Spare parts for rolling stock maintenance can be quickly and efficiently

(vii) Predictive Maintenance – Advanced statistical methods, such as ML, can be employed to monitor the life cycle of various key components and dynamically define the optimum time for inspection and maintenance. This would have drastic benefits for availability, punctuality, plus safety, while greatly reducing Maintenance Time, Inspection- and Maintenance Costs, and Mean Time to Failure (MTTF). This area of predictive maintenance is particularly well adapted to the statistical methods of ML.

a. Predictive Maintenance of Rolling Stock – is a relatively unexplored area in research literature, even though a large amount of data already exists. It is an important area of work, but with challenges of cooperation between stakeholders.
b. Predictive Maintenance of Infrastructure – Conditions are much more favorable, as there is less competition and more cooperation between stakeholders for data on this aspect. Inspection and maintenance data is already collected on a huge scale.

Notable accomplishments already implemented:

i. ORBIS programme by Network Rail, 2021
ii. Replacing manual with automated inspection for tunnels (Network Rail, 2019), track machine vision system (Japan, 2019), robotic inspection (Catapult Trans port 2021, and HiBot 2015, 2020) are good examples of good developments.
iii. Felix (2018) is the first certified mobile robot for automatic inspection of railway coaches and crossings
iv. Erevos Project (Esmera, 2017) for aerial drone monitoring of railways.
v. Indian Railways has implemented Smart maintenance using data analytics (Global Railway Review, 2020)

(viii) Automatic Train Operations are also an area which computer scientists have long sought to automate (MacCormick 1988). AI could fine-tune these methods to look after anomalous cases and smooth over technical difficulties or human error.

Railway Systems Abroad: Case Studies

Europe

This year, 2021, is the European Year of Rail. The European Commission (EC) initiative seeks to highlight the importance of railways in Europe as a safe, convenient, and eco-friendly transport mode.

Along with Norway and Switzerland, 25 EU member states have joined the Platform on International Rail Passenger Transport, where they proposed that online ticket booking for international rail travel must be facilitated by better aligned timetables across member countries. In addition, launch of 15 pilot projects was proposed by the EC, intended to become operational by 2030.

In addition, the EC, in its European Strategy on AI & Data 2020, envisions turning Europe into a global hub of trustworthy AI in this decade, with a European Data Space legally protected and regulated.

In line with these twin objectives, Europe's Sustainable and Smart Mobility Strategy aims to double railway passenger freight traffic by 2030 and 2050 respectively and stimulate innovation and data use and AI for smarter mobility. To this end, the EC established its Shift2Rail Joint Undertaking in 2016, to focus on railway research and innovations.

These target capabilities include buzzwords such as automated train operation, Mobility-as-a-Service (MaaS), logistics on demand, service timed to the second, guaranteed asset health and availability, intelligent trains, sustainable & smart mobility, etc.

UIC declares in its report [1] that, while there is some good innovation in some instances in the field but in the broader picture, *AI is not yet prevalent on the European rail system as of now.*

Japan

Japan is considerably ahead of Europe in implementation of AI and related technology in its rail transport sector. However, being written in Japanese, sometimes this news is not accessible in English: it must be searched for only in Japanese. Thus, we find that Japan has already implemented, or is actively working on, the following:

(i) Seamless transport integration across operators, and even medium, is an old con cept in Japan with Suica/PASMO as a near-universal payment- and access gateway for a variety of services.

(ii) JR East has been experimenting with an AI-based guidance system at stations (to answer passenger inquiries etc.) on a pilot basis, as part of its "Move Up" 2027 proj ect.

(iii) JR East recently launched "smart maintenance" of overhead lines and signal infra structure equipment by cameras and sensors for automatic fault detection by AI, in addition to the regular East-i track inspection system.

(iv) JR East recently introduced AI-based non-contact interactive displays for passen gers at 6 major stations on a pilot basis.

