Research Activities of the Centre for Railway Research at IIT Kharagpur

CRR @ IIT Kharagpur

Centre for Railway Research
Indian Institute of Technology Kharagpur

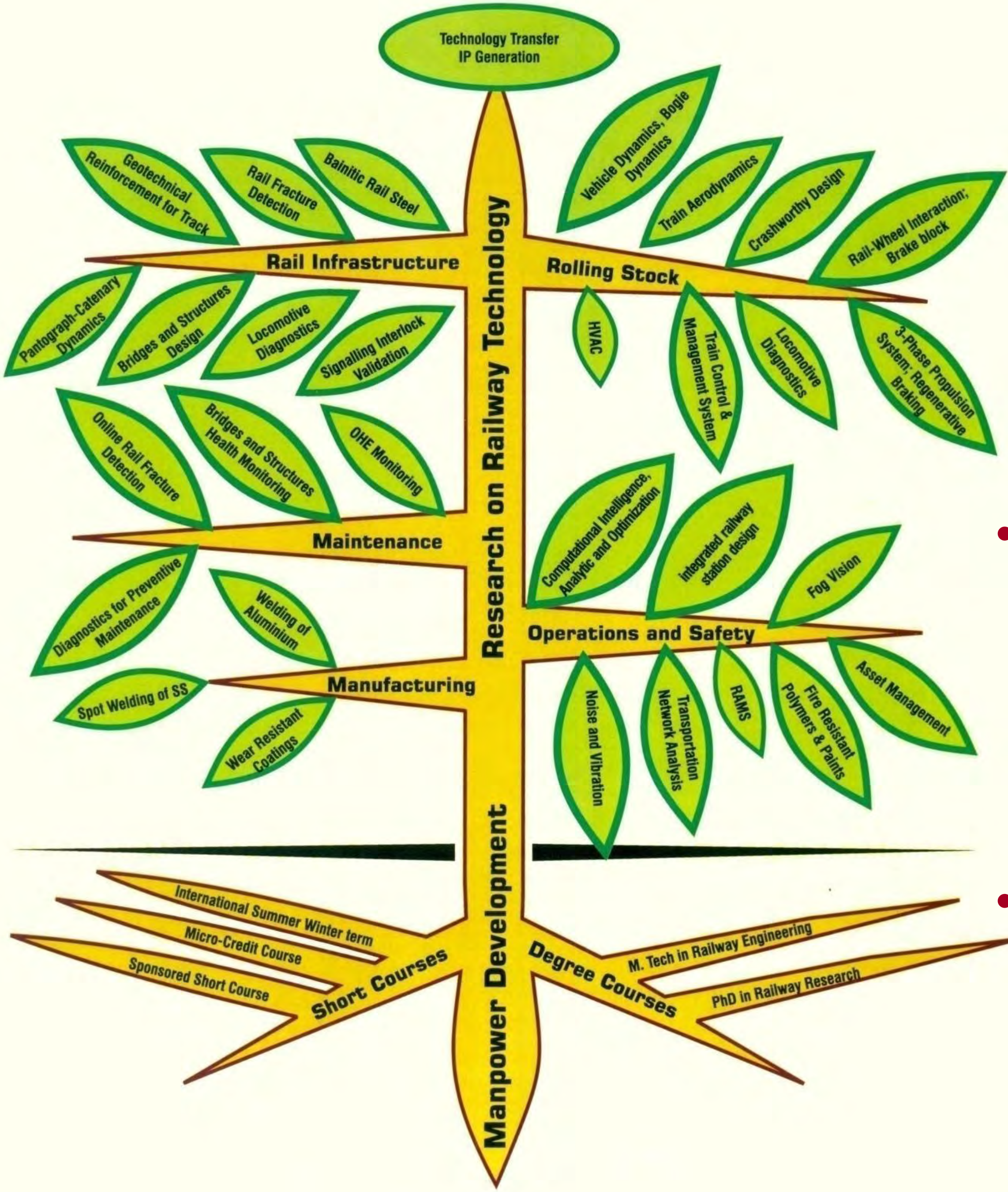
“Here in the place of that Hijli detention camp stands this fine monument of India, representing India’s urges, India’s future in the making”

---- Pandit Jawaharlal Nehru – 1st Prime Minister

Centre for Railway Research

- First Centre for Railway Research (CRR) set up by Indian Railways (IR) at IIT Kharagpur for a long-term research framework

  MoU signed on February 13, 2010.
- Projects with RDSO collaboration funded by IR on the following major thrust areas:
  - High Speed Rail
  - Heavy Haul Technology
  - Advanced Materials and Manufacturing
  - Advanced Maintenance and Operation
- New Areas of Research
  - Computational Intelligence, Analytics and Optimization
- Human Resource Development
  - Short term courses on railway research
  - M.Tech. program on Railway Engineering
  - Ph.D. students working on Railway Research

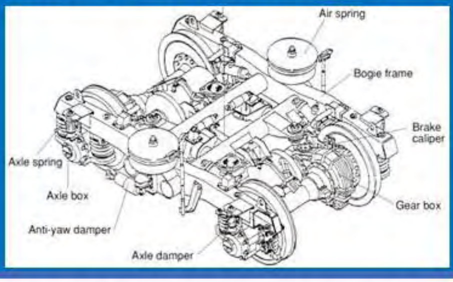


Plan for growth of CRR

- **Science universal – National/Foreign collaboration for Research and HR development**
- **Technology local - National R&D for local adaptation**

Research Capacity Building

Design of Bolsterless bogie for 250kmph & 350kmph passenger coach – academic interaction with KTH (Sweden), U of Tokyo

