
Review of Literature

Historical Overview of Research Literature

Most of the available literature on Railways worldwide is dealing with statistics, commercial operations or on technological advancement and innovations. It however is not contributing directly to the subject of increasing speeds. The topic of the study is very narrow and available literature on the subject is limited, most of the literature available is either very generic or deals with the specific problem.

A large section of the literature available is on mathematical modeling for optimization techniques for wagon management and freight loading, which that is beyond the scope of this study. The literature available in India on IR mainly deals with the historical background of railways, statistics, safety/accidents, gauge conversion, electrification and other financial issues. There are however many contemporary articles on IR mainly dealing with financial issues, restructuring if IR also raises the issues of viability, asset utilization and of low average speeds on IR.

Research Literature in the Area Relevant to the Topic

Alex Landex et al,¹² have defined easy and effective way of calculating the capacity consumption on rail line. They describe how increasing train speed increases line capacity however at higher speeds braking distances are also increased and results in loss of line capacity, hence network specific speeds are to be planned for optimal line capacity.

“Throughput” in railway terminology refers to the passenger & freight transferred across a section in a period of time as described in the study report of the Multidisciplinary Team¹³. Throughput can either be increased by the number of the trains in given section, by increasing in the loading in that train or by a combination of the both. The first option is referred to as the increase in the line capacity and the second as increase in the loading. The report outlines two broad strategies for increasing the throughput. The first is the capital intensive strategy of “physical capacity enhancement” through building new lines and reduction of block section by better signaling.

The second strategy involves operational initiatives which results in throughput improvement with the existing infrastructure through means like reduction in the speed differential, high speed turnouts, higher hauling power to trailing load ratio etc. The report places on record that horsepower of the

¹² Landex, Alex, et al, Evaluation of Railway Capacity by, Centre for Traffic and Transport, *Technical University of Denmark*

¹³ Multidisciplinary Team (2005). Throughput Enhancement. *Railway Board Order SERB-I/2005/23/12 Dated 11/4/05*

motive power required to pull the train will depend on the speed at which the train is required to run and track geography; moreover this strategy is complementary to the earlier two.

The Multidisciplinary Task Force¹⁴ has further given number of recommendations to increase throughput on IR, where the recommendations are more in line of improving operational efficiencies. Some of the major recommendations of the report are: reduction in no. of traction changing points, extended run of locomotives, saving in loco and crew through efficient loco and crew utilization, computerization of loco and crew operation, zero-based time tabling, removal of speed restrictions, reduce speed differential etc.

It further states that to meet this growth rate IR has already formulated a set of operating and marketing strategy during Xth Five Year plan such as introduction of high speed rolling stock for freight and elimination of speed differential between passenger and freight trains, introduction of higher axle load on selected routes, improvement of asset reliability & improved monitoring of the rolling stock.

Information available in Year Books of IR & White Papers on Indian Railway indicates that a substantial amount of IR traffic moves on the High density routes: Delhi - Mumbai, Mumbai- Chennai, Chennai - Kolkatta, and the Delhi – Guwahati route (called the Golden Quadrilateral) and the diagonals

¹⁴ The Multidisciplinary Task Force Report on Impact on Throughput on various operational initiatives, setup by Ministry of railway, New Delhi, July 2006

connecting Delhi, Mumbai, Kolkatta and Chennai. These routes are already saturated with line capacity utilization being more than 100% in most parts. These 7 main routes along with other main feeder routes (17383 route kilometers) were identified as the High Density Network (HDN) on IR.

These HDN routes account for 28% of IR's total route kilometers, but carry 71% of total traffic. To relieve the congestion that exists on two of the densely saturated routes. Ministry of Railways have already set up DFCC¹⁵ in October 2006 to construct Dedicated Freight Corridor¹⁶ (DFC) covering about 2762 route km on two corridors. Upgrading of transportation technology, increase in productivity and reduction in unit transportation cost are the focus areas for the project.

Report Of The "Working Group On Railway Programmes For The Eleventh Five Year Plan (2007 – 2012)" has cited that the terminal year of Xth Five Year Plan has seen unprecedented growth in the freight operations & decision to use the carrying capacity of the wagons optimally by increasing the axle load of the wagons on selected routes up to 15 per cent as one of the major contributor to the same. During ongoing XIth plan there is a major thrust

¹⁵ "Dedicated Freight Corridor Corporation of India Limited (DFCC)" is a special purpose vehicle created to undertake planning & development, mobilization of financial resources and construction, maintenance and operation of the Dedicated Freight Corridors.

¹⁶ Report of the Task Force, The Delhi-Mumbai & Delhi-Howrah Freight Corridors, *The Secretariat for the Committee on Infrastructure Planning Commission, Government of India*

to develop freight terminals, in addition, to achieving the target of 1100 million tons in the terminal year of eleventh plan.

Increasing of axle loads of wagons also called Carrying Capacity (CC) Enhancement is highlighted as one of the major successful freight initiatives taken by IR recently in the paper on International Railway Conference¹⁷. Prior to November 2004, wagons were allowed to be loaded upto CC+2 tones, where the permissible axle load was taken as 20.23 tones. From November 2004 onwards, the loading was permitted up to CC+4+2 and subsequently it was enhanced to CC+8+2 tones on sixteen specified route and CC+6+2 tones on nominated coal routes. As per a rough estimate total increase on this account will be 60 MTPA this will correspond to additional 60 trains loaded every day on IR.

Raghuram and Niraja¹⁸ have evaluated the implications of initiative of increasing the axle loading, leading to increasing carrying capacity of the wagons on IR. They have also examined its impact and implications on the infrastructure and suggested that rigorous checks & monitoring to be carried out to evaluate long term the effect of this strategy. They have critically examines the turnaround performance of IR during Xth five year plan & have raised serious questions about the sustainability of these strategies and calls for working out more sustainable strategies for future challenges.