(v) JR East, in its flagship "Move Up" 2027 Vision, plans the integration of IT-related so lutions in transportation services for increased expansion through seamless mobil ity achieved by "expanding the range of coalitions with external networks" using Big Data, AI, IoT, and Autonomous Driving technology; Smart Trains featuring driv erless operations, robotic maintenance, sensor-based monitoring, and fault-detec tion and touch-less and gate-less ticketing; and expanding the role of the Suica platform as a one-stop for cashless transactions and verification.

(vi) With these measures, among others, the Mobility-as-a-Service (MaaS) concept, complete with the AI-backed ICT it requires, is likely to find its fullest expression soon.

Conclusions: Role of UIC (and Similar Bodies) and Takeaways for IR

(i) Increase revenue and decrease expenses,

(ii) Centralize and integrate knowledge management pan-India,

(iii) Foster capacity-building through institutions, and

(iv) Secure data and processes through a strong IT Security Framework

Advances have already been made by the Indian Railways to use AI-based technology to create a robust system, such as PLC-based automation, database softwares and apps by IRCTC and CRIS, automated data entry through Google Forms, online Knowledge Portals for sharing new techniques, specifications, and processes, along with a slew of measures to enable online working post-Covid.

Globally, acceleration of AI technologies will create great opportunities for the Railway sector, especially in operations and passenger management. Such tremendous potential for positive change must be harnessed and directed by a driving force from existing institutions.

Key success factors highlighted by UIC are also important in this respect. UIC asserts that its own involvement is crucial to the success of the European model. As a takeaway, we can conclude that the Indian Railways must play a similarly dominant role here:

(i) Involvement of Railway experts – in selecting accurate data to be collected, assisting data scientists and engineers, providing the right tools to work and act on the infor mation. Hence, the role of Railway experts in interpretability and decision-making is a must.

(ii) Interpretability & Decision-Making – AI technologies operate on a black-box model to solve problems, so the interpretation of results in view of their limitations is a cru cial question. Hence, the final decision, especially where safety-related, would still be taken/authorized by humans.

(iii) Leadership for change – a broad approach, by Kotter's 8-step process Model of Change, 1996 (urgency?coalition?strategy?vision?obstacles?short-term wins?gains? culture change):

a. Establishing a Sense of Urgency
b. Forming a Powerful Guiding Coalition
c. Creating a Vision
d. Communicating that Vision
e. Empowering others to act
f. Planning and Creating a Short-Term Vision
g. Consolidating Improvements for More Change
h. Institutionalizing New Approaches

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Jindal Rail Infrastructure Limited

Fast Tracking New Wagon Design and Development – Case of BFNV Wagons developed for Steel Industry

Fast Tracking New Wagon Design and Development – Case of BFNV Wagons developed for Steel Industry

Background

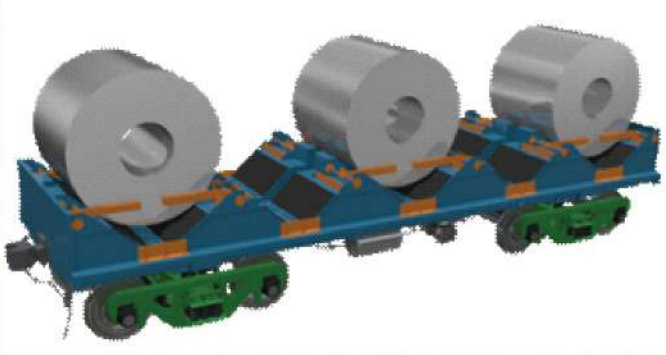
Ministry of Railways has been encouraging Private Sector investment in Railway Wagons with a various Schemes such as CTO, AFTO, SFTO and GPWIS. SFTO Scheme incentivizes investment in Special Purpose High Capacity wagons to boost throughput while Private Wagon Design Approval (PWDA) Policy lays down an enabling provision for design & development of new wagons to meet specific industry as well as customer requirements. Design and development of BFNV wagons for steel coil transportation was fast tracked through a collaborative arrangement between RDSO and Jindal Rail at the strategic level and through use of digital simulation techniques to accurately capture the requirements of squeeze load testing and oscillation trials at the operational level. This article documents the key stages in successful development of the new design BFNV wagon over a period of about two years spanning wagon design, prototype manufacturing and oscillation trials.

