OPERATING

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OPERATING - I

AN INTRODUCTION TO RAIL TRANSPORT

Transport is an important infrastructure in maintaining and developing any economic activity. Rail transport occupies a very important place in surface transport, particularly in a country like India, which is not endowed with much of waterways and has a very large size. Rail transport assumes a greater importance in our country, particularly in view of limited resources of natural oil and abundant availability of coal, an energy source easily usable for rail transport, whether directly or indirectly, through electric energy indigenous or imported. Railways have a positive edge over road, being many times more energy efficient than the latter. Comparative position of energy efficiency on different modes of transportation is as under:

Freight	BTU/Tonne km
* Electric traction	62.7
* Diesel traction	77.5
* Diesel truck	1587.3
* Barge	328.0
* Pipeline	281.7

(Source: NITIE study for NTPC & Annual Statistical statement of IR year 11-12)

Notwithstanding disadvantages like being track bound, highly capacity intensive, Railways have played a very important role in the economic development of the country. Though road transport has progressed much faster during the post-independence era, Indian Railways still continue to play a major role in the transport effort required by the nation. Indian Railways carry about 40% of the total passenger kilometers and 60% of the total net tonne kilometers of traffic that is offered to any mechanized mode of transport in the country. Given below is the growth profile of passenger and freight traffic on Indian Railways.

NUMBER OF PASSENGERS ORIGINATING (In millions)

Year	Suburban (All Classes)	Non-suburban					
		Upper Class	Second Class			Total Non-Suburban	Grand Total
			Mail/Exp *	Ordinary	Total		
1950-51	412	25	52	795	847	872	1284
1960-61	680	15	96	803	899	914	1594
1970-71	1219	16	155	1041	1196	1212	2431
1980-81	2000	11	260	1342	1602	1613	3613
1990-91	2259	19	357	1223	1580	1599	3858

2000-01	2861	40	472	1460	1932	1972	4833
2001-02	2999	41	496	1557	2053	2094	5093
2002-03	2934	42	513	1482	1995	2037	4971
2003-04	2986	42	571	1513	2084	2126	5112
2004-05	3178	44	609	1547	2156	2200	5378
2005-06	3329	50	668	1678	2346	2396	5725
2006-07	3514	58	713	1934	2647	2705	6219
2007-08	3689	66	776	1993	2769	2835	6524
2008-09	3802	76	895	2147	3042	3118	6920
2009-10	3876	86	983	2301	3284	3370	7246
2010-11	4061	100	1046	2444	3490	3590	7651
2011- 12	4377	112	1188	2547	3735	3847	8224

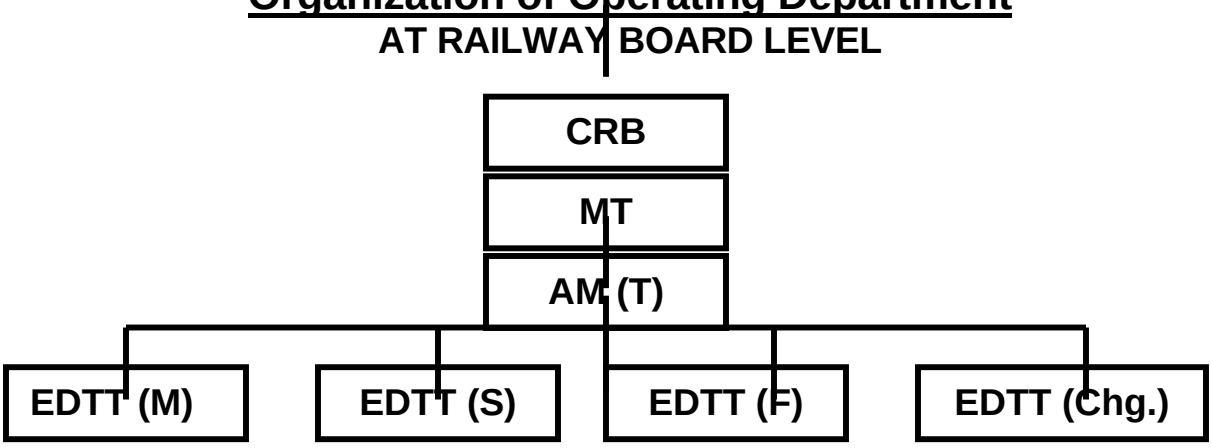
* Also includes Sleeper Class

BULK COMMODITIES

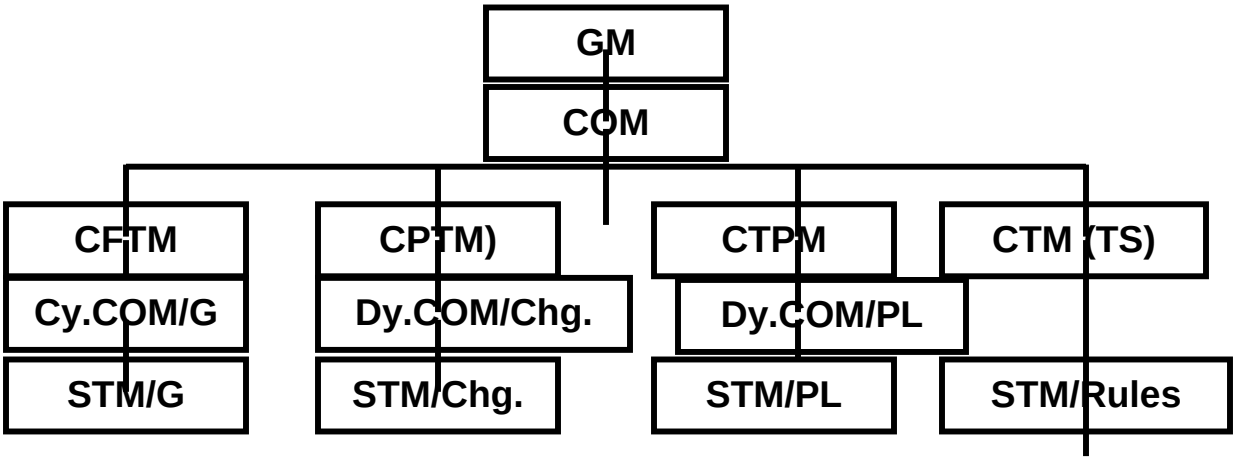
Sr.No.	Commodity	Tonnes Loaded (in millions)		Variation over last year	%age share in Total Loading of 2011-12
		2010-11	2011-12		
1	Coal	420.37	455.81	35.44	47.04
2	Food grains	43.45	46.40	2.95	4.79
3	Iron & Steel	32.82	35.15	2.33	3.63
4	Iron Ore & Other ores	118.46	104.70	- 13.76	10.80
5	Cement	99.08	107.66	8.58	11.11
6	POL	39.29	39.77	0.48	4.10
7	Fertilizers	48.22	52.70	4.48	5.44
8	Containers	39.29	39.77	0.48	3.92
9	Limestone and Dolomite	16.37	17.66	1.29	1.82
10	Stones (including Gypsum) other than marble	11.66	12.96	1.3	1.34
11	Salt	4.64	5.14	0.40	0.53
12	Sugar	3.76	4.56	0.80	0.47
13	Commodities other than above	46.02	48.53	2.51	5.01

Organization of Operating Department

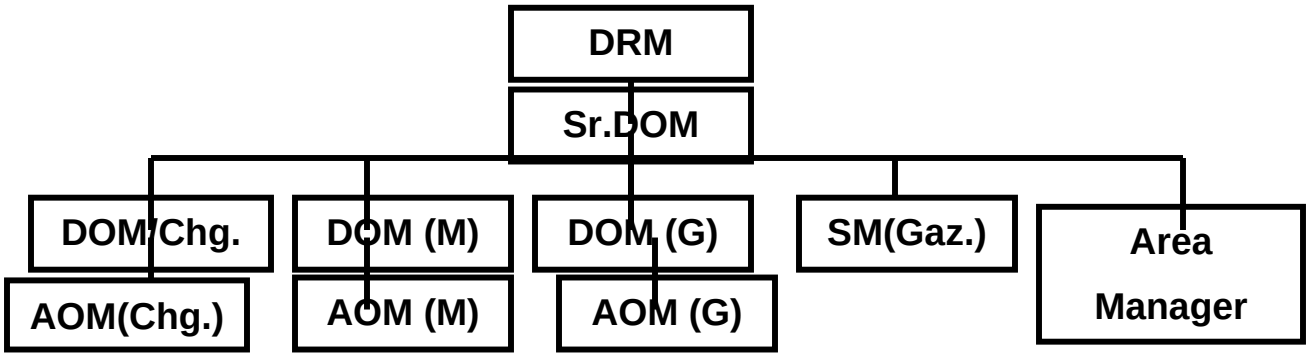
AT RAILWAY BOARD LEVEL



AT ZONAL RAILWAY LEVEL



AT DIVISIONAL LEVEL



Functions of Operating Department

Railway operation encompasses all the activities connected with the running of a railway. However, Operating department in particular has its role in producing a service called Transportation. In this activity, Operating department harnesses the efforts of all the departments of the Railways and optimizes usage of operational assets viz. track, signals fixed installations and rolling stock. Broadly, the functions can be categorized as under:

Planning of Transport Service: This involves both long term as well as short term planning. A lot of spadework has to be done to run trains on day-to-day basis. Passenger trains are planned to be run and detailed timetable issued once every year. Arrangements of rolling stock and locomotives are made to meet the expected demand. Similarly, facilities of wagons have to be made available for the goods traffic. Demands for the wagons for different commodities vary during different seasons of the year. Railways have to plan to meet these fluctuations in demand. Planning would involve not only the individual trains but a lot of other activities necessitating creation of capacity to form and start trains at originating stations, run through a section and receive at the destination station. Though organization of the Railways gets involved in this planning process, the basic framework is provided by the Operation department to which the plans of other departments responsible for provision and maintenance of operational assets, fit in.

