Study for Safety Operation and Management of Railway in the Republic of Ghana

Workshop session 5; Rolling Stock

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Locomotive

- Only 7 out of 39 Locomotives are available.
- Main reasons for suspensions are shown below.

Series 2601 locos can't operate on current track conditions because of their heavy axle load.

Damaged in an accident

Heavy wear of tires

Passenger car

- Passenger cars are in an extremely bad condition because of corrosion and deterioration.
- Worker trains on the Western Line are operating without continuous brakes because the passenger cars are not equipped with brake shoes or brake hoses.

Passenger cars left neglected at Takoradi station

Cars in operation are also in bad condition

Freight wagon

- Only 91 out of 220 wagons are available.
  (43 manganese wagons and 48 bauxite wagons are available.)
- 70 new bauxite wagons will be procured soon. Meanwhile, many spare wheels for existing wagons have already arrived through Indian government support.

Continuous brake in use

Some wagons are used over the inspection period

Spare wheels have arrived from India

Workshop & Depot

- Many expensive facilities have been abandoned;
  Only indispensable facilities such as cranes, wheel lathes, etc. are maintained for use.
- Due to the lack of maintenance budget, they have a severe shortage of spare wheel sets and grease.

Many cars left derelict in the workshop

Maintenance facility in an unusable condition

Worn tires are reused by overlay welding

Which is older?

Ghanaian Locomotive
Introduced in
1996
(16 years old)

Japanese Locomotive
Introduced in
1977
(35 years old)

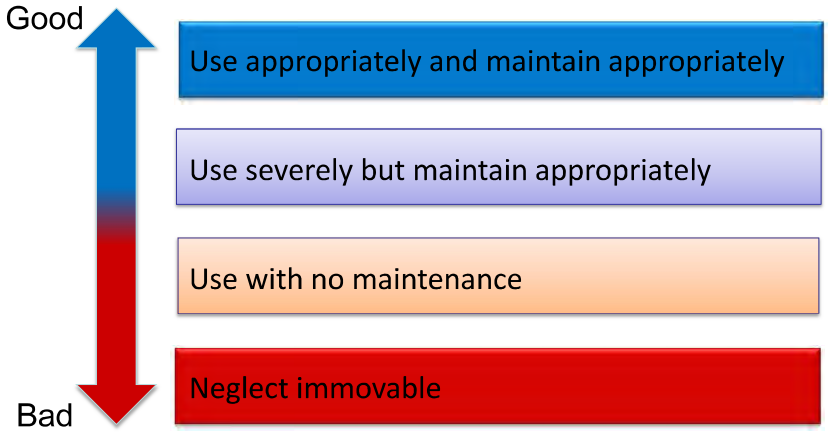
Which is older?

Ghanaian passenger car
Introduced in
1985
(27 years old)

Japanese passenger car
Introduced in
1973
(39 years old)

Importance of Maintenance

- Which is the current situation of Ghana Railway ?
  - Deterioration depends on not only usage but maintenance.



Importance of Maintenance

- Ghana railway has been trapped in a vicious cycle due to the extreme shortage of maintenance budget.

By operating on bad-conditioned rolling stock, deterioration of the track is also accelerated.

Operating on a bad-conditioned track, rolling stocks deteriorate faster.

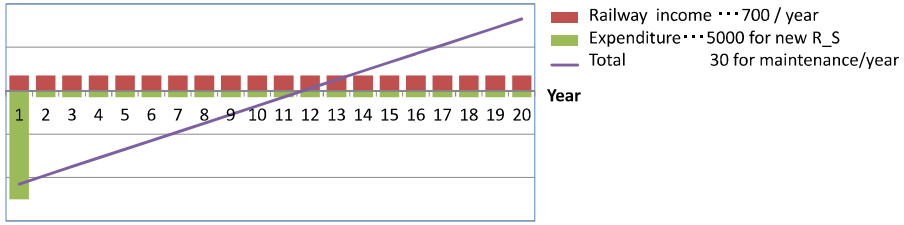
Serious accidents and suspension causes transportation income to reduce even more.

Since important parts and consumables cannot be purchased, less train operation results in less revenue & maintenance budged

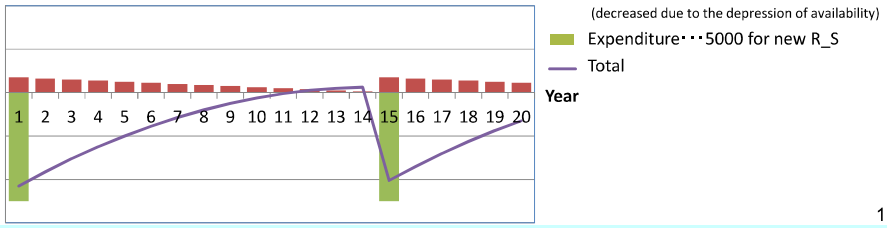
Rolling stock deterioration progresses dramatically due to neglect. Rolling stock will never recover.

Importance of Maintenance

- Maintenance pays after all.
  - With Maintenance



  - With No Maintenance



Importance of Maintenance

- **Maintenance consists of 3 M's factors and depends on 2 M's policies**

➢ **3M's Factors**

Man

Machine

Material

➢ **2M's Policies**

Money (Budged) & Management

- Ghana railway is low on expenditure for maintenance.
- Ghana railway needs efficient maintenance strategy.

Summary of current situation

Current situation

- Ghana railway is almost dying.
- Ghana railway has been trapped in a vicious cycle due to the extreme shortage of maintenance budget.
- Ghana railway needs to realize importance of maintenance for safety operation.

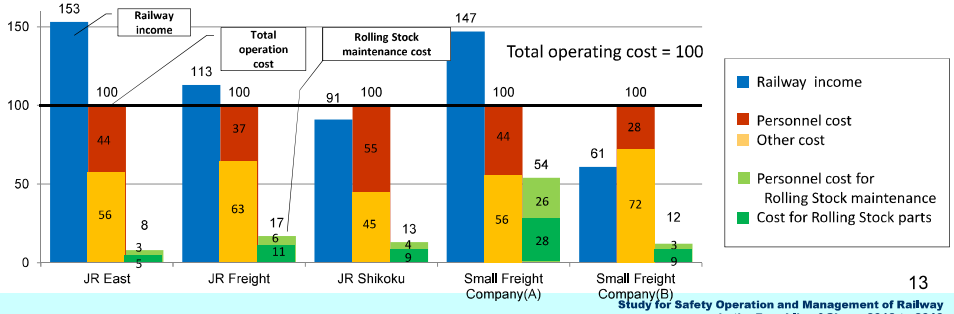
Key Issue

- Ghana railway needs to formulate the budged system which allocate appropriate expenditure for maintenance and operation.
- Ghana railway needs to develop an efficient maintenance strategy.

Rolling Stock Maintenance Cost

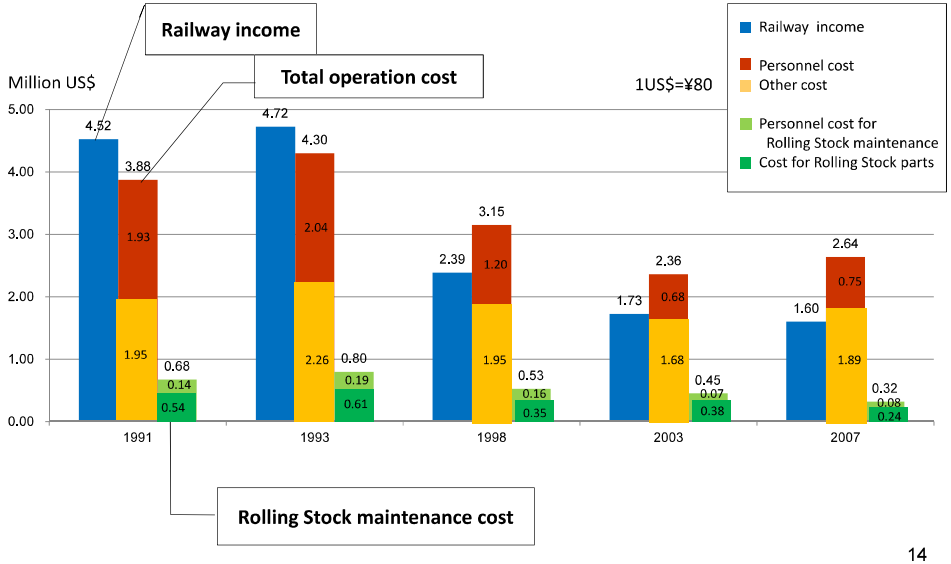
Maintenance Cost Ratio to Operation Cost (2007)

Company	Operation (km)	Railway Income (M$)	Total operating cost (M$)	Remarks
JR East	7,526	23,662	15,500	Largest passenger railway company in Japan
JR Freight	8,335	1,889	1,678	A freight railway company which operates throughout Japan
JR Shikoku	855	377	414	JR regional company in Shikoku island Non-electrified
Small Freight company (A)	4	2.04	1.39	Taiheiyo Coal Services& Transportaion CO.,LTD. Small coal railway
Small Freight company (B)	22.3	1.60	2.64	Kosaka Smelting & Refining Kosaka Line Small mine railway stopped operation in 2009



