UNIVERSITY OF BIRMINGHAM

Low Carbon Railways

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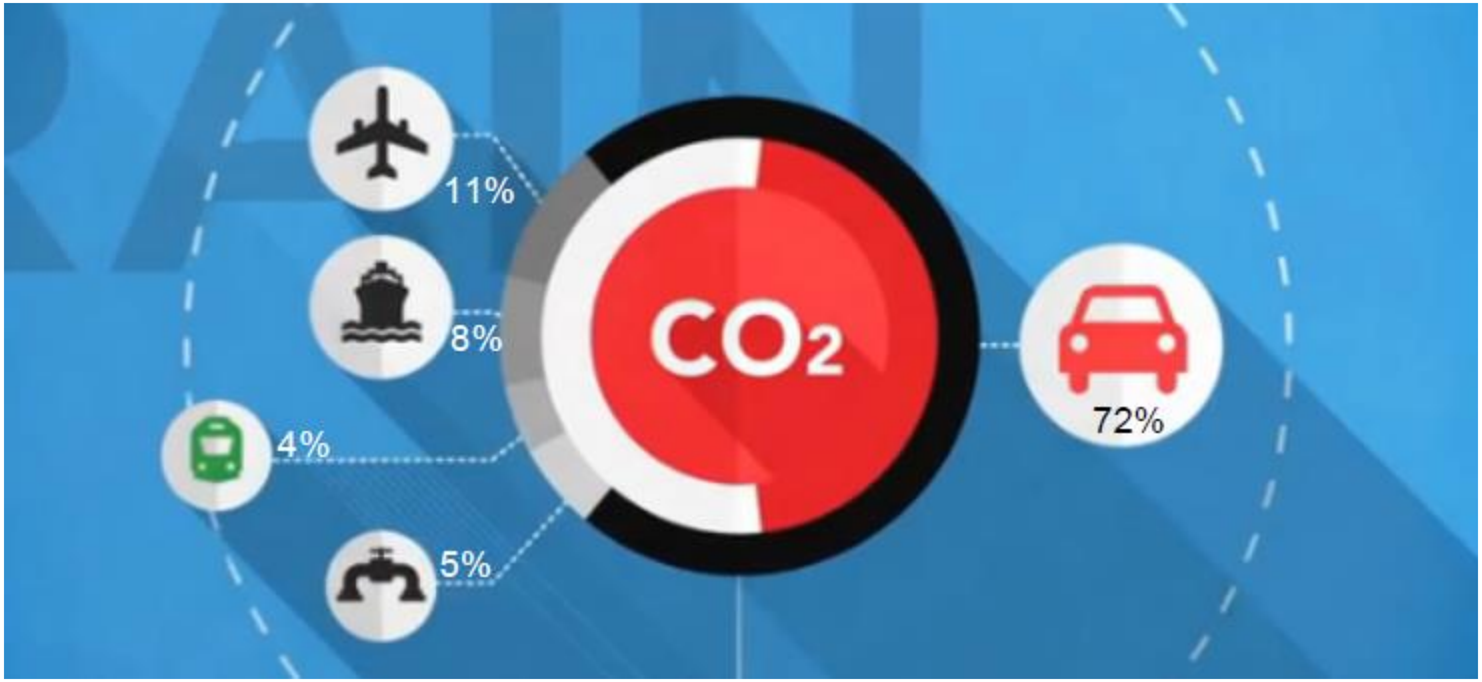
TALL POPPY CAMPAIGN