Running of trains and continuous watch: Running of trains would involve ordering of trains, booking of crew, watching that the conditions are safe for it to run and arranging various requirements on the run. Efficiency of operation of trains depends on the quality of planning whether short term or long term. Transportation staff, both at originating and terminating as well as roadside stations, are busy round the clock to ensure timely and safe running of trains. Passenger trains run on a predetermined schedule, fluctuations in the traffic do not generally influence their running. On the other hand, except for a few scheduled goods trains, goods trains run as and when there is adequate load. A goods train generally leaves when there are a definite number of wagons to be cleared for a particular destination/yard in the same fashion as a village tonga leaves for the town when it is full. Exceptions in both cases exist, though rare.

Safety: Safety is the prime attribute of any transport system. No user would like to use a transport system, which does not provide a reasonable amount of safety to the limb, life and property of the user. Safety is, therefore, an integral part of operations and it is the responsibility of Operating department as well to ensure that trains are operated in a safe manner. This requires rigid observance of rules and procedures of safe train operation.

Economy and efficiency: While maintenance departments are responsible for making the assets available to the Operating department in proper fettle, it is the responsibility of the latter to make most optimum utilization thereof. Operating department is, therefore, responsible for the productivity of the system. This is measured in terms of operating indices like tonne kilometers and passenger kilometers.

Classification of Traffic

Railway traffic by the very nature is divisible into two categories (i) coaching, and (ii) goods. Coaching traffic includes a passenger, parcel and luggage. Passengers and their luggage are moved by the passenger trains. In the railway parlance, all mail, express and passenger (stopping) trains are included in this category. Parcel traffic is either moved in special parcel trains or in the space available in luggage vans of trains carrying passengers. Occasionally, additional parcel vans are also attached to passenger trains.

Freight traffic is cleared by goods trains and the rates at which this traffic is booked are different than meant for parcel traffic. When adequate coaching vehicles (parcel vans) etc., are not available, even parcel traffic is cleared in goods vehicles but they are moved by passenger trains or parcel trains.

Unit of traffic:

While unit of booking traffic is a passenger or a consignment whatever its size or weight may be, from the operating point of view, a unit of movement is a train.

Passenger trains operate on a fixed schedule to a fixed composition (number and type of coaches), which are suitably advertised to the users. Nature, time and volume of the service is decided on the basis of passenger traffic that would normally be expected. The day-to-day demand gets regulated to some extent by the availability of supply of the service. It is only on the long-term basis that demand influences supply.

Freight traffic is booked at goods sheds and goods terminals. The unit in case of freight traffic is a consignment. This may vary from a few kilograms to a few thousand tonnes. From this point of view, traffic is divided into two categories as under:

(1) Wagon Loads:- In this category fall consignments which are booked and loaded utilizing the capacity of wagon in full. Weight would vary according to the volume of the commodity. Earlier this type of traffic was the main traffic of Indian Railways. Wagons are booked from one goods shed or a siding to the other. These are collected by shunting trains into the feeding yards from where these are grouped into trains. Wagons move to the destination switching from one train to the other at different points. Since, however, a wagon is not a unit of movement on the Railways, it takes quite a bit of effort on the part of Railways in collecting individual wagons from road side station, forming them into trains at marshalling yards and again distributing at the destination stations. So this type of traffic is slowly easing out of the Railways.

(2) Train Loads:- Railway is eminently suited to this type of traffic. This is suitable for bulk users which have a train load of traffic to be carried to one point. Bulk of the traffic that Indian Railways are carrying today is trainload traffic. Not only major factories and mines offer such traffic, even agricultural and horticultural produce moves in train loads. Since there are large number of commodities which are required to be moved on Indian Railways, they require different types of wagons too.

Types of Trains

Trains can also be divided into two broad based categories:
(1) Trains carrying passengers; and
(2) Trains carrying goods and animals.

Mail and Express trains are those passenger trains, which run between two important stations separated by a long distance. These trains do not stop at all the stations enroute, but only at a few stations where stoppages are warranted by sufficient volume of traffic and operational requirements. In this category also fall super fast trains, which have extended long runs and operate on long distance routes connecting different corners of the country. Passenger trains, except with a few exceptions, stop at all stations. Parcels are cleared by all trains carrying passengers.

Goods trains

Following are the types of goods trains, which normally run on Indian Railways:

(1) Through trains - These are the trains, which run from one yard to the other. They start from the originating yard with full load and neither attach or detach wagons enroute. Bulk of the movement on IR is of this type.
(2) Shunting trains - These trains originate from a yard with wagons meant for the roadside station and also pick up wagons awaiting clearance in the direction of movement of these trains at roadside station. If these trains clear wagons carrying small consignment, they are called "Small Quick Transit" (SQT) trains. Their number is dwindling very fast.
(3) Mixed trains - There are certain trains, though their number is very small, which clear goods traffic and have some passenger coaches attached to them. These are called "Mixed Trains".

Passenger Train Operation

Movement of human beings is an important economic and social need. Large majority of rail users judge the efficiency of railway system on the basis of an occasional journey performed by them. Passenger train operation, therefore, assumes a very great importance in the system of things for the railways.

Passenger trains are arranged to be run by the railways on a regular basis. Their schedules are revised periodically to suit seasonal requirements. These schedules are advertised to the public and are well known to the staff. Utilization of staff and infrastructure is also so planned that the entire operation becomes a routine and goes in a clock like motion. Accordingly, passenger operation is relatively simple, straightforward and does not require very great effort on day-to-day basis.

Efforts have been made that schedules of work laid down for smooth passenger train operations are meticulously observed and watched like a hawk by the Operating officers as any dislocation in these schedules can lead to innumerable problems. Any dislocation in passenger train operation which requires a lot of effort on the part of operating officer not only on the long term basis but also on day to day basis. The punctual running of passenger trains, therefore, assumes importance not only from the point of view of the image of the Railways, but also because loss of punctuality leads to delays, dislocations in goods traffic and deterioration in the efficiency in the indices of both passenger and freight transportation.

Indian Railways serve the country as the main mechanized mode of transport for the inland traffic. Long distance trains criss-cross the length and breadth of the country, bringing people from different parts together. Though in the past, when road transport had not been developed, Railways provided the only mechanized mode of transport in the country, whether short distance or long distance, with the development and advances in the motor transport and establishment of elaborate road network, bulk of the short distance traffic has moved to the road. Railways are also encouraging transfer of this traffic to road as road transport is more suitable mode for this type of traffic. Railways are mainly concentrating on long distance, inter-regional traffic and urban transport in the major metropolitan cities. Only that part of non-suburban traffic can be served by railways better that forms high-density corridors and it is too large for the road transport to cater to. These corridors are between major industrial and commercial centers like Kanpur, Delhi, Ahmedabad-Vadodara-Bombay-Pune. Railway is also suitable for certain extensions of suburban traffic converging into large cities which act as magnets for employment and trading activities, and attract large number of passengers on regular basis.

Time Tables

Time table is a schedule in a table form, showing details of arrivals and departures at every station of all trains carrying passengers. These timetables are issued by every zonal railway every year, effective generally from 1st July. On Indian Railways there is another time table, "Trains at a Glance", which is issued by the Railway Board and carries stoppages of important trains at important stations only all over the Indian Railways, as against the Zonal Time Table which indicates stoppages of all scheduled trains at every station on the railways. The objectives of passenger time table are as under:

(1) Information for intending passengers regarding schedules of arrivals and departures; through sectional and suburban trains; connections at various stations; and the amenities and facilities available to the passengers at stations;
(2) A guide to the railway staff in arranging trains, crossings, precedences, receipt and despatch at terminals, and provision of motive power, crew, maintenance and other facilities;
(3) A guide to postal services for transmission of mail;

(4) A data base for calculating the requirements of rolling stock; locomotives and running staff;

(5) To satisfy statutory requirements. Section 65 of the Indian Railway Act lays down that railways must exhibit time tables for the guidance of the public.

The origin of Railway time table is very interesting. Railways in Great Britain, where the railways started first, were hesitant to issue time tables and advertised fixed schedules of trains they were running. With the teething problems galore, they were not sure whether they would be able to live up the commitments after they tell the public fixed schedules of their trains. At that time, one Mr. Bradshaw used to sell maps. In order to increase his sales of maps, he also started publishing schedules of the trains, which could take people to the places of which he used to sell maps. Railway companies consented to his publishing the time tables as it did not involve any commitment on their part. Soon, however, they realized the usefulness of advertisements of the fixed timings as their clientele went up and the companies started issuing the time tables themselves. With the passage of time, teething problems were also taken care of. Today, there is statutory obligation in some of the countries, for the Railway companies to publish their schedules. Indian Railways are required to do so under Section 49 of Indian Railways Act, 1989.

Types of Time Tables

Time Tables can be divided into two categories:

(1) For passengers

Zonal Time Table and Guide - This time table is published annually by each of the zonal railways. In addition to the train timings, there is additional information, which is useful for the passengers. This mainly relates to rules regarding reservation, refunds, cancellations of confirmed booking, fare tables and other facilities, which Railway administrations provide for the convenience of passengers. Copies of these time tables are available for sale at the booking offices and book stalls.

(a) Trains at a Glance - This is an abstract form of time table for all Indian Railways. Important trains are shown with time of arrivals and departures at important stations right from the originating station to the terminating station in one table only. Users have, therefore, not to refer to a number of tables to find out the schedule of a particular train. Main points of information for passengers are also given.