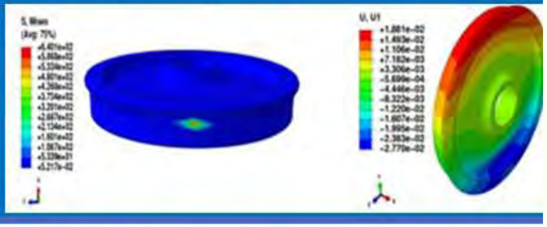


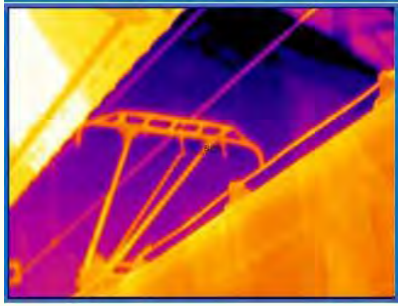
Vision
Build resources
Master the technology
Develop & transfer new technology

Performance Enhancement of Ballasted Rail Tracks – potential for heavy haul and high speed

Develop new rail steel to carry increased axle load from 25MT to 32MT and increase rail life – academic interaction with Cambridge U

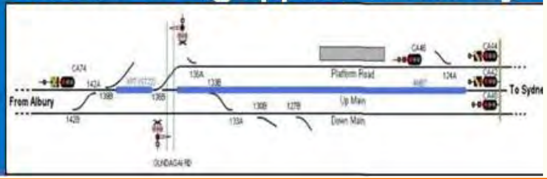
Rail wheel creep and warping research to help set operational standards





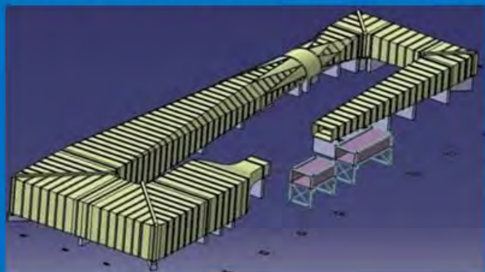
OHE Monitoring System – indigenous product development to save cost

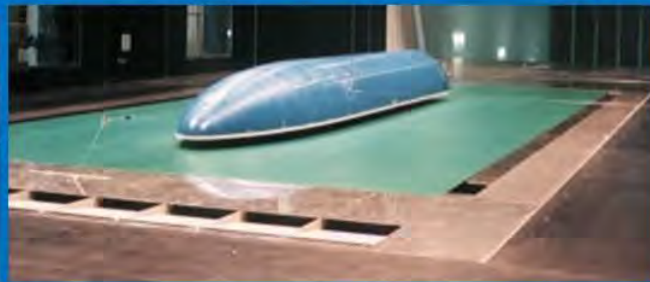
Validate signalling interlocks to eliminate human error in signal design – formal verification methods developed for VLSI circuits being applied to railways