TRANSPORT

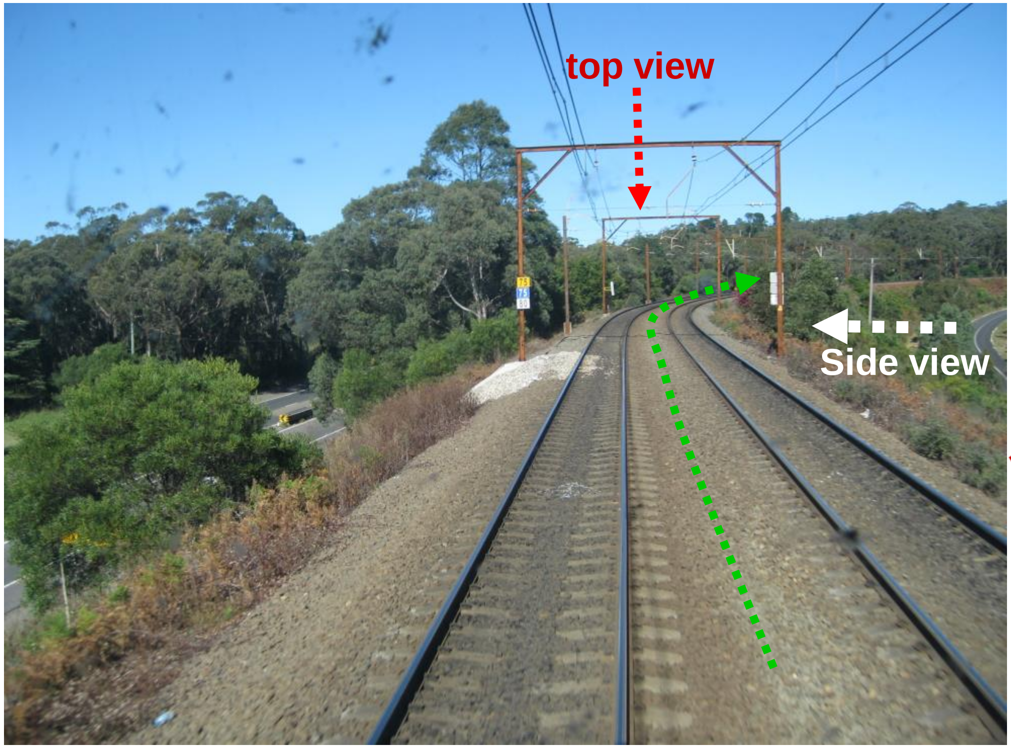
CO_2

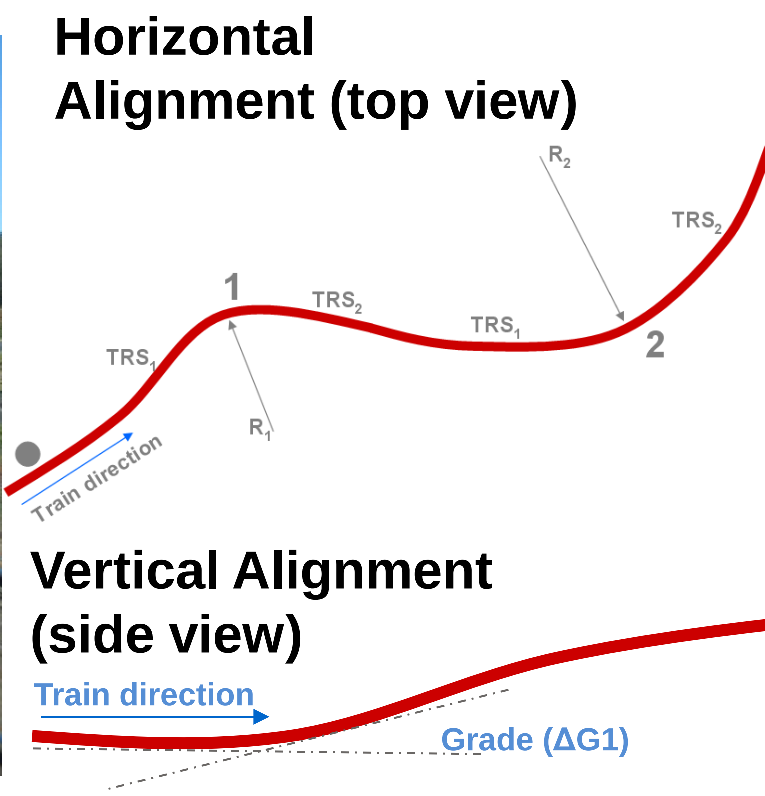


Kaewunruen et al. (2016) Frontiers in Transportation and Transit Systems; UIC (2016)