Concept Design

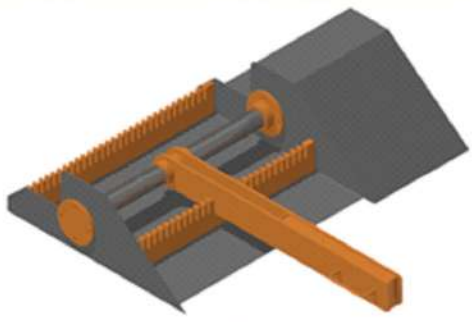
The following functional requirements given by JSW Steel Ltd., one of the largest producers of Hot Rolled (HR) and Cold Rolled (CR) Steel coils in the country, formed the basis of Concept Design:

- Adequate space between two adjacent coils
- Secure locking arrangement of coils
- Loading of Coils using by C hook and U hook
- Low loading and unloading time and unloading of coils using forklift trucks

The Concept design incorporating Eye to platform saddles was developed after evaluation of global practices and approved by RDSO in April 2019.



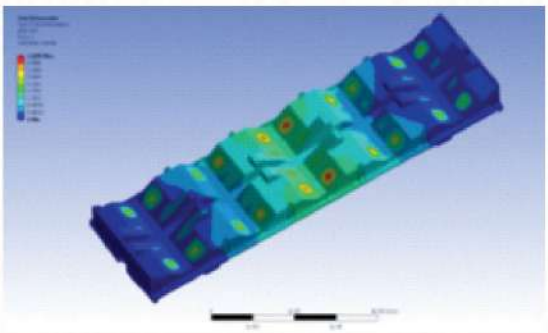
3D model of BFNV wagon



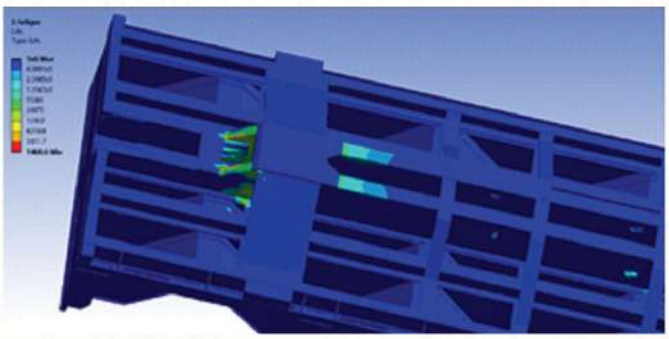
3D model of Coil locking system

Detailed Design Development

All subsystems like bogies, couplers, draft gear, air brake equipment etc. were kept as per Indian Railways Standards and components like underframe, saddles and locking system were designed by JRIL. Complete wagon structure and components were analyzed through finite element analysis method. The FEA results were reviewed and verified by RDSO.



Stress results after FEA



Life cycle results after Fatigue analysis

Fatigue analysis and Nucar analysis were done by RDSO.