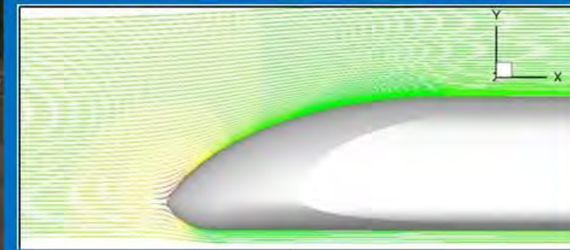
Research Capacity Building

Wind Tunnel Facility with Moving Floor

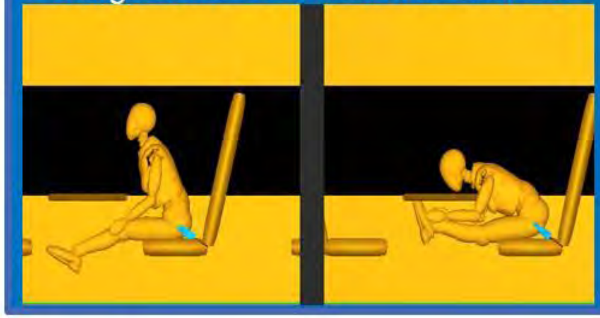


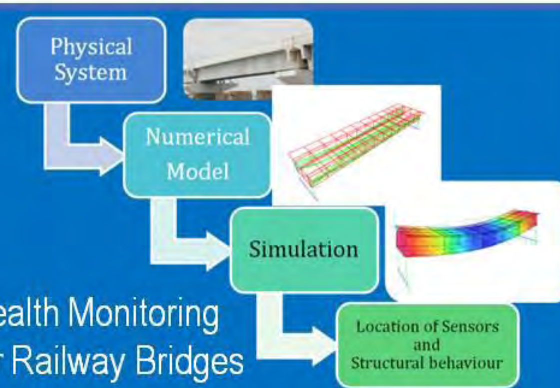


Aerodynamic Design of High Speed Rolling Stock



Safe Seating and Berthing Arrangements for Indian Rail coaches



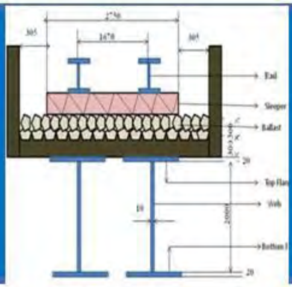


Health Monitoring for Railway Bridges

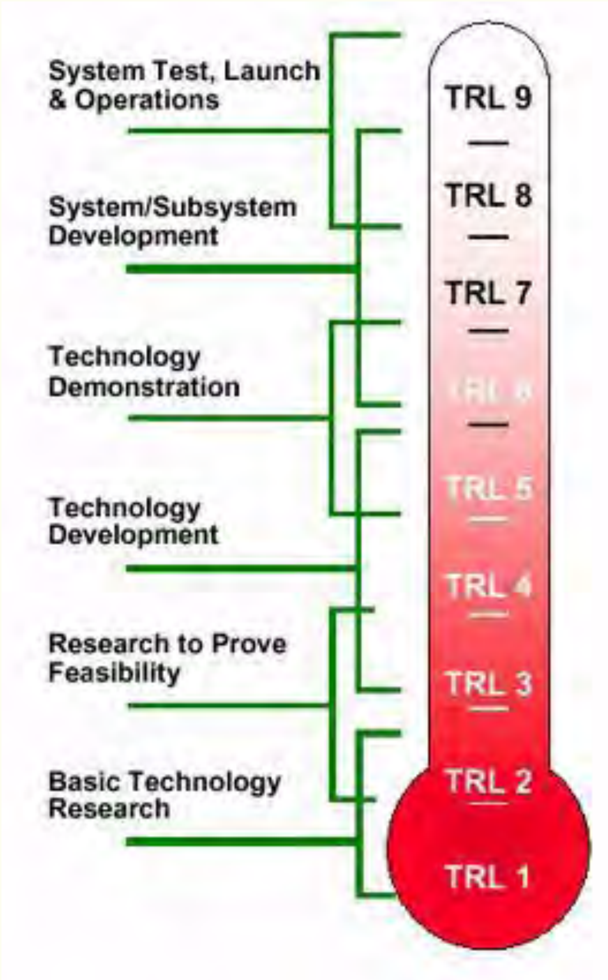
Water level monitoring for flood

Fault Diagnostics for Motors and Bearings of Locomotives for preventive maintenance

Development of Standards for Steel Concrete Composite Bridges for high speed trains



A Roadmap for CRR



NASA Steps to mature technologies and integrate them into systems

- **Where are we ?**
  - **Projects on Track, Bridge, Maintenance, Materials, Vehicle Dynamics, Signal, Heavy Haul, High Speed**
  - **Essentially directed basic research upto TRL 3-4**
  - **To take it upto TRL 7 it is essential that Teams get connected to IR technology units**
  - **To develop global technology standard essential to connect to global railway research**

Maturing Technologies to Products

- Suspension and bogie design
- Bainitic steel for railway tracks
- Online monitoring system of OHE traction parameters.
- Modelling and validation of interlocking for railway signalling systems

- Fog vision
- Rail/weld defect detection

Concept

Lab R&D
Proof of concept

Lab scale demo

Scaled up
Economics and viability

Product
Reliability, Optimization for cost and quality

Industry

Industry Partners
- **BEML**
- **SAIL**
- **National/Multinational Industry (discussion stage)**

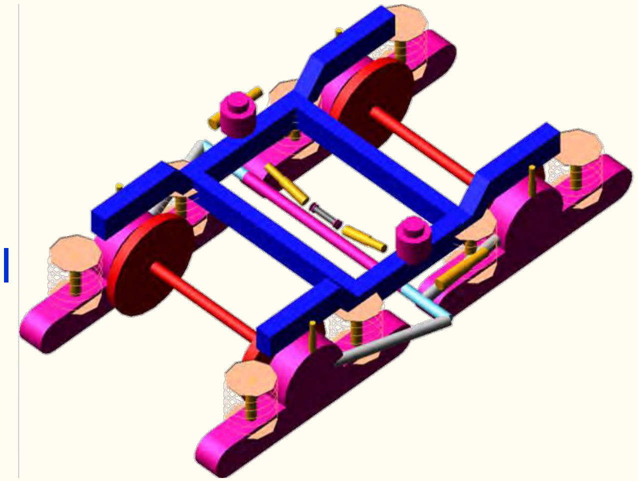
Institute activity

Suspension and Bogies Technology for High Speed Trains

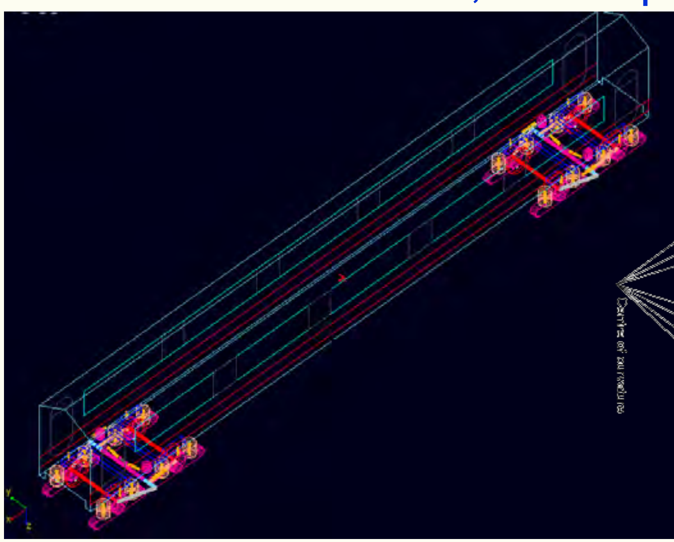
Implementation of Shinkansen-like Design

- Implements air spring, laminated rubber (chevron) spring, lateral and anti-yaw dampers, steering mechanism, graded circular wheel profile, directional primary spring stiffness, friction damping, etc.
- Ride comfort on test track
- Derailment speed: 288kmph on 4km radius irregular curved flexible track; 360kmph on straight track.

