Chapter 7

Implementation of Higher HP/TL Ratio: Issues & Economics Involved

Previous chapters have elaborated the benefits of strategy of running freight trains with higher speed and it was shown that for to achieve it is essential to improve HP/TL ratio to 1.5 and beyond. This chapter will go into details of locomotives deployed in IR, trailing loads of the common freight trains and what are the inputs required to improve the HP/TL ratio in terms of additional locomotives & related infrastructure.

Effort is to construct different scenarios taking into account various approaches to savings obtained by deploying higher HP/TL ratio. In final part of the chapter economical & financial aspects of the recommended strategy is touched upon. Answers to the questions like what will be the constraints and how infrastructural inputs can be managed, is sought. The role of PPP in this respect is also be explored. In the end consolidated requirement of locomotives for the targeted growth as per Vision 2020 is developed.

Freight Trains & Trailing Loads in IR

IR mainly runs block rakes, where a typical load (full rake) consists of 40 BCN wagons or 58-59 BOX/BOXN wagon. Some freight rakes are used continuously in dedicated operations over a closed loop journey. These are known as closed-circuit rakes for example coal or iron ore rakes or 48 BTPN tankers for petroleum products. Much of the bulk goods movement occurs on such closed-circuit rakes. IR also move fast container trains called "Conraj" at 100 KMPH.

The details of wagons used over IR are placed in appendix VII. The freight trains over IR can be classified in 2 broad categories in terms of their loads. The table 7.1 shows these two catagoris of rakes formation & their details: number of wagons, gross weight with the different extent of permitted loading.

Table 7.1 Trailing Load of Various Types of Trains with loading limits

Wagon Type	Extent of Permitted Loading[43]	No of Wagons in a rake	Gross Wagon Weight in tons	Rake Load in tons	Axle Weight in tons
BOX, BOXN, BOXHS, BOBR, BOY, BOBRN, BOST	CC	59	80	4720	20.00
	CC+2	59	82	4838	20.50
	CC+4+2	59	86	5074	21.50
	CC+8+2	59	90	5310	22.50
BCN, BCNA,BCNAHS		40	86	3440	21.50

Source: Data collected from Mechanical Directorate Railway Board

[43] CC indicated carrying Capacity, CC+8+2 indicates excess loading upto 8 tons and additional 2 tons for the measuring errors.

Locomotives in IR

About 66% of freight moves on Electric Traction & rest on Diesel. The share of electric traction is set to rise further with more electrification. In locomotives, pace of technological up gradation has been maintained in IR with thrust on improving efficiency, increasing HP, increasing speeds, reducing asset failures, and consequently costs. IR has state of the art loco technology with 6,000 Hp AC three-phase electric locomotives with speeds upto 130 KMPH being manufactured at the CLW (Chittaranjan Locomotive Works) with technology transfer from ABB of Switzerland. In Diesel, 4000 Hp locomotives are manufactured at the DLW (Diesel Locomotive Works) in Varanasi. Further, 6000 HP Diesel locomotives are under procurement from General Motors.

On IR Driving Unit (DU) consists of either single locomotive, two locomotives (called Multi) or three locomotive bank (called Consists). Most of the freight trains are powered by single Locomotives and use of multi locomotive over IR is still scanty, limited to high gradient sections. About 25% of the total DUs in case of Electric & 30% in case of Diesel are "multi" (Table 7.2).

Table 7.2 Driving Units deployed at present over IR.

Driving Unit	Single	Multi & Consists	% Multi of total DU	Total DU
Electric	1237	412	25%	1649
Diesel	875	375	30%	1250

Source: Data taken from railway Board, MOR

Tables 7.3 & 7.4 show commonly used freight locomotive configuration and HP/TL ratios, with respect to the different rake loads.