Prototype development, manufacture and testing

a. Tooling

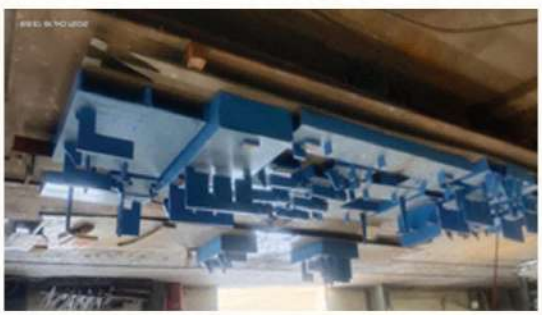
Underframe Fixture

Underframe Fixture with underframe

Center Girder Fixture

Head Stock Fixture

Center Sill Fixture



Fixture for Misc. components

b. Manufacturing

Underframe with saddle

Saddle web plate

Center sill web

Body Bolster Assy

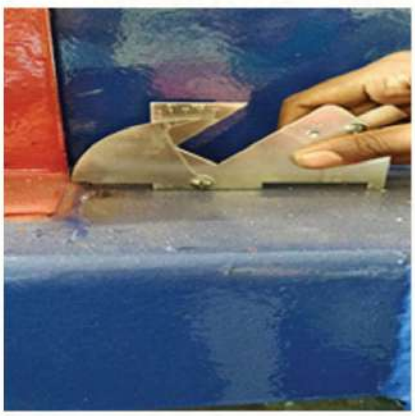
c. Inspection and Testing

Wagon body loaded with coils for Squeeze Load Test

Prototype Wagon-BFNV001

Weighment

Paint DFT inspection



Weld size inspection

Oscillation Trials

Oscillation trials were successfully conducted from 5th Feb 2021 to 20th Feb 2021 on Mahoba to Khajuraho route of Northern Central Railway. The wagon is cleared for 22.9t axle load at 110 Kmph speed in both empty and loaded conditions.

Wagon-BFNV001 loaded with coils for Oscillation trials

Design Validation of BFNV Wagon

Results of squeeze load testing of the prototype BFNV wagon and oscillation trials of BFNV wagon broadly validate the wagon design finalized using digital simulation techniques as detailed below:

Comparison of results (Theoretical using digital simulation Vs Actual)

Finite Element Analysis and Squeeze Load Test

Steel Specification : IS:2062 E 450 BR Cu

Yield Strength : 450 Mpa

Max. Stress Limit : 405 Mpa (Buff Load) 300 Mpa (Pay Load)

Load Case	Test Type	Max. stress (Mpa)		Max. deflection (mm)	
		Value	Location	Value	Location
Load Case-1 Buff force of 250 t on empty wagon	FEA	57	On centre girder bottom flange at wagon centre	0.5	At sole bar bottom flange near head stock
	Actual test	-70.58		3.92	
Load Case-2 Payload of 78t	FEA	24.5	On centre girder web plate near bolster	1.57	At solebar bottom flange at wagon centre
	Actual test	154.26		1.21	
Load Case-3 Payload of 78t + Buff force of 250 t	FEA	54	On centre girder web plate near bolster	2.75	On centre sill flange at head stock
	Actual test	170.57		1.63	
Load Case-4 Payload of 97.5t	FEA	30.5	On centre girder web plate near bolster	2.1	At solebar bottom flange at wagon centre
	Actual test	168.3		2.54	

NUCAR and Oscillation Trials

Parameters	Empty Condition		Loaded Condition	
	OT	NUCAR	OT	NUCAR
Max. VA 'g'	0.96	0.42	0.59	0.33
Max. Average VRI	4.31	4.36	4.14	3.98
Max. LA 'g'	0.48	0.16	0.27	0.35
Max. Average LRI	4.20	3.86	3.18	4.75
Lateral Force Hy2m (in ton)	1.36	1.30	2.53	3.06
Derailment Coefficient	0.75	0.36	0.25	0.19

Conclusion

Use of digital simulation techniques is the way forward for fast tracking new design wagons to meet the transportation needs of the industry as demonstrated by RDSO and JRIL in development of BFNV wagons for transportation of HR and CR steel coils.

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Improvement in Water filling arrangement and reduction in Water Wastage and complaints at En-route stations in LHB rakes (Under slung water Tank fitted).