Railways
NOW & FUTURE

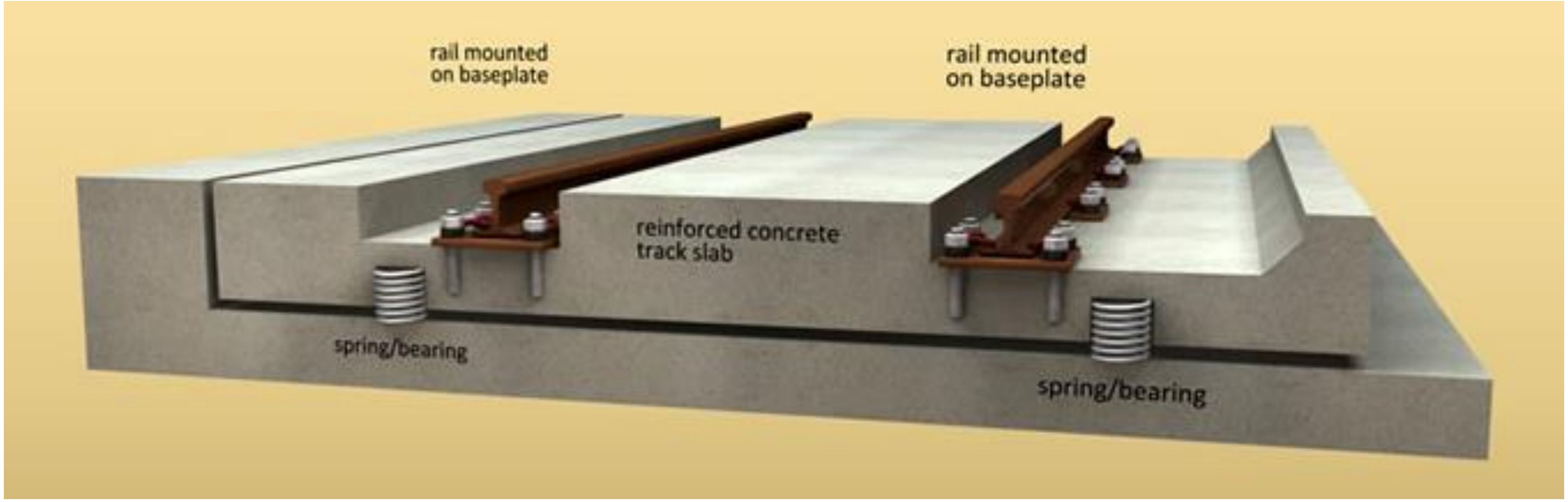
Ballasted Tracks





Railways
NOW & FUTURE

Slab Tracks

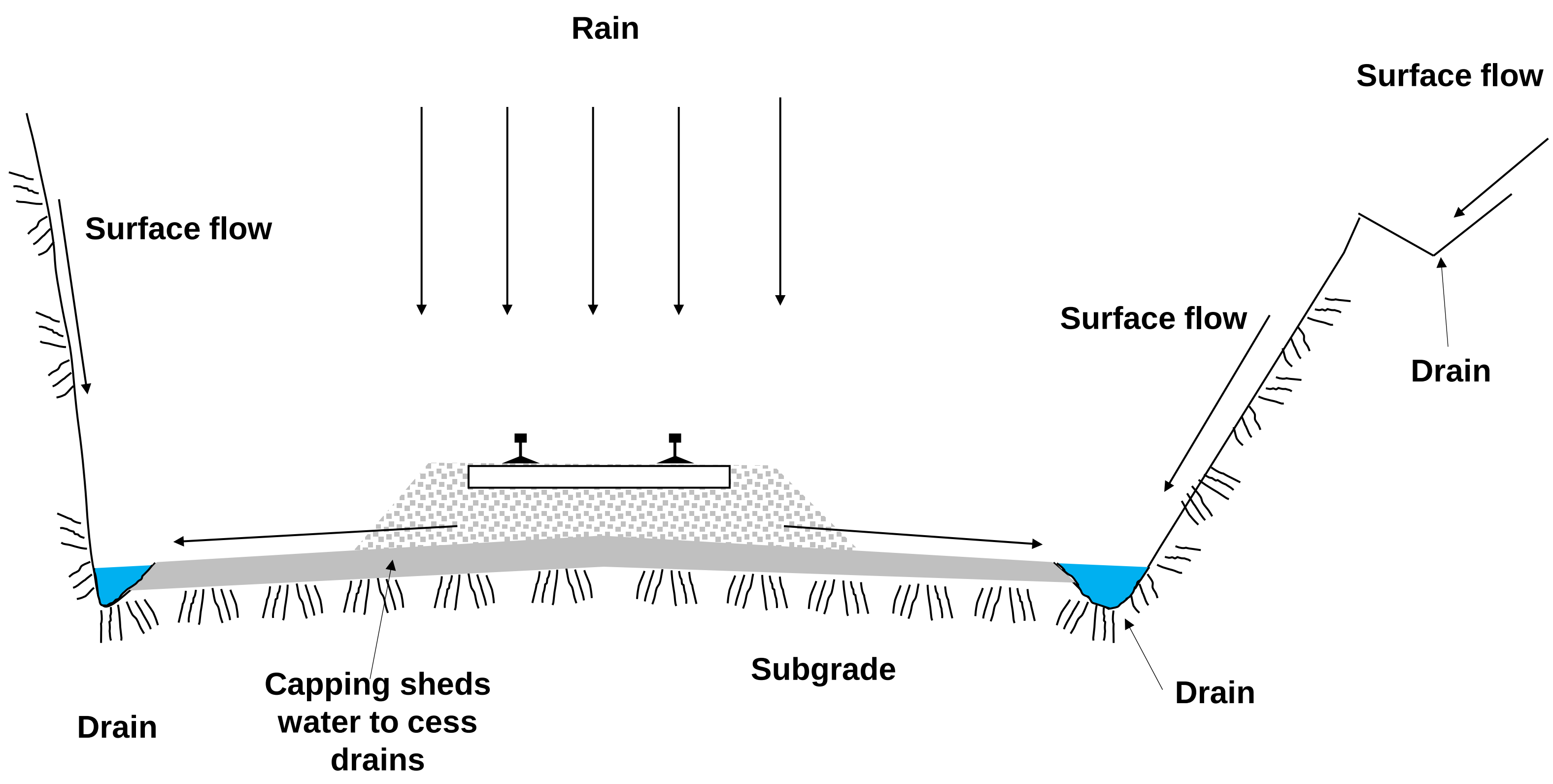


Wikipedia (2016)

SYSTEMS
NOW & FUTURE

Wikipedia (2016)

SYSTEMS COMPLEXITY