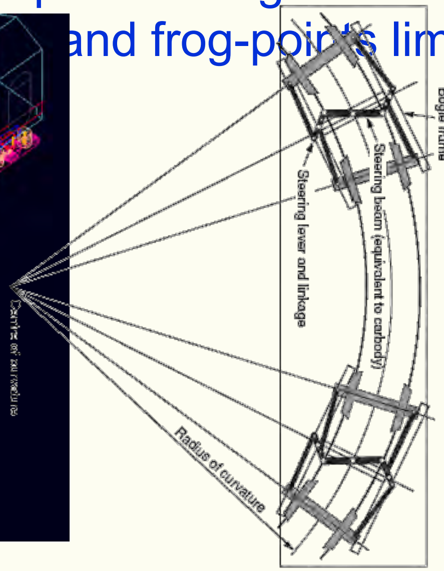
and frog-points limited

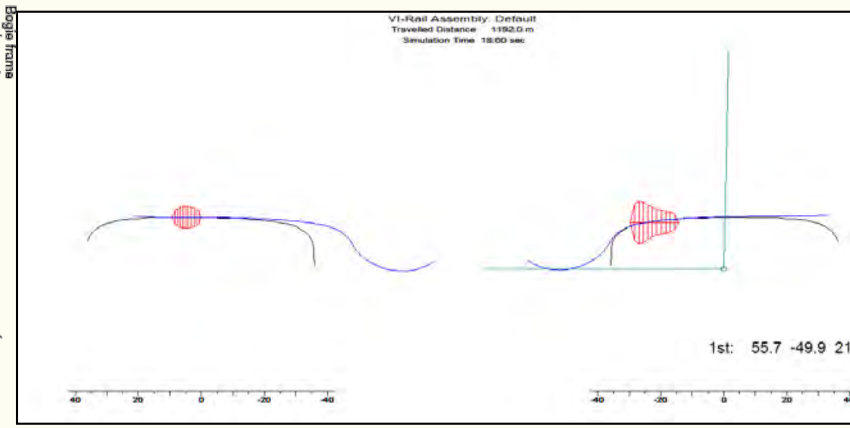


Bogie template in VI-Rail



Vehicle Assembly

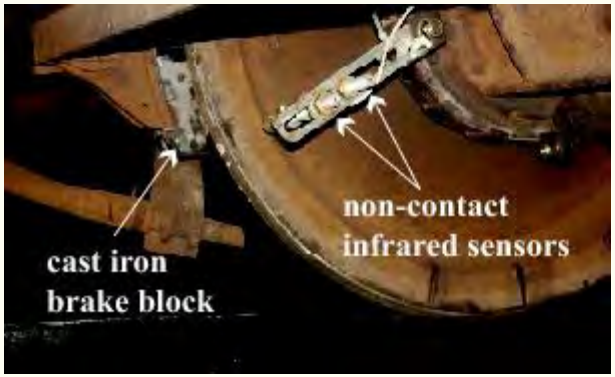


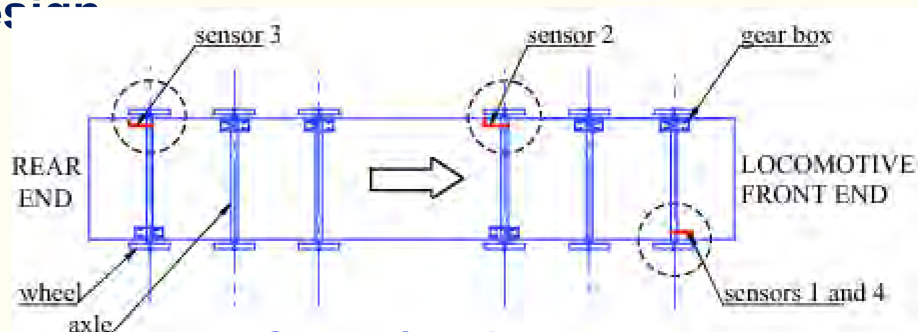


Critical Speed and Flange Contact Analysis

Creep and Warping in Wheel Sets

Accurate characterization of material behavior at high temperatures
Valid material models for creep response
Propose possible changes in material and manufacturing procedure, brake design, braking pattern and wheel design

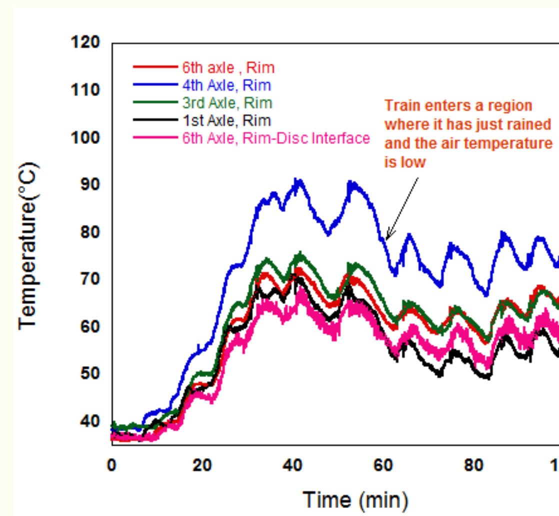




Sensor locations

Recommendations:

- Brake blocks used on locomotives and coaches/wagons must of a single make
- Maintenance practices must be altered to ensure effective braking of all wheel sets.
- For better troubleshooting in event of failure, sensor data must be stored for over 90 days
- Mechanisms must be evolved to monitor wheel gauge even during running condition.



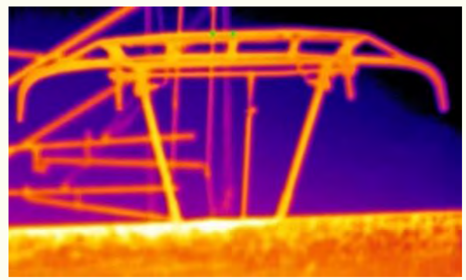
Temperature Profiles

Online monitoring system for OHE traction parameters

Tested technology with offline processing done at IIT Kharagpur in 1999.

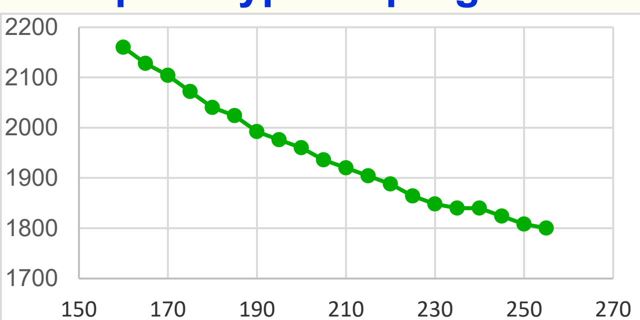
- o Carry out live scanning of contact wire in dynamic condition
- o Measure contact wire thickness, height, stagger and slope with location
- • Thickness of contact wire up to 16.5 mm, target resolution 0.3 mm
- • Stagger up to 700/350 mm, target resolution 5mm
- • Height of the contact wire, target resolution of 5mm

All above targets achieved in laboratory and in initial trial run. Refinement of algorithms and field prototype in progress