Improvement in Water filling arrangement and reduction in Water Wastage and complaints at En-route stations in LHB rakes (Under slung water Tank fitted)

Abstract

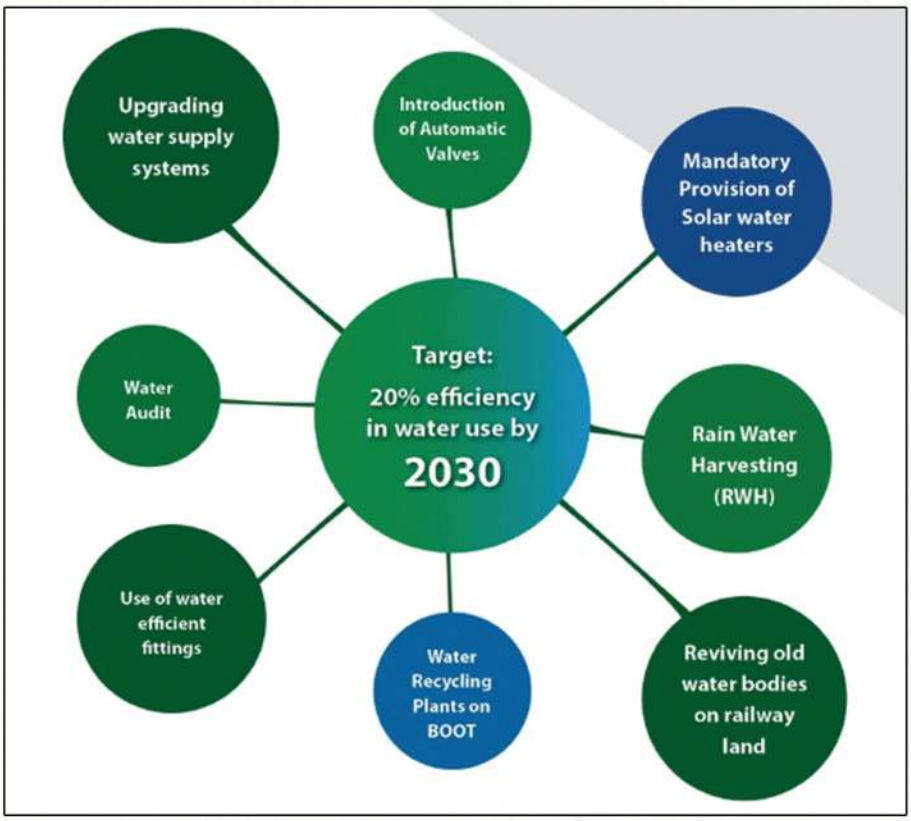
Now a days Water conservation is becoming more and more challengeable to save our environment as well as our lives. It is difficult to establish the exact degree of the importance of water to man in his arduous climb up the ladder of civilization. It is certain, however, that without water there would be no life of any kind on the earth and that, without availability of water in adequate quantity and free of pathogenic organisms, man's progress will be tremendously hindered.

The responsibility for reducing this tremendous waste, falls on governments and, specifically, on health administrations. It is the aim of this monograph to assist the government officials who must meet this challenge.

In Indian Railways 13,523 passenger trains are run daily, on both long-distance and suburban routes. The effort of saving little bit of water during filling in each coach shall not only save our environment but also revenue of Railways.

Objective

1. During water filling in LHB coaches, overflow water quantity to reduce/minimize.
2. Save water/ save money as per water tribunal water save during filling water in it,
3. During water filling in LHB coaches, over flow of water spill on plate-form to be com pletely stopped.
4. Complaints of passengers to satisfactorily resolved,
5. In view of safety preventing any incident related to slipping