Kaewunruen et al. (2015) Frontiers in Environmental Sciences

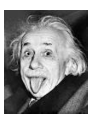
Why we do research?

IMPROVE

SAFETY & RELIABILITY

DESIGN & ANALYSIS

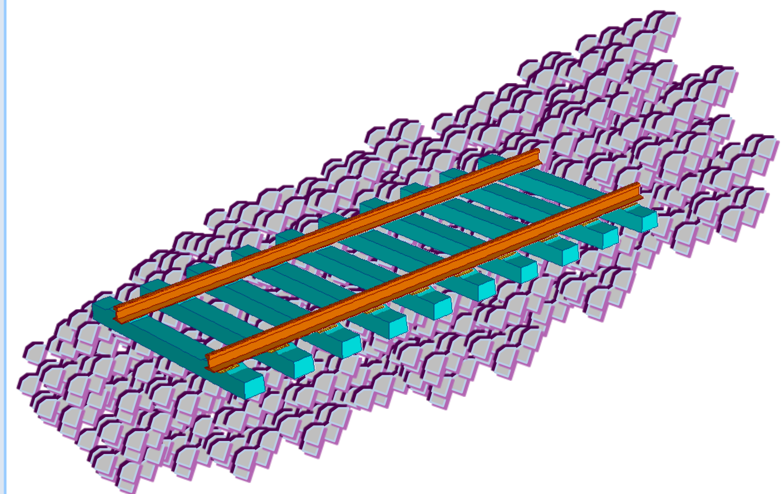
Zac
analyse geometry and train speed…



Customer *wrote*
I want faster services !