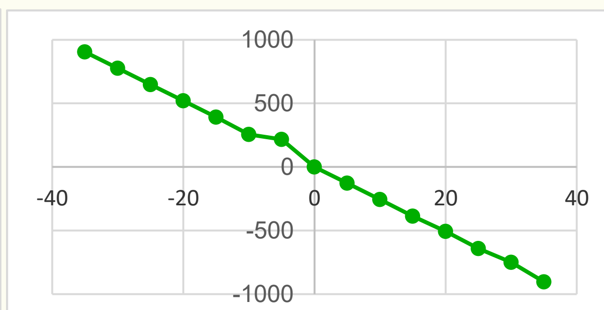


Hot spots detected with Infra-red Image

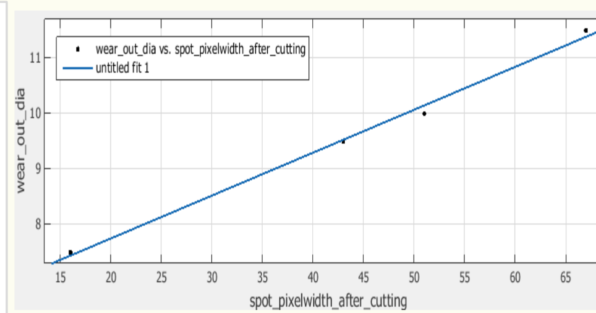
Experimental Setup for height, stagger and diameter measurement



Height measurement data



Stagger measurement data

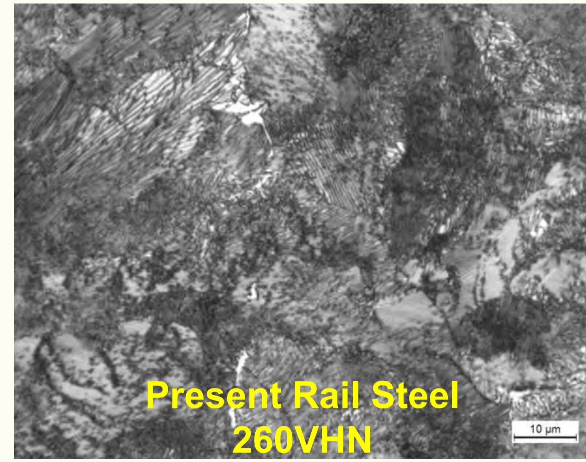


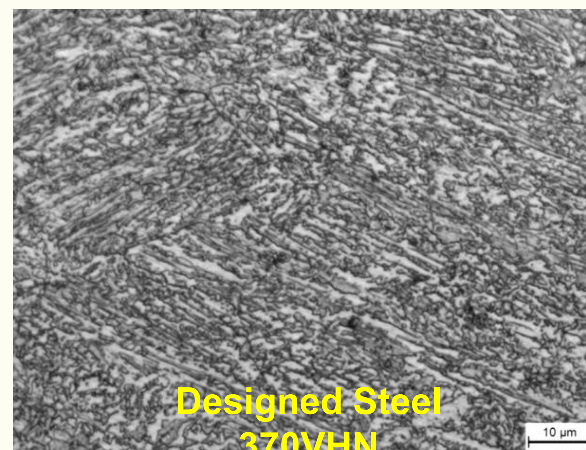
Diameter measurement data

Thermomechanically Processed High Strength Bainitic Steel Rails

Development of bainitic rail steel of low carbon low alloy or low carbon micro alloyed steel possessing good weldability properties.

Feature	Present 880 Grade	Lab. Target
Microstructure	Pearlitic	Bainitic
Ultimate Tensile Strength (MPa)	880 (Min.)	1000 (Min.)
Impact Energy (Joules)	10	2 times higher
Fracture Toughness ($MPa.m^{-0.5}$)	29	50
Wear Resistance		Twice of present grade





Steel compositions (wt%)

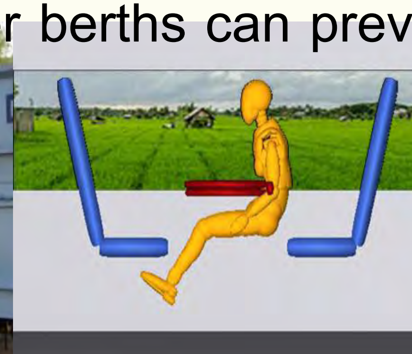
Steel	C	Mn	Si
Present Rail Steel (Gr. 880)	0.74	1.04	0.31
Designed Steel	Low C, low alloy steel containing Mn, Si, Cr, Mo, Ni		

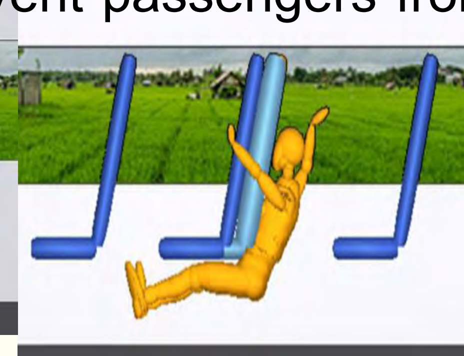
Seating Arrangements for Occupant's Safety

Study occupants' injury severity level for current seating/berthing arrangements in IR coaches and possible alternative seating/berthing strategies/orientations/materials

Recommendations:

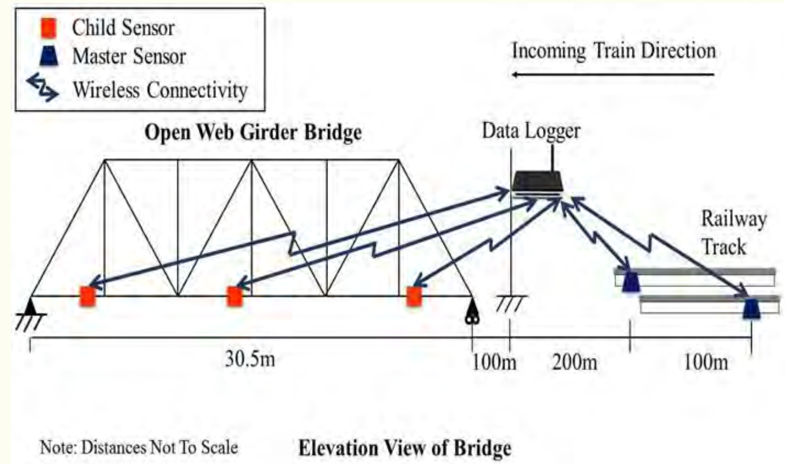
- Seating arrangements where passengers face train rear: effective way of reducing injuries
- Use of aluminium foam padding sharply reduces the chances of head injury for chair car passengers, and abdomen injury, for passengers seated behind a snack table
- Open bay berth type arrangements in sleeper coaches are not safe in general for passengers in lying down positions.
- Side berths resulted in higher injury severities.
- Use of Geonet netting in sleeper berths can prevent passengers from flying off their berths following a crash.