Rolling Stock Maintenance Cost

Small Freight (B) - Kosaka Line (1991-2007)



Key Issues for Ghana Railway

Effective Maintenance Strategy for Ghana Railway

- Prioritize the function of Ghana railways and formulate cost-effective maintenance considering the following elements
  - Stable income
  - Competitiveness versus road transport
  - Non excessive investment

- Retain Mineral Freight Transportation for securing a stable income
- Focus on the prevention of serious accidents, especially derailments occurring frequently

Target for Urgent Improvement Plan

■ **Main Fatal Railway Accident**
Collision, Derailment, Fire, Speed-over, Explosion
and Natural Disaster

■ **Provision for Railway accident**

- Infancy : the front half of 19th C :
  Build stable equipment against Breakage of rail, axel, boiler, etc.
- Developing stage: the latter half of 19th C
  Establish **Basic Safety systems,** Lock, Block, and Brake
  Institute Operation Rules and Develop Maintenance Technology
- Enrich stage/ 20th C
  Set up Back up system for Human Error
  * **Basic safety systems**
    - ➢ Lock : Interlocking a series of turnouts
    - ➢ Block : Blocking another train entering into a section
    - ➢ Brake : Braking equipment of Rolling stock

Selection of Key Technical Subject

■ Retain Mineral Freight Transport
- Target the minimum number of rolling stocks required for Minerals Freight Transportation including reserve cars

Series 1670 locomotives

Mineral Wagons

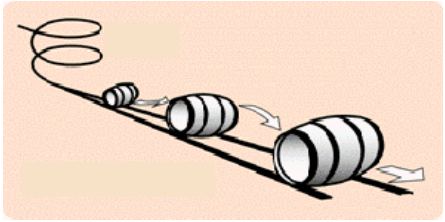
■ Focus on the Prevention of serious accident

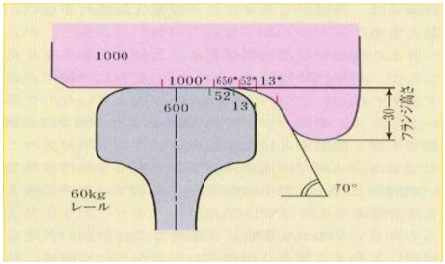
wheel set (Wheel & Axel)

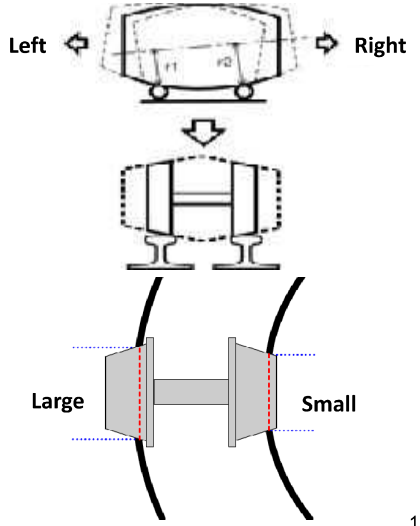
Brake system

Key Technical Subject : Wheel set

■ **Wheel profile is concerned with self-staring**

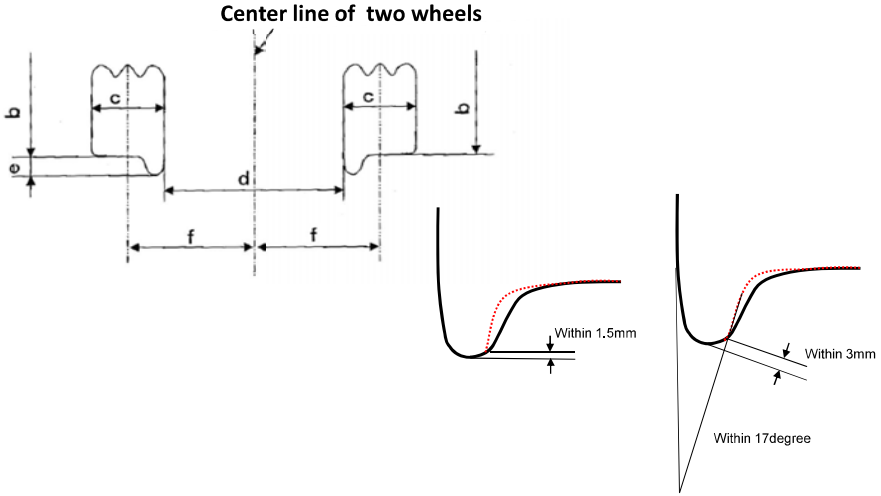






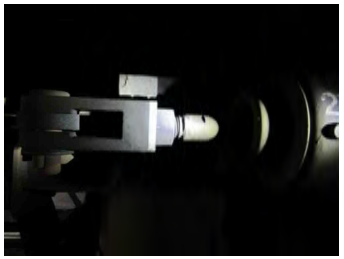
Key Technical Subject : Wheel set

Measures to be controlled



Key Technical Subject : Brake Test

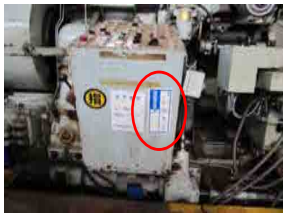
Brake Test before operation



Brake Test in Daily Inspection

Another Important Issue: Facilities Management

■ Keep Facilities in a good condition you can use anytime



Name tag, Responsible for Daily Maintenance

Daily Check List

Wheel Lathe Machine

Another Important Issue: Materials Management

■ Keep Materials in a good condition you can use anytime

Open shelf in a shed

Electric parts

Covered shelf in a field

Rubber parts

The first step of Maintenance

■ Typical Methods in Japanese Maintenance System

■ **The 5 S's**

- **整理(Seiri) : Sort**
  Eliminate all unnecessary things, and keep only essential items
- **整頓(Seiton): Set**
  Everything should be in its place.
  The place for each item should be clearly identified.
- **清掃(Seisou): Shine**
  Clean the work place and equipment, and keep it clean.
- **清潔(Seiketu): Standardize**
  Work practice should be consistent and standardized.
  Everyone should know exactly what his or her responsibilities are.
- **躾(Situke): Sustain**
  Maintain and review standard.
  Do not allow a gradual decline back to the old ways

■ **The 3 Fixed**

▪ **Fixed Position** ▪ **Fixed Item** ▪ **Fixed Quantity**

5 S's

- Sort
- Set
- Shine
- Standardize
- Sustain

The first step of Maintenance : Examples of 5 S's

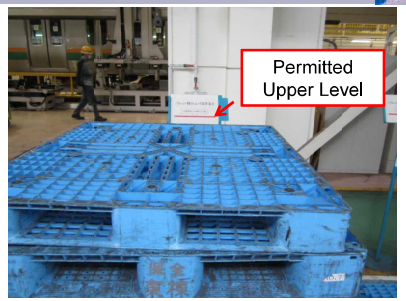


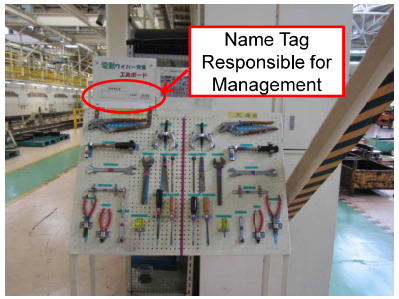

The first step of Maintenance : Examples of 3 Fixed

3 Fixed

- **Fixed Position**
- **Fixed Item**
- **Fixed Quantity**

The first step of Maintenance : Examples of 3 Fixed

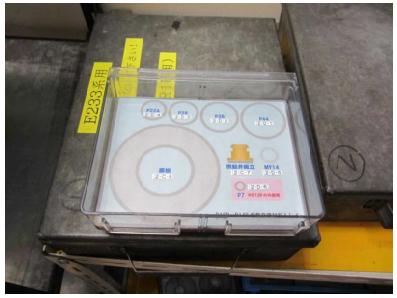





The first step of Maintenance : Examples of 3 Fixed



The first step of Maintenance : Examples of 3 Fixed



The first step of Maintenance : Examples of 3 Fixed

Summary

Current situation

- Maintenance is important for safety operation.
- Ghana railway has been trapped in a vicious cycle due to the extreme shortage of maintenance budget.
- Ghana railway needs an appropriate budged system and an efficient maintenance strategy.

Issues and measures

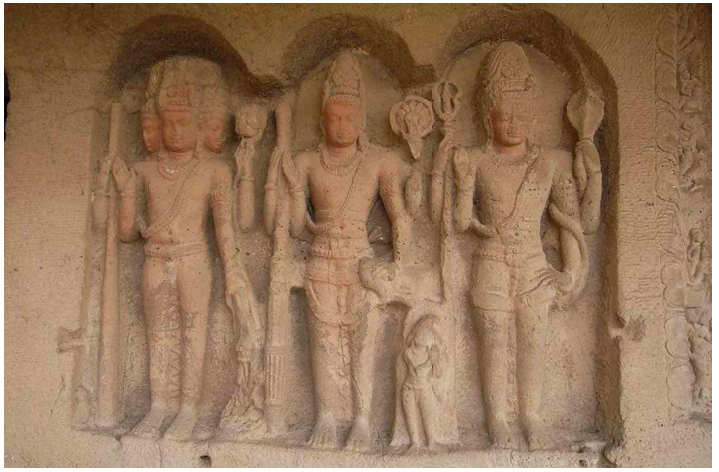
- Ghana railway should prioritize mineral freight transportation and focus on the prevention of serious accident
- Key technical subjects are ‘Wheel set’ and ‘Brake system’, targeting on series 1670 locos and mineral wagons.

