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Introduction of Double Stack Container Train on IR- a Path Breaking Achievement

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WHEN OAKLAND global ocean carrier APL introduced technology to load rail cars on top of each other in 1984, critics said it wouldn't work. To show the reliability of its "stack train" technology, APL loaded a container with a dinner table, set it with crystal, china and silverware, and railed it across the country. Everything arrived intact. Still, not everyone was convinced.

Double-stack technology caught on as a cheaper way to move auto parts and consumer goods across North America. The market has grown 100-fold since 1984. As stack train celebrates its 20th anniversary, it remains an attractive alternative to long-haul trucking, which has been hurt by rising fuel prices.

1. Indian Scenario

When Pipavav Railway Corporation Limited (PRCL) - a joint venture company of Ministry of Railways (MOR) and a private port, Gujarat Pipavav Port Limited, mooted the idea of running double stack with the existing flat wagons and existing axle load of 20.32 tonnes in 2003, many people find it impossible thing and the concept did not find favor in Rail Bhawan.

But with the change of guard in the Rail Bhawan in May 2004, the concept was again given a try by PRCL. This time the everything was in favor of the concept and MOR has taken keen interest in the implementation of this concept. Within a short time of four months from the time of detailed study of the infringements, the first double stack train has become the reality on Indian Railways on 23rd March 2006 between Jaipur- Pipavav (950 Kms) .