Railway Bridge Health Monitoring System with Wireless Sensor Networks

- Data logger will send sensed data to the remote server for analysis and alerting using GSM/3G.
- Energy of the network is optimized using event detection scheme based data collection. The data collection and transfer to remote site are automatic.
- for health



Event Detection Scheme

Water level measurement system consists of radar water level sensors and data logger.

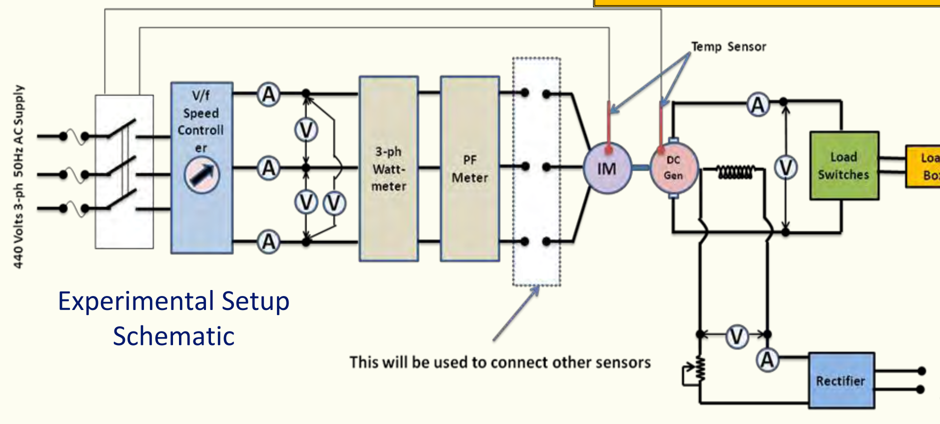
Modelling to find optimum location of sensors

On-board Intelligent Embedded Platform for Detection of Weak Failure Modes and Prognosis of Severe Faults in Locomotives and Associated Equipment

CRR @ IIT Kharagpur

Fault diagnosis system developed using signature analysis of stator current.

- Development of fault models
- Detectability vs. severity of faults
- Design of intelligent algorithms
- Design of embedded platforms



Experimental Setup Schematic

Type of Faults:

- Stator faults
- Rotor bar, end ring, and various eccentricity faults
- Bearing faults
- Spring faults

The experimental setup

The developed fault diagnoser

Broken Rotor Bar

Stator winding burn out

Broken Bearing

Broken Spring

Thres-hold	Missed Detection	False Alarm
0.015	7.4%	39.4%
0.021	10.9%	36.8%
0.030	15.9%	21.1%
0.039	19.51%	2.63%

Detection statistics for Rotor fault

Development of Composite Brake Block

Improvements:

Low specific wear rate

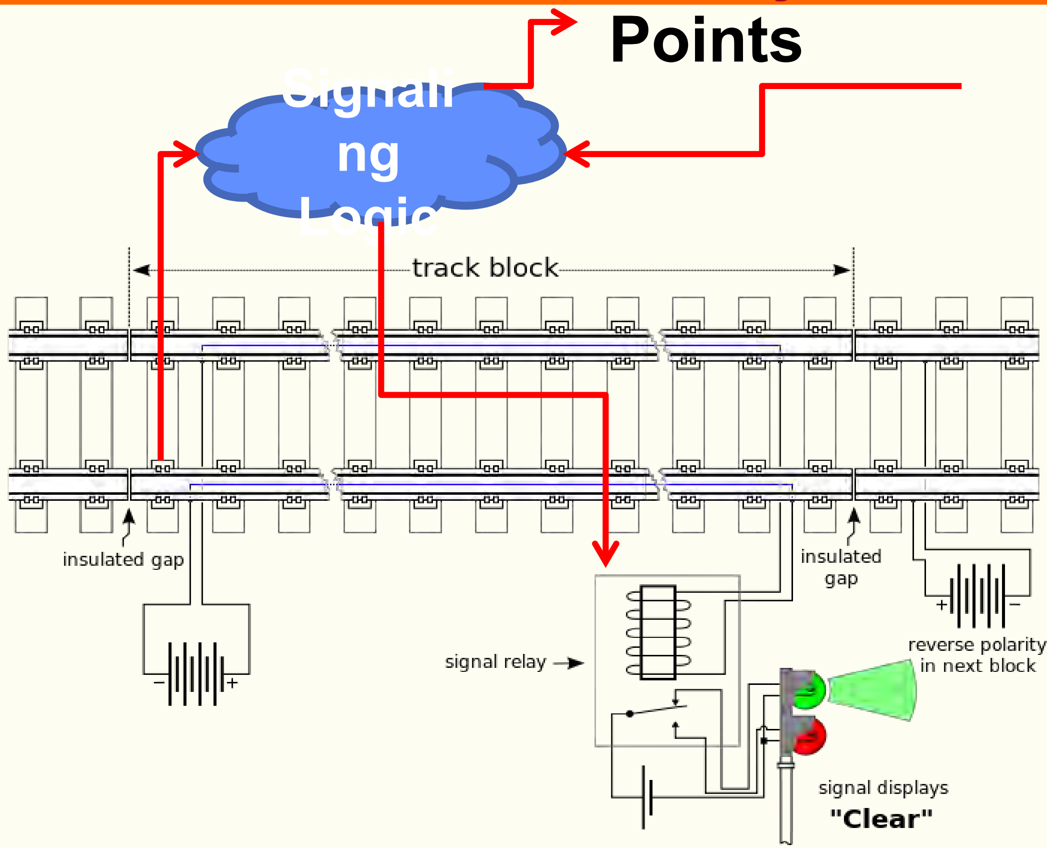
Low optical smoke density

High thermal conductivity

L Type Composite Brake Block

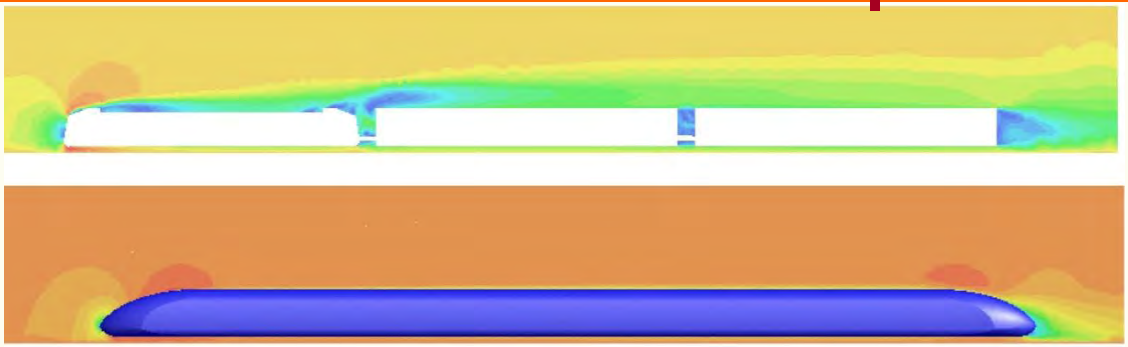
SL. No.	Tests as per existing specification	Brake blocks developed at IIT KGP		Existing Samples of brake blocks			
		Composition 'A'	Composition 'B'	1	2	3	4
1.	Hardness (HRR Scale)	87.7	85.6	100-120	70-90	85-105	88-108
4.	Cross Breaking Strength(kg/cm²)	94.3	167.56	190 min	100 min	100 min	200 min
5.	Modulus of Elasticity (N/mm²)	1958.48	1390.36	4500 max	1200 max	2000 max	4000 max
7.	Specific wear rate (cc/kwh)	1.464	-	3 (Max)	2.2 max	2 ± 20%	2.30
8.	Thermal Conductivity W/(m-k)	0.67	0.64	-	-	-	-
9.	Optical Smoke Density	[illegible]	[illegible]	[illegible]			

Modeling and Validation of Interlocking for Railway Signaling Systems



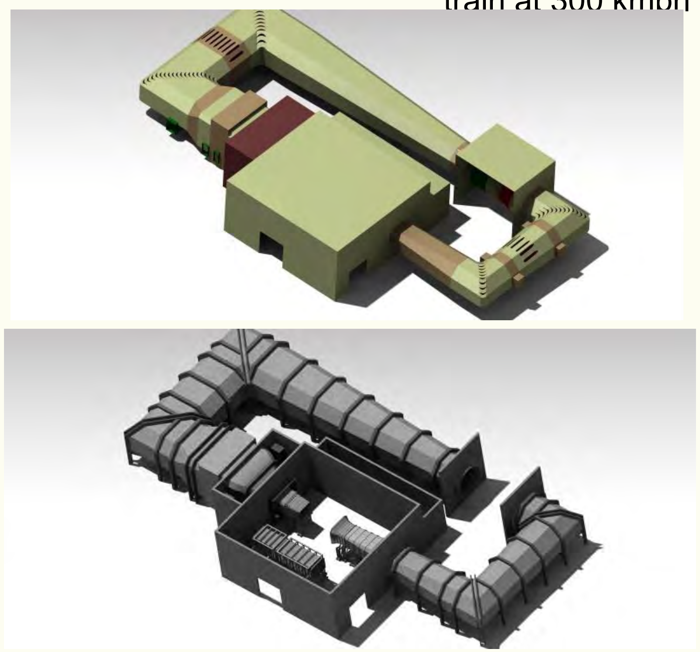
- India has started replacing all interlocking equipment with software controlled EI equipment
- Manually developed application logic used to program electronic interlocking equipment. This may lead to proliferation of errors (even after rigorous FAT and SAT testing)
  - Cases reported from UK and Australia
- The use of formal methods has been recommended in EN50128 railway

Aerodynamic study of traction rolling stock for high speed

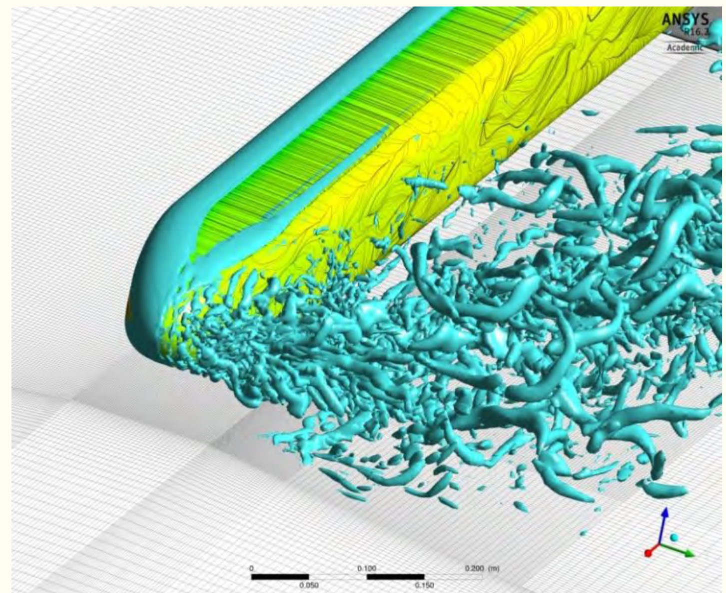


Flow over a WAP-7 locomotive pulled train at 125kmph and a streamline body train at 300 kmph