Improvement Goals (as an urgent improvement plan)

- Improve maintenance methods about ‘Wheel set’ and ‘Brake system’.
- Retain mineral freight and sweep away serious accidents caused by rolling stocks

Trimurti : Three forms of Hindu

- **Vishnu is the Maintainer in Hinduism**



Vishnu: Maintainer

Brahma : Creator **Shiva: Destroyer**

at Ellora Caves

Indian Railways: Perspectives on Safety

Presented by:
Puneet Kumar, Group General Manager, RITES

27 September 2012

Agenda

- **Indian Railways & RITES Overview**
- Indian Railways Safety Perspective
- Preventive Maintenance – Diesel Locomotives
- Preventive Maintenance – Wagons
- Preventive Maintenance – Coaches
- RITES – Credentials

Indian Railways – Nation's Lifeline

Key Statistics for the Indian Railways

Parameter	#	Comments
Track length	64,460 route-km 114,000 track-km	One of the world's **longest railways**
Employees	1.33 million	Largest employer in India
Revenues	USD 19 billion	One of the largest railways
Daily freight loading	2.5 Mn tonnes	35% of national freight
Passengers	21 Mn daily	20% of market

- Indian Railways (IR) is not just large – it is also successful
  - IR has 230,000 wagons, 53,000 coaches, 9,200 locos & 7,000 stations
  - IR is a profitable organization despite India's low fare policy
- IR has a 159 year old legacy in India and caters to the bulk of the country's infrastructure requirements (unlike developed countries)

Indian Railways – System Performance

System Performance – Overview

#	Parameter	1950-51	2010-11	% increase
1	Route length (km)	53,596	64,460	20
2	Passengers originating (million)	1,284	7,651	496
3	**PKM (billion)**	**67**	**979**	**1,371**
4	Lead (km)	52	128	147
5	Freight originating (million tonnes)	93	922	891
6	**TKM (billion)**	**44**	**625**	**1,318**
7	Lead (km)	470	679	44
8	Locomotives	8,209	9,213	12
9	Coaching stock	19,628	53,220	171
10	Wagons	205,596	229,381	12
11	NTKM/wagon day	710	9,247	1,202

- **More than 13 fold increase in passengers and freight** with only marginal increase in network & rolling stock
- **Modernization, change of traction, concentration on trainload traffic, constant optimization** required to ensure successful performance

Indian Railways – Over the Years

Indian Railways – History

- Has 1½ centuries of development of systems , rules and technology from:
  - Steam to diesel to electric traction
  - Wooden to steel to CST 9 to pre-stressed concrete sleepers
  - Non interlocked to standard III interlocking to route relay interlocking to CTC
  - Copper wire fixed line communication to mobile telephony
  - Manual train control charting and reservation to the world's largest computerized passenger and freight system

Improvement in systems & rules spans entire gamut of railways

Indian Railways – Structure

Indian Railways – Key Characteristics

- IR is **entirely state owned** and managed under Ministry of Railways, Govt. of India
- It is divided into 16 territorial zones and further subdivided into 68 territorial divisions
- **Largely self sufficient** with a number of production units manufacturing locomotives, coaches, equipment, spares, etc – less than 4% of spares are imported
- Incorporates a number of training establishments and public sector units under its aegis
- **RITES – oldest of the PSUs – set up in 1974 for export of rail consultancy**

Rail Bhavan

RITES Bhavan

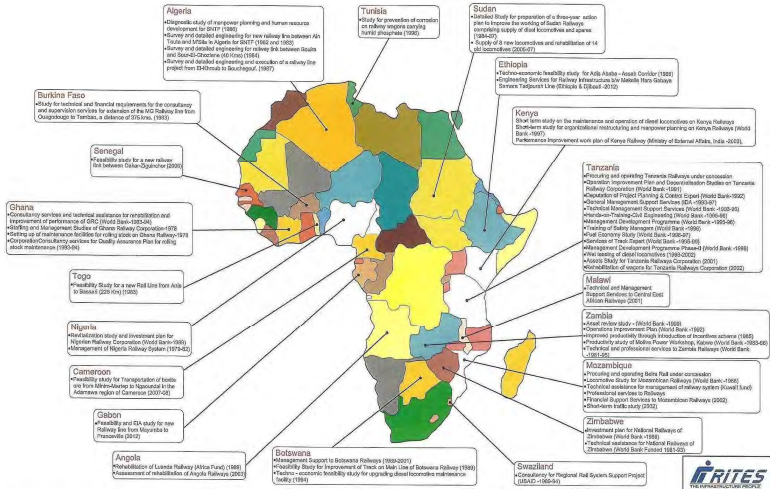
RITES

RITES – Overview

- **38 years of experience** of rail consultancy, both in India and abroad; owned by Ministry of Railways, Government of India
- Resource base of nearly 3,000 staff, including over 1,400 specialists of high professional standing in fields of engineering, maintenance, management, etc
- Specialises in providing **multidisciplinary consultancy and training in transport and infrastructure sectors**
- Worked with World Bank, African Development Bank, Asian Development Bank, UNIDO, UNDP
- ISO 9001-2008 accreditation
- **Operational experience in over 62 countries** in Africa, South East Asia, Europe, Middle east and Central and Latin America

RITES – Presence in Africa

RITES – Projects in Africa



Agenda

- Indian Railways & RITES Overview
- **Indian Railways Safety Perspective**
- Preventive Maintenance – Diesel Locomotives
- Preventive Maintenance – Wagons
- Preventive Maintenance – Coaches
- RITES – Credentials

Indian Railways – Safety

Safety Requirements and Dependencies

- Indian Railway operates a **vast and dense** network – 16,000 train runs daily sharing same set of tracks
- City networks are even more intense – e.g. **Mumbai** local train network
  - **Highest passenger density** of any urban system in the world
  - 2,500 daily trains carrying 7 million passengers average daily
  - 450 km of track covered

Safety is of paramount importance

- **Scope of safety**
  - Hardware: Fixed infra (S&T, tracks, OHE) & movable rolling infra (locos, wagons, coaches)
  - Software: Inspection systems, train running procedures, etc.
- **Safety Dependencies**
  - Working of railway staff
  - Discipline, rules and procedures
  - Track, rolling stock, signals, electrical equipment
  - Quality of spares
  - Quality of maintenance, etc.

Indian Railways – Key Drivers of Safety

Key Drivers for Safety in Indian Railways

1. **Signaling and Interlocking**
   - Archaic systems such as semaphore signals (1870), ball token system (1920)
   - Developed into **Modern Signaling System** with features such as route relay interlocking, centralized train control etc
2. **Communication Protocols**
   - From Morse Telegraphy to optical fibre based voice and data communication
   - Mobile Radio (between Guard & Driver)
   - Emergency Communication by Satellite Phones
3. **Track Development**
   - Shift to **modern tracks** – long welded rails; PSC sleepers with fasteners; and **modern maintenance methods** – use of track machines, portable accelerometers , track recording cars and similar sophisticated gadgets
4. **Rolling Stock Improvement**
   - Locomotives – ALCO, GM, ABB
   - Coaches & Wagons – 4W stock replaced by reliable and stable 8W stock; air brakes; standardization of maintenance facilities; preventive maintenance
5. **Human Resource Development**
   - Use of multiple modes/mechanisms to ensure development – lateral recruitment; trainings, aptitude tests, aligned key performance indicators and incentives

Indian Railways – Safety Organization

Safety Organization – Structure

Board Level
- **Chairman (Overseas Safety)**
- **Member Traffic (MT)**
- **Advisor/Safety**
- **5 Directors (Safety Directorate)**

Zonal Level
- **General Manager**
- **Chief Safety Officer**
- **Junior Administrative Grade Officers from the main departments**

Divisional Level
- **DRM with Sr. DSOs/DSOs**
- **SS/Asst. Scale officers**
- **Safety counsellors**
- **Supervisors**

Indian Railways – Role of Safety Organization

Safety Organization – Roles & Responsibilities

- Reporting and enquiry into accidents
- Implementation of recommendations of CRS and enquiry reports
- Compilation and analytical reviews of trends of accidents and remedial action
- Monitoring of disciplinary action and adequacy of punishment
- Liaison with other departments for safe working of maintenance and operational practices
- Safety and ambush checks of functioning of operational and maintenance departments
- Signal sighting committees and rectification of deficiencies noticed
- Preparation and circulation of safety circulars, posters and bulletins etc.
- Regular counselling and monitoring of operating and maintenance staff
- Co-ordination for relief and restoration during accidents

Accident Classification

Accident Classification – Overview

1. **Train Accident**
   - Collision / Derailment / Fire in trains / Level Crossing Accidents / Others/Miscellaneous
   - Reported through Safety Wing
2. **Indicative Accident**
   - SPAD / Averted Collision
   - Reported through Safety Wing
3. **Unusual Accident**
   - Cases of train wrecking / sabotage, Theft / Robbery, Fire / explosion in railway premises, floods / breaches, run over cases etc.,
   - Reported through Security Wing
4. **Equipment Failure**
   - General failure of equipment – locomotives, rolling stock, tracks, signaling etc.,
   - Reported through Punctuality Wing

Accident Response & Relief

Accident Response & Relief – Overview

First response to accident

- Convey information
- Medical assistance
- Passenger assistance
- Organise alternative transport
- Security
- Communication
- Send relief to site
- Preserve clues and evidence
- Joint measurements

Equipment to provide relief

- 115 breakdown trains including 57 140 tonne cranes
- 185 accident relief trains including 10 SPARTs
- 174 accident relief medical vans
- Hydraulic re-railing equipment and hydraulic rescue devices in ARTs
- Special trained manpower to attend to accidents
- Capacity to mobilize special trains for evacuation

Indian Railways – Safety

Safety Perspective – Summary

- Safety is a continuous and ongoing exercise
- Indian Railway has detailed procedures to deal with accidents, conduct time bound enquiries and suggest remedial actions
- Focus on safety is evident in the importance placed upon training of:
  - Running staff – drivers, assistant drivers and guards and
  - Train passing staff – station masters, cabin men, points men , etc.

