Preface

Railway has fascinated most of us with its capacity to transport a large mass of passengers and goods on land. Importantly, it does this with the most efficient use of energy. This is a common knowledge and policy planners are well aware of it, unfortunately, one less discussed aspect of Railway, in the technical literature is that the Railway has always been a cradle for innovation. Right from its birth, at the beginning of the Industrial Revolution, when the wheels were put on the boiler and tracks of steel laid to present, Railways has always been a pioneer in ‘innovation’ (Tony Judt, 2010). Recently automobiles have taken over the major share of short distance transport and air travel has similarly captured the long distance travel, but despite its relative decline, the spirit of innovation is still alive and kicking in Railway. It is therefore very apt, that a book is written that catches this spirit of innovation in Railway, while pointing to the direction where the innovations are most active.

Railway has used innovation as a tool for improving itself. It has also created a bunch of new services during its growth spurts. It gave birth to the travel and tourism industry (Tony Judt, 2010). It started the concept of circulating areas wherein the travelling public could relax, shop or dine while waiting for their next connecting train. From the Railway’s desire to give last mile connectivity, the idea of common ticketing for multimodal transport was born.

The study of Railway is a multidisciplinary task. Railway has a rich history to discuss and the study, the building and the operation of the railway needs a complex finance study and analysis, operating and optimising the railway network is a management domain problem and finally, maintaining the asset has challenges in all spheres of engineering study. A comprehensive book covering all these railway functional areas is difficult to find. And even more difficult is finding a book totally dedicated to Railway research. Frequently, we may find literature on the application in a Railway field in a particular research field but not the other way around. Therefore, there is a felt need for a book on Railway related research to cater to a wider audience of researchers, policy maker, railway lovers and investors.

This book attempts to be an easy read and technically challenging too, a difficult task to accomplish!

Multidisciplinary Approach

The chapters in the book can be broadly grouped into five subgroups - General, Finance, Safety, Operation and Engineering. The general section discusses the history of railways in two historically important world cities (Ellis, C. H., 1954). In the study of cities of emerging economies, the Railway network plays an important role in increasing the productivity of Urban agglomerates (Ellis, P., & Roberts, M., 2015). This has led to city planners trying to build a railway network into the city transit system, and this is also
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covered in the general section. It also has a chapter on the desirability of a more extensive railway network to overcome accident fatalities in a city (Covey, J., Robinson, A., Jones-Lee, M., & Loomes, G., 2010).

The next section of the book covers the very important topic of finance. Railway is a means of ‘mass’ transportation, be it passenger or freight. The scale associated with Railway Transportation precludes all small to medium-size investors. More often than not, it has to be built by government investments only. But the limited-size government funds are also needed by other competing sectors. This includes sectors of high importance like Defence, Healthcare, Education, etc. Therefore, Railway finds it difficult to earn its fair share of investment. It is more often than not, taken as a commercial investment and not as a welfare investment. This approach causes the investment to come in with the burden of expectation of a good rate of return (Perkins, S., 2005, September). This is unfair, as Railway has a much wider impact on welfare, productivity, environmental and other happiness indexes (Diener, E., 2000). This is usually not quantified in monetary terms. If these impacts are financially measured by tools (Gordon, L. A. 1974), which are already available, then the attractiveness of Railway investment is increased manifold. This is the central theme of the finance section.

The third section is on Safety. Railways always have had its right of way, therefore, it is safer than other modes of transport. Railways have the lowest fatality per passenger kilometre of any land-based transport system, but the right of way also leads to high speeds and most of the railway accident will be catastrophic, involving large-scale loss of life and material. Therefore, built-in safety while designing the system is of paramount importance in Railways. The contributing factors to accidents may range from human, to equipment and to weather. As the frequency of operation increases, with headways coming down to 90 seconds, maintenance windows are shrinking. This calls for automation in running and carrying out maintenance with predictive tools (Hall, S., 2003). The section concentrates on the modern day challenges on safety.