Zac
research and development on rail infrastructure…

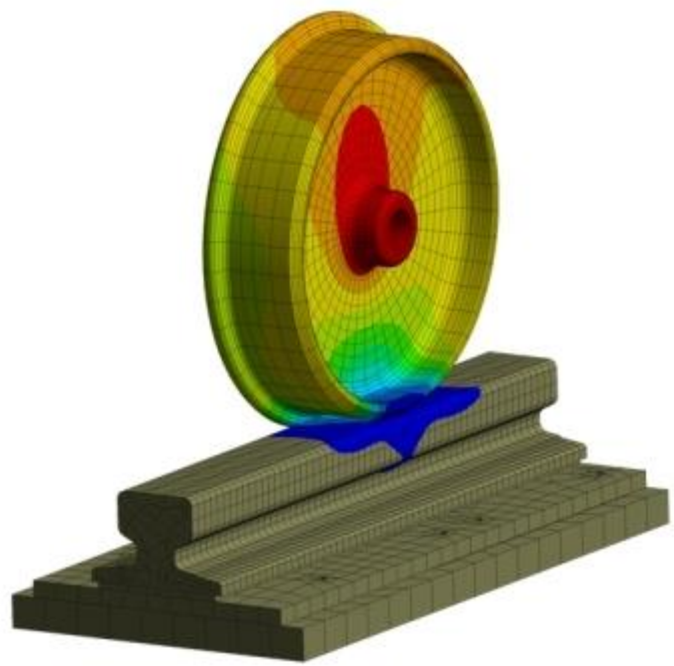
IMPROVE SERVICE LIFE



Customers are the centre of everything we do

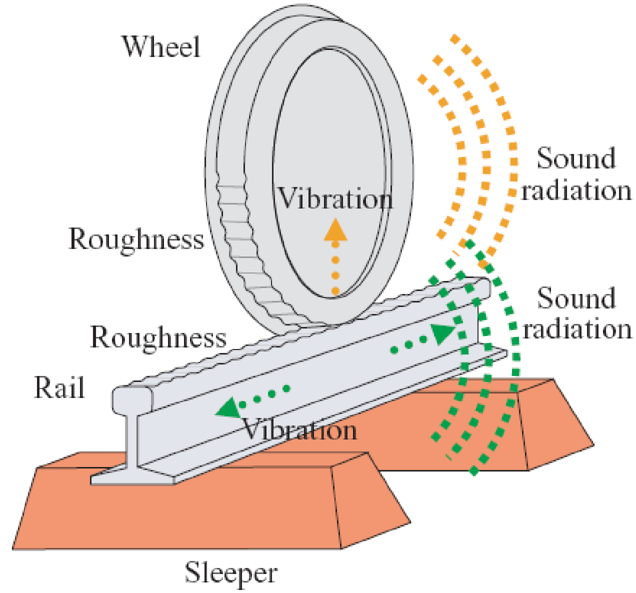
TRAIN-TRACK INTERACTION

Zac