The best safety device is a careful man

Agenda

- Indian Railways & RITES Overview
- Indian Railways Safety Perspective
- **Preventive Maintenance – Diesel Locomotives**
- Preventive Maintenance – Wagons
- Preventive Maintenance – Coaches
- RITES – Credentials

Indian Railways – Locomotive Preventive Maintenance

Locomotive Preventive Maintenance – Objective & Structure

Key Objectives	IR Resources
1. Improved availability – measured in terms of ineffective locomotives over 24 hrs or outage for freight traffic on hourly basis 2. Enhanced Reliability (Kms per locomotive failure) 3. Higher resource productivity 4. Lower costs 5. Safety	▪ Satellite Diesel Sheds (T20 &T40 schedules) ▪ Homing Diesel Sheds (M4, M8, M12 & M24 schedules) ▪ Diesel Workshops (Periodic Overhaul – 8 Years or one million kms, whichever is earlier) ▪ Locomotive Re-building/Mid-life Rehab.Unit

Locomotive Preventive Maintenance – Major Thrust Areas

Major Thrust Areas for Preventive Maintenance

1. Maintenance systems & concepts	▪ Refers to concepts such as consolidation of maintenance activities, implementing information systems, adopting must change systems, etc.
2. Quality of maintenance	▪ Focus on quality using quality cells; establishing a quality index system; ensure specific manufacturer warranties and robust recruitment for quality org.
3. Availability and quality of spares	▪ Incorporate zero-based estimation; centralize procurement; establish long term relationship with vendors and develop standardized procedures, etc.
4. Infrastructural facilities	▪ Provide appropriate infrastructure to ensure gradual reduction in maintenance activity frequency; adopt a turnkey approach to development of infrastructure
5. Unit Exchange System (UES)	▪ Establish an appropriate UES for capital spares centrally to reduce downtime thus, increasing availability of assets

Consolidation of Maintenance Activities

Overview

- Important to consolidate maintenance activities because:
  - High tech aid cannot be provided in low volume/multi-location approach
  - Major schedules require additional/special focus
- Involves concept of **mega/zonal sheds** for **major schedules** incl. overhauling & re-manufacture of most sub-assemblies
- Other sheds for **minor schedules** – additional facilities to include automatic washing, sanding, centralized lube oil, etc.
- Incremental investment in mega sheds based on payback period
- Workshops to deal with POH, special repairs and reconditioning and overhauling of major assemblies

Locomotive Maintenance Information System (LMIS)

Overview

- Need for reliable system of computer based data accumulation and communication of locomotive maintenance history and information among sheds to be installed at all service points, loco sheds with suitable link up with workshops and HQ

- History of locomotive as well as major sub-assemblies
- Diagnostic analysis like spectrographic analysis, load box results
- Fuel and lube oil consumption
- Cause-wise and assembly-wise failure analysis
- Vendor wise analysis of service life of critical components and time trends of wear rates
- Planning of scheduled maintenance
- Downtime on account of scheduled and unscheduled maintenance and due to other major causes
- Cost of maintenance analysis – labour and material costs etc.
- Consumption pattern of material and forecasting of spares and budget required
- Monitoring of UESs and stock levels of other spare parts
- Analysis of manpower deployment, training needs and planning for staff training

Adoption of a 'Must Change' System

Overview

- '**Must Change' system** to be employed for component replacement – **piecemeal replacement** of wearing components leads to **unscheduled maintenance & avoidable downtime** of locomotive (sometimes as high as 45%)
- Serviceable components reliability and residual service life are often inconsistent
- Sub-assemblies prone to failure on this account include:
  - Cylinder head and valve lever mechanism
  - Power assembly
  - TM
  - Expressor
  - TSC
  - ECC, Axle box, fast coupling, LOP, RTM Blower & FP etc.

Reduced Frequency of Maintenance

Overview

- 'Trip and minor schedules account for large portion (sometimes upto 50%) of loco down time and visits to shed (up to 75% in some cases)
- '**Must Change'** leads to increased periodicity of major schedules
- **Service points** at terminals & yards for topping up of fuel, lubricants and water leads to increase in intervals of trip schedules etc.
- Some **design improvements**
  - Air intake filtration system – wire mesh filters to self-cleaning inertial air filters with secondary paper filter
  - Roller suspension bearings for traction motors
  - Topping up of cardium compound for gear case lubrication – improved quality of gear case seals and labyrinth to eliminate leakages

Diagnostic Aids

Overview

- Retro fitment of Micro processor based control systems
- Alternatively, a tailor made plug-in type dedicated digital analyzing equipment for checking overall condition of the electrical system of the locomotive may be developed
- FFT (Acoustics based) techniques for inspection of roller bearings of axle journals and traction motors
- Microprocessor based wheel flange and diameter measuring instrument for optimizing wheel turning interval and stock removal

Quality of Maintenance – Key Components

Key Components

A **Quality Cells**	▪ Established at all levels viz. HQrs., workshop, shed and service points
B **Quality Index system (QIS)**	▪ Established at each maintenance location ▪ Composite index of quantitative and qualitative performance
C **Warranty Claims & ASS**	▪ Extend from manufacturer to the last maintenance point to cover entire supply chain ▪ Replace poor quality work/equipment
D **Recruitment & Training**	▪ Training facilities, qualification examinations for promotions, standard course material; provisions for lateral entry

Procurement Practices

Key Areas of Improvement

A **Vendor Management**	▪ Vendor approval, evaluation & re-validation – Establish detail vendor approval criterion – Provisional approval for first 2-3 years; continuous appraisal and re-validation after 3 years – Rate contracts for 3 years with assured minimum off take and price escalation (long term relationships with vendors)
B **Tender Approval Criteria**	▪ Include past performance (quality/delivery) ▪ Include technical criteria (R&D capabilities, etc.)
C **Centralize procurement**	▪ Reduce procurement cost and effort; better price discovery ▪ Match order size with vendor capacities

100 % Service Level

Overview

- Stock outs of 30-50% commonly observed in sheds/shops
- Need for dedicated Purchase and Inventory Control set up
  - Procurement Organization Structure (HQrs.>Divisions> Sheds/shops)
  - Concept of Stock and Non-stock items
  - Procurement action for Stock Items
- Performance criterion for Procurement Organization should also include service level in addition to quality, unit cost of spares & inventory levels etc.

Zero based Estimation

Overview

- Availability of spare parts suffers from
  - Inadequate budget
  - Inadequate forecast of actual requirements
- Necessary to establish set of norms for consumption of various maintenance spares based on service life

Development of Drawings, Specifications and Inspection Procedures

Overview

- Need to standardize the drawings, specifications and inspection procedures for various components
- OEMs for various sub-assemblies such as air brakes, electrical traction and control equipment, fuel injection system etc. generally do not part with their drawings and specifications and thus sometimes procurement is done with incomplete/incorrect drawings or as per samples leading to quality issues

Development of Service Points & Turnkey Approach

Overview

- For increased intervals between trip schedules, proper facilities are essentially required at service points
  - Concrete apron on track to provide two locomotive berths
  - Storage tanks with piping and dispensing units for topping up fuel, lubricants and treated water
  - Location based on traffic pattern and other requirements
- **Turnkey approach** is essential for setting up multi-disciplinary maintenance facilities – helps **reduce set up time from initiation to completion**

Minimum Module of Shed Maintenance Facilities

Overview

- Shed maintenance facilities should have the following facilities at the minimum:
  - Covered shed for repairs of at least one loco length (at least 17 m) with a 3T gantry crane
  - Heavy Repair bay with 30T EOT crane
  - Load Box Test Equipment
  - Sections for:
    - Traction Motor/Traction Generator and Auxiliaries Electrical equipment
    - Cleaning section for Radiator, Lube Oil Cooler etc
    - Cylinder head, Liner, Piston Overhauling
    - Compressor Overhauling
    - Turbo, Fuel Pump Support, Cam rollers, Water Pump, Lube Oil Pump Overhauling
    - Buffers and Bogie components
  - Test stands for air brake; fuel injection pump, governor, injector, test benches for relays and speedometer, turbo balancing, & spring testing
  - Rooms for each test stand, spares, storage of lube oil, cardmium compound, etc.
  - M&P and Tools – wheel lathe, induction heater, Bosch tanks, etc.
  - Computers, communication facilities, electricity, water supply etc.