Table 7.3 Diesel Locomotives & HP/TL Ratio

				HP/TL Ratio				
				BOXN				BCN
		LOCO	HP	CC	CC+2	CC+4+2	CC+8+2	
1	single	WDG2	3100	0.66	0.64	0.61	0.58	0.90
2		WDG3A	3100	0.66	0.64	0.61	0.58	0.90
3		WDG4	4000	0.85	0.83	0.79	0.75	1.16
4		WDG6/ GM[44]	6000	1.27	1.24	1.18	1.13	1.74
5	Multi	2 WDG3A	6200	1.31	1.28	1.22	1.17	1.80
6		2 WDG4	8000	1.69	1.65	1.58	1.51	2.33

Source: Data taken from railway Board, MOR

Table 7.4 Electric Locomotives & HP/TL Ratio

				HP/TL Ratio				
				BOXN				BCN
		LOCO	HP	CC	CC+2	CC+4+2	CC+8+2	
1	single	WAG5	3900	0.83	0.81	0.77	0.73	1.13
2		WAG6	6000	1.27	1.24	1.18	1.13	1.74
3		WAG7	5000	1.06	1.03	0.99	0.94	1.45
4		WAG9	6000	1.27	1.24	1.18	1.13	1.74
5		WAG9H	6000	1.27	1.24	1.18	1.13	1.74
6		2 WAG2	6360	1.35	1.31	1.25	1.20	1.85
7	Multi	2 WAG5	7800	1.65	1.61	1.54	1.47	2.27
8		2 WAG7	10000	2.12	2.07	1.97	1.88	2.91
9	Consists	3 WAG5	11700	2.48	2.42	2.31	2.20	3.40
10		3 WAG7	15000	3.18	3.10	2.96	2.82	4.36
11	Multi	2WAG9	12000	2.54	2.48	2.36	2.26	3.49

Source: Data taken from railway Board, MOR

[44] Under Procurement

The shaded boxes shows the configurations where HP/TL ratio is better than 1.5. As we can see it is possible mainly with multi or consist formations. Single locomotives are not able to provide enough power and all single locomotives have to be replaced with multiple if HP/TL ratio of 1.5 or better is to be maintained. Only BCN rakes can be run with one WAG9 locomotives giving 1.7 HP/TL ratio. Implementation of higher HP/TL ratio would mean augmentation of locomotive HP by way of deployment of higher power locomotive or use of multiple locomotives.

Implementation of higher HP/TL: Requirement of Locomotives

Table 7.4 shows the requirement of additional locomotives to convert all DUs to multi. The detailed calculations are at Appendix VIII.

Table 7.4 Requirement of Additional Locomotives To Convert All DUs to Multi without taking any savings

Driving Unit	Additional Loco to convert single to multi	Adding maint. spare (15%)	present Holding	Addition Requirement %
Electric	1237	**1422**	2502	64.3
Diesel	875	**1006**	2000	57.8

Source : Appendix VII

Above requirement is without taking into operational efficiencies obtained due to reduced WTR & line capacity gains, keeping the numbers of DU at the present level which will not be the case. Improved line capacity and corresponding gains in speeds & WTR will bring down the overall requirement of DUs.

Different scenarios have been worked out by taking different approaches to the accrued savings and result is tabulated in table 7.5.

Table 7.5 Requirement of Locomotives to operate multiple Driving Units in Different scenario of savings

No.	Approach	Scenario Details of savings adopted		Additional Locos Required	
				Electric	Diesel
1	Factoring WTR improvement on present DU	15% reduction in WTR & 5% additional reduction due to operational/reliability improvement leading to corresponding 20% less requirement of DU's		662	415
2	Factoring Wagon transit time reduction improvement	30% reduction in rake transit time (arising out of improved WTR) & 5% additional reduction due to operational/reliability improvement leading to corresponding 35% less requirement of DU's		93	-16
3	Working out loco requirement from no of rakes run	(a)	Overall operational efficiency of 30% (due to improvement of 30% line capacity)	287	282
		(b)	Conservative approach with overall operational efficiency of 20%	686	608
4	Running BOXN with Multi & BCN with single loco	(a)	Overall operational efficiency of 30%	-220	-183
		(b)	Overall operational efficiency of 20%	106	77

Source: Calculations are at Appendix IX

It is observed that with different approaches we are getting different requirement of locomotives, however it is clear that if IR has to convert all DU to multi new locos have to be inducted. If conservative approaches are to be adopted the requirement of locomotives comes to the range of 690 for Electrical & 610 for Diesel (approach 1). If savings are to be taken at 30% the requirement comes down to half or less than 300 (approach 2 & 3a). These estimates are only indicative and will depend on overall efficiency gains to the system. However the requirement of the locomotives is not going to be very high in the range of 1000 to 1500 as one would tend to think.