(b) Military Time Table - This time table is not made available for general public. Defense are one of very big users of rail infrastructure and a number of special trains for Defense are run by Railways. In order that these trains can be run at short notice, we have detailed timings of such trains worked out, which are also revised along with revision in the public time tables from time to time. These timings are kept secret.

(2) For Railway staff

(a) Staff copy of public time table - Train timings portion of zonal time table, without the additional pages for guidance of passengers and advertisements, is bound and copies given to staff dealing with passengers for their guidance.

(b) Working Time Table - Large amount of information is required to be

conveyed to the railway staff connected with running of trains and maintenance of the infrastructure on the railways. They must not only know the timings of the trains but also a lot of information about the track, signals and other facilities and this information is conveyed to the staff through the working time tables. These time tables are printed division wise, and it is desirable for all railway officers to familiarize themselves with these time tables.

(c) Graphic Time Tables - These time tables are in the graph form and are prepared for the guidance of the Control staff. These time tables are prepared section wise, indicating over a graph not only Mail, Express and Passenger trains, but also Goods trains that can be run during 24 hours. These are also called 'Master Charts'. These are generally displayed in front of the Section Controllers in their cabins, so that they can constantly relate actual running of trains to the fixed schedules laid down in the time tables.

Factors influencing framing of time tables

As seen earlier, time tables are for the benefit of users as well as railways. Factors that influence framing of a time table can also be broadly classified into two categories:

(1) Users Requirement.

Departure and arrivals - Train journeys in India are generally long and take a lot of time. It is convenient to the passengers to leave originating station in the evening and arrive at the destination in the morning so that they are able to perform the journey without wasting any working time during the day. No wonder, most of the trains from the major cities leave in the evening and arrive in the morning. Passengers performing journeys to and from important stations enroute also like the trains to arrive at convenient timings and not in the middle of the night. All this is always not possible to accommodate, but efforts are made by Railways to adjust timings in such a manner that this requirement of passengers is kept in mind. With the increase in the number of trains, staggering of departures and arrivals become unavoidable, otherwise a lot of additional capacity would be required at the terminals and sections to deal with large number of trains in the evenings and mornings. This would also lead to idling of assets for bulk of the time as no trains would be scheduled to leave or arrive around mid day or mid night. Trains should touch important cities and junctions at convenient time.

(a) Connections at junctions - Railway trains run between selected pair of stations. Large number of passengers travel to stations, which are not served, by direct trains. They have, therefore, to change trains at junction stations. It is, therefore, the requirement of the passengers that the connecting trains should leave the connecting junction station as soon after the arrival of the first train as possible, so that they are not required to waste a lot of time waiting for the next train. It is also necessary that such connections are not so very tight that the passengers miss the previous train. Railways have, therefore, to

design their time tables in such a manner that passengers are reasonably assured to connection within about an hour or two of the arrival of the previous train. At certain junctions, staff are authorized to detain connecting trains up to a limit if an earlier train is running late.

(b) Halts for meals, etc. - Since railway passengers have to travel long distances and all trains are not equipped with catering facilities, halts at meal timings are provided at stations having facilities for meals, refreshments. These halts are long enough to buy their requirements from the platform.

(c) Overall speed - Whatever the requirement of passenger's enroute, every long distance passenger desires to complete his journey as early as possible. There is, therefore, need to provide fast, long distance trains to cut down journey time of bulk of the passengers. Railways have, therefore, introduced a large number of super fast trains during the last decade or so.

(d) Range of travel distance - From the view point of travel distance, railway passengers can be classified into three categories:

i) Short distance- This category of passengers travel between major industrial commercial centres or capital/district cities and town or villages around such major cities. This group of passengers generally lives in surrounding town and villages and commute to the city centre/industrial centres for employment regularly. The travel distance is generally up to about 80 kilometres. In very rare cases, people travel on regular basis for more than 80 kilometres also. These passengers like to reach the cities in the morning hours to be able to attend offices/factories and want to go back as early as possible after the office is closed so as to arrive at their residence in the evening. These passengers generally travel in groups as they belong to the same place and travel together regularly. Their livelihood is dependent on punctual running of trains. They are very vociferous and do not tolerate changes which do not suit them. At locations where industries work in shifts, there is traffic around such locations both ways. It is, therefore, essential for the Railways to provide stoppages for passenger trains for the category of passengers at convenient timings. At a few places, even long distance trains are provided halts to enable these passengers to reach their work centres in time.

ii) Medium distance - In this group are included passengers whose range of travel falls between 80 to 300 kilometres. Some of these passengers travel between two important cities and prefer to have over night trains. Alternatively, they use long distance trains, which are fast, but finding accommodation on such long distance trains may be a bit difficult. A large number of passengers in this group are those who work in major cities and have roots in places where they are not able to go back every day. They stay at the place of their work and visit their native place frequently, say once or twice a month. Another section of this group are those passengers who travel mainly on social or business

occasion from one village/town to another. They require at least one train a day in each direction so that they can travel conveniently.

iii) Long distance - These passengers prefer fast trains with increased level of comfort. They require trains, which do not have many stops enroute and are able to cover the entire journey in as short a time as possible.

(2) Operator's Requirement

This has to be kept in mind that the trains are run for the use of passengers and their basic requirements are supreme. Railways make efforts to ensure that they are able to cater to all reasonable requirements of the users. There are, however, certain departmental requirements, which influence framing of time table. These can broadly be classified into the following categories:

(a) Infra structural requirements - While continuous exercises to augment infra structural facilities available for running of trains continue, these do act as a constraint to introduction of more number of trains as well as timings when trains can be scheduled. Terminal facilities like platforms, stabling lines, examination lines and repair facilities at the passenger terminals influence not only introduction of additional trains, but also timings of the trains. As there is only a certain number of trains which can be attended to during a given time, departures and arrivals of the trains have to be so spaced as to permit handling at the terminals depending upon the layout at the terminals. Simultaneous departure of one train and reception of another train may also not be possible. While framing timetable, therefore, an interval between the two operations would be required.

Availability of coaches and locomotives is another factor which influences scheduling of trains. Since these are costly assets, proper use of them has to be maintained.

Railway line also has a capacity, which is provided based on certain requirements. This limits the number of trains that can run and the timing at which those trains can be run. It may be convenient for the passengers to travel at a given time but lack of adequate line capacity may force railways to run the trains at time, which may not be suitable to the passengers.

These infra structural constraints can be overcome but this is very costly proposition. Even when adequate funds are available, there is long gestation period between planning and installation of facilities. This problem is particularly acute in developing countries.

(b) Maintenance requirements - The infrastructure required to run the trains also need maintenance periodically. The train services are so time tabled so as to enable the maintenance of rakes and locomotives at terminals as well as at intermediate points. Most of the routine maintenance of coaches and locomotives is attended to at one of the terminals, which is considered as the base and is responsible for proper mechanical condition of the equipment. This is also called 'Primary Maintenance'. Maintenance at the terminal at the other end is called 'Secondary Maintenance'. In addition, routine examination is carried out at important intermediate stations also.

Another requirement of coaches enroute is cleaning, watering and that of locomotives fuelling or loco changing for which time also has to be provided.

In addition to the rolling stock, fixed installations like track, platforms, signals and electrical overhead equipment (OHE) also need repairs. Time tables provide a suitable

block of time during day light hours for this maintenance. Efforts are made to ensure that no passenger train is scheduled during this block of time so that equipment can be maintained in proper fettle.

(c) Operational requirement - In the running of trains, there are a number of operational factors, which have to be provided in the timetable. There are some trains, which run faster than others. Slower trains have, therefore, to be stopped to give precedence to fast trains. In addition, on a single line section, only one train can run at a time in a block section. We generally do not have facilities on such sections where two trains running in the opposite direction to each other can cross without one of them being stopped. Generally less important train is scheduled to stop for crossing of fast train. Similarly, number of platforms at terminals as well as at important junction stations may be limited and a train may be delayed for reception till an earlier train vacates the platform.

There are a number of slip coaches, which are required to be attached or detached at junction stations. Additional halt is required to be provided for performing shunting for this purpose. This also necessarily slows down the trains. Indian Railways have, therefore, taken a conscious decision to reduce the number of slip coaches wherever possible and it is not very inconvenient to passengers to change trains. A large number of slip coaches have already been discontinued and trains accelerated.

(d) Change of locomotives - Locomotives required to be changed either at places where traction changes or at stations where loco shed is located and locomotives are required to go to the shed as per the loco link.

(e) Loading/unloading of parcels/luggage - Stations having lot of luggage of passengers and parcels are also required to be provided additional time to permit loading/unloading.

(f) Staff requirement - There is a limited time up to which railway staff is expected to perform their duties. They have, therefore, to take over and made over their charge at fixed locations. A bit of additional time is provided for the staff to examine the equipment and documents etc., being taken over.

(g) Unforeseen circumstances - There are a number of circumstances like signal failure, alarm chain pulling, occasional failures for which provision has to be kept. If no provision for such eventualities is kept, it is likely that the trains may run late frequently. This is generally up to the maximum of 3% of the total running time and is called 'traffic recovery time' and is provided short of big junctions, divisional/zonal interchange points. It may, however, be noted that in actual practice on most of the railways very little traffic recovery time is available.

Important Connotations used in connection with Time Table

1. Maximum Permissible Speed (MPS) - This is the speed which a driver cannot exceed. This is also called technical speed and is dependent upon the technical condition of the track, signalling and rolling stock in use. It is generally different for different sections and trains. Most of the express trains on Indian Railways have MPS of 100 kmph or more. In order to increase this speed limit, signalling and track need to be carried out and Commissioner of Railway Safety has

to satisfy himself before he permits this limit to be enhanced. Our fastest trains so far were Rajdhani Expresses. But with the introduction of Shatabdi Express between NDLS - BPL, the fastest booked speed is now 150 kmph between NDLS - AGC.