Dubble Stack Train Entering Botad Yard

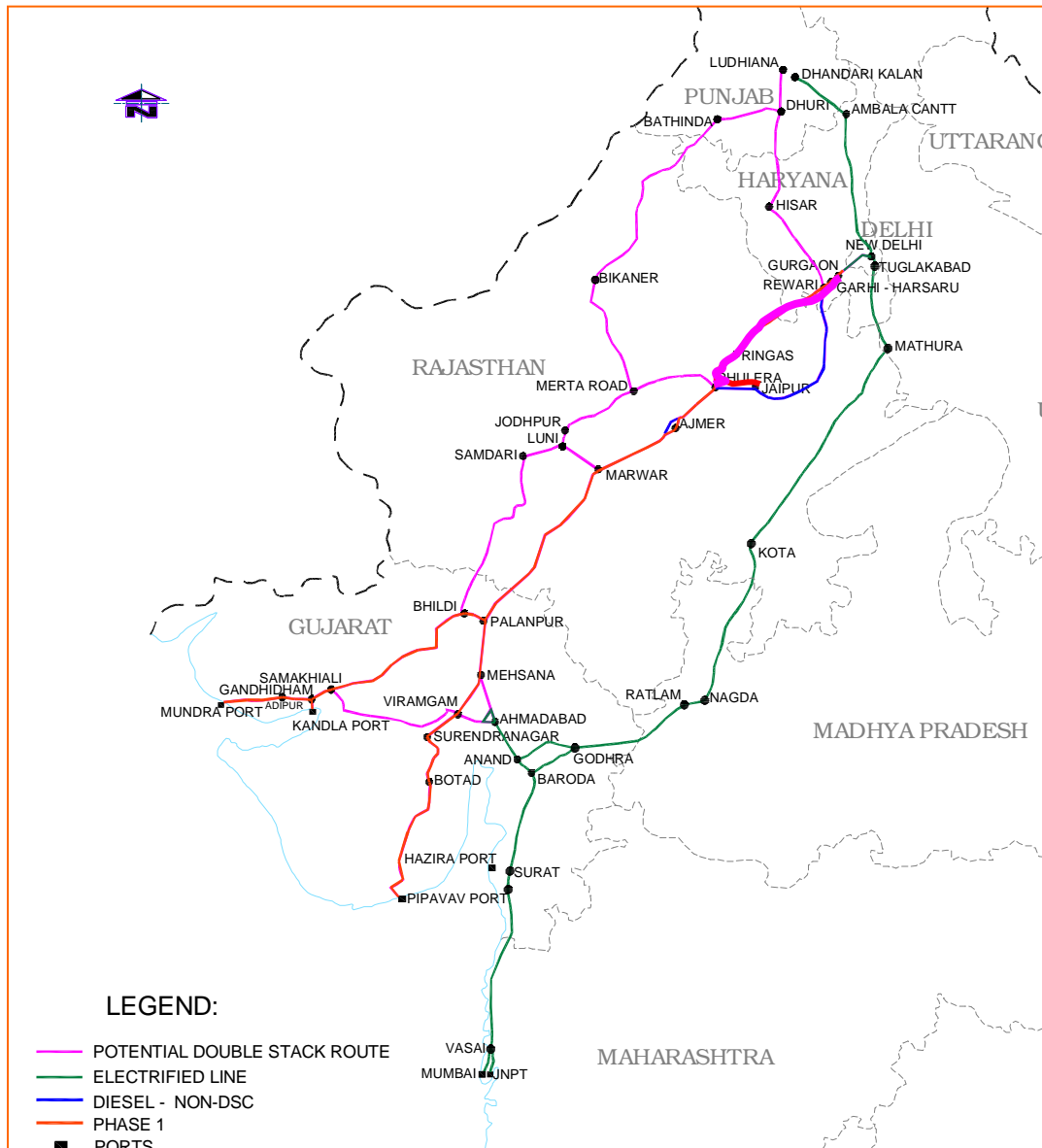
No. 1

2. Why Double Stack?

The growth in containerized transport of trade volumes has shown a CAGR of 17.2% against the overall growth of 8.6% at all Indian ports. In the post-liberalization era (1991 onwards) container traffic has increased more than 7 fold. Container traffic, besides registering the impressive growth, also covers a vast hinterland for each port which calls for a transport infrastructure capable of providing sufficient capacity for fast, cost effective service to Indian shippers and enable them to face the competitive world markets.

- The present rail share in container transport is around 27% and is not increasing because of several reasons. Some of the reasons are the comparative benefits offered by road transport: faster, door to door service, aggregation of smaller volumes, lesser waiting time at ports and terminals, avoidance of additional handling of cargo at rail terminals. All these help reduce costs in comparison to rail. Some of the problems faced by railways in not matching these factors are related to existing constraints:
 - i. IR has severe axle – load restrictions reducing the payload per unit of transport. This affects throughput, cost of haulage and detention at terminals
 - ii. Lower speeds of goods trains’ increase transit time.
 - iii. Freight rates for high rated cargo are consequently higher as compared to roads as well in comparison to other countries.
- Container traffic will increase to 14 million TEU’s per year in next ten years. The number of trains required shall be 137 trains per day at the present level of 30% rail share. If the rail share is to be increased to 50 %, the trains required shall increase to 225 a day. This magnitude can not be handled with current bottlenecks and line capacity constraints.
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- In India, presently Mumbai is the epicenter of the Container traffic. Out of a total 4.5 million TEUs handled at all ports during 2004-05, 2.37 MTEUS (53%) were handled at JNPT/NSICT ports alone. The rail share from JNPT/NSICT had been 26 % of which 80 % was for Northern hinterland which translated into 8 trains per day each way on Mumbai- Delhi route. At this growth rate, JNPT/NSICT are likely to handle 900000 TEUs for Northern Hinterland in 2006-07 requiring 15 trains to be run each way to and from Delhi area. It may increase further with the operation of 3rd berth at JNPT, which is likely in Sept 2006.
- Such line capacity constraints can not be eased overnight. Delhi- Mumbai freight corridor will take time. Therefore there is an urgent need to think of strategies to give immediate relief. Running Double Stack Container trains on non electrified routes is one such feasible strategy.

- The ports of Mundra, Pipavav and Kandla in Gujarat are connected to the entire North hinterland of Rajasthan, Haryana, Delhi, Punjab and Himachal Pradesh by non electrified rail routes. These ports are projected to handle around 7,00,000 TEU's in 2009-10. This will further go up to 1.6 million TEU's in 2014-15. A noteworthy feature of these ports is a very high coefficient of rail share; against 26% from JNPT, Pipavav and Mundra have a rail share of more than 93%.
- Ports of Pipavav, Mundra and Kandla will generate 17 trains in 2009-10 and 43 trains by 2014-15. These numbers will find it hard to move.