Once the decision for having the Railway network is made, investments are made and the tracks and rolling stock are in place, the next big challenge is to operate the network efficiently. The goal is to transport a maximum load in the minimum possible time. This ‘Operation’ which is significantly different from road traffic is covered in the next section (Landex, A., et.al. 2006). The Railway works with a constraint of being guided traffic. A train has to necessarily be at the track and it can overtake the front-running train only at predetermined places only. Commands for undertaking this operation are issued by the central controller. Thus, timetable management for normal running and its disruption management for abnormal running have to be carefully analysed. An overview of the tools available is covered in this section.

In the initial days Railway was a boiler on wheels and now it has evolved into a 10 Megawatt substation on wheels. The scale of the engineering challenge can be imagined, wherein not only these huge energy sources are to be moved around, but are moving at such breakneck speeds that it can challenge other transport competitors on speed, comfort and safety (Profillidis, V. A., 2000). The last section deals with engineering innovations for addressing these challenges. A train is a multidisciplinary system and incorporates the latest advances in the fields of computers, communications, electrical motors, vehicle dynamics, comfort engineering, etc. Therefore, the engineering section also follows a multidisciplinary approach.
**Sustainable Growth**

With increasing awareness of climate change and its consequence, there is a stress on using greener solutions to our transport problems. There is a renewed interest in all policy makers and city planners across the world to strengthen the public transport infrastructure. Railways have emerged as the primary choice due to its sustainability and for causing minimum damage to the environment (Schafer, A., et. al, 1999). There is a need for more financial tools which capture these social impacts. These tools will help the policy makers to justify their decision for committing finances to relatively costly railway infrastructure.

In the developing world where the railway has never lost its primacy. A new awareness has now dawned to policy planners of emerging countries that increasing Railway network is adding numbers to their GDP growth. The mainly agrarian economy of the developing world is becoming manufacturing and service oriented, resulting in new urban agglomeration. High Speed Railways and Metro Rail are the transport of choice for bringing in and moving people around in this new urban environment.

In a typical emerging economy, the governance structure consists of an executive comprising of an entrenched bureaucracy and a legislative body consisting of politicians. Politicians exist from one election to another but the bureaucracy has typically three decades of service in government. Because of longer tenures, the bureaucracy will look at the financial evaluation of a project mostly on discounted rates as the effects are long term while a political party with their ears to ground will look at the economic evaluation. The voting public will get a sense that the governance structure ‘cares’ for their wellbeing if a beneficial project springs up in their neighbourhood. This leads to a situation wherein the ruling party announces a railway project in the neighbourhood but the bureaucracy, tasked with implementing the decision, stalls it, trying to wait out the issue till the next election.

A Railway project may never be justified when compared to other means of transport if evaluated at Net Present Value (NPV) because of its high capital cost and longer gestation period. But if evaluated on economic appraisal basis (Grant-Muller, et. al., 2001), Railway projects will have an advantage as they have a much wider positive impact. Extensive goodwill for Railway projects have a reason which is not wholly intuitive. This book written with less emphasis on the complex mathematical equations makes for an easy reading and is thus recommended for policy makers to understand Railway impact better.

**Organization of the Book**

Chapter 1 reveals that developments in urban railway transport in nineteenth century London and Paris was driven by innovation. The author argues that a careful study of these developments will help emerging cities across the world when they face questions that are similar to those faced by London and Paris during that age.

Chapter 2 reports a high rate of traffic fatality in the city of Chennai, India. The analysis shows that pedestrian accidents contribute to a high percentage of the accident statistic in densely populated areas of the city. Modelling this problem reveals that a proximity to high carriage public transport, most likely railway, will reduce the risk of an accident.

Chapter 3 brings out the planning challenges for building a transit system in a major city of an emerging economy. The author argues for a developing a framework for building a transit system based on other cities across the world. He suggests that the primary aim of the planners should be to achieve cross-sector integration of transit systems with urban development.
Chapter 4 studies the different Railway investment appraisal techniques. The author admits that there is plenty of competition for scarce investment resources which are available with the government. For deciding where to invest, both economic and non-economic factors—political, social, etc.—have to be considered. The author discusses the tools for the same, namely Net Present Value (NPV), Internal Rate of Return (IRR) and Cost Benefit Analysis (CBA).

Chapter 5 discusses the technique for Railway demand forecasting. It suggests how to use the historical data together with various forecasting methods to make accurate estimates of future demand. Qualitative and various quantitative methods are studied and discussed, with particular emphasis on SARIMA model.