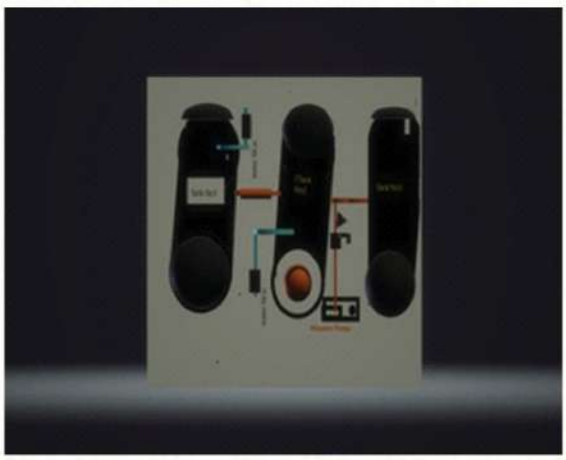


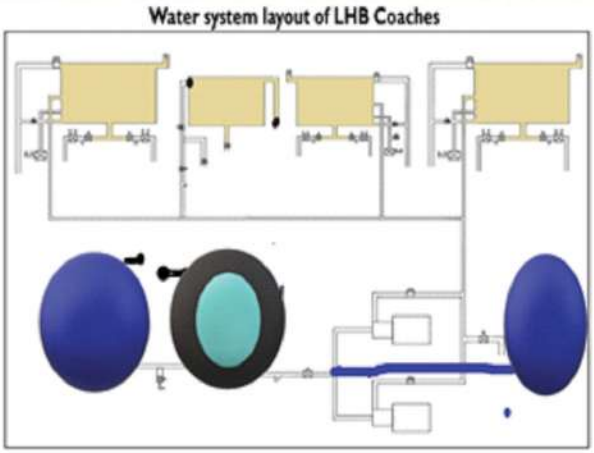
Problems Statements

LHB coaches are fitted with under slung water storage tank. While watering at en-route stations, following problems are observed:

1. During water filling at Pit line/En-route stations, there is no direct indication for water overflow to the water filling staffs because water gets overflow on opposite side of coach. Due to this delay in indication, water gets continuously overflowing to drain/track till gets observed. (wastage of excess water)
2. LHB coaches water filling/overflowing pipe height is higher than Platforms. Due to thi when water gets overflowed, the jet of water goes on Platform and spills on it and causes following inconveniences
   - Passengers standing on Platforms and their belongings gets wet due to spillover water.
   - Passengers can slip while boarding/ de-boarding on the train and which may cause any unusual incident.
3. Water Tank Level Indicator provided in both side to be ensured in working condition which helps in estimating how much water added or not required to fill water .

Schematic diagram of existing water tank





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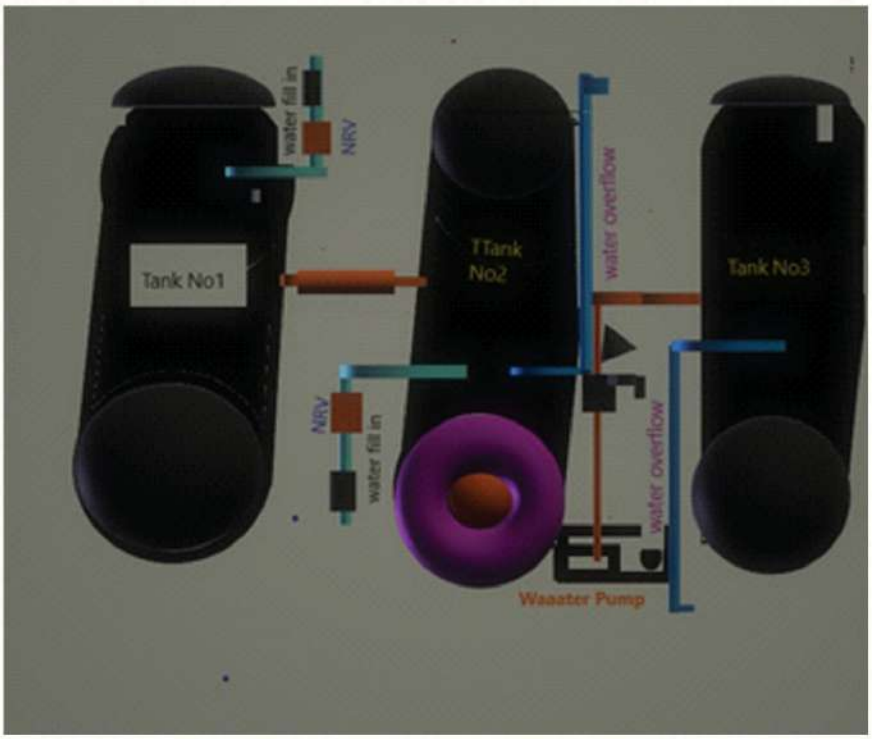
Modified Water system of LHB coach under Frame