3. Advantages

DSC train operation has been very advantageous in removing these constraints and will reduce the unit cost of transportation. The main advantages of DSC operation are as under;

- a) Number of trains can be reduced by 48%, for the same throughput.
- b) The payload capacity of the container train has been increased from 1500 MT to 2500 MT to match the carrying capacity of the locomotives.
- c) The terminal congestion can be minimized. Dwell time of containers at terminals and ports shall reduce.
- d) Matching of throughput for larger ships can be fulfilled in lesser time.
- e) Cost of unit transportation will reduce. Indian Railways has already given discount of 25 % on haulage cost for DSC movement.
- f) Rolling stock requirement of locos and rail flats will reduce substantially.
- g) Rail share will increase with the same rolling stock.
- h) Will encourage direct service of bigger ships to Indian Ports.
- i) Overall transit time of containers will reduce.

This justifies the need for carrying more containers per train by using the vertical space by double stacking containers and optimizing the use of an alternative route to highly congested JNPT- Delhi route.

A Macro level estimation of savings in various costs has been tabulated below based on the total throughputs of Gujarat Ports.

	2005-06	2007-08	2009-10	2014-15
Projected TEUs	200959	326671	483557	1239285
No of trains with SSC	6.5	10.5	15.6	39.9
No of Trains With DSC.	3.4	5.6	8.3	21.2
Saving in Rakes Ass. 17 % extra transit time for DSC Trns	7.4	12.0	17.8	45.6
Saving in Cost of Rakes (Rs. Crs.)	88.7	144.1	213.3	546.7
Saving in Locos assu.17 % extra transit time	2.5	4.0	5.9	15.1
Saving in Expenditure on Loco account in Rs Crs.) / annually	1.20	1.95	2.88	7.39
Saving on Account of Maintenance of Rakes in Rs Crs. / Annually	4.43	7.21	10.67	27.34
Saving in Fuel in Crs of Rs	9.1	14.8	22.0	56.3
Saving in Crew in Crs.of Rs.	2.4	3.8	5.7	14.6
Total Saving in revenue Expenditure	17.13	27.85	41.22	105.65
Total saving in USD (1USD=45 INR) in Million	3.80	6.18	9.15	23.4

Apart from above, savings on deferment of line capacity works, detention of boxes at ports and ICDs, savings in the ICDs and manpower for running less no of trains are to be accounted.

This justifies the need for carrying more containers per trains i.e. using the vertical space by double stacking containers and optimizing an alternative route to the existing JNPT- Delhi route

4. How it has been done?

The Railways is considering the idea of running DSC trains from last 10 Years. The first technical study on this concept was got done by PRCL through RITES in 2001, for the diesel route connecting port of Pipavav , since DSC operation is not feasible on electrified route because of restriction of vertical clearance. RITES has identified three routes connecting Pipavav Port and indicated the numbers and location of the fixed structure which shall infringe the DSC operation on these routes based on the information collected from Zonal Railways. The routes identified were as under;

- i) Gurgaon- Rewari- Jaipur- Phulera- Mehasana- Surendranagar- Pipavav.
- ii) Gurgaon- Rewari- Jaipur- Phulera- Jodhpur- Luni- Samadari- Bhildi - Mehasan- Surendranagar- Pipavav
- iii) Gurgaon- Rewari- Ringas- Phulera- Mehasana- Surendranagar- Pipavav.

The comparative distance for Gujarat Ports is as under;

Route (Port to Gurgaon)	Distance in Kms		
	Kandla	Mundra	Pipavav
Viramgam- Mehasan-Phulera- Jaipur	1144	1198	1233
Viramgam- Mehasan-Phulera- Ringas	1079	1134	1168
Bhildi- Palanpur – Ringas	1015	1070	-
Bhildi- Samadari – Jodhpur – Ringas	1094	1149	-
Viramgam- Mehasan-Marwar- Luni- Jodhpur- Phulera- Ringas	1221	1276	1311

In the mean time Railway Board had engaged CANAC for the detailed examination of this concept, using CIDA funds. They had given their inception report in Nov. 2004. They have suggested implementing the DSC operation in three phases. They have recommended that new type of wagons should be designed and track should be upgraded to higher axle loads for final phase implementation. They could not conclude their study.

Since delay was taking place in implementation of this concept, PRCL has requested MOR to give permission for carrying out the detailed physical survey on the Gujarat – Pipavav existing BG route via Jaipur- Ajmer to identify the infringements and suggest ways and means to modify the infringements obstructing the DSC operation. Accordingly MOR has permitted to carry out the foot by foot survey for DSC operation vide its letter dated 24.08.2005.