Improved Maintenance Facilities

Overview

- Inadequate provisions are made in following areas leading to loss of productivity:
  - **Material handling** like palletisation, transfer trolleys, open gantry
  - **Handling devices** such as engine block manipulator, upenders for TMs, turn over device for armature, etc.
  - **Time saving devices** such as pneumatic and hydraulic tools, digital read-out go and no-go gauges, induction heaters, and data logging systems for load box results
  - **Cleaning devices** such as portable hot jet washers, turn table type spray washers and industrial floor cleaners

Unit Exchange System – Issues

Key Issues in Implementation of UES

- Insufficient appreciation of the benefits at operational level which results in not maintaining minimum UE spares through repair/replenishment
- Inadequate funding and capacity to supply of initial UES especially for major items such as power pack, engine block, bogies etc.
- Inadequate transportation between sheds and shops affecting repairs/replenishment
- Inadequate recycling capacity in sheds/shops
- Non-availability of spares for repairs of defective assemblies

Agenda

- Indian Railways & RITES Overview
- Indian Railways Safety Perspective
- Preventive Maintenance – Diesel Locomotives
- **Preventive Maintenance – Wagons**
- Preventive Maintenance – Coaches
- RITES – Credentials

Wagon Maintenance – Background

Context Overview

- Historically, maintenance of wagons has **not been a focus area** compared to that of locomotives and coaches
  - No major maintenance other than **periodic overhaul**
  - Poor reliability has adversely affected **availability & utilization**
- Continuous improvement in system of train operations
  - From yard-to-yard operations, frequent marshalling and attachment/detachment of wagons at stations, operational pattern is changing to block rakes movements with end-to-end running and CC movement of rakes
- Technological up-gradation of freight stock resulting into consolidation of maintenance needs for:
  - Braking system; Roller bearings; Improved materials for wagon body; Secondary suspension

Strategic Wagon Maintenance – Key Improvement Areas

Key Areas of Focus

A. **Improve Maintenance Scheduling**
- Schedules to avoid under/over maintenance
- Item-wise classification based on frequency of maintenance required

B. **Define KPIs and develop tracking mechanisms**
- Norms of availability and reliability; consider UE spares and design capabilities
- Diagnostic tools & equip. for fault detection
- Dashboards to review KPIs across units

C. **Establish enablers**
- Org. structure focused on maintenance
- Infrastructural facilities with investment levels, benefits and time frame for implementation

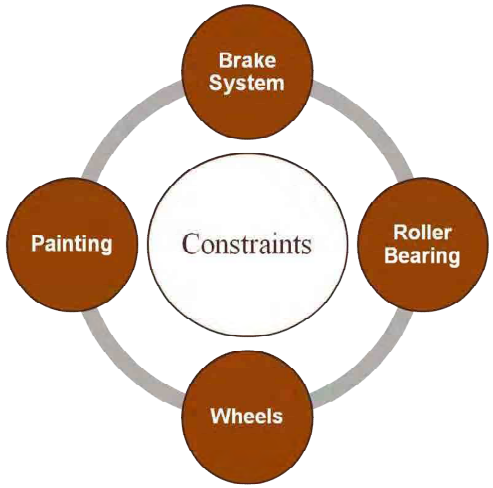
Strategic Wagon Maintenance – Areas of Concern

Key Areas of Concern

- Unchecked theft and vandalism in yards
- Inadequate train examination facilities in yards leading to detachments of wagons
- Lack of adequate infra to handle train examination enroute & at terminals
- Indiscriminate loading and damages during marshalling
- Severe corrosion requiring heavy repairs during periodic overhaul
- Inadequate skills of maintenance staff to effectively maintain stock (lack of effective training) with upgraded technology
- Unsatisfactory quality of repairs in shops – non-availability of materials leading to rejection
- Overloading/irregular loading and condition of track leading to increased spring breakages

Strategic Wagon Maintenance – Constraints

Key Constraints



Review of Existing Maintenance Practices

- Maintenance schedules for various types of wagons – concept and periodicity of ROH and POH
- Comparative practices on Foreign Railways – IOH, POH and Rehabilitation

Broad Maintenance Strategy

- Items based on utilization should be catered to at intervals different from those which require less frequent maintenance based on condition only
  - Utilization (Kms) based maintenance - bogie exchange
  - Condition and cost based maintenance - wagon body

Maintenance of Critical systems and their schedules (1/2)

- Brake system – complete re-manufacturing in bogie change depots
- Springs – Tightening of quality standards of manufacture/procurement
- Wheels – Condition monitoring of wheel wear by micro-processor gauging system leading to less frequency of wheel profiling

Maintenance of Critical systems and their schedules (2/2)

- Bearings – Condition monitoring by diagnostic arrangements to reduce frequency of examination on the open line
- Painting – Better quality paints and proper painting system

Recommended maintenance packages during wagon life cycle

- Bogie change in Bogie Change Depot based on type & utilization pattern
- Mid-life rehabilitation in workshops
- Periodic Overhaul (POH)

Examination in Yards/Terminals (Spot repairs) (1/2)

- Present concept for examination and repair
- To ensure out-of-course repairs leading to detachment of wagons from the rake are minimal
- Pathways on either side of examination line for movement of mobile vans/trolleys equipped with
  - Tools,
  - Gauges
  - Gas welding set
  - Pneumatic tools
  - Jacks and
  - Heavy maintenance components such as springs, knuckles, DVs etc.

Examination in Yards/Terminals (Spot repairs) (2/2)

- Lifting arrangements on line for change of springs, suspension items etc.
- Brake test arrangements on examination line
- Adequate lighting and communication facilities
- Use of diagnostic equipment to detect hanging parts – reducing manual and visual examination to minimum.

Out of Course Repairs (Sick line repairs)

- Highly undesirable. Arising out of detachments during examination
- Infrastructural improvements in areas of Spot repairs, Bogie Change, POH and rehabilitation shall result in reduced incidence of sick marking

Facilities in Bogie Change Depot (1/5)

- Lifting and shifting facilities
  - EOT Crane 10 t
  - Power Hydraulic Jacks 20t
  - Gang operated jacks 10t (4 per set)
  - Hydraulic jacks motor operated 25t
  - Platform truck with hydraulic hoist
  - Fork lift truck assembly for loading/unloading CBCs, springs, DVs, Brake cylinders etc.
  - Material pick up van
  - Wagon mover rail cum road
  - Turn table

Facilities in Bogie Change Depot (2/5)

- Standard hand tools
  - Portable hydraulic hand tools
  - Electric portable drills
  - Electric portable grinders
  - Gas cutting equipment
  - Torque wrenches
  - Hand tools pneumatic

Facilities in Bogie Change Depot (3/5)

- Machinery
  - Bogie washer
  - Bogie painting booth
  - Wheel lathe surface type*
  - Wheel flange welding machine*
  - Centre lathe
  - Air compressor with pipeline
  - CO2 automatic welding machine
  - Drilling, grinding machines
  - Blacksmith equipment
  - Manipulators
  - Drying oven

Facilities in Bogie Change Depot (4/5)

- Testing equipment
  - Single wagon portable air brake test rig
  - DV test stand
  - Test equipment for slack adjuster
  - UST machine
  - Roller bearing diagnostic equipment (FFT)
  - Magnetic flaw detector
  - Microprocessor based wheel diameter / profile measuring / recording equipment

Facilities in Bogie Change Depot (5/5)

- General
  - Model room
  - PCs

Additional Equipment for Workshops (1/9)

- Body Repair Shop
  - Trestles
  - Man – manipulators
  - MIG CO2 welding equipment for welding purposes. Such equipment may either be trolley mounted or over hung type depending on space available in the body repair shop
  - Provision of motorized capstons on either end to facilitate positioning of wagons
  - Hydraulic moving platforms
  - Rail-cum-road vehicles

Additional Equipment for Workshops (2/9)

- Specially designed forklift trucks for transfer, loading/unloading of:
  - draft/buffing gears
  - vacuum cylinders
  - other underframe fittings
- EOT crane attachments
- Pallets and stillages
- Scrap bins

Additional Equipment for Workshops (3/9)

- Bogie Shop
  - Bogie washers
  - CO2 welding equipments
  - Manipulators for positioning down hand welding
  - Drying ovens for electrodes
  - Magnetic flaw-detector portable
  - Bogie painting booth
  - Roller conveyors, roller transfer cables
  - Pallets and stillages
  - Winches for bogie movement
  - Repair stands for bogies

Additional Equipment for Workshops (4/9)

- Wheel shop
  - Wheelset washing and cleaning machine
  - Wheel profile and diameter measuring/recording equipments (micro processor based)
  - Wheel flange welding machine
  - Ultrasonic flaw detector, axial direction incidence type with wheelset rolling apparatus
  - Axle box washing and cleaning machine
  - Fast fourier transform (FFT) analyser
  - Bearing inner race pullout equipment