Cost Considerations of Running Multiple locomotives: Impact on Line Haul Cost

No direct study on the actual impact of running multi in place of single locomotive on the energy is available. Energy is one of the major components of the line haul cost[45] of the trains (about 40-50% of total)[46] in case of electric traction. Specific Energy Consumed (SEC) depends on the load moved to the large extent. Small percentage of energy of the order of 2-5% goes into running of auxiliaries & utilities which is independent of the load moved. Moving trains at higher speeds and acceleration will definitely increase SEC as higher train air resistance comes into the force, moreover return direction empty trains running with multiple loco will push up SEC. However on the flip side energy will be saved due to avoidance of frequent starts & stops. There is a need to carry out detailed study for determining exact impact on the SEC & energy consumption due to switching over to multiple locomotives.

[45] Line Haul Cost; Cost of running a freight train in GTKM, which includes all operational costs like, maintenance, crew, energy & financial cost of locomotive

[46] Appendix for details

For the sake of a rough analysis it was assumed as a worst case scenario 5% extra energy is consumed due to multiple operation. Other assumption made was that there will be 10% drop in the maintenance cost due to increased reliability and reduced loading on locomotive. Saving in crew requirement will be substantial in direct proportions to DUs. With these assumptions impact on the line Haul Cost was calculate in different scenario (appendix X) and the findings are as per table 7.6.

It is seen that if DUs are not increased or remain within a limit line haul cost infect decreases (approach 3). Even if locomotives are increased by 300 the effect on the Line Haul cost is marginal. The higher increase in locomotives to beyond 650 increases LHC by 7.1%, this is mainly because of interest & depreciation charges of the additional locomotives. The cost will come down with increased reliability and increase of outage by the loco sheds which is likely to happen as "multi" are used. Similar calculations can also be done for Diesel. There is a need to do detail analysis and capture all the benefits to establish the impact of the LHC.

Table 7.6 Impact of Running Multi on the Line Haul Cost of Electric Locos

No.	Approach	Scenario: Details of savings adopted	Locos Increased	Increase/ Decrease in LH Cost
1	All Multi	20% less requirement of DU's	686	7.10%
2	All Multi	30% less requirement of DU's	287	1.06%
3	Running BOXN with Multi & BCN with single	(a) Overall operational efficiency of 30%	-	-5.66%
		(b) Overall operational efficiency of 20%	106	-0.58%

Source: calculations at Appendix X

Economics of Higher Speeds: Justification of Progression to Higher HP/TL

IR is hard pressed for upping the asset utilization. Vision 2020[47] sets an annual growth target of 10% for years to come. Low speeds of freight trains, is brought out as one of the key challenges facing IR at the moment and has envisaged increasing the speeds to 100 KMPH. Vision 2020 has set steep target of freight loading for the future from present level of 656 million NTKM to 1407 million NTKM by 2019-20. Railways cannot achieve these unless it efficiently utilizes their resources to the maximum. Increasing freight speeds and gaining from reduced speed differential appears to be a step in right direction.

A 30% increase in line capacity and corresponding freight loading potential is there for IR to exploit. Additional profit it can generate for IR by adopting higher HP/TL strategy for Electric Traction alone, will be of the order of 2100 Cr annually (taking 20 paise profit per NTKM moved)[48].

The total investment required for additional 250 Electric locomotives will be in the order of 5000 Crores[49], which includes the cost of locomotives and additional maintenance infrastructure. It is an economically viable option. Investment required is just a fraction of annual plan expenditure of IR (25000 Crores, 2006-07).

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47 INDIAN RAILWAYS VISION 2020, Government of India, Ministry of Railways, (Railway Board) December, 2009

48 30% of 53822 NTKM= 16146, Profit at 0.2=3229 Cr. 66% for Electric Traction =2131 Cr.

49 250x14 Cr.=3500 Cr.+150 Cr. for Maintenance facilities

From Where These Locos Are Going To Come From?