2. Booked Speed - This is the speed which determines the normal running time of the trains and on the basis of which time table is prepared. This is generally 10% less than the maximum permissible speed.

With effect from 1st December 2006, however, this distinction of speeds has been dispensed with.

3. Average Running Speed - This is the average speed of the train on run. For calculating this, total time consumed in halts is deducted from the total time taken by a train between originating and termination stations.

4. Commercial Speed / Overall Speed - This is the average time taken by the train per hour from its start to termination. Long distance passengers are concerned with this. They are not interested how fast a train runs between the stations. What they are concerned about is how fast it can reach its destination.

5. Speed Restriction - Maximum permissible speed and booked speed relate to the particular section of the railway engine. Actual condition of the track bridges, curves and nature of signalling at certain stations may require the trains to be run at speeds which should be lower than the booked speed of a particular train. For this, special speed restrictions are imposed, which are of two types:

(a) Permanent Speed Restrictions - These speed restrictions are the ones which are supposed to be for sufficiently long duration and are mentioned in the Working Time Table. Since copies of the Working Time Table are available with the train crew, no other intimation is required to be given to them on day to day basis. The time which the trains are expected to lose in observing its estrictions is built into the running time and is time tabled accordingly. These restrictions last the currency of a timetable and are reviewed at the time of revision in the timetable.

(b) Temporary Speed Restrictions - A number of speed restrictions may have to be imposed for a short duration either on account of defects in track and related equipment or to facilitate repairs to the track and OHE and signalling installations. Requirement of time for such repairs is assessed well in time before a new timetable is introduced and this time is separately provided for in the timetable and is called 'Engineering Allowance' (EA). This time is also provided in the timetable short of junction stations or at the divisional/zonal interchange points. If there are repair works elsewhere on the section, trains would run late and this would be adjusted before the junction interchange points.

Minimum Running Time

This is the time, which a train should take between two stations when running at maximum permissible speed. This is calculated taking into consideration the permanent speed restrictions that may be in force from time to time in the concerned sections. This would be different for different trains and the driver is in no case permitted to take less than the minimum running time relevant to his train. Guards of the trains and Section Controller keep a watch on this aspect so that in case of overspeeding by the drivers, they may take steps to check them.

Normal Running Time

This time is based on the booked speed of the train and is generally about 10% more than the minimum running time. The driver is expected to run faster to the minimum running time when running late and is expected to make up time.
As stated above now this difference in running times has been done away with and trains are expected to adhere to one set of running times only.

Calculation of Running Time

Calculation of running time is based on a number of factors, viz.:

(a) Distance between the two stations
(b) Hauling power of the locomotive
(c) Load of the train
(d) Permissible speeds
(e) Permanent speed restrictions
(f) Gradients and curves
(g) Time required for acceleration and deceleration.

This time is calculated with the help of computer by RDSO and is further validated through trials.

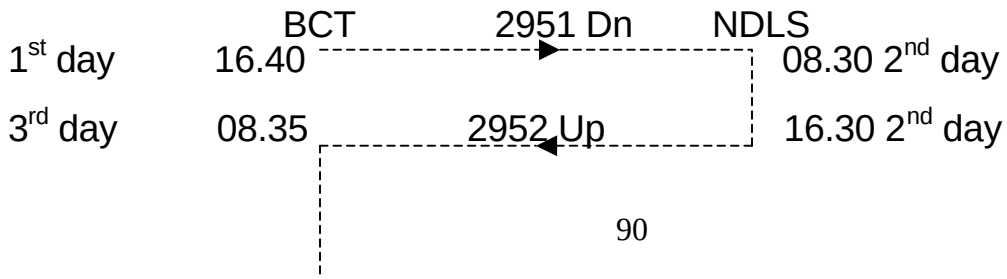
Authorized Detentions

This is a time for which a train can be detained at a junction station to wait for another train running late in order to facilitate passengers to maintain connections at the junction stations, some trains can be detained for a specific period, after this detention the train can give connection to another nominated train so that undue hardship to the passengers is not caused. These are, however, the outer limits and connecting train cannot be detained, if it is not likely to connect the trains to be connected within the prescribed limit. This is given in the Working Time Table.

Rake Links

Every train has certain specific set of coaches in a definite formation, which is called a rake'. This standardization is necessary to ensure the same type and level of accommodation not only for the guidance of passengers but also for the convenience of management. Since run of a train to the destination and back may take much time to permit the service to be run next day, there is a need for more than one rake. A number of rakes are, therefore, linked together in such a way that one rake is available at either end to run the service as per the schedule. There may be certain trains, which are single rake trains, and these trains are so scheduled as to run whenever the rake becomes available at either of the terminals. If it is a short distance train, it maybe possible to run the train on daily basis with single rake. However, if it is long distance trains, frequency of the trains will get influenced by the availability of the rakes. If long distance trains are to be run, more frequency than permitted by the single rake, additional rakes have to be introduced in to the circuit, which work in links. This is what we call a rake line. A simple example of a rake line is given below:

Rake Link:-



3rd day 16.40 → Repeat as 2951 Dn

Number of Rakes Required - 2
Primary Maintenance at BCT
Secondary maintenance at NDLS

Goods Train Operation

Goods train operations are inherently more complex than passenger operations for a variety of reasons. Freight operations involve supply of empty wagons for loading of traffic, picking up and collection of loaded wagons from goods sheds and sidings, grouping of loads and formation of trains for varying distances in marshalling yards, arrangement of locomotive and crew, and constant monitoring of the movement of trains of loaded wagons as well as empties right up to the destination. The demands of traffic fluctuate from place to place, day to day at the same place and at different seasons of the year, depending on production which itself is subject to fluctuation owing to weather, consumption patterns, market variations, and sources of supply, labour problems and a host of other factors. The Railways deal with a huge variety of articles, raw material, finished products, packed goods, dangerous goods, livestock and over dimensional consignments. Such a large variety requires different types of wagons for transport, demand for which will fluctuate according to varying patterns.

For this reason it is not generally possible to run goods trains to a fixed schedule or time table as is the case with passenger trains. A goods train which is planned, hence does not automatically run to fixed timings but has to be specially 'ordered' or 'arranged'. Difference between passenger and goods trains in this regard is that crew and locomotives for passenger trains become available on the basis of links, those have to be specially ordered by the control office for goods trains. The conditions required for running of goods trains are availability of:

1. Sufficient load in the yard or at goods shed or in siding and feasibility of train formation in time
2. Power
3. Crew & Guard
4. Path

The running of a goods train depends on three organizations:

1. The marshalling yard or siding which forms the train
2. The loco shed which arranges locomotives
3. The control office which arranges and supervises the movement

The Dy. Chief Controller in charge of goods operation is responsible for ordering goods trains in close coordination with the Power Controller, Traction Loco Controller and the Marshalling Yard/sidings etc.

The provision of power and loco crew is the responsibility of the Power Controller from the mechanical/electrical department as the case may be.

Both diesel and electric locomotives do not require frequent maintenance unlike steam locos in use earlier, and can operate over a very large range of territory, it is not economical to allot or base locomotives at individual sheds in each division, as a single centrally located shed can easily meet the maintenance needs of a large territory. In their case, therefore, based on the outward and return runs plus allowance for detentions at yards at each end of the run, the turn round time is

worked out and each division is allotted a number of engine hours, depending on the total number of services to be run. It is the responsibility of the Maintenance department to ensure availability of locomotives up to this level, and of the Operating department to ensure optimum utilization of locomotives so made available.

Wagon Usage - The wagon is the main earning asset of the railway; but it fetches earning only when loaded and moving. Therefore, every effort must be made to load as many wagons as possible and to keep the fleet mobile. Therefore, for a given daily level of loading of wagons that Division or Railway is more efficient which is able to manage with a lesser number of wagons plying on the Division or its 'wagon holding' or 'wagon balance', is an important index of the efficiency of operations of a Division or Railway. However, a difficulty will immediately become apparent, viz. that if a Division were to load a large number of wagons for destinations outside its own jurisdiction, very soon it would run out of wagons. Such a difficulty was faced from the very beginning when companies owned their own wagons. In the beginning, individual companies accepted booking of goods only for stations on their own jurisdiction. The customer was required to 'release' the wagon and arrange a fresh booking over the next railway company's jurisdiction. Obviously, this was a very cumbersome and expensive process and soon enough arrangements were evolved between companies to allow through movement or "interchange or wagons". These arrangements were regulated through the Indian Railway Conference Association. To prevent misuse of wagons by destination railways by detaining the wagons on their own systems for their own local loading, they were required to pay:

1. A per day hire charge for the duration that a wagon would remain on their system for transit to destination land back to the owning railway;
2. If the wagon was detained beyond this period, a penalty charge at a sharply increased rate was levied.

Wagons now move freely between different zonal railways in India. But the above system of 'hire charges' is still prevalent between India and Pakistan/Bangladesh to a limited extent.

Pooled and Non-Pooled Wagons

As various railway companies had evolved their own wagon designs, a wagon of lone railway system might not be considered safe or up to the standard by another railway company. To get over this difficulty, the IRCA evolved a system of examination of wagons at inter-change points by its own train examination staff, which system came to be known as "neutral train examination". Such wagons as conformed to a standard design and were considered fit to move freely between one railway and another were taken into the common "wagon pool". Special types of wagon meant to carry special cargo on a particular railway or wagons not conforming to the standard design were called "non pooled" and when loaded to an adjacent railway, were required to be returned immediately to the owning railway by the shortest route. Gradually the vast majority of wagons came to be "pooled".