PRCL has conducted this survey from 25.09.2005 to 30.09.2005. PRCL has also find out the possibility of running DSC trains on the existing wagons within the present axle loads limitations.

5. Physical Survey

The survey was done on the existing BG route from Gurgaon to Pipavav via Rewari- Jaipur- Marwar- Palanpur- Mehasan- Viramgam- Surendranagar- Pipvav comprising of Delhi, Jaipur, Ajmer, Ahmedabad, Rajkot and Bhavanagar divisions of Northern Railway(NR) , North Western Railway(NWR) and Western Railway (WR) respectively. The survey of routes connecting ports, of Mundra and Kandla beyond Palanpur was not done since the alternative short route from Palanpur was under gauge conversion. Other alternative route via Rewari- Ringas – Phulera is also planned for Gauge Conversion.

6. Methodology of Survey

- A box structure of more than double stack height having provision of varying the height was fabricated in Loco Workshop, Ajmer, NWR. This box structure was manufactured in two stages, one fixed portion and other movable portions from angle irons. In order to reduce the weight of the movable structure only the thin plates were welded at three places. The movement of the movable part is done with the help of pulley and wire rope system. In order to reduce the cost of this box, the released materials were utilized as far as possible.

PHOTO of BOX Structure



- This box structure was mounted in a BOXN wagon by welding the fixed part of the box with bottom and sides of the wagon. The measuring device i.e. a calibrated scale was mounted on one of the legs of the structure.
- The train consisting of this test wagon, a locomotive and a brake van was run throughout the route during day time under the escorts of concerned railway officials and the team of experts from PRCL headed by Vice- President (Tech.), the Author.
- The movable part of the box was raised manually at each structure and height of the structure from the rail level was noted along with the span and width of the fixed structures.
 - The locations of HT lines, LT lines, and telegraph lines crossing over the track were recorded, during the run of this test train.
 - The survey was started from MADAR (AJMER), on 25.09.2005. The test train reached Pipavav Port on 27.09.2005. Then the survey started from Ajmer on 29.09.2005 towards Gurgaon and reached Gurgaon on 30.09.2005. This survey was completed in 6 days.
- The team has taken the dimensions for 20 ROB, 01 rail bridge, 31 FOBs , 01 water tank, and noted the location of 178 H.T. lines, 24 LT lines , 83 telegraph lines and 66 telegraph posts.

The summary of the infringements is given below;

Particular	Gurgaon - Jaipur (KKU)	Jaipur- Pipavav	Total	As given by RITES
ROB	10	10	20	9
Rail Bridge	1	0	1	0
FOB	11	20	31	22
HT Lines	3	19	22	51
LT lines	10	14	24	118
Telegraph lines	20	63	83	45
Signaling post	0	66	66	0

7. Oscillation Trails.

Research Design and Standard Organization (RDSO) has carried out the oscillation trials with the existing BLC flat wagons. The trails have found successful upto the maximum speed of 85 Kmph with 9-1/2' high containers loaded upto the maximum height with gross load of 30.5 MT each. These trials are conducted on the PRCL section between DASA _ Savarkundla. They have tested 6 combination with various CG heights . The brief for worst case parameters noted during the trails are as under;

No.	Parameters	A- Car		B- Car	
		Max value	Speed (KMPH)	Max value	Speed (KMPH)
1	Vertical Accl. (g)	0.299	85	0.547	85
2	Vertical RI	3.029	85	3.578	85
3	Lateral Accl. (g)	0.332	85	3.657	85
4	Lateral force Hy2m(t)	2.83	70	3.76	85
5	Derailment coefficient	0.60	85	0.49	60

Based on the above results RDSO has drawn the following conclusion;

No adverse riding characteristics were noticed from the oscillation trail test data and the pattern of oscillograms recorded for double stack container operation upto a maximum speed of 85 kmph and the values of maximum RI, lateral force and derailment coefficient were within the given limit. There was no resonance in the long run.

8.0 Modification of Infringements

8.1 Infringements modified for Phase-1, (two 8-1/2' high Cont.)

RDSO has developed an envelop for the straight track having height of 7300 mm and width of 4360 mm for two 9-1/2' containers without any restriction to the movement. For two 8-1/2' containers and A class ODC this envelop has been modified to 6500 mm height and 4360 mm width. Considering these dimensions the modifications have been carried out.