improve wheel-rail and passengers' comfort… :D



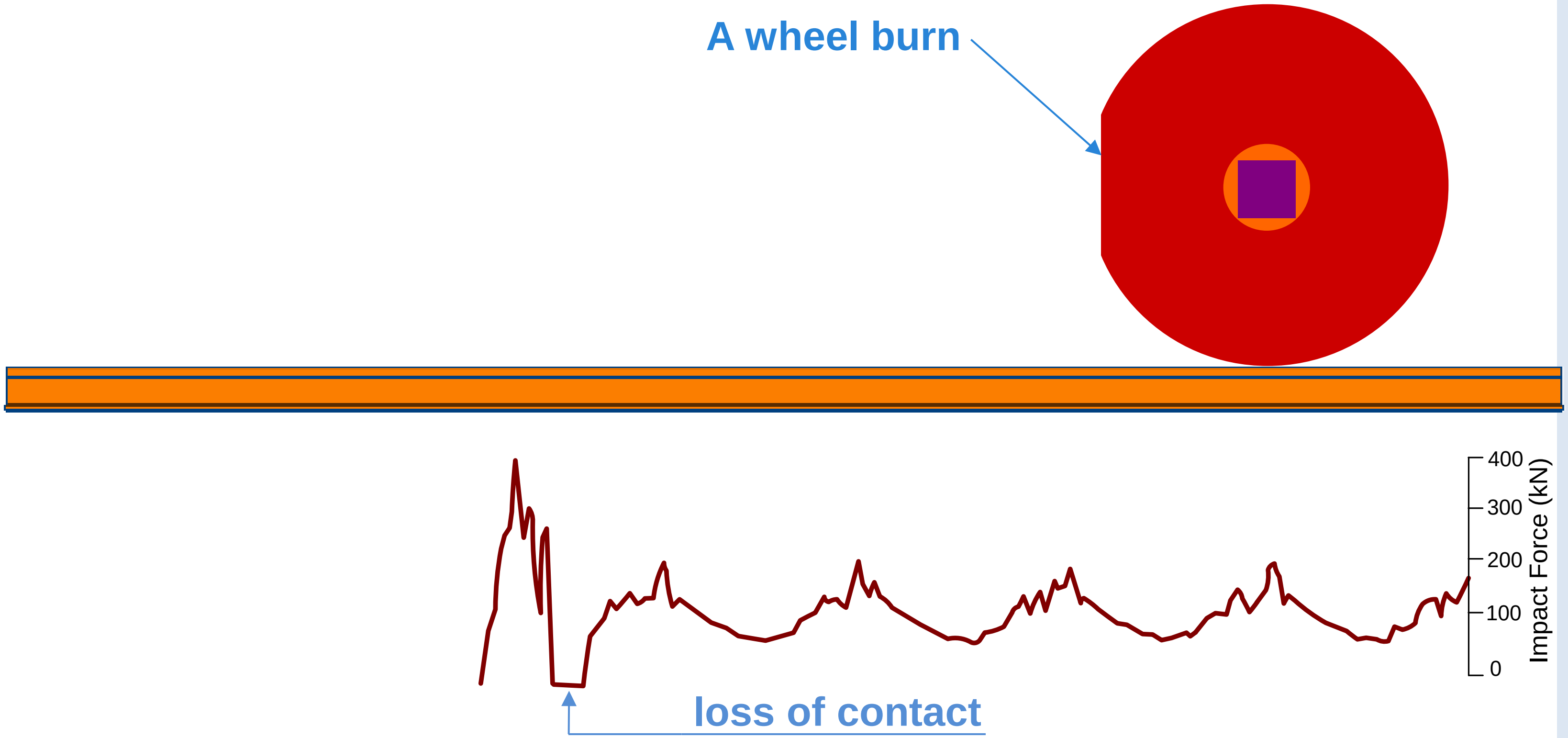
Zac
research and development on rail noise and vibration…

MITIGATE
NOISE AND VIBRATION



squeal | flanging | impact | rolling

Wheel/Rail Loading (i)