There was yet another category of wagons which might be of low capacity or of very old construction and maintenance not up to accepted standard which could only be used for specific internal movement within each railway and were known as "local traffic wagons". Such wagons were not acceptable in interchange.

The exchange of wagons at terminal junctions between one railway and another thus enables free movement of goods through to destination irrespective of the jurisdiction on which the originating and terminating stations might lie. With the nationalization of railways, the coordinating role of the IRCA has gradually been taken over by the Railway Board.

The working of the wagon pool may be compared to a bank advancing capital to a business. Each Railway contributes its own wagons to the pool, which might be considered as equivalent to depositors keeping their money in bank accounts. In turn, each railway is authorized to draw out of the pool up to a certain number of wagons, depending upon its loading targets and the 'turn round time'; somewhat like the limit up to which a bank may allow an advance to a business firm. For this reason, as with the business firm's advance from the bank, the receipt of additional wagons from other railways through interchange, which adds to the wagon balance of the railways, is considered an additional loan from the pool and is accounted as a debit transaction, while the handing over or making over of wagons to another railway, which reduces the wagon balance, is considered as return of loan to the pool and is a credit transaction. Wagon holding beyond the target may be considered as so much not borrowing of wagons from the pool, and the objective must, therefore, be to achieve the targeted loading with as little borrowing as possible.

The Railway Board, by watching the wagon balance and the movement of broad streams of traffic through important interchange points can readily feel the pulse of operation and regulate it as necessary. That is why the fulfillment of interchange quotas between Railways is considered one of the most important operating performance indices. In a similar manner, interchange targets and wagon balance targets are set and monitored for each division.

Goods Train Speeds

Just as in the case of passenger operations, punctuality is considered the index of efficiency so in the case of goods operations speed is the index of efficiency, as better speed of goods trains means better utilization of both of locomotives and wagons and also economic utilization of running staff. The essential pre-requisites for better running speed are right time start of goods trains from originating yards/sidings and running the train to path.

Wagon Turn Round

The availability of wagons for loading will depend on the speed with which wagons once loaded can be made available again for loading. This is referred to as "wagon turn round", which is one of the common measures of efficient utilization of wagons. Wagon turn round is defined as the "interval in dates between two successive utilizations of a wagon". A simple formula for calculating wagon turn round is as follows:

$$T = \frac{B}{L+R}$$

Where, T is wagon turn round

B is effective daily average wagon balance

L is the daily average number of wagons loaded
R is daily average loaded wagons received
Thus, if a division has an effective holding of 6000 wagons with 400 wagons per day originating loading and 200 loaded wagons received from other divisions, the wagon turn round will be:

$$\frac{6000}{400+200} = 10 \text{ days}$$

Therefore, the turn round improves when loading and loaded receipts increase, and deteriorates when loading and loaded receipts come down; as for example, by increased intake and movement of empties, this latter factor is not significantly under the control of a division and, therefore, an increase in empty movement may lead to a deterioration in wagon turn round although the division may be functioning efficiently. Wagon turn round, therefore, is not a very reliable indicator of wagon utilization, but the simplicity of the concept and its calculation make it a convenient, if somewhat incomplete management tool.

More reliable and comprehensive indices of wagon utilization are the following:

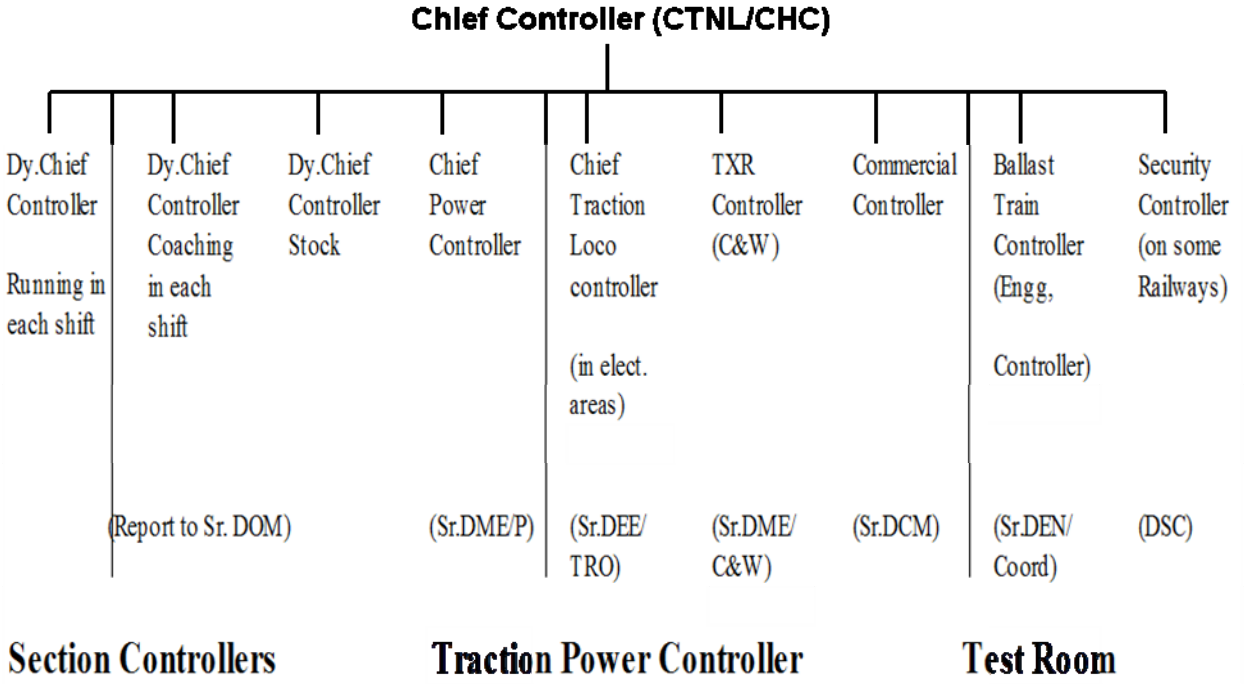
1. Wagons per wagon day, which is a mobility index.
2. Tonne kms. per wagon day, which is the index of the work done. This may be expressed either as gross tonne kms (GTKM) per wagon day, a figure that includes both wagon tare weight and pay load, or as net tonne kms (NTKM) per wagon day in which only pay load is counted.

Operating Control Organization & Functions

The purpose of Control

As an organization develops and becomes more complex, the need for coordination between its various units becomes more urgent. The Control organization is one of the principal means by which this essential coordination is obtained in railway operation. Position of the Control officer in the railway organization can be compared with that of the brain in human body. Just like the brain, it guides all operations on the railway.

Organization of a Divisional Operating Control



The Functions of Control

The complete operation, passenger as well as goods on a division or part of a division in every aspect is in the hands of the Control. This involves:

the systematic timing, working and loading of all trains both goods and passenger;

2. the correct ordering and use of locomotive so as to reduce to a minimum the productive time of power and personnel, and losses on account of wasted haulage capacity on trains and thus to keep the "turn round" as low as possible;

3. to so distribute coaching and goods stock and direct its loading, despatch, and movement, particularly through intermediate marshalling yards, and to so direct its placement and quick release so as to attain the quickest possible "turn round";

4. To keep in the closest touch with the operation of continuous sections and divisions so as to avoid congestion and lack of fluidity;

5. from experience gained, to suggest improvements and to eliminate conditions that lead to congestion;

6. To settle promptly and wherever possible without recourse to correspondence, questions of irregularities and to educate and assist stations in correct methods;
7. To provide a continuous supervision by a central competent authority over the entire operation including:
   (a) Running of and working of engines both train and shunting;
   (b) Working of all trains generally;
   (c) Distribution and movement of rolling stock;
   (d) Arrangement, imposition and removal of engineering blocks and allied restrictions;
   (e) Duty hours of running staff;
   (f) Operation of terminals and junctions including yard shunting
   (g) Prompt and economical movement of rakes/piecemeal stock.
8. To provide an impulse of human energy and brain power throughout the section and by coordination and direction ensure the free movement of traffic and thereby obtain the maximum output from each unit involved at the minimum cost to the administration.

The function of the Control office may, for the purpose of understanding be conveniently classified under the heading of planning, execution and review, though in practice, of course, all three activities would be going on simultaneously.

Planning

1. Forecast of interchange;
2. Forecast of train to be run section wise
3. Forecast of supply of empties for bulk loading transhipment, etc.;
4. Forecast of unloading;
5. Planning for engineering blocks and special moves.

Information required for this purpose:

1. Power availability
2. Availability of loads
3. Disposition of empties and planning for loading
4. Analysis of midnight divisional wagon balance

The plan is made by CTNL daily at 0800 hrs. and reviewed by Sr.DOM and HQ is informed by 1000 hrs. both immediate and antecedent, for taking remedial action to prevent their recurrence.

Execution

The day's plan is to be executed by yards, loco sheds, TXR depots, transhipment supervisors, area controls, SMs and must, therefore, be communicated to them as soon as it is finalized.

Instructions are given in the course of the morning conference, modified as necessary after conference with the HQ. The performance is reviewed once at 1600 hrs. and briefly at night.

Review

Objectives:

1. Analyzing shortfalls of previous day to take remedial measures and pin point weak spots;
2. Provide basic data for planning for current day.

The following are the main features of the previous day's performance which are reviewed:

* interchange
* Divisional wagon balance
* Train running
* Disposition of empties
* Particulars of stabled loads
* Yard balances
* Unloading on division
* Registrations and loading
* Transhipment performance
* Punctuality
* Power utilization
* Sick line working
* Accidents, unusual occurrences
* Special type stock
* Crane wagons (heavy lift)

H.Q. Role

The operations of the division require close coordination with and assistance from other divisions and railways. While close direct contact is maintained with neighboring divisions, the conference with HQ is the principal means of achieving coordination, particularly with reference to:

1. Level of interchange between divisions and adjoining railways;
2. Loco holdings on different divisions;
3. Pinpointing excessive balances, hold ups, providing assistance to clear extra power, regulation, imposing quotas and restrictions;
4. Advising traffic in sight from other railways/divisions.