Additional Equipment for Workshops (5/9)

- Roller bearing washing and cleaning machine
- Oil bath for heating inner race
- Bearing injection cleaner
- Automatic bearing grease filler
- Mobile roller tables, belt conveyors, monorail with hoist and mechanical turn table
- Magnetic particle surface crack detection machine
- Pallets and stillages
- Turn tables

Additional Equipment for Workshops (6/9)

- Spring shop
  - De-buckling press
  - Washing and cleaning machine for spring plates
  - Shot peening machine for top plates
  - Bar straightening machine
  - Bar peeling machine
  - Centreless bar grinder
  - Spring end grinding machine
  - Eddy current crack detector
  - Shot cleaning machine
  - Magna-flux crack detector
  - Pallets and stillages
  - Forklift trucks for transfer and stacking – 2t capacity

Additional Equipment for Workshops (7/9)

- Paint shop
  - Shot blasting equipment
  - Paint chamber and spray painting equipment
  - Paint drying apparatus (closed paint shed with temperature control and circulating fans)
  - Paint mixing equipment
  - Magnetic stenciling arrangements

Additional Equipment for Workshops (8/9)

- Ancillary shops
  - Press brake for fabrication of small components
  - Hydraulic press for pre-setting of rubber pads during draft pack assembly
  - Test stands for various valves
  - Test rig for slack adjusters
  - Pallets and stillages
  - Air brake/vacuum brake, brake test lab with repair equipments
  - Conveyor system for transfer of various assemblies from body repair shop to concerned sections/shops
  - Mechanical turn tables
  - Forklift trucks
  - Revolving stands

Additional Equipment for Workshops (9/9)

- Common
  - Wagon washer
  - Wagon mover rail-cum-road type
  - Electronic weighbridge
  - Inter-communication system
  - Self tilting trailers handled by tractor
  - Pallet handling forklifts
  - Special stillages with platform trucks

Shop Leaving Standards (1/3)

- Applicable to all components subjected to wear and tear
- Basic philosophy is no major repair should arise after work in POH shops and Bogie change depots
- Must change list of items for POH
  - Bogies
    - Side bearers
    - Snubber
    - Side panel manganese wear liners
    - Adapters
    - Side panel anti rotation lugs
    - Pedestal jaw
    - Spring shackles
    - Shackle pins
    - Shackle pin stone
    - Suspension bracket bushes

Shop Leaving Standards (2/3)

- Wheels and bearings
  - Wheels
  - Bearings
  - Sealing rings
  - Labyrinth rings
  - Locking studs
  - Locking plates
  - Grease
- CBC and buffing assembly
  - Knuckle
  - Knuckle pins
  - Knuckle thrower
  - Toggle
  - Lock lift
  - Striker casting wear plate
  - Knuckle wear plate
  - Yoke pin
  - Draft rubber pads

Shop Leaving Standards (3/3)

- Brake assembly
  - Brake blocks and keys
  - Horizontal floating lever bushes
  - Brake rigging pins
  - Brake shaft bushes
  - Piston rods
  - Distributor valves
  - Rubber fittings of air brakes or vacuum brakes
  - Release valves
  - SAB device
  - Hose rubber
- Body/door/underframe
  - Top pivot casting
  - Side bearers

Unit Exchange Spares (1/2)

- UES is key to development of quality standards and improvement in reliability and availability of wagons
- Need to be introduced in shops and bogie change depots to improve cycle time and also quality standard
- Only certified quality unit exchange assemblies should be supplied to sickliness dealing with out-of course repairs

Unit Exchange Spares (2/2)

- Major UE assemblies
  - Bogie with brake rigging, pivot, side bearers etc.
  - Wheel sets complete with roller bearings
  - Wheel set plain bearings
  - Distributor valves complete
  - Brake cylinder/vacuum cylinder
  - Slack adjuster
  - CBC complete
  - Draft gear complete set
  - Buffer assemblies complete
- Scale of UES is to be worked out regularly to ensure adequate provision

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- Preventive Maintenance – Wagons
- **Preventive Maintenance – Coaches**
- RITES – Credentials

Minimum Module of Maintenance Facilities in Coaching Depot (1/3)

- Covered shed with two tracks with space to roll out bogies and pits for at least 1-2 coaches
- Reinforced concrete paving for use of jacks.
- Examination line with pit, catwalk, water supply and drainage
- Adequate lighting in the examination line and sick line
- Battery charger of capacity 200 Amps.
- Electrical supply for charging of batteries and pre-cooling
- Paved pathways

Minimum Module of Maintenance Facilities in Coaching Depot (2/3)

- M&P and Tools
- Welding Plant
- Whiting jacks of adequate capacity
- Gas cutting equipment
- Air Compressor-350 cfm
- 2T tram beam hoist
- Portable Trolley Light
- Ultrasonic Testing Apparatus
- Vacuum cleaner
- Pressure jet cleaner
- Grinder
- Drill
- Computer system

Minimum Module of Maintenance Facilities in Coaching Depot (3/3)

- Work and Office Accommodation
- Store room
- Tool room and machine shop
- Fitting and carpentry room
- Painters room
- Trimming room
- Welding booth
- Air compressor room
- Electric Train Lighting and Air Conditioning repair room
- Supervisor's rooms
- Computer room
- Record room

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- **RITES – Credentials**

RITES – Credentials

Credential Overview (1/2)

- RITES , backed by Indian Railways, has right credentials to offer its technical and professional services to Ghana Railway Corporation Ltd. (GRCL)

Key Offering	RITES Credentials
Training programs and training infrastructure	▪ Complete access to training facilities of Indian Railways ▪ Trained over 3000 foreign railway personnel under WB, UNDP, ITEC and Commonwealth secretariat programmes
Export packages for diesel locomotives, rolling stock & spares	▪ Over US$ 300 million worth of export undertaken ▪ Includes 204 diesel locomotives, 356 Passenger coaches and DMU's and 270 Wagons
Rehabilitation of locomotives, rolling stock and other assets	▪ Hitachi locos of Sudan in GOC, India ▪ Wagons in Tanzania, Tunisia, Cambodia and KTMB Malaysia ▪ CE 761 Traction Motors for Sudan ▪ Railway bridges in Sri Lanka

RITES – Credentials

Credential Overview (2/2)

Key Offering	RITES Credentials
System improvement for rolling stock maintenance including improvement of productivity in workshop/depots	▪ Number of consultancy projects taken up in countries including Sri Lanka, Sudan, Zambia, Zimbabwe, Iraq, Iran, Kenya and Malaysia etc.
Technical assistance for rehabilitation and modernisation of existing railway systems including setting up/modernisation of workshops/sheds /depots for maintenance and operations of diesel locomotives and rolling stock	▪ Creation of and up-gradation of loco and DMU maintenance facilities in Sri Lanka ▪ Workshop modernization and equipment supply to CFM Railway Angola, Myanmar and Sri Lanka ▪ Asset Review studies in Kenya, Zambia and Tanzania ▪ Revamp of railway network, CFM Railway Angola ▪ BOT project for air-conditioned coaches in Bangladesh ▪ Turn-key projects of expansion of capacities in Indian Railways coach factories viz. RCF and ICF

Welcome to
A Presentation on
Safety on Indian Railways

Presented by:
A. Jha,
General Manager (Track and Survey),
RITES Ltd., India
27 Sept. 2012

Structure of Presentation

- RITES profile
- Railway Experience
- Indian Railway System
- Safety on Indian Railways
  - Civil and Track Infrastructure
  - Signalling and Telecom. Infrastructure
  - Rolling Stocks and Their Maintenance Infrastructure
  - Corporate Safety Plan 2003-2013
  - Results of Implementation

RITES' Profile

- The Consulting Company of Indian Railways
- Leading Transportation Consultant in the World
- Started out as a Railway Consultant; now branched out in other Sectors - Highways, Ports, Urban Transport, Airports and Ropeways
- Operational Experience of over 55 Countries, including UK, Malaysia, Iran, Iraq, UAE, Saudi Arabia, Jordan etc.
- Combines in-depth Knowledge with Best Engineering and Managerial Practices to Provide State-of-the-Art Solution
- ISO 9001 Certified

RITES – Service Spectrum

Concept to Commissioning for

- Multi-Modal Transport Studies
- Design & Detailed Engineering
- Project Management & Construction Supervision
- Quality Assurance
- Railway Operation & Management
- Environmental Studies
- Systems Engineering
- Training
- Privatization & Concessioning