Remennikov and Kaewunruen (2008) Structural Control & Health Monitoring

PRACTICAL PROBLEMS

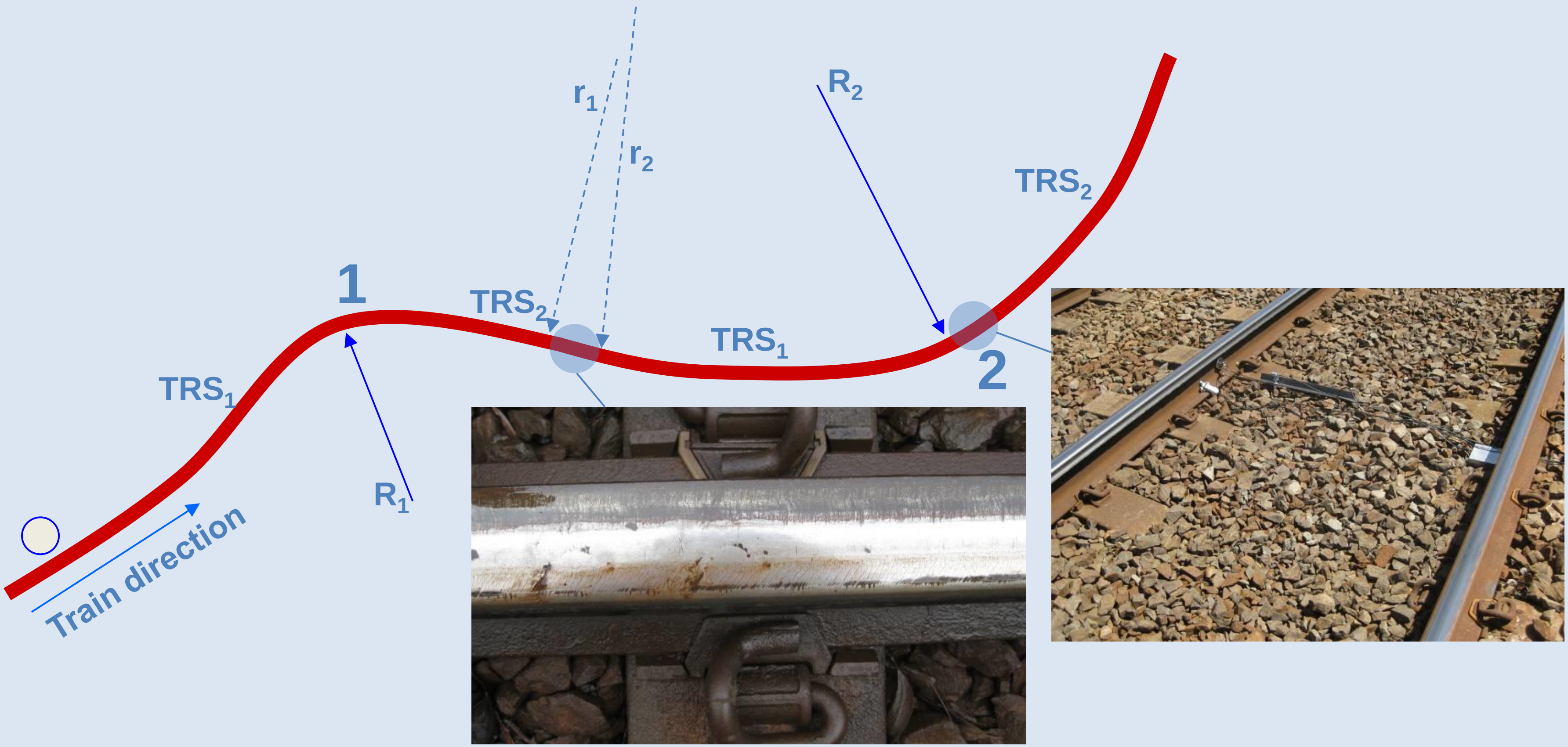
Effect of Impact loads on ballast degradation