For implementation of phase-1, part-1 DSC operation 6 no ROBs and 09 no. FOBs, 19 HT lines, 14 LT lines, 63 Telegraph lines and 66 signaling posts have been modified. The details are as under;

ROB Modification

	Location	Dimensions	Tentative Cost	Suggested Method
1	BAR (363.25Kms)	S=4.8m B=6.75m H=6035mm	82	The temporary LC has been built and the existing ROB raised.
2	PNU (652.25KMs)	S=23m B=9.7m H=5055mm	10	The traffic has been diverted on the adjacent new ROB and the old has been broken.
3	MSH- Linch (5/0Kms)	S=40.0m B=21.0m H=6160mm	05	On NH-8. The track has been lowered by 300 mm,
4	DASA (22.7Kms)	S=4.8 m B=7.5m H=4995mm	200	Small ROB on State Highway. This ROB is being raised although the traffic has been diverted on the newly constructed LC. ROB has been dismantled
5	SVKD(64.93Kms)	S= 9.3m B=7.5 m H=5530mm	75	Small ROB on village road on cutting. This ROB has is being raised and the traffic has been diverted on the existing LC which is 0.5 kms away. ROB has been dismantled.
6	Rajula city	S=9.3 B=7.5 H= 6445	30	Small ROB connecting three- four houses of a villages. Is being rebuilt.
Total cost in Lacs of Rs.			402 (0.89 Mn USD)	

FOB Modification

	Station	Ht in mm	Tentative Cost	Suggested method
1	FL	5310	5.0	Has been raised

2.	Kishangarh	6425	0.00	Track has been adjusted
3	Madar	6430	0.00	Track has been adjusted
4	RANI	6400	6.5	FOB has been raised.
5	Abu Rd.	5860	5.00	Fob has been dismantled and now being raised.
6	PNU-1	6340	0.00	Track adjusted
7	PNU-2	6450	0.00	Track has been adjusted.
8	MSH	4995	1.0	FOB has been dismantled
9	Viramgam	6410	0.00	Track has been adjusted.
Total cost in Lacs Rs.			17.50 (0.03Mn USD)	

Modification of other Infringements

Zone	NWR		WR	PRCL	Total	Unit Cost Rs Lacs	Tentative Cost Rs Lacs
Sections	Jaipur- Madar	Madar- Palanpur	Palanpur- SUNR	SUNR- PPSP			
HT LINES	0	1	12	6	19	10	190
LT Lines	6	6	2	0	14	1.0	14.0
TEL. Lines	14	25	21	3	63	0.25	15.75
Sig. posts	24	0	42	0	66	0.00	0.00
Total Cost							219.75 (.48 mn USD)

Hence for commencement of DSC train from Jaipur to Pipavav and further connecting to Mundra and Kandla, it has costed approximately, Rs 640 lacs, for implementation of DSC with 8-1/2 ' containers.

After modification of the above infringements the first Double stack Train has been inaugurated by Hon'ble Minister for Railways, Government of India.



8.2 Infringements to be modified for Phase-1, (for two 9-1/2' containers)

For implementation of part-2 of phase-1, 6 nos. ROBs, 16 nos. FOBs has been to be modified, the details are as under;

ROBs

	Location	Dim.	Cost in Lacs	Method
1	Kishangarh	S=24.9 m B=24.0m H=6600 mm	15.0	Track is being lowered, by 700 mm
2	PNU	S=32m B=11.7m H=6635mm	15.0	Track is being lowered by 450 mm
3	MSH	S=40.0m B=21.0m H=6160mm	15.0	Track is being lowered 1200mm
4	Siddhpur	H=6900mm	15.0	Track is being lowered by 400mm
5	Limdi	S= 26m B=34m H=6510 mm	35.00	Track is being lowered by 600mm
Total Cost in Lacs of Rs.			95 (0.21mn USD)	