For the purpose of this study it is assumed that 30% savings can be achieved and additional requirement of the locomotives have been taken as 300 each for Electric & Diesel.

Arranging 300 additional locomotives will need some planning; manufacturing capacities at CLW & DLW[50] are saturated. IR is already facing shortages of the locomotive due to additional passenger trains being introduced and phasing out of old locomotives. What Indian railways can do immediately is to concentrate on approach 4: Running BOXN with Multi & BCN with single loco which can be managed with the present & incoming fleet of the locomotives. Up-gradation to Complete Multi Operation can be planned in 2-3 years time horizon, enough time to plan and procure additional locomotives.

Railway mainly depends on its loco manufacturing units CLW & DLW for meeting its requirement of locomotives. Present production capacity of CLW & DLW is as per table 7.7.

Table 7.7 Present Production of Locomotives

	Passenger	Goods
CLW	45	185
DLW	100	150

Source: Electrical Directorate, Railway Board

[50] CLW: Chittranjan Locomotive Works: IR's Electric Loco Manufacturing Unit, DLW : Diesel Locomotive Works, Varanasi : IR's Diesel Loco Manufacturing Unit

If we assume that about 300 additional locos will be required to implement higher HP/TL ratio on IR the total requirement for freight locomotives for next 3 years as per rough estimate will be as per table 7.7. This shows that the production of locomotives has to be increased by about 250 for Electric and 175 for Diesel. Production capacities at CLW and DLW will have to be augmented and trade will have to be tapped for supply of the balance locomotives.

Table 7.7 Additional Yearly Requirement of Locomotives to implement higher HP/TL ratio

Yearly requirement	Electric	Diesel
Against Condemnation	35	75
New Trains (55)	100 DU= 210	75 DU=150
For converting to Multiple	100#	100#
Total	345	325
Yearly Shortfall	245	175

Requirement of additional locos have been spread to 3 years

Consolidated Requirement of Locomotive for Targeted Growth

The projected growth of Electric loco holding till 2020 is as per figure 7.1. The required holding by the end of year 2020 is expected to go beyond 6000 from present 2500. Indian Railway will require about 5300 additional Electric locomotive by the end of 2020 for the amount of forecasted tragic growth. This takes into account the locomotives required for increased HP/TL ratio, increased electrification to 85% & requirement against condemnations.

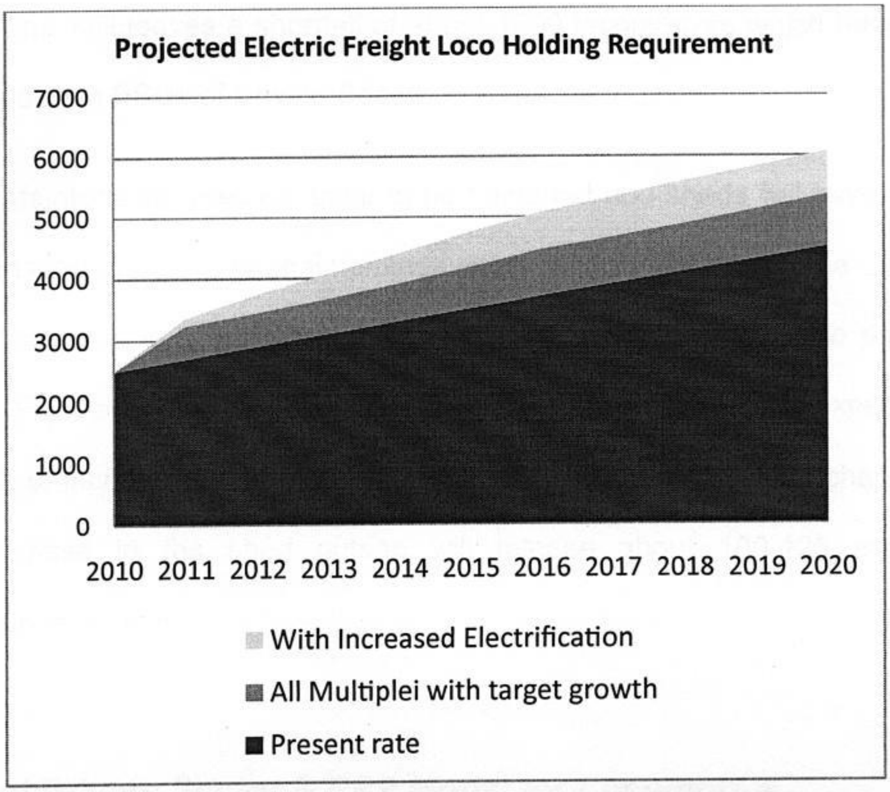

Figure 7.1 Projected Electric Freight Loco Holding Requirement
Data at Appendix XI