¹⁷ International Railway Conference 14-15 February 2007: New Delhi Background Note, Confederation of Indian Industry

¹⁸ Raghuram, G. (2007). Turnaround' of Indian Railways: A Critical Appraisal of Strategies and Processes. *W.P. No.2007-02-03 February 2007, IIM Ahmedabad*

In the Final Report on Throughput Enhancement¹⁹, the team has concluded that speed differential is the most critical factor which impact on line capacity and throughput & elimination / significant reductions in speed differential will bring about increases in line capacity to the tune of 33% & will negate the need for various infrastructural augmentation required to build additional capacity. It also brought out that augmenting of HP/TL ratios in case of freight trains and tightening passenger schedules are strategies, which impact favorably on line capacity and throughput because they, essentially, reduce speed differential.

In a simulation study on Effects of Operating Heterogeneity on Railway Capacity, Mark Dingler²⁰ has developed relationship between factors like speed differentials, acceleration et on line capacity through simulation studies on American Railroads. It is shown through the findings that delays to the trains increases with high speed differentials and randomness.

Farràs²¹ in his thesis did detailed analysis based on the Blocking Time Theory to evaluate different alternatives to increase line capacity like signalling system and infrastructural extensions on double track line between Den Haag and Rotterdam. His computations carried out using a simulation tool showed

¹⁹ Throughput Enhancement (2005), Report of the Multidisciplinary Team. Railway Board (Order ERB-I/2005/23/12 Dated 11/4/05 1)

²⁰ Dingler, Mark. Using the RTC Simulation Model to Evaluate Effects of Operating Heterogeneity on Railway Capacity. *The William W. Hay Railroad Engineering Seminar Series*

²¹ Farràs, Crespo, Ignasi, (2005). Timetable Analysis And Evaluation Of Upgrading The Capacity Of The Railway Link: Rotterdam-Den Haag. Universitat Politècnica de Catalunya, <http://hdl.handle.net/2099.1/3286>

that signalling improvements appear not to give a substantial contribution to increase the capacity. On the other hand, removing the capacity bottlenecks located at stations and merging points by means of second-track extensions per line direction might achieve a significant reduction of track occupations in order to fit the timetable.

M. Abril et al²², through their analysis, has demonstrated through several capacity study in Spanish railway infrastructures that line capacity is extremely dependent on infrastructure, track, and operating parameters. He had shown that capacity decreased with reduced speeds, increase of commercial stops & train heterogeneity. Line capacity improves with reduced distance between railway signals and timetable robustness. With these operating cost increases particularly for lower priority services, displacement of freight onto less economical routes or onto the highways cause loss of economic development opportunities for the country. However he did not specifically demonstrate the effect of the locomotive power on the line capacity.

Hindu Business Line article "Rail Budget Sidetracks Freight"²³ commenting on 2009 Rail Budget, raises some pertinent questions o that is how IR plans to achieve the growth target in absence of any concrete freight

²² Abril, M., F. Barber, L. Ingolotti, M.A. Salido, P. Tormos, A. Lova. An Assessment of Railway Capacity. *Department of Information Systems and Computation Dept. of Applied Statistics and Operational Research, and Quality Technical University of Valencia Camino, SPAIN*

²³ Naik, S. D. (2009). Rail Budget Sidetracks Freight. *The Hindu Business Line*
Source :
<http://www.thehindubusinessline.com/2009/07/10/stories/2009071050190900.htm>
accessed on 18.10.09

plan and how it is going to raise the finances for the ambitious plans drafted & there is a need to make a roadmap for freight operations if IR has to match Asian counterparts probably hinting at China. He writes:

“The Railways has to traverse a long way before it can match the standards of some of the Asian countries, let alone global standards. It has an ambitious Eleventh Plan target of Rs 2.3 lakh crore for capacity expansion, there is no indication or roadmap in this Budget as to how the ambitious targets are going to be met. There are no specific announcements relating to any new freight policy measures or expediting the work on dedicated freight corridors. The work on these corridors has not been moving at the desired pace”.

Summary

The available literature broadly focuses on the freight initiatives taken by IR and its implications. Most of the study reports of IR list various steps taken by railways in past and what has been planned. The reports and studies however do not go into the “cause & effect” analysis of any approach and whether certain approach is better than other or not. Increasing the train speed to enhance the line capacity does find the mention amongst the strategy outlined in numbers of articles but detailed approach and analysis is not available except for Throughput Enhancement Report of the Multidisciplinary Team. The proposed study plans to do just that and go into the detail to examine the problem of line capacity in IR with relation to the speed of the trains. Go into the bottlenecks in the present scenario, analyze the root cause, proposed short term and long term strategies & operational/financial

implications thereof. The final objective of the study to present a ready guide to the railway planners, to assist them in taking decision on future operational strategy, capacity building and infrastructure planning.

This chapter deals with the theoretical concepts of line capacity and throughput. How these important terms are defined and what are the factors on which they depend? In later part of this chapter, a flow chart is developed about the effect of these factors on line capacity & throughput.

Defining Line Capacity

Line Capacity is a measure of the ability to move a specific amount of traffic over a defined rail line with a given set of resources with acceptable punctuality, very number of tons moved, average train speed, on-time performance, minimum number of trains per day, etc.). The difference between theoretical line capacity & practical line capacity should be clearly understood.

Theoretical Capacity:

Maximum number of trains physically possible to move across rail line under ideal conditions.

Practical Capacity:

Maximum number of trains possible supporting for actual conditions and achieving a reasonable level of reliability.