- Drag studies on existing Indian Railways train shapes
- Convergence to more efficient shapes for aerodynamic drag and noise reduction



Design of Low noise wind tunnel



Vortex shedding around simplified model of high speed train under side wind

Manpower Development

Degree course

M.Tech in Railway Engineering started in July 2015

(20 seats for Indian Railways, 10 seats for others)

Railway officers pursuing degree progams:

MTech. – Six (continuing)

PhD. – Three (continuing)

MS – One (continuing)

Students working on sponsored railway research projects

MTech. – Twenty four (completed)

PhD. – Three (completed) and Three (continuing)

Short Courses

GIAN (Micro-credit course)

High Speed Rail Systems (Winter 2014)

1 week courses under Continuing Education

Design and Analysis software for railway applications

RAMS for railways

Lectures/Workshops by International experts

Patents/Award

1. Cost Effective Mechanical Testing Equipment For Characterising Creep Behaviour Of Materials Under Combined Tension-torsion Loading – Patent filed, awarded certificate of appreciation for **Gandhian Young Technology Innovation awarded in 2016.**
2. Algorithm of fog removal from images – Patent filed, received award under DST-Lockheed Martin India Innovation Growth Programme (IIGP) 2016

Possible patents

1. Bainitic Steel
2. Instrument for OHE monitoring
3. Validation of interlocking for railway signalling systems

Awards

Uchchatar Avishkar Yojna – UAY-2016 (Pradhan Mantri Yogana Scheme)

Project Title: Advanced bogies and rail wheel traction control for meeting high standards of comfort, safety and performance of metro coaches

Publications (2014 – 2016)

- Journals – 14
- Conference proceedings – 7
- Book chapters – 3

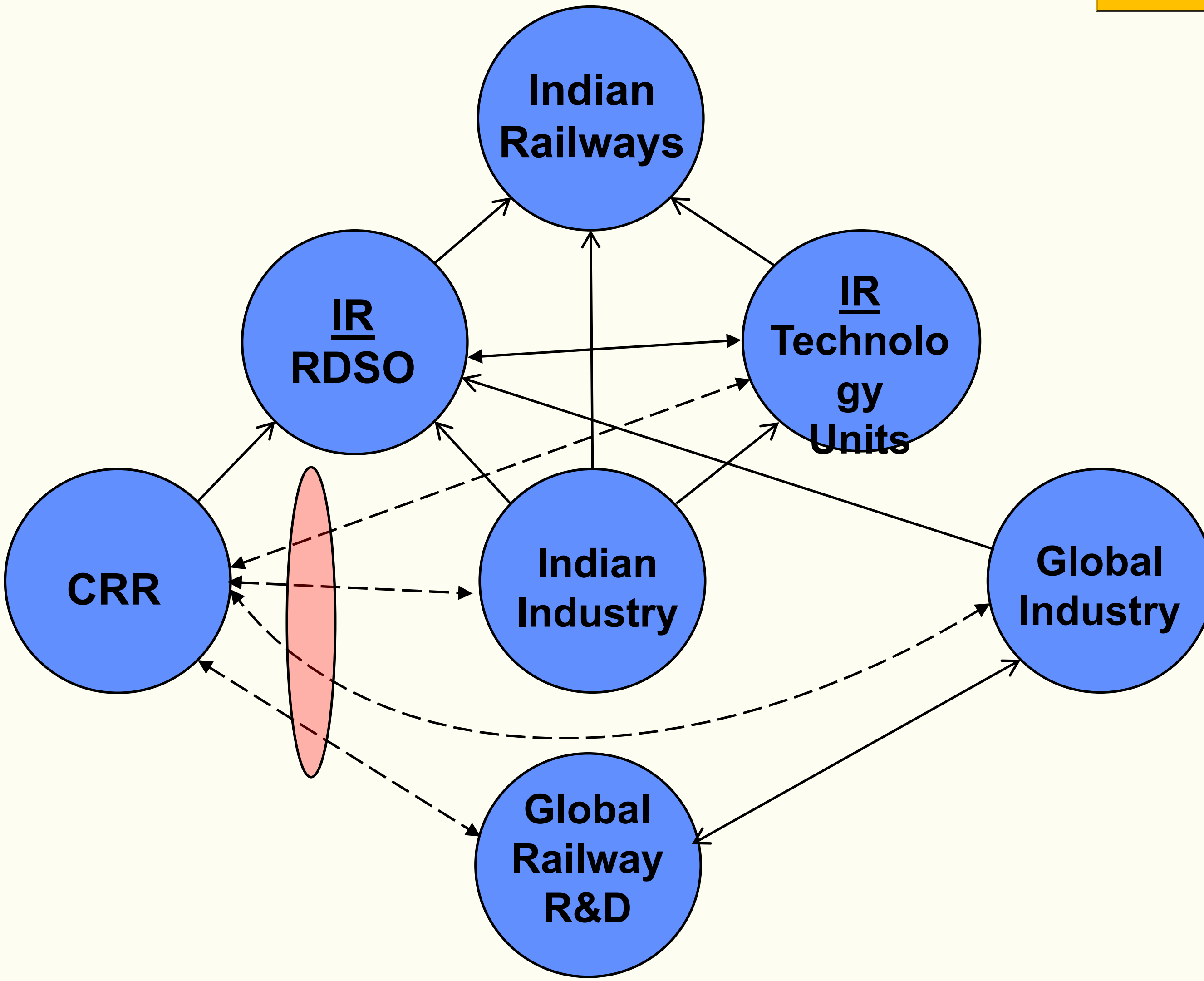
Centre for Railway Research

G+7 building under construction

G+7 building

- G+4 with 4500 m^2 floor space completed (funded by IR) Research and teaching laboratories in railway engineering

Railways Technology R&D : Nodes and Links



Strategies to build and nurture the missing links needed !


THANK
YOU!