FOBs

No.	Location	Vertical Ht.	Modification	Cost
1.	Kanakpura	6525	To be raised	2.5
2	Kishangarh	6425	To be raised	2.5
3	Madar	6430	To be raised	2.5
4	Marwar	6810	To be raised on goods line	2.5
5	Falna	6520	to be raised	2.5
6	Sirohi Rd.	6510	to be raised	2.6
7	PNU-1	6340	0.00	
8	PNU-2	6450	0.00	
9	Palanpur	6450	raised on goods line	5.0
10	Siddhpur	7000	Train can be passed	
11	Mehasana -1	6690	to be raised	2.5
12	Mehasana -2	6470	to be raised	2.5
13	Mehasan-3	6730	to be raised	2.5
14	Katosan Rd.	6440	to be raised	2.5
15	Viramgam	6410	Raised on line no.5 &6.	.2.5
16	Botad	6750	to be raised	2.5
17	Dhola	6860	to be raised	2.5
Total Cost in Lacs of Rs.				37.5(0.08mn USD)

Hence the total additional cost for implementing phase-1, part-2 will be Rs.132.50.0 Lacs. The phase-1, part-2 can be implemented up to July 2006 at total cost of Rs 772 (1.71 Mn USD) Lakhs . While these costs were estimated by RITES as 10700 Lakhs (23.7 mn USD) for less no. of infringements.

Indian Railway was even thinking of spending 200-300 Crores (45-65 Mn USD) of Rupees on the Kandla- Delhi route for modifying the routes and increasing the axle loads and thinking of designing of new wagons of well shape and tri- axle bogie.

8.3 Phase-2.

In the phase-2. Delhi area will be connected to all the Gujarat ports after the gauge conversion of Rewari- Ringas- Phulera. The expenditure for modification of infringements will be the part of this conversion cost.

For Phase-2, a mega ICD having facilities for handling DSC trains should also be developed around Gurgaon / Rewari.

9. Comparison with USA

Double stack trains introduced on Indian Railways on flat has been a unique concept This type of concept has been utilized for the first time in the world. The DSC train movement on flat wagons is the most efficient way of double stacking as the payload per meter length of the train is higher than US rail roads. I have visited the US rail roads and studied their double stack movement in detail. A brief comparison is done in the table below;

Car Name	Pay Load	Combination of loading	Tare Wt	Load per axle Ton	Wheel dia in mm	No of wgn's 620 m. train	Teus per train
3 Unit Draw bar stack car	74	2X20' /40' Bottom, 40 top	25	25	838	36	144.
4 Unit Draw bar stack car	75	Same	25	25	838	36	144.
Art. 5-unit -40' Well Car	55	Same	17	36.	838- End 965- Art.	45	180
Flat Wagon of IR	61	Same	19.25	20.06	840	45	180

From the table above it is evident that the most efficient wagons i.e. Articulated 5-unit 40' well car can take the 180 TEUs equivalent to our flat wagons in the same length as of our trains i.e. 620 meter, but the payload capacity is 55 tonnes and axle load requirement is 36 tonnes. However, the train length on US rail roads is almost three times to our train lengths.

10. Recommendation for Indian Railways (IR)

- IR should plan our DSC operation on flat wagons, instead of well wagons.
- IR have got the wider gauge compared to North America. Hence our stability criterion may be more liberal.
- The increase in throughput is 100% as compared to 60 % in case of well wagons. (Without articulation)
- The articulation concept may not be feasible due to the severe restrictions of payload of the wagons. For our loading pattern we require at least 45-50 tons of axle loads for articulated wagons.
- The new design has to be developed for well wagons.
- The cost of well wagons will be almost double that of flat wagons.
- The tare weight of the wagon will be 33% more compared to the flat car.
- For our 100% DSC operation weight wise even 22.5 Tonne of axle load is sufficient.
- IR should explore the possibility of enhancing the axle loads of present wagons from 20.32 to 22.5 tons.
- Axle load beyond 25 Tonnes may prove counterproductive as for higher axle loads the wheel diameter has to be increased
- The loop lengths for dedicated freight corridors should be as per present three train lengths, so that hub- spoke system can be followed through railway network. The switching stations fitted with modern technology should be constructed near the major container ports and ICDS.
- Use of end of telemetry system should be encouraged in order to save time in shunting operations.

11. Conclusion:

With the introduction of this concept on IR , the container transportation is going to be cheaper substantially. The direction of transportation may also see a change in the near future. It may not be surprising that JNPT which is the hub of container business may loose its significance, particularly for the Northern India cargo which is more than 40 % of the total EXIM cargo in containers. The east coast ports may not be able to attract the cargo meant for East Asian countries. The ports on Gujarat coast namely Pipavav, Mundra and Kandla will become significant. This change will be in the larger interest of nation.