While primarily an operating instrument, Control can and should be of immense value to other departments, e.g.

Commercial department - It can be of considerable help in tracing missing consignments and in the connection of unconnected consignments; expediting the quick disposal of wagons detached out of course for such reasons as broken seals, hot axle, etc., in quickening the release of wagons by ensuring adequate labour at goods sheds and transhipment points for prompt release of wagons, and for balancing the supply of tarpaulins (wagon sheets) when loading general goods in open wagons. It can also be used for the census of passenger trains, to ensure a high standard of service to the public.

Engineering department - By regulating and planning the working of ballast trains and Engineering blocks, it can do much to save waste of labour and ballast train time, while by conveying prompt information to the persons concerned regarding patches of track needing immediate attention it can make for safety of working and expedite such action thus minimizing dislocation of traffic. Prompt release and loading of wagons by departmental users is also watched.

Loco department - By effective control over the distribution of fuel to various sheds and by an economic utilization of loco power it can do much.

C&W department - Role of C&W department is in maintaining proper health of coaches and wagons. For this purpose, there are sick lines and carriage depots available on the division. Their performance and problems are monitored by the Control office located in the divisional office. C&W controller keeps the Sr. DME informed of any problems arising in the maintenance from time to time so that timely decision can be taken at the appropriate level.

There are detachments of coaches and wagons from running trains at road side stations. C&W controller keeps a watch on them, not only for prompt attendance to them but also for preventing such out of course detachment in future.

Similarly it keeps a watch on the running of 'close circuit' rakes and other rakes like 'Premium Train Examination' rakes so that their integrity does not get impaired and the kilometer-logging is up-to-date.

Signal & Telecommunication department - Failures of signals, block instruments etc., can cause loss of punctuality and efficiency on the railway. Control office watches these developments like a hawk. Though no separate controller for this purpose is posted in Control offices, one of the Signal Inspectors in the divisional office keeps liaison in the Control. Control officers maintain a register where defects of signals reported by drivers are recorded so that prompt action to rectify them can be initiated.

The very function of Control office depends on the functions of telecommunication network on the division. We have telecommunication staff posted in Control offices round the clock, and who are part of the Control organization, for keeping a watch on the functioning.

Security - Law and order and indiscriminate use of alarm chain apparatus are watched closely in Control offices. In areas where such problems exist, we have RPF staff also posted in the Control offices to keep liaison with their out posts.

Stores - Expeditious movement of railway materials is essential for the efficient functioning of all the departments. At certain control offices, therefore, we have Stores chasers who watch the movement of stores delivery vans, keeping liaison not only with their staff but also the consignee for whom material is carried in these vans.

Marshalling Yards

A marshalling yard is a place where goods trains originate and terminate. Goods wagons, loaded and empty, arriving from different directions are sorted out and classified according to a plan so as to enable fresh trains to be formed with optimum load for the locomotive and running of goods wagons in full loads or large blocks through to destination or to the farthest possible common point. The need for marshalling yards, of course, arises from the fact that on the railways the unit of movement, which is the train, is much larger than the unit of booking which could typically be even a wagon and, therefore, facilities for consolidating the wagons together into train as well as for breaking up trains and sorting out into individual wagons become essential. This situation has, however, undergone a material change now due to more and more running and loading of rake-load traffic.

Marshalling yards are an important part of the goods operations scheme and, in fact, the predominant proportion of total wagon time may in some cases be spent not on trains but in marshalling yards. That is why the marshalling yards are even referred to as 'necessary evil' which, if not properly worked can easily become a 'graveyard' for wagons. The yards are normally located at the following types of places:

1. Junction routes
2. Junction of gauges
3. Major ports
4. Major industrial complexes
5. Collieries

Marshalling yards may be hump yards or flat yards. In India on the M.G. only flat yards are permitted, and on the B.G. also by far the most numerous are the flat yards. A hump yard is one wherein an artificial gradient, shaped like a camel's hump, is introduced on the shunting neck so that wagons pushed up to the crest of the hump by a shunting engine can free run down on the other side, and can be sent into separate lines or sorting sidings by operation of the relevant points as the wagons are moving. This enables a hump yard to handle or sort out a vastly increased number of wagons. Thus under Indian conditions, whereas a flat yard with a single shunting neck can handle about 400 to 500 wagons a day, a hump yard can handle more than 1500 to 1600 wagons per day. However, the speed picked up by a wagon while rolling down the hump into the sorting sidings necessitates special arrangements for braking of the wagons to prevent damage because of excessive impact. This is the reason why hump yards were not permitted on the M.G. where the existing wagon design was unable to take heavy impact.

The main functions of the marshalling yards may be summarized as under:

1. To pass through trains after changing engines or crew,TXR examination, detach sick wagons, if any, and adjust the load of the train, if necessary, according to the maximum permissible on the next engine run;

2. To sort out terminating trains and local loads originating in the yards;

3. To form originating through trains for farthest point possible or farthest destination possible in accordance with marshalling orders laid down by the HQ office;

4. To form shunting goods trains for different sections served by the yards, including suburban sections, if any;

5. To hold back trains and wagons till they are able to be got out;

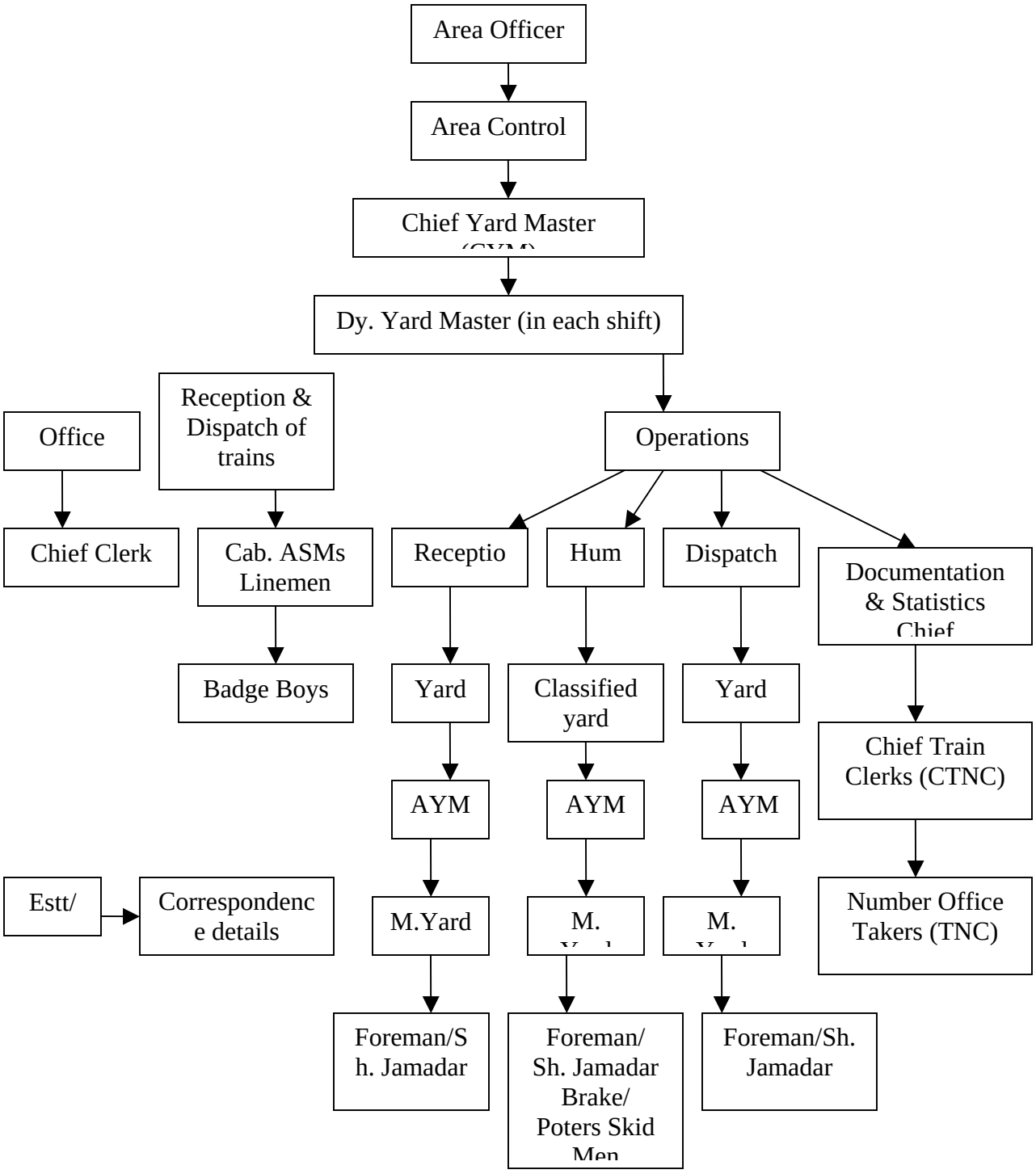
6. To move train engine and shunting engine/pilot between yards and loco sheds;

To place and withdraw wagons from various points in the local area such as goods sheds, sick lines, transhipment shed and departmental sidings, industrial sidings, etc.