RITES - Resources

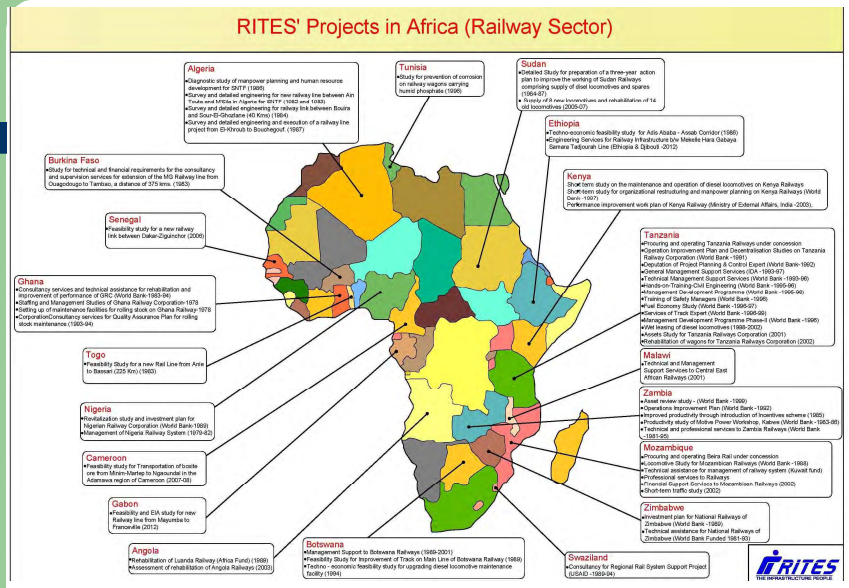
- Employs over 3000 Staff
- Over 1000 Specialists of High Professional Standing
- Can draw from vast pool of resources of Indian Railways

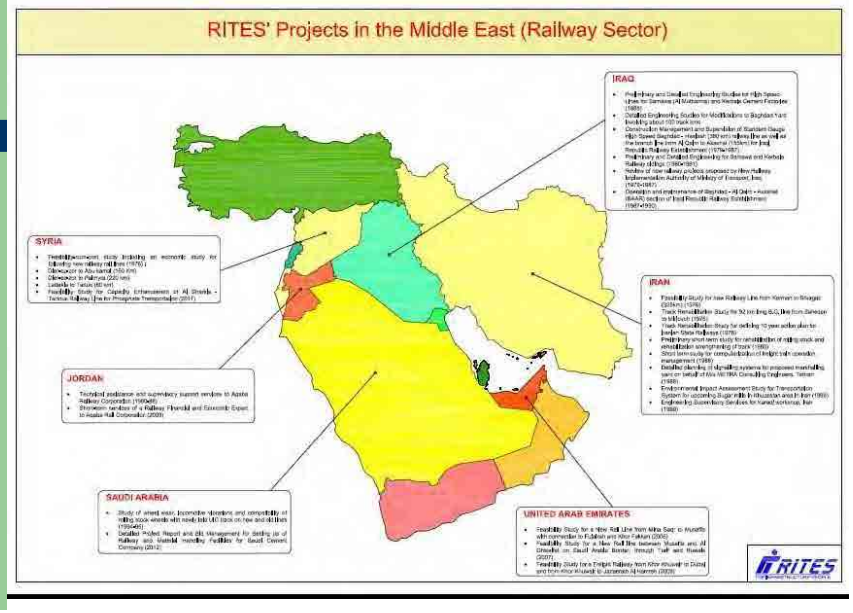
RITES - Clients

- Most Foreign Assignments from National Govt. & Apex Organisations
- In India – Clients range from Governments to Large Corporates and Industrial Establishments.
- Many Foreign Companies

Global Reach

Experience of Working in Over 55 Countries





RITES – Major International Projects

- British Rail - Upgradation of West Coast Line
- Iraq - High Speed Railway to Kerbala and Samawa
- Iraq – Project Management of 535km High Speed Railway for Baghdad-Hsaibah and Al Qaim-Akashat
- Iraq - Management of Baghdad-Al Qaim-Akashat Railway

RITES – Major International Projects (Contd.)

- Iran - Feasibility Study for 325 km Railway from Kerman to Shurgaz
- Saudi Arabia - Traffic and Economic Study for Rail Expansion Projects
- Syria - Feasibility Study for Dier-ez-zor – Abu Kamal (150km), Dier-ez-zor - Palmyra (220km) and Lattakia – Tartus (80km) Railway Lines
- Malaysia - Ipoh-Rawang(180km) High Speed Electrified Railway

RITES – Major Recent Rly. Projects in Africa

- Mozambique – Concession for 25 years with operation and Maintenance of Beira Rail Corridor
- Tanzania - Concession for 25 years with operation and Maintenance
- Feasibility Study for 650 km Long New Railway Lines in Gabon
- Feasibility Study for New Railway Lines in Ethiopia and Djibouti between Mekelle-Semera-Tadjourah Port (660km)

RITES - Major Projects in India

- Delhi Metro
- Bangalore Metro
- Kashmir Railway Project in Jammu & Kashmir
- Dedicated Freight Corridors (3000km) between Delhi-Mumbai and Delhi-Kolkata
- Feasibility Study for 4 New DFCs (6500 km)
- Konkan Railway

Factors in Selection of Transport Mode

- 1. Safety
- 2. Cost
- 3. Transit Time
- ✓ Safety runs at the top amongst factors in selection of mode of transportation.
- ✓ Only safe modes can flourish.
- ✓ Railway recognized as the safest mode of mass transportation

Indian Railways

- <u>The network</u>
- Route Length : 64460 km
  - Of which Broad Gauge : 55,188 km (19,223km DL/ML)
  - And Meter Gauge : 6,809 km (and NG : 2,463km)
  - Of which Electrified Track : 19,607 km (14,365km DL/ML)
- Locomotives : 9,213 nos.
- Wagons : 217,000 nos.
- Coaches : 45,123 nos.
- Staff : 1.3 million
- Freight Traffic : 625,723 million tkm per Year
- Passenger Traffic : 978,508 million pkm per Year

Indian Railways (Contd.)

- Average Daily Transport Output of
  - 2.8 Million Train km
  - 21 Million Passengers
  - 2.54 Million Tonnes freight loading
  - 11,824 Passenger trains run
  - 6,000 Freight trains run
- For a system of this magnitude, SAFETY has to be of Paramount Importance.
- Without Safety, No Reliable Service and thus, No Sustainable Business

But What is Safety?

- Safety is a product of good practices at all levels of functioning i.e.
  - Design
  - Manufacturing
  - Operations and Maintenance
- Safety is compromised when laid down standard practices are infringed.
- First symptoms are Deterioration in Safety Performance, leading to Increase in Number of Failures

But What is Safety? (Contd.)

- Overlooking Warning Signals can be Disastrous
- System is Like a Chain – Weakest Link Decides its Strength

Major Components

- Three Major Components being addressed today
  - Civil and Track Infrastructure
  - Signalling and Telecom. Infrastructure
  - Rolling Stock and Its Maintenance Infrastructure

Civil and Track Infra.

- Upgraded Track Structure adopted on most of the routes
  - Prestressed Concrete Sleepers
  - 52kg/m-60kg/m High Strength Rails (90kg/mm^2 UTS) on Concrete Sleepers
  - Steel Channel Sleepers on Girder Bridges
- Track Structure being Standardized to UIC-60 (60kg/m) laid on PSC Sleepers on All BG Routes, especially on High Density Routes to Reduce Rail Fatigue under Higher Axle Load Traffic
- All New Construction and Replacement of Overaged Tracks by PSC Sleepers only

Civil and Track Infra. (Contd.)

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Civil and Track Infra. (Contd.)

- Fish Plated Joints being Eliminated by Welding Single Rails into Long Welded Rails
- All New Construction/Relaying/Gauge Conversion Works being done with LWR on Concrete Sleepers
- Long Rail Panels of 260m/130m being Manufactured to Minimize No. of Welded Joints
- Progressive Shifting to Flash Butt Welding which is Superior in Quality to Alumino Thermic (AT) Welding
- Turnouts being Improved Systematically

Civil and Track Infra. (Contd.)

- Turnouts with Cast Manganese Steel Crossings and Curved Switches made of Heavier Rail Sections Being Used for Greater Reliability, Durability and Higher Permissible Speeds
- Planned to lay Thick Web Switches on Group ‘A’ Routes
- All Rails and Welds are Ultrasonically Tested Periodically – Self Propelled Ultrasonic Rail Testing (SPURT) Cars being used for this.
- Progressive Increase in Use of Tie Tamping and Ballast Cleaning Machines for track Maintenance

Civil and Track Infra. (Contd.)

- Horizontal and Vertical Geometry being Maintained More and More with Track Recording Cars, Oscillograph cars and Portable Accelerometers
- Modern Bridge Inspection and management System Adopted, Including
  - Under-water Inspections
  - Integrity Testing of Foundations
  - Non-destructing Testing Techniques
  - Fatigue Life and Residual Life Assessment Techniques
  - Mapping Unknown Foundations
  - Rehabilitation/Replacement of Identified Overaged and Distressed Bridges

Signalling & Telecom. Infra.

- Main Objective of Railway Signalling is to Provide a Safe Environment for Train Operations, Work Personnel and the General Population
- System has to be "Fail-Safe" i.e., when they fail, they provide the most restrictive signal
- Should Prevent Accidents that Could Interrupt Operations
- Enable Movement of as Much Closely-spaced Trains as Demand Dictates
- Signalling System is Both Fundamental and Vital to Safe and Efficient Operations

Signalling & Telecom. Infra. (Contd.)

- Network Divided into Blocks
- Train Detection in a Block, Usually Performed by
  - Track Circuits or
  - Axle Counters
- Track Circuiting has been Completed for over 97% Stations of 'A', 'B' and 'C' Routes of Indian Railways
- Block Proving by Axle Counters Implemented on Over 3,000 Block Sections
- Relay/Electronic Interlocking System Implemented on All Major Routes

Signalling & Telecom. Infra. (Contd.)