Scope of Project

1. Solve the problems as per problem statements.
2. Modification in minimum cost.
3. Modification in minimum sch time.
4. Safety measures in views In Existing system

Procedure

1. Coach placed on pitline/sick line.
2. Remove dummy from tank No.1,2 for providing water overflow pipe.
3. Already prepared L pipe with elbow and reducers as per designed.
4. After fitment BKT to provide for securing.
5. Both side water filling pipe remove from elbow.
6. Non Return Valve 40 mm horizontal fit in water filling pipe (both side).

Modified system function as given below

1. Existing water system water filling pipe work as twin function one water filling and 2nd water over flowing (one side filling and other side over flowing)
2. But in Modified system in water filling pipe provided Non return valve. So it will only one function as water filling.
3. 2ndfuction of existing pipe stop by NRV, results water not come out plate-form side so all problem related safety to passenger ,spread on PF not generate the complaints.
4. Modified system two addition pipe provide which function as air vent and overflow of water which indicate water fill in system. This function already in existing system but op posite side of coach ,not visible, which not alert immediately to water filling man .now same side provide tank air vent pipe /water overflow pipe. Which is visible indication so that action will be before that's save water

Material List

SN	Description of Item	Qty required per coach
1	NRV 40mm	02 Nos
2	Reducer 1-1/4''/1''	02 Nos.
3	Elbow 1''/1''	04 Nos.
4	Nipple 40 mm,8'' long.	04 Nos
5	Pipe size 1'' ,length 16''	02 Nos
6	Pipe size 1'' ,length 36''	01 Nos
7	Pipe size 1'' ,length 76''	01 Nos

Existing system

Existing Water filling /Overflow Pipe

After Modification

Additional Non-Return Valve Provide on Both water filling /overflow pipe line.

Additional Water over flow provide with elbow for water jet downward to earth.

Water Level Indicator –on Water tank

Water Filling pipe couple en-route

Coach Water filling side

Indicate on Coach side Water filling pipe and over flow pipe

Expenditure calculation

Total material cost per coach=Rs.3000.

2Manpower per coach= Rs 1100/coach

Per coach expenditure on Modification.=4100.

Total expenditure for modification in all LHB coach of IR = 4100 x 529=Rs 2,168,900

Cost saving calculation

1.During water filling in LHB coach , over flow of water spill on plate-form Nil.

Train 12919/12920 DADN-Katra Vasno Mata Per Rake as per Link route water filling station.

2. water save 20 to 25 Lts./coach/station

3. So water save 20 x22 =440 Lts / water filling Point .

4. Nos off water filling as per sch in one trip =14 water filling point/station.

5.So During one trip total water save 440x14=6160 Lts

6. Per Month 7 trip so total water save in month =6160x7=43120 Lts

In this Link 04 Rake used so total water save in Month=43120x4=172480 Lts

A)So in 12 Month water save=172480 Ltsx12=2069760 Lts

Cost of Water @40 paisa per litter=2069760/0.4=Rs 8,27,904

B)Water Pump Capacity 40HP discharge 213000 Lts/Hrs,Approx. 30 unit per Hrs

So Power energy consumed during Transfer of above water 2069760 Lts is 291.515 unit

Power energy save 291.515 unit.

Unit rate approx. at MP is 12 Rs/ unit so total coat of energy is 291.515x12=3498.18

Total Save water save cost+ Power Energy save cost=827904+3498.18= Rs 831402.18

LHB 529 Rake are running in IR with above problem. So

AVg Saving per year 831402.18x529=Rs 43,98,11,753

Total all LHB coach invest cost for modification. =Rs.2,168,900.

Actual Saving per year =43,98,11,753 - 2,168,900 = Rs 43,76,42,853

Implementation

Modification successfully done in 07 Coach No. at Indore Coaching Depot. And 01 at Bandra Terminus Depot and is being continued further.

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