A large marshalling yard consists of reception yard, classification yard and despatch yard and also facilities for bypassing through trains. A loco shed, sick line, various sidings, goodshed, transhipment shed and grid yard for formation of shunting trains are also indicated. A yard of this type wherein wagons enter at one end and progress forward in one direction from stage to stage until departure is called a uniflow yard. The layout indicates that trains from both, up and down directions, can be dealt with in this yard. That is why it may be called a 'single yard'. It is also possible to have separate yards for receiving UP trains and DOWN trains as is the case, for example, at Mughalsarai or Baroda.

Organization and working - A large yard may handle up to 3000 and more wagons per day. It is, therefore, increasingly becoming the practice to place the bigger yards under the direct supervision of a junior or senior scale officer who is called 'Area Officer'. Although the officer directly controls only the Operating staff, he is also given the responsibility of coordinating the functions of various departments working in the yard - commercial, carriage & wagon, loco, signal and telecommunication, electrical, security and civil engineering - who are all contributing directly or indirectly to the functioning of the yard.

An organization chart of the Operating staff in a large yard is given below:-


Area Officer
Area Control
Chief Yard Master
Dy. Yard Master (in each shift)
Office
Reception & Dispatch of trains
Operations
Chief Clerk
Cab. ASMs Linemen
Receptio
Hum
Dispatch
Documentation & Statistics Chief
Badge Boys
Yard
Classified yard
Yard
Chief Train Clerks (CTNC)
AYM
AYM
AYM
Estt/
Correspondence details
M.Yard
Number Office Takers (TNC)
Foreman/Sh. Jamadar
Foreman/ Sh. Jamadar Brake/ Poters Skid Men
Foreman/Sh. Jamadar

Evaluation

The principal statistical indices for evaluating marshalling yard operations are of two types viz. volume and efficiency. The reporting period for marshalling yard operational statistics is usually the calendar month.

The volume of work done is assessed from the number of trains received, number of trains despatched, the number of wagons received, the number of wagons despatched and number of wagons dealt with.

The efficiency of operation is known through the average detention to wagons, which figure may be further taken down indicating detention to through wagons, local wagons and empties. Other indices are the number of wagons dealt with per shunting engine hour, the percentage of right time starts, the percentage of mismarshalled loads originating, the cost of damage to wagons, occupation of line in reception and despatch yards, detention to trains at adjoining stations for reception, intensity of utilization of hump and cost per wagon etc.

Line Capacity and Throughput

There is a limit to the number of trains that can be run on a section. The total number of trains that can be run during a period of 24 hours on a section is called 'Line Capacity of the Section'. For a single line section, this is calculated as number of trains that can be run each way during this time period. On double line sections, this capacity is worked out for both directions separately.

There are a number of block sections on a section. Capacity of the block section on which trains take maximum time is reckoned for the purpose of the capacity of the section. This block section is called the 'Critical Block Section'. The number of trains that can run through this Critical Block Section can also run through the entire section.

A train takes some amount of time to run between two block stations. This is called 'Running Time of the Train'. In addition to this time, there is a little more time required for the purpose of closing the section by normalizing the signals and points behind the train, closing the block section by giving 'Train Out of Section' report to the station in the rear, granting/receiving line clear for the subsequent train, setting of route and taking 'off' signals, etc., before the subsequent train can start. With token working this time is taken as 5''. This additional time is called 'Block Operation Time'. For calculating line capacity of a section, total time of 24 hours is divided by running time of the slowest train over the Critical Block Section plus Block Operation Time.

The simplest formula for this purpose is Scott's formula, which is as under:
Scott's Formula

$$C = \frac{1440}{T + t} \times E \times \frac{1}{2}$$

Where
C = the line capacity
T = running time of the slowest train over critical block section
t = block operation time
E = efficiency factor (80)

Calculation of line capacity on the basis of above formula takes into consideration the slowest train on the section which would generally be a goods train. The very purpose of calculating line capacity is to find out the number of goods trains, as the number of passenger trains is already known. Ex-GIP Railway, therefore, refined this formula further and calculated the available capacity for running of goods trains. In this formula, the total time consumed in running of passenger train is deducted from the total time available and it is calculated how many goods trains can be run in the remaining time.

This formula is as under:

$$Cg = \frac{1440 - (Tp + t)}{Tg + t} \times K \times \frac{1}{2}$$

K = 50%

In this formula, efficiency factor (K) is taken as 50% as a number of gaps between passenger trains may not be usable for running of goods trains.

Since provision of line capacity is a very costly proposition, Railway Management has been conducting continuous research in this subject. South Eastern Railway had once employed one American Consultant to suggest more accurate formula for working out line capacity. This formula is known as Steinbeck's Formula, which is as under:

Steinbeck's Formula

$$C = \frac{1440}{S} \times Y$$

Where S = Ta + Tb + O + W

Ta = running time on 'a' side

Tb = running time on 'b' side

O = Block operating time for two trains

W = Waiting time for the next train

Y = Efficiency factor (70)

All these formulae are, however, theoretical and do not take into consideration the physical features over the entire section. Indian Railways, therefore, adopt Charting Method which is the most practical way of assessing line capacity. For this purpose, running of trains is plotted on the time distance graph relating to the section for which the capacity is to be calculated. To begin with, time of all 'scheduled trains' are plotted on the graph and in the gaps between different scheduled passenger trains as many goods trains are inserted as are viable thereby giving the maximum line capacity.

To provide for operating irregularities, incidents and delays, 'Time Allowances' gaps between the line occupation times are inserted. The minimum permissible time allowance is known as 'Tolerance'. The greater the tolerance, the easier it becomes to confine the detrimental effect of irregularities to a smaller number of trains. The adoption of smaller tolerance may increase the capacity of the line, but it will also reduce the prospects of adhering to the schedules. Tolerance provided on various railway systems vary from 0-5 minutes to 10-15 minutes, no guidelines exist on Indian Railways for this purpose.

(a) Maximum Line Capacity is the maximum number of trains that can be theoretically run on a section so that it is impossible to introduce even a single extra train.

(b) Practical Line Capacity is the number of trains per day, which is obtained from the above mentioned maximum line capacity after allowing for time required for maintenance of P. Way, time margins for scheduling any other operational necessities etc. Train scheduling is generally based upon this express of line capacity.

(c) Economic Line Capacity is the number of trains, which can be run at the least cost per train. When line capacity is under-utilized, increase in train services at first follows the law of increasing returns due to more intensive utilization of fixed assets. However, as the number of trains on a section grows larger and larger and the section gets saturated, it becomes more and more difficult to increase train services without

adversely affecting the utilization of rolling stock and train crew and maintenance of track.

Augmenting Line Capacity

As the traffic increases, we have to run more trains, which necessitates augmenting the line capacity. Since the capacity works are very costly, careful planning is necessary to ensure that capacity is created as required. There should neither be wastage of capacity nor should the traffic be required to suffer for want of adequate capacity. Line capacity proposals are, therefore, preceded by detailed studies of the future traffic requirements and various alternatives are carefully evaluated so that most economical methods for increasing line capacity can be adopted.

Bulk route kilometerage is on single line. The capacity of the single line section is augmented by improvement in both 'T' as well as 't' of the Scott's formula. There can be improvements in 'E' also.

'T' may be reduced by:

(a) Reducing length of block section by providing additional crossing and passing stations;

(b) Increasing speeds of trains by improvements in mode of traction, track, and rolling stock and signalling.

'T may be reduced by:

(a) Higher standards of interlocking;

(b) Token less block instruments

(c) Panel interlocking;

(d) CTC and automatic signalling etc.

'E' is affected by time tabling, staff efficiency, upkeep of equipment, efficient operation of terminals, adequate number of loop lines, total length of the section, spacing of block posts/stations etc.

The following sequence may be useful for improving efficiency:

(a) Time tabling - run trains with similar speed characteristics together to reduce 'speed spread', avoid mixed traction, have directional running, tighten inter-sectional running times, punctual running; goods trains - link, crack and unit trains improve sectional trains;

(b) utilize motive power hauling capacity fully, utilize motive powerintensively;

(c) Simplify rules - certification of complete arrival, reminder caution orders;

(d) Training of staff

(e) Incentive to running staff

On double line sections, capacity can be increased by improving signalling, providing intermediate block signalling, automatic signalling etc. When the level of traffic further increases we have to resort to laying of a third line or quadrupling section, as the situation warrants.

Throughput

The ultimate objective of increasing the capacity of a section is to carry more traffic and not merely to increase running number of trains. A more reliable index of productivity is, therefore, throughput expressed as gross or net tonne kms per route

km per annum. In certain countries very heavy trains having a tonnage up to 30000 tonnes are run as compared to average train load of most of the trains on Indian Railways of about 3000 tonnes on B.G. We have also made a small beginning in running heavy trains on Gaya-Gaziabad section on Eastern/Northern Railways. These trains are 9200 tonne trains. There is, however, lot of difficulties in running trains having varying speeds and loads on the same section. We have passenger trains running up to a maximum permissible speed of 130 - 140 kmph. On the same section, goods trains run with a maximum speed of about 75 kmph or in some cases upto 100 kmph. A great deal of care has to be taken if heavier trains are run on the same sections where there is heavy passenger traffic.

Another difficulty in increasing loads of our goods trains is the screw coupling with which our conventional wagons are fitted. Screw coupling has a maximum draw bar capacity of 18 tonnes thereby giving a maximum possible trailing load up to 2400 tonnes on the level track. This gets further reduced on graded sections. Indian Railways have, therefore, switched over to CBC coupling having a draw bar strength of 80 tonnes which can take a trailing load of 7200 tonnes.

Capacity of loop lines is another factor. With our standard loop length of 686 meters, only 70 conventional wagons can be accommodated, giving a total tonnage of 2240 tonnes. BOX trains having 45 BOXs and a total load of 3600 tonnes can be accommodated on a standard loop line. This type of wagons were introduced in 1960s. Then, new type of box wagons called BOXN were introduced. Fifty eight of these wagons can be accommodated in a standard loop line, giving a total tonnage of about 4700 tonnes. More and more of this type of wagons are now in use to clear more and more traffic.