- ballast breakage ✓
- impact load ✓
- track stability ✓

Kaewunruen (2014) International Journal of Railway Technology

PRACTICAL PROBLEMS

Track Geometry



Kaewunruen et al. (2015) Acoustics Australia

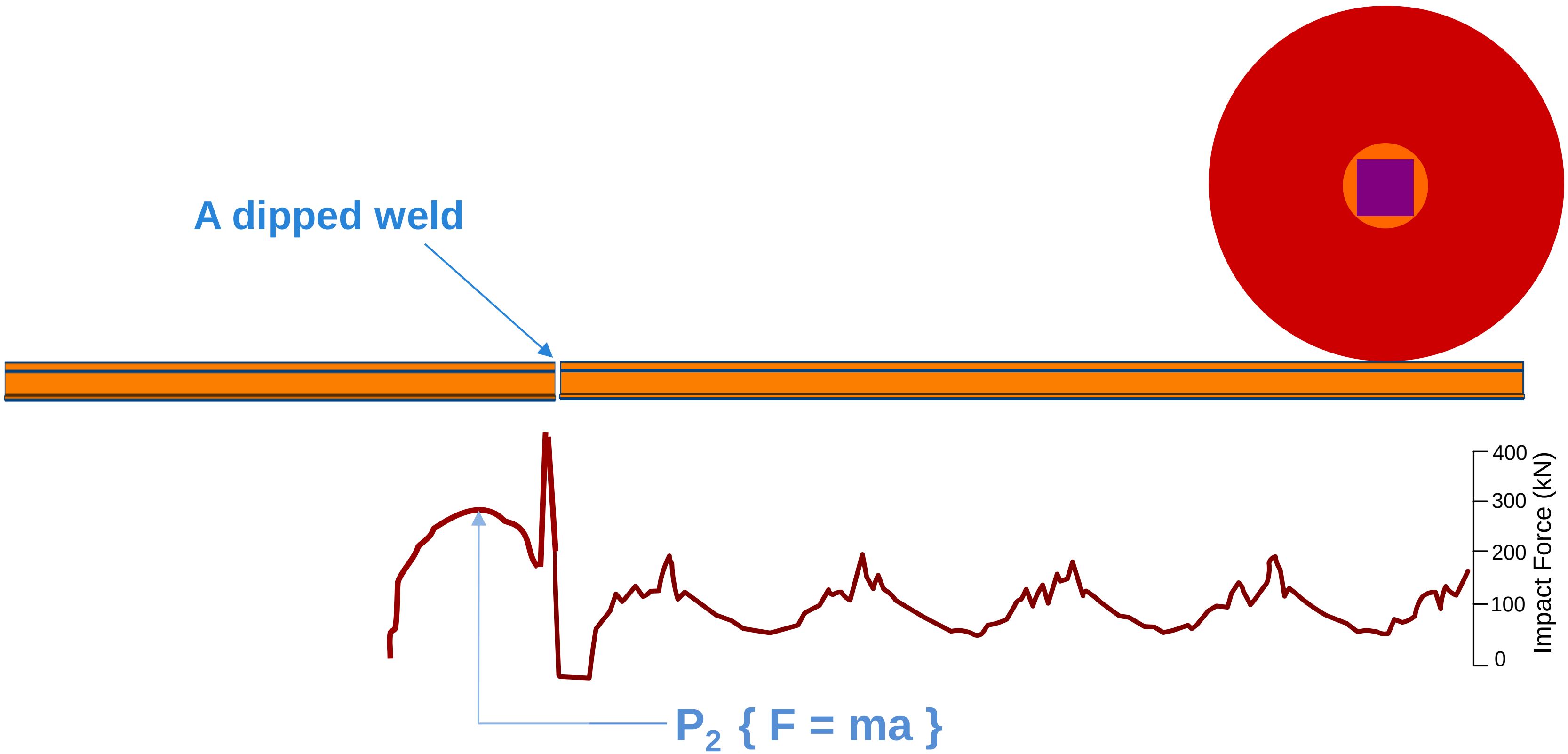
PRACTICAL PROBLEMS

Rail Squat Strategies

field investigation ✓
finite element analysis ✓
metallurgical studies ✓

Kaewunruen and Remennikov (2009) Engineering Structures

Wheel/Rail Loading (ii)



PRACTICAL PROBLEMS

Impact loads due to crossing and turnouts

- FEM: ABAQUS, Vampire & NuCars
- Vibration mitigation
- New component materials

- Component Failures
- Impact Forces
- Ground vibration

Case Study: complex urban double slips

Kaewunruen (2014) Structural Monitoring and Maintenance

PRACTICAL PROBLEMS

Reduction of failures due to crossing and turnouts

Field Trials
Sleeper/bearer pads
Composite bearers

PRACTICAL PROBLEMS

Noise

measurement
classification & detection
correlation with parameters

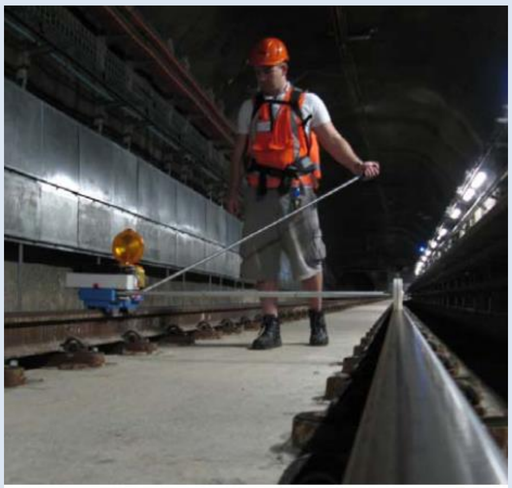