- Automatic Train Protection System
  - These are Systems which provide security against inappropriate movements of a train if the driver is not managing the train appropriately, irrespective of whether the driver is currently capable of managing it.
- Train Protection Warning System
  - Successful Pilot Project on 50 route kms. of Southern Railway
  - Service Trials in Progress for 2nd Pilot on 200km Long Delhi-Agra section
  - Approved for Deployment on High Density Sections covering 895 route km

Signalling & Telecom. Infra. (Contd.)

- Auxiliary Warning System
  - These require a response from a driver if a warning is given, e.g. at a signal showing a restrictive indication or on the approach to a speed restriction
  - If the driver does not acknowledge the warning in a few seconds, the brakes are automatically applied
  - Successfully working on Mumbai suburban section with significant reduction in SPAD cases

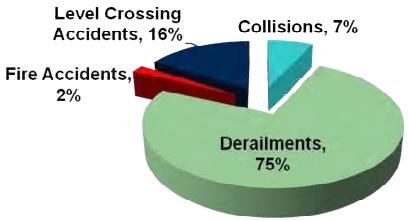
Signalling & Telecom. Infra. (Contd.)

- **Implementation of ACD**
  - ACD implemented on 1,736 route km of NF Railway
  - Trials are On with Modified ACD on Southern Railway
  - Approved for Adoption on Further 5,160 route km

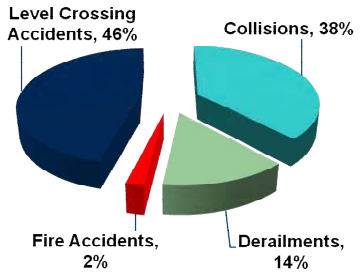
Signalling & Telecom. Infra. (Contd.)

- **Communication Systems**
  - Important in ensuring safety when signalling fails
  - Train Control Communication
  - ✓ Overhead (Non-Electrified area)
  - ✓ Comm. Cable (Electrified area)
  - ✓ Optic Fibre Cable
  - Mobile Train Radio Communication
  - ✓ VHF Communication
  - ✓ GSM-R

Accidents, Their Causes & Fatalities



Causes of Accidents (2003)



Fatalities from Accidents (2003)

Corporate Safety Plan 2003-13

- **Collisions constitute 7% of Total Accidents but Account for 38% of Total Fatalities**
  - Collisions will be eliminated by Extensive Use of Anti-Collision Device (ACD)

Corporate Safety Plan 2003-13 (contd.)

- **Derailments constitute 75% of the Total Accidents but Account for only 14% of Total Fatalities**
  - **Derailments will be reduced by 60% by the Following Measures**
    - Replacement of Overaged Tracks, Bridges, S&T Gears and Rolling Stock
    - Elimination of 4-wheeler Tank Wagons, which are Accident Prone
    - Reduction of AT Welded Joints, which are Weak Areas
    - Improved Training Facilities and Enhancement of Human Skills
    - Rail and Weld Failures Cannot be Completely Eliminated but Measures like "Continuous Track Circuiting" and Use of SPURT Cars for Rail Flaw Detection are Helpful.

Corporate Safety Plan 2003-13 (contd.)

- **Fire Accidents Constitute 2% of Total Accidents and Account for 2% of Total Fatalities.**
  - **Fire Accidents and Fatalities will be Reduced by 80% by Adoption of Fire Retardant Materials in the Existing Coaches.**

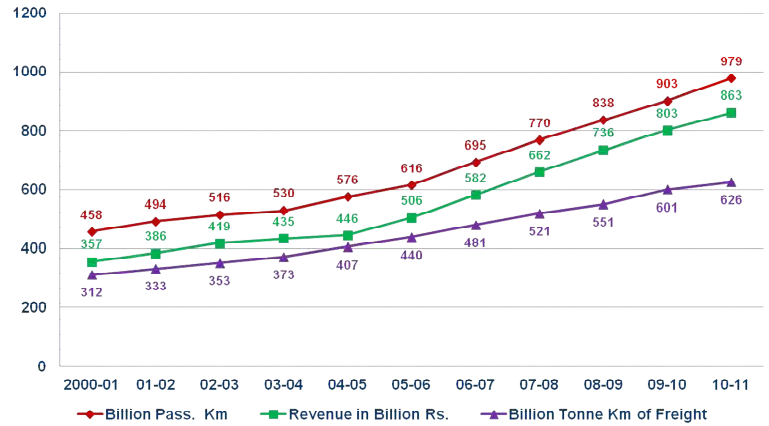
Corporate Safety Plan 2003-13 (contd.)

- **Level Crossing Accidents Constitute 16% of Total Accidents but Account for 46% of Total Fatalities. Rising Trend in Last Decade.**
- **Measures Adopted**
  - **Construction of Flyovers/Underpasses at Level Crossings Where TVU>=100,000**
  - **Manning of Unmanned Level Crossings**
  - **Provision of Interlocking of Level Crossing Gates**
  - **Use of Train Actuated Warning Device and Anti Collision Device, and**
  - **Social Awareness Programmes**

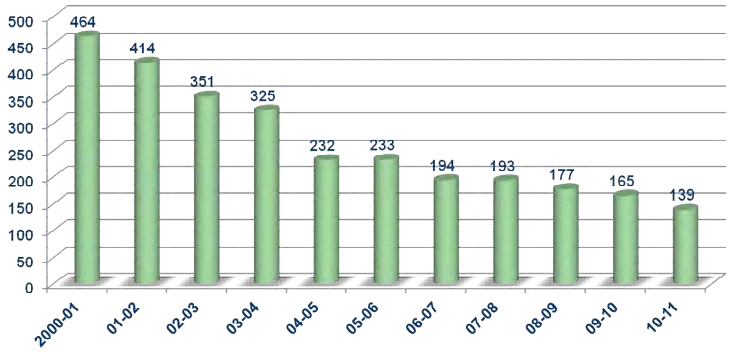
Corporate Safety Plan 2003-13 (contd.)

- **Overall Consequential Train Accidents per Million Train km will be Reduced from 0.44 in 2002-03 to 0.17 in 2012-13**

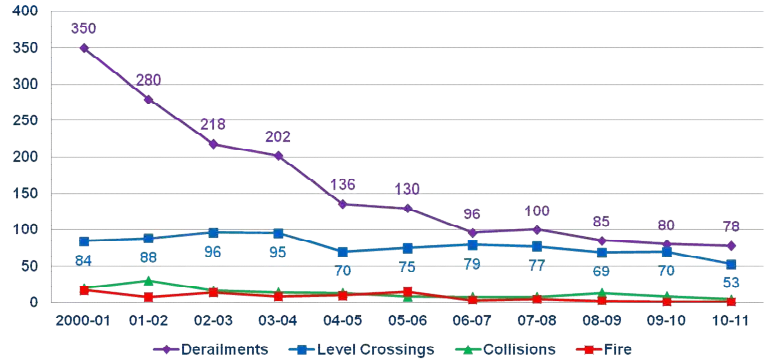
Turnover Indices of IR



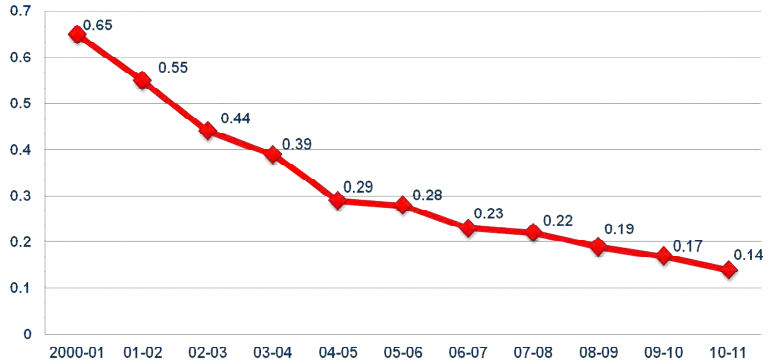
Trend of Train Accidents per Year



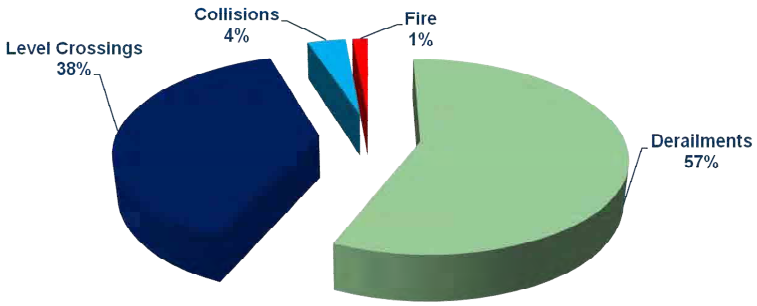
Accidents by Category



Trend of Accidents per Million Train-km



Accidents by Category in % (2011)



Results of Implementation

- Consequential Train Accidents per Million Train km has Reduced to 0.14 in 2010-11
- Casualty Rate : 0.01 per Million Passenger Carried
- ACDs and Train Collision Avoidance System are on Extensive Trial

Questions Please?

Thanks for Your Kind Attention