Chapter 6 addresses the common dilemma of local government to find funds for railway infrastructure. The author states that the Urban Rail infrastructure is coming up in a big way around the world and funding these projects is a big challenge. An innovative option of ‘Land-based Value Capture’ as one of the sources for funding is discussed in this chapter.

Chapter 7 analyses the intercity modal choice and argues for high-speed rail as the preferred choice, but a High-Speed Rail infrastructure needs a huge investment. The chapter uses gaming theory in capturing the modal decision of the travelling public to facilitate the investor’s decision-making process.

Chapter 8 urges the administrators and the decision makers for pricing the public transport, treat budget constraints as constraints and not the goal of arriving at pricing. Intangible social benefits should be taken into consideration before fixing the public transport tariff.

Chapter 9 recognises the challenges of Railway maintenance managers in estimating the safety risk. FRA and FAHP modelling techniques are suggested in this chapter. This technique absorbs the domain expert knowledge in formulating railway safety and risk analysis. This is recommended when enough risk data is unavailable and there is a high level of uncertainty.

Chapter 10 lays out a roadmap for assurance of signaling safety. It outlines the formal model of a signaling system for safety assurance. It advocates the benefits of initial investment in formal capture and validation of signaling properties.

Chapter 11 is on automatic signaling software testing. For bringing in automation, Railway is becoming more and more dependent on signaling software. Development of automated software testing tools to achieve higher safety levels in software code is discussed in this chapter.

Chapter 12 is again on automated testing. The chapter argues that the modern safety systems in the trains are increasing complexity by the day. Testing these functions comprehensively in the field is becoming difficult. Therefore, it advocates model based testing to address these issue.

Chapter 13 proposes an alertness monitoring system for vehicle drivers. This is based on using physiological signals. It recommends the usage of PERCLOS, a drowsiness measuring tool to monitor the train driver alertness during a run. Speech is another variable monitored in conjunction.

Chapter 14 suggests an operation research model for railway operations. It argues that railway operations involve many subsets of operation problem. Therefore, while taking a holistic view of the operational problem the author develops an extensible basic model.

Chapter 15 attempts to develop an algorithm for solving a train timetabling problem. By definition timetabling is, running trains within the track capacity to satisfy operational needs. A stochastic simulation model for generating a feasible timetable is developed in the chapter.

Chapter 16 is on the emerging trends of intelligent transportation systems in Railways. Using the increasing availability of computing power and extensive networking, the author advocates the use of Intelligent Transportation Systems to achieve higher speeds, an increase of carrying capacity and more precise real-time information to travelers.
Chapter 17 develops an Integrated Traffic Management system using Data from Traffic, Asset Conditions, Energy and Emissions. The Traffic Management System (TMS) takes into account many sources of information and tries to optimize conflicting objectives. Data exchanges between different sources and decision-making is discussed in detail in this chapter.

Chapter 18 discusses the after effects of a disruption in the urban rail transit system. Recovery techniques after disruption are discussed in this chapter. A VNS algorithm, based on station skipping and short turning is developed and has proven to be the most efficient in recovery after a disruption.

Chapter 19 models the energy supply to the railway. There are different systems adopted worldwide for Railway Electric Traction. The system is complex as there is a moving load which may be consuming or regenerating. Moreover, it will transit from one feeding station to another during its journey. These complexities are discussed in the chapter.

Chapter 20 discusses the traction motor maintenance issue as this is the most critical equipment in the rolling stock. Maintenance hour reduction by condition-based monitoring in place of pre-scheduled maintenance is advised. Online algorithms to detect weak faults, together with a predictive algorithm are used for condition monitoring.

Chapter 21 is on another critical component of rolling stock - the bogies. The bogie in a train is critical safety, riding comfort and speed. In this chapter simulation model of bogie with passive and forced/active steering mechanisms is developed.

Chapter 22 is on safety and comfort issues of the railway infrastructure. This is a study on air-conditioning of the underground station and emergencies in tunnels. The authors discuss the objectives in the modern system and the tools available to achieve it. They also point to future research directions.

REFERENCES


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