The projected future acquisition plan upto 2020 for the Electric Locomotives is as under:

Source	Locomotive
CLW	2595
Electric Locomotive Factory Madhepura [51]	700
High Power Locomotive from Japan [52]	250
Total	**3495**

[51] New production facility under planning

[52] IR has decided to import new class electric locos from Japan. The railways intend to use 9000 HP engines for the western corridor and 12000 HP electric locos for the eastern corridor.

This still leaves a shortfall of about 1800 locomotives which have to be arranged from PSUs of Private Sector.

Maintenance also will have to be tightened and sheds will have to plan for increased outage. The maintenance spare reserve will have to be cut down from present level of 15% to 10% by adapting better maintenance practices and quality control. Some reliability improvement is automatically expected as a result of increasing HP/TL ratio, as brought out in the previous chapters. A 5% increase in the shed outage will release about 100-125 additional locomotives on line.

Role of Private Sector & PPP Model for Locomotive Manufacturing

In India, we now have adequate base of technologically and financially strong private players, likes of Siemens, Alstom, Bombardier, General Electric, Electro-Motive Diesels Inc., who can supply locomotives or enter into PPP agreement with railways for JVs or loco lease. IR has already moved in this direction by approving to setup a green field electric locomotive factory at Madhepura, Bihar, however it will have to move faster on this project. This joint venture project with a private partner has a planned capacity of 120 locos a year. IR is expected to procure 800 electric locos of 12,000hp power capacity from this factory in 10 years.

Public Sector Company Bharat Heavy Electricals Ltd. (BHEL) has already supplied electric locomotives. It has expertise to produce 6,000 hp diesel locos & is exploring foreign partnerships with GE, Toshiba, and others for production of higher capacity locomotives. Recently (2008) BHEL has entered an agreement with IR to supply several dozen high-horsepower locomotives. Potential of public sector & private companies can be tapped to a great extent if Govt. comes out with right intent.

IR needs a robust institutional arrangement to drive benefit from PPP arrangement. Proper risk sharing arrangement, fast track approvals, proper concession agreement, regulatory framework are some of the areas Railways will have to work out. Delays will have to be cut down since private players tend to lose interest if award process takes a long time says Rajesh Samson[53].

Summary

How the adequate powering of locomotive can be implemented on the IR was examined in detail in the chapter. To increase the HP/TL ratio to 1.5 to start with and finally to 2 in the long terms we will have to run trains with higher HP locomotives or by providing 2 or more locomotive called "Multi" and "Consists" formation. At present IR is providing these for few trains only. Requirement of additional locomotives was calculated developing different scenarios. The requirement of locomotives came out to be 685 in the worst scenario & about 300 in case 30% savings are assumed, which was found to be a reasonable assumption. Since IR is already facing shortage of locomotives it was observed that to start with if only BCN rakes are provided

[53] Samson, Rajesh (2010). A PPP Model in The Indian Railways, *Rail Business, Jan 2010.*

with the multi driving unit IR will be able to manage with the existing stock itself.

The strategy was found to be economically viable as earning potential generated from line capacity & WTR gains will justify the investment in additional locomotives required to enhance HP/TL ratio. The effect of this strategy on the running cost (LHC) was found to be minimal. Lastly it was observed that there is a need to increase the production capacity of locomotives & tighten their maintenance, if this strategy is to be implemented. PSUs & private companies can also play a vital role in bridging the gap in the supply of the locomotives and Railways has to plan for the same.

The present production & acquisition plans for electric locomotives also fall short of the requirement as per Vision 2020 targets. IR will have to plan for about 1800 additional locomotives through trade or ramp up the capacity at the production units.