System of braking is another factor in increasing the trailing load. On automatic vacuum brake system, which used to be fitted on most of our rolling stock, braking distance for heavier trains was very long. We hence are increasingly using compressed air brake system which is very efficient and all BOXN/BCN wagons are fitted with air brake system. In addition to this, Rajdhani Expresses and most other important trains are also run on air brake system.

A new beginning has now been made by IR to increase the throughput of the section by resorting to what is known as increased axle-load. In this, those commodities which are dense, like ores, are permitted to be carried in excess of marked carrying capacities of the wagons, which is for average commodities. Introduction of this measure has paid rich dividends in increasing the throughput on various sections.

INFORMATION AND COMMUNICATION TECHNOLOGY APPLICATIONS IN TRAIN OPERATIONS

FOIS - FREIGHT OPERATIONS INFORMATION SYSTEM

The Indian Railways carries nearly 1000 million tonnes of freight in a year. This translates to about 5000 freight trains daily. Freight trains bring two thirds of the Indian Railway revenues and are referred to as the bread earners for the Railways. The major commodities carried by Indian Railways are Coal, Iron Ore, Foodgrains, Iron & Steel, Cement, Petroleum products, Fertilizer and Containerized Traffic. There are specialized wagons to handle the transportation needs of the different types of commodities. Unlike passenger carrying trains, freight trains do not run to a fixed schedule and thus making freight operations a highly information intensive activity. Based on this information managers make allocation decisions continually to dynamically optimize utilization of resources like wagons, locomotives, crew and paths on the network. Real time information allows good decision making and thus ensures high levels of mobility within the system.

The Freight Operations Information System (FOIS) was the first project which CRIS embarked upon. In fact the creation of CRIS is a by product of this effort in the mid eighties. FOIS began as an application to track and monitor the movement of wagons, locomotives and unit trains. Now it is a complete management module for freight trains handling the billing and revenue collections as well. It has played a major role in the improved wagon productivity on Indian Railways and the objective is to use the information to further improve productivity, customer service and thus meet the needs of a rapidly growing economy

FEATURES: Apart from monitoring the movement of freight trains, the system calculates freight and other charges based on complex rules of business and generates the Railway Receipt , the bill payable by the shipper. Today electronic collection of freight has reached an astounding figure of Rs 100 crores (US$ 20 million) per day. The system has the capability of tracking and tracing consignments and publication of information to the end users. To bring in greater transparency, Indian Railways have begun automatic allotment of rakes to customers for select commodities based on priority rules, operational restrictions, and commercial agreements. Services are provided to major customers by integrating FOIS with their legacy systems. It is capable of keeping record of asset ownership and maintenance, which is now being integrated to an SAP based asset maintenance management system. Most importantly, it also generates performance reports for terminals, train movements, asset use, financial statements and their trends over time that have been used for bringing about systemic improvements

CONTROL OFFICE APPLICATION: Train operations on the Indian Railways are controlled and monitored by the Control Rooms in each of the seventy seven divisional offices. The Control Room is the nerve center of the division. The fluidity of train movements over the jurisdiction of the division is dependent on the efficiency of

the Control Room operations. The Control office, by its very nature never shuts down and works all hours of the day and every day of the week. The Control Office Application has changed the way the trains are monitored as train movements are captured in real time and movement of scheduled and unscheduled trains planned and controlled through the computer aided interface.

The Control Office Application is the latest addition to train operations related IT applications. Along with Freight Operations Information System (FOIS), COA has led to all information on train operations being computer generated. It is this application that feeds the National Train Enquiry System (NTES) that provides passengers up to date information on train running. The objective of the Indian Railways is to further improve the operations by using technological aids that enable quicker data capture and intelligent applications that provide better planning and forecasting tools.

FEATURES: The application requires the controllers to enter data related to the train operations as they receive information from the control points or stations. The application charts the running of the train in a section (a portion of the divisional network) and also generates the advance forecast based on various operational parameters. The train is then virtually handed over to the adjacent division as per its physical movement to maintain continuous flow of information.

The key features of the application include the ability of the controller to order trains, view all possible routes, divert or re-route trains, if required. The application has the facility for capturing and viewing details of consist or composition of the train, details of the crew and locomotive. Reporting of unusual events is enabled through the user friendly interface. There is also a chart that shows details of line occupancy, caution orders, and abnormal working. One of the key elements of the application is the ability to forecast or extrapolate the running of trains which allows the controller to plan better. For managerial supervision the charts can be printed apart from the fact that structured MIS reports are also generated.

COA has been designed such as it can be integrated with any other application. The National Train Enquiry System (NTES), the Punctuality Analysis Module (PAM), and Freight Operations Information System are all integrated through an Enterprise Application Integration Software.

INTEGRATED COACH MANAGEMENT SYSTEM: Millions of passengers book their journeys everyday with the confidence that when their train rolls up on the appointed day, it would bring a coach which has place for them. To meet this expectation day in day out, Indian Railways need to track over 50 thousand coaches. By efficiently deploying the fleet, railways are able to run more services for the benefit of their passengers, while minimising any chances of disruption and disappointment. IR also must ensure that these assets receive timely servicing and maintenance. Depending upon the need, the system can deliver historical records from past years in printed reports, or up-to-the-minute information on an official's cell phone.

The Integrated Coach Management System does exactly all this and more. There are three modules that give a comprehensive view to the managers and facilitate quick identification of available resources and their allocation as per the requirements.

FEATURES: The COIS (Coaching Operations Information System) module of this application provides detailed, real-time information for planning, executing and

monitoring the operations of passenger services. Since the system is aware of the plans, it requires minimal data input. Even this input is easy because the users can literally drag and drop coaches in a virtual representation of their yards. Another module, called the CMM or Coach Maintenance Management module, has been developed to facilitate and record maintenance of coaches and the management of spare parts inventory. It is fully integrated with the operations modules for generating alerts, interchange of information, request for placement of rolling stock for repairs, delivery and acknowledgement of certification of coaches for service, etc.

The Punctuality Analysis & Monitoring (PAM) module of ICMS automatically picks up the delays from the Control Office Application (COA) and produces real-time insight into the state of the operations. The system provides consistent and accurate reports for all level of management, from the operative to the strategic. Since ICMS already has most of the related information, it is the natural place to also monitor and analyse the punctual running of trains.

SOFTWARE AIDED TRAIN SCHEDULING

Many people find it extremely fascinating to pore over the Railway time table, especially while undertaking a train journey. The route that the train traverses through, the stations en route both significant and lesser known ones, the timings and the stoppages - all these are part of the romance of train journeys. The time table is something like the compass was for the early traveller or the star studded night sky for the seafarer.

Creating a time table for trains on a busy network like the Indian Railways is an extremely challenging task. Planners on the Zonal Railways work independently and then collaboratively with other Zonal level planners to design the All India time table. The two main objectives are that it should be convenient to the passenger and feasible to run on the system. Introducing new train services and augmenting older ones is an art and a select group of planners are highly skilled in this task. Indian Railways decided to provide software tools to aid the planning process. The Software Aided Train Scheduling and Network Governance (SATSaNG) project is entrusted with the task of building such a tool. The entire resource allocation process will now be aided by the tool leading to more efficient allocations and robust time tables

FEATURES: Fixed Infrastructure Resources Module (FIRM)

The Infrastructure Module will have information on the fixed infrastructure and definitions required for assignment of train services. All information on tracks and signaling will be used to determine the appropriate definitions for conflict free assignment of fixed infrastructure resources. The user interface will include a view of the IR network map.

Rolling Assets Module (RoAM)

The rolling assets resources module will handle all the mobile resources, the rakes, the locomotive and the running staff. The rules for utilizing these resources will be handled within this module.

Scheduling Module for Allocation of Resources to Trains (SMART)

The Scheduling Module is at the heart of the Time Tabling software. This is the module where all the assignment of resources will be done. The resources will be

assigned to train services in a manner that there is no conflicting demand on the same resource and the entire allocation is consistent across all the resources. Publish Report and Exchange Supporting System (PRESS)

The publishing module will contain all the output from the scheduling module and publish it to the other applications like COA, ICMS, PRS, NTES, and CMS. This module will also be used to publish hard copies of the time table in the format specified by the user.

Capacity Module

The capacity module will take all passenger train schedules as fixed and can be used to identify potential freight paths. Further this module will have the capability of building in "what if" scenarios.

Simulation Module and Run Time Estimation Reports (SMaRTER)

The simulation module will contain three elements; the train performance or run time calculator, the sectional simulation tool and the terminal simulation tool.

Demand Evaluation Module to Assist in New Design of Services (DEMANDS)

The Demands Module will contain analysis of the data from the Passenger Reservation System (PRS) and Unreserved Ticketing System (UTS).

Latest status of these projects: AS ON OCTOBER 2012

APPLICATION	MODULE	STATUS
1 Freight Operations Information System (FOIS)	FOIS Phase-II (TMS Expansion	Non-device locations enabled under nodal concept, more than 99.9% RR's booked through TMS
	IREPG	E-Payment facility extended to a total of 620 customers.
	Automatic identification (RFID)	Detailed estimate for rollout prepared and submitted to NR
Control Office Application (COA)	COA	COA application is running in all 77 division/area control officers
Integrated Coaching Management System (ICMS)	Management System (ICMS) Coach Maintenance Module (CMM) pilot	Lucknow and New Delhi depot users are using the application. Hand holding by CRIS team
Software Aided Timetable Management System	SATSaNg/TTMS	Version 2.0 of SATSaNG application released. Data entry initiated.