IHHA 2017 CAPE TOWN 02 – 06 September 2017

HEAVY HAUL TRACK WORKSHOP

Cape Town · South Africa · 02 - 03 September 2017

DATE	SESSION	SLOT	TIME (min)	TOPIC	SPEAKER/PRESENTER
		0800 - 0830	30	**Welcome from IHHA / Course Outline** IHHA Chair	Semih Kalay
				IHHA CEO	Scott Lovelace
				SAHHA Chair	Brian Monakali
				Course Leader / Manager	Pierre Lombard
Saturday 02 September	1	0830 - 0915	45	**Fundamentals of Wheel-Rail Interaction**	Harry Tournay
	2	0915 - 1000	45	**Track Components, Special Trackwork, Construction**	Danie Barnard
	3	1000 - 1045	45	**Overview of Bridges & Structures for Heavy Haul**	Nigel Peters
		1045 - 1115	30	**Coffee Break**	
	4	1115 - 1200	45	**Track Geometry**	Willem Ebersöhn
	5	1200 - 1245	45	**Ballast Maintenance**	Rainer Wenty
		1245 - 1330	45	**Lunch**	
	6	1330 - 1430	60	**Substructure, Drainage & Track transitions**	Hannes Gräbe
	7	1430 - 1515	45	**Track Buckling and Neutral Temperature Management**	Andrew Kish
		1515 - 1545	30	**Coffee Break**	
	8	1545 - 1630	45	**Track Inspection in the Heavy Haul Right of Way Environment**	Willem Ebersohn
	9	1630 - 1715	45	**Vehicle/Track Condition Assessment**	Semih Kalay
	10	17:15 -18:00	45	**Vehicle/Track Condition Assessment using instrumented vehicles**	Ravi Ravitharan
Sunday 03 September	11	0800 - 0845	45	**Rails and Rail Welding**	Nigel Peters
	12	0845 - 0930	45	**Rail Grinding & Friction Modification**	Michael Roney
	13	0930 - 1015	45	**Vehicle/Track Interaction related derailments**	Robert Fröhling
		1015 - 1045	30	**Coffee Break**	
	14	1045 - 1130	45	**Maintenance Management and Economics**	Michael Roney
	15	1130 - 1215	45	**UIC on Heavy Haul activities in Europe**	Bernard Schmitt
	16	1215 - 1300	45	**Questions & Discussions with lecturers in attendance**	Pierre Lombard
	17	1300 - 1315	15	**Closing**	Pierre Lombard
		1315 - 1400	45	**Lunch**	

Session 1: Fundamentals of Wheel-Rail Interaction – Harry Tournay

This presentation will focus on the attitude of a railway wheelset on the track, the associated wheel/rail forces and the typical resulting damage modes. Given this developed basic understanding, and together with associated contact mechanics, preventative design initiatives are discussed in principle and in support of some of the presentations to follow. Fundamentals of contact mechanics will be presented together with initiatives to develop limits for wheel / rail forces. This will include the basics of surface and sub-surface stresses, and the development of associated models to describe the damage associated with the interaction of surface and sub-surface material flow, wear and fatigue. The presentation will conclude with the possible way forward towards improved wheel / rail interaction. The presentation will reference Guidelines to Best Practices for HH Operation for Infrastructure Construction & Maintenance Issues (ICMI) as well as Management of the Wheel / Rail Interface (MWRI).

It will address:

- The action of a single railway wheelset (Forces).
- Contact mechanics associated with high and low rail and tangent contact (Surface and subsurface stresses).
- Wheel and rail damage mechanisms associated with wheel / rail forces and surface and subsurface stresses.
- Overview of causal and preventative mechanisms in principle.
- Overview of analytical and experimental approaches to model, replicate and determine limits to wheel and rail damage.
- Way forward to improved wheel / rail contact design and maintenance methods.

Session 2: Track Components, Special Trackwork, Construction – Danie Barnard

The lecture will give the participants an overview of a typical Infrastructure layout with the focus on the track components and functions. While the focus of the lecture will be on track components and its functions, maintenance and management of the track structure will also be discussed. The second portion of the lecture will specifically look at upgrading of existing track to a heavy haul service. The replacement, upgrading and adjustment options to the existing track structure will be looked at. Construction possibilities and processes will also be touched on. In this portion the focus will not only be on technical detail and options but also on business and operational needs during the upgrading period.

The lecture will cover:

- Track Components
  - Typical Infrastructure Layout
  - Formation Design and Drainage
  - Rail profiles, Properties and Construction
  - Rail Management, Rail Wear, Fatigue and Defects
  - Rail Welds and Welding Practices
  - Turnout types and Properties
  - Crossties/Sleepers, Different Types and Designs, Fastening Systems
  - Ballast Grading and Functions
- Upgrading Track for Heavy Haul Service
  - Business and Financials
  - Reinforcing the Track Structure and Operational Needs During Upgrading
  - The Formation design and reconstruction
  - Ties/ Sleepers , Pads and Fastening Systems and relaying processes
  - Rail and replacement processes
  - Rail Management
  - Ballast and formation (width)
  - Turnout replacement, formation repair and placement methods
  - Structure Evaluation, Testing and Strengthening

Session 3: Overview of Bridges & Structures for Heavy Haul Operation – Nigel Peters

After a brief introduction into the load environment in which heavy haul bridges must survive, this presentation will discuss the various types of bridges, their decks and their substructures and foundation support. It will list considerations to be used in the selection of new bridges as well as material selection criteria. It will discuss a Bridge Management Program and it should contain. Also, it will discuss inspection of bridges, its purpose, the various types of inspections, and frequency. It will also highlight key areas for inspection, defects and possible causes. It will discuss rating of bridges and how those ratings factor into decisions on remedial action and what those remedial actions may be. Also discussed will be fatigue of bridges and fatigue damage. Maintenance and maintenance level of bridges will be reviewed. Guidance on when to rehabilitate versus when to replace will also be given. And finally, areas of possible future research on railway bridges will be highlighted.

- Introduction
- Types of Bridges: Deck types, Span types & Substructure and foundation types
- Considerations in the Selection of type of Bridges
- Recommended Bridge Material for Heavy Haul Operation
- Bridge Management program and what it should entail
- Inspection of Bridges: Purpose, Types of inspection and Frequency
- Key Areas of Concern during an inspection
- Major contribution causes to problems
- Rating of Railway Bridges
- Remedial Actions for Deficient Bridges
- Fatigue & Fatigue damage
- Maintenance of Railway Bridges
- Guidance on when to Rehabilitate versus Replacement
- Rehabilitation of Bridges
- Replacement of Bridges
- Areas of Further Research Needed

Session 4: Track Geometry – Willem Ebersohn

This workshop defines track geometry, it's terminology and how it can be measured and managed. US Federal Regulations for Tracks Standards will be introduced and demonstrated. The challenges associated with the design of Superelevation as it pertain to long and heavy trains will be discussed. This workshop will further introduce the concepts of track substructure stiffness and its influence on track performance. One of the preconditions of efficient and sustainable heavy-haul operations is a railway track structure that is capable of supporting and distributing repeated heavy axle load wheel forces without loss of stability or undue deformation. The track substructure stiffness and its variation along the track combined with the induced track loads determine the track performance and component behavior. In order to support the required capacity for a line, the track geometry has to be managed to the required standard that will support the speed and freight throughput.

- Introduction to Code of Federal Regulations Title 49 PART 213 - TRACK SAFETY STANDARDS.
- Track Geometry in the Track Plane – Gauge.
- Track Geometry in the Horizontal Plane – Alignment.
- Track Geometry in the Transverse Vertical Plane – Cross level and Warp.
- Curve Speed.
- Curve Elevation.
- Longitudinal Vertical Track Geometry – Surface (Profile)
- Superelevation as it pertains to Long Trains

Session 5: Ballast Maintenance – Rainer Wenty

This lecture concentrates on the function of ballast and its influence on track quality, maintenance cycles, sustainability of maintenance and on track cost at all. The load bearing and load distribution function of the ballast will be explained, also the mechanisms which lead to ballast degradation. Examples of ballast degradation and its influence on track quality will be shown. Next step is how to determine the necessity of ballast rehabilitation. Different methods of ballast rehabilitation will be discussed and how to maintain a good track geometry. Hints will be given how to choose the right machine for certain demands and different track maintenance strategies will be discussed. Finally life cycle considerations and best practice examples will be presented.

- The load transfer function of the track
- Drainage function of ballast
- Degradation of ballast
- Interaction of ballast quality and track quality
- Ballast cleaning/undercutting
- Track geometry
- Track Maintenance
- Sustainability of track maintenance
- Digitalization aspects of track maintenance
- Optimization of track machine application
- Best practice examples

Session 6: Substructure, Drainage & Track Transitions - Hannes Gräbe

This lecture concentrates on the function of the subballast layer and the subgrade as part of the entire track structure. The design of the track substructure layers will be discussed in terms of granular layer thickness design. Subgrade problems and remedial measures will be introduced as well as possible actions for axle load increases. The second part of the lecture focuses on track drainage principles and specific examples of surface and subsurface drains. The lecture concludes with the important topic of track transitions and how differential stiffness and settlement are responsible for track component deterioration and vehicle dynamics at transitions.

- Subballast and subgrade terminology and functions
- Geotechnical Requirements
- Subgrade problems and treatments and soil improvement
- Geosynthetics
- Drainage principles & Track Drainage (surface & subsurface)
- Track Transitions
- Differential stiffness and settlement
- Mitigation design, solutions and best practice

Session 7: Track Buckling and Neutral Temperature Management - Andrew Kish

The presentation will provide key results of over 25 years of research on track buckling prevention and improved rail stress management with some updates to the IHHA Manual's Sections 1.6 and 6.5. In particular, the presentation topics will focus on the fundamentals of track buckling in terms of the principal causes and parameters, track buckling safety criteria and buckling temperature concepts, and key relevant aspects of rail stress and neutral temperature (RNT) behavior. A simple and versatile track quality based safety and maintenance criterion will be presented to serve as a baseline to track buckling prevention guidelines. Illustrative applications of the criterion will include a new "critical neutral temperature" based safety concept and maintenance approach, and a "science based" strategy to determining hot-weather speed restriction temperatures for buckling risk reduction.

Learn the Answers to the Following Questions:

- Why is track buckling a serious problem?
- How do tracks buckle and what are the key influencing parameters?
- What are the three key track buckling prevention rules and how to apply them?
- What are some current best practice guidelines to more effectively manage CWR?

Session 8: Track Inspection in the Heavy Haul Right of Way Environment – Willem Ebersohn

The first half of the workshop will be devoted to demonstrating the current practices of heavy haul for:

- Visual Inspections
- Walking, and Hi-Rail Inspections, using the findings of a FRA sponsored Track Inspection Time Study to demonstrate the type of defects found as a percentage of total defects found over a 4 year period by FRA track inspectors.
- Electronic track inspections and Data management and analysis, which will be demonstrated at a high level.

The latest development in laser vision measurement technology combined with High Resolution Imagery used with high accuracy GPS has made it possible to survey tracks and ROW features by mounting the equipment on revenue vehicles. These surveys define the absolute position of the track (GPS based Space Curve for each rail) at an accuracy of 10mm (0.39") longitude and latitude and 15mm (0.59") elevation. The data processing and visualization capabilities has opened up the opportunity to change the way in which railroads survey their ROW infrastructure asset's condition and define the location referencing from which infrastructure performance can be determined.

Currently Augmented Reality assists in bringing information to inspectors and maintainers in the field in a safe and responsible manner. This technology will also provide remote instruction capabilities to support field maintainers.

Given the severe Heavy Haul environment, thorough and timely track inspections are crucial for detecting developing conditions that could compromise safety, asset life, and operating efficiency. However, the inspector is confronted with a serious dilemma when track is increasingly stressed but available windows in which inspections and maintenance can be performed are shrinking. Crucial visual inspection, which continue to be an essential means for assessing track, are described along with current electronic inspections.

Visual Inspection

- Walking & Hi-Rail Inspections
- Inspection from train.

Electronic Inspections

- Current Geometry Car Technology.
- Gage Restraint Measurement Cars:
- Gage Widening and Strength.
- Crosstie Replacement Program Development.
- Gage Strength.
- Internal flaws: Rail Defect Detection & Surface defects.
- Rail Stress measurement.
- Performance based systems.
- Rail Surface Coefficient of Friction Measurement.

Data management

- Data processing to create management Information
- Management Information referenced to Primary Asset based asset Register.

New Developments in Track Inspections

Session 9: Vehicle/Track Condition Assessment - Semih Kalay

The heavy haul railways around the world are increasingly moving toward detector and performance-based rolling stock maintenance to improve efficiency by reducing the cost of maintenance and inspection. Advances in sensors, data collection systems, computer software and communications have enabled the development and deployment of sophisticated, reliable and accurate wagon and track monitoring systems capable of automating many train inspection processes; offering opportunities to replace, supplement and enhance the safety and productivity of railway operations. In many instances automated wagon health monitoring systems are capable of examining vehicle performance attributes while in motion, providing additional insight on vehicle behavior in a dynamic on-track environment. A more recent trend has been to identify and fix the problem track locations which produce excessive loads in order to reduce the stress state of the railways by using advanced track inspection systems. Automated track geometry inspection cars are being augmented by machine-vision and high speed video camera systems to identify broken, worn, or missing track components. Performance based track geometry measurements systems are being used worldwide to monitor track conditions using instrumented freight wagons to improve the frequency and the quality of track inspections.

Currently, the various car health monitoring systems are being used to identify poorly performing cars and bogie components. In the near future, technology will allow for the detector systems to be integrated in order to assess the overall condition of the car and its components and to plan shorter and longer term and proactive maintenance actions. Automated wayside and onboard wagon condition monitoring devices are expected to free wagon inspectors to concentrate on freight wagon repairs to improve productivity of rail operations. As a result inspection cycles for rolling stock will be extended, and maintenance will be performed when needed.

The detector data management systems store the detector data and provide users with the capability to make predictive, condition-based maintenance decisions rather than having to rely solely on visual inspection. It also makes data available to a wider range of stakeholders than possible before. This means that wagon owners, who did not previously have access to inspection data, can (given railroad permission and a password to access the data) manage their assets remotely. These databases use a variety of automated equipment identification systems located at detector sites to determine vehicle location, direction of operation, and load condition. This information is than utilized to determine optimal maintenance locations.

This presentation will answer the following questions:

- What are the recent advances in on-board track inspection systems?
- How is the data from vehicle and track health monitoring systems used?
- How can I inspect the wheel/rail contact condition?
- What are the state-of-the art technologies for wheel/rail friction and rolling contact measurements?
- How do I identify out-of-round wheels and wheel surface defects using wayside detector systems?
- How can I identify overload and imbalanced loading in wagons?
- What type of technology is available to detect poorly performing wagon bogies?
- How can I use wayside temperature detectors to determine brake effectiveness?
- How do automated wheel profile and brake pad measurement systems work?
- How can I identify defective axle bearings defects long before they cause overheating?
- Are there any technologies available to inspect wheel internal and surface defects?
- What are the latest developments in machine vision systems to determine a railcar’s safety?
- What is conditioned-based rolling stock maintenance?

Session 10: Vehicle/Track Condition Assessment using instrumented vehicles - Ravi Ravitharan

The railway network is steadily growing with significant capital investments in infrastructure and modernisation. The heavy haul railway operators are demanding higher productivity and throughput to meet increasing cost pressures. Shrinking maintenance windows and maintenance budgets require strategies to ensure safe operations and service reliability.

Technology and system approach are utilised by leading heavy haul railway organizations to overcome these challenges and to further improve their operations. The Instrumented Revenue Vehicle (IRV) Technology and associated sophisticated automatic data processing system are key technological innovations providing significant benefit to these railway organizations. The IRV is an intelligent automated condition monitoring tool which is integrated into normal railway operations, and is capable of monitoring vehicle – track dynamic responses to improve railway system performance.

The IRV technology is retrofitted to standard wagons used for revenue services. It automatically collects dynamic performance data and identifies high risk track related defects, and the precise locations of the defects, in a timely manner. It prompts appropriate operational restrictions, such as the application of temporary speed restrictions and scheduling of maintenance activities to limit further damage to rail assets and eliminate potential catastrophic consequences such as derailment. The IRV technology is also used to measure the effectiveness of maintenance activities, identify track deterioration trends and detect irregular operational actions. As a result of IRV technology, the track conditions and vehicle-track system performance can be remotely and automatically monitored without halting standard revenue operations. Such monitoring occurs close to real-time, since the data is automatically transmitted directly from IRVs during operation. By contrast, the traditional dedicated track geometry cars operate during non-traffic hours and they do not monitor vehicle-track system performance of dominant vehicles which are operating in the network. Further, measurements are conducted once every few months. The biggest cultural change within heavy haul and other railway organisations utilizing IRV is that they have moved from reactive to proactive maintenance and operation. This IRV technology has the ability to collect vast amounts of data about vehicle-track performance during normal railway operations. Overcoming challenges in automatic and timely processing of the measured big data, improved visualization techniques and data analytics have enabled the conversion of this data into useful information, which was previously unavailable. Now, instead of reacting to problems when they arise, IRVs have provided timely and accurate information which enables railway organizations to analyze long-term trends and predict the condition of infrastructure well in advance. With the implementation of IRV technology, railway entities avoid operating reactively, and spending valuable resources, and interrupting services in the process. With IRV technology they are able to adopt informed, proactive, predictive and preventative evidence based maintenance strategies to extend the lifespan of rollingstock fleet and track infrastructure. This, in turn, has improved the availability of their expensive long-term railway assets.

This lecture will outline the IRV technology, as well as how it is assisting railway operators to assess vehicle-track condition and to increase productivity and reliability, to eliminate maintenance issues, to reduce maintenance costs, to ensure safe operation and to extend asset life.

This lecture would cover the following points:

- Why vehicle-track condition assessment is required in railway environment?
- What are the limitations with the traditional track condition monitoring systems?
- Why system approach is essential in heavy haul railways?
- What is Instrumented Revenue Vehicle Technology (IRV)?
- How often IRV collects the vehicle-track information? How does it transfer the information?
- Are the IRV data accurate and validated? What is the resolution of vehicle/track condition information gathered using IRV?
- How the heavy haul railways are utilising the IRV data?
- What are the benefits of correlating vehicle performance with track condition?
- How IRV identifies effectiveness of track maintenance?
- How IRV identifies locations where temporary speed restrictions are required due to track fault? How do you remove guesswork related to application of temporary speed restrictions?
- How do you move from reactive maintenance approach to proactive evidence based track maintenance?
- What are the benefits of utilising near real time vehicle-track condition assessment using the instrumented Revenue Vehicles.

Session 11: Rails and Rail Welding – Nigel Peters

This first part of the presentation will focus on rail and rail performance, including rail wear and rail defects, and the influencing factors. It will explain how chemistry, mechanical properties, and microstructure play a part in the performance of rail. It will also touch upon external factors related to operation and vehicle characteristics. Specifically it will:

- Discuss rail wear and influencing factors
- Explain rail defects, both surface and internal
- Explain work hardening effect versus tonnage versus plastic flow
- Explain RCF
- Explain causes of RCF
- Explain types of rail chemistries and their influence on hardness and wear
- Explain microstructure of heat treated and non-heat treated rail and influence on wear
- Explain tensile strength and yield strength requirements versus elongation
- Explain fracture toughness of rail
- Concluding remarks

This second part of the presentation will primarily focus on the two main types of rail welds, namely flash butt and thermite welds. It will give a brief description of the weld types, weld performance, and explain weld deterioration, weld failure modes and failure causes. The concluding remarks will suggest areas of improvements for both types of welds. Specifically it will:

- Define types of welds
- Give background information on types of welds
- Suggest a method of defining weld performance
- Explain deterioration of welds
- Explain failure modes of welds
- Explain causes of weld failures
- Explain path forward for weld improvement

Session 12: Rail Grinding & Friction Modification – Michael Roney

The lecture will explain the mechanics of rail grinding, how the depth of cut evolves as a function of the contact geometry, applied pressure and the sequence of grinding motor angles. The value of rail grinding will be explained within the context of maintaining rail integrity and extending the life of the rail asset. Best practice will be defined as the practice of preventive rail grinding on tight and prescribed intervals. This practice will be directed to the importance of understanding the root cause of rolling contact fatigue and ensuring that rail grinding addresses the expected crack growth trajectory, while protecting the work hardened zone.

The presentation will review how rail grinding must preserve the transverse conformality of the wheel/rail contact over the life span of the wheel and rail with properly designed "as ground" rail profiles, and covers how this must be adjusted for wide gauge conditions and transposed rails. In the longitudinal plane, it will be explained how grinding reduces dynamic increments to wheel loading from vertical track irregularities such as weld dips and rail corrugations.

Rail metallurgy is another factor that should be considered in a rail grinding strategy. The presentation deals with optimal depth of cuts for different rail metallurgies and track geometries and axle loads and how cyclic metal removal depths relate to the best practice rail grinding cycles. It concludes with an overview of how to plan a productive and effective rail rectification by grinding.

Friction will then be introduced as a factor in both wheel/rail damage and in energy losses. It will be discussed how lubricants provide a protective layer that greatly influences loss of metal at the wheel flange/rail gauge face interface. Then the mechanics of curve negotiation will be reviewed within the context of how lateral forces are affected by friction levels on the top of the rail. Friction management and rail grinding are introduced as complementary maintenance tools that work together to get optimal wheel and rail service lives.

The presentation will outline best practice friction levels that will best balance wheel/rail forces, wear, locomotive traction and train braking. It will then turn to the characteristics that need to be considered in choosing a cost effective rail gauge face lubricant. Given an effective lubricant, the lecture will define best practices for spacing wayside lubricators, what to consider in choosing their track side locations, and what has been determined for best lubricant distribution settings. A parallel approach will be taken to define the characteristics of effective top of rail friction modifiers, and the parameters for 100% effective friction control, such as lubricator spacing and product distribution settings. The lecture will conclude with a review of how maintenance workforces can be organised and equipped to sustain effective friction management.

Rail Rectification by Grinding

- What is rail grinding and how does it work?
- Why it is important to grind rails
- Rail grinding best practice defined
- How rail grinding control of rolling contact fatigue must address the root cause of the cracks
- How to maintain the important work hardened zone of the rail
- The importance of maintaining optimal "as ground" rail profiles
- Controlling vertical track irregularities like rail corrugation or dips at welds
- How grinding must address wide gauge conditions and transposed rail
- Changing rail grinding treatments for premium vs. standard carbon rails
- Recommended preventive grinding metal removal rates
- Optimal cycles for preventive grinding
- Planning an effective grinding program

Friction Modification

- Why control friction?
- Lubrication and its role in protecting wheel/rail wear
- The effect of friction on lateral forces
- How grinding and friction control work together to extend rail and wheel life
- Target friction levels
- Characteristics of effective rail gauge face lubricants
- Best practices for rail gauge face lubrication, spacing, location and settings
- Achieving top of rail friction control
- Characteristics of effective top of rail friction modifiers
- Best practices for applying top of rail friction control
- Maintenance organisation to sustain the benefits
- 100% effective friction management

Session 13: Vehicle/Track Interaction related derailments – Robert Fröhling

The objective of this session is to present derailment conditions related to vehicle-track interaction. The material is based on Chapter 8 of the "Guidelines to Best Practices for Heavy Haul Railway Operations – Management of the Wheel and Rail Interface. June 2015. International Heavy Haul Association." Other literature as well as the material from the "Railway Safety Investigation Course" offered by the Transnet Freight Rail Chair in Railway Engineering at the University of Pretoria has also been incorporated.

The focus of this session will be on vehicle and train dynamics and the resultant interaction mechanisms that can lead to a wheel climb, wheel lift or wheel drop-in derailments. Factors contributing to an increase in lateral forces and/or a decrease in vertical forces are listed and discussed. This is followed by a section on derailments in turnouts. Finally a summary is presented of track and rolling stock component failures which are not directly linked to vehicle-track interaction dynamics.

Outline:

- Vehicle and train dynamics
- Wheel actions in derailments
- Contributing factors to wheel actions
- Derailments in turnouts
- Derailments due to track or rolling stock component failures

Session 14: Maintenance Management and Economics – Michael Roney

The presentation will introduce, at a high level, how track quality and service condition can be quantified, trended and projected to guide assessment of its performance vs. service demands, and the timing for maintenance and replacement interventions. For the rail asset, this will cover best practice in tracking rail defect trending and projection of rail wear, and will discuss how limits are set of allowable wear and rail defect levels to determine the optimal time for rail renewal. Rail sleeper condition distributions will be discussed against the context of determining a multi-year plan for sleeper replacement. Track quality indices will be illustrated as key drivers for scheduling tamping and lining operations, and it will be shown how this can be related to assessing ballast cleaning and renewal programs. The first part of the lecture dealing with the analysis of track maintenance needs will conclude with notes on how risk assessment can be an overlay to the multi-year maintenance plan, and how the effectiveness of past maintenance actions can be assessed and incorporated into continuous improvement of track maintenance planning.

The second part of the workshop lecture on track economics will introduce the framework for life cycle costing as a tool for assessing the trade-off economics for evaluation of alternatives in track design, maintenance and operational changes. Examples will show how discounted cash flow timelines are analysed to determine the lowest cost alternatives. Then it will be illustrated how unit costs are calculated for budgeting and planning track production programs and evaluating the incremental cost of track maintenance per gross tonne-kilometer of traffic. A framework will then be shown to evaluate the impact of track maintenance on train delays. Case studies of the economics of heavier axle loads, differences in track quality and the impact of a new track design technology will be used to inform participants of their impacts while illustrating the methodology for evaluating trade-off economics.

Analysis in Support of Track Maintenance Management

- The value of forecasting track component condition and quality
- Projecting rail defect rates
- Projecting rail wear
- Setting limits on rail wear and fatigue
- Determining optimal timing for rail replacement
- Projecting sleeper replacements
- Planning when to do tamping and ballasting
- Accounting for risk in planning track programs
- Evaluating maintenance effectiveness
- Recommended preventive grinding metal removal rates
- Optimal cycles for preventive grinding

- Planning an effective grinding program

Economics of Track Infrastructure

- Introduction to infrastructure Life Cycle Costing
- Evaluation of alternatives
- Evaluation of alternatives: an example of a track decision
- Development of unit costs
- Costing train delays
- Trade-off economics of axle loads
- Economics of track quality
- Evaluating new track designs and technology
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Session 15: UIC on Heavy Haul activities in Europe - Bernard Schmitt

This session, entitled “Longer trains in Europe” will cover the following aspects:

1. European framework
   - Splitted network
   - Definition of advantages and potential of longer trains
   - Railway needs: challenges for a win/win situation with IM
2. Experiences and current activities
   - Baltic states
   - Sweden
   - Germany
   - France

3 .Operational and technical issues

- Composition of longer trains
- Train dynamics, lengthening of trains and elasticity
- Compliance with braking and deceleration distances
- Approval processes

4. UIC projects
   - CEO’s task force - Increase of length
   - UIC Platform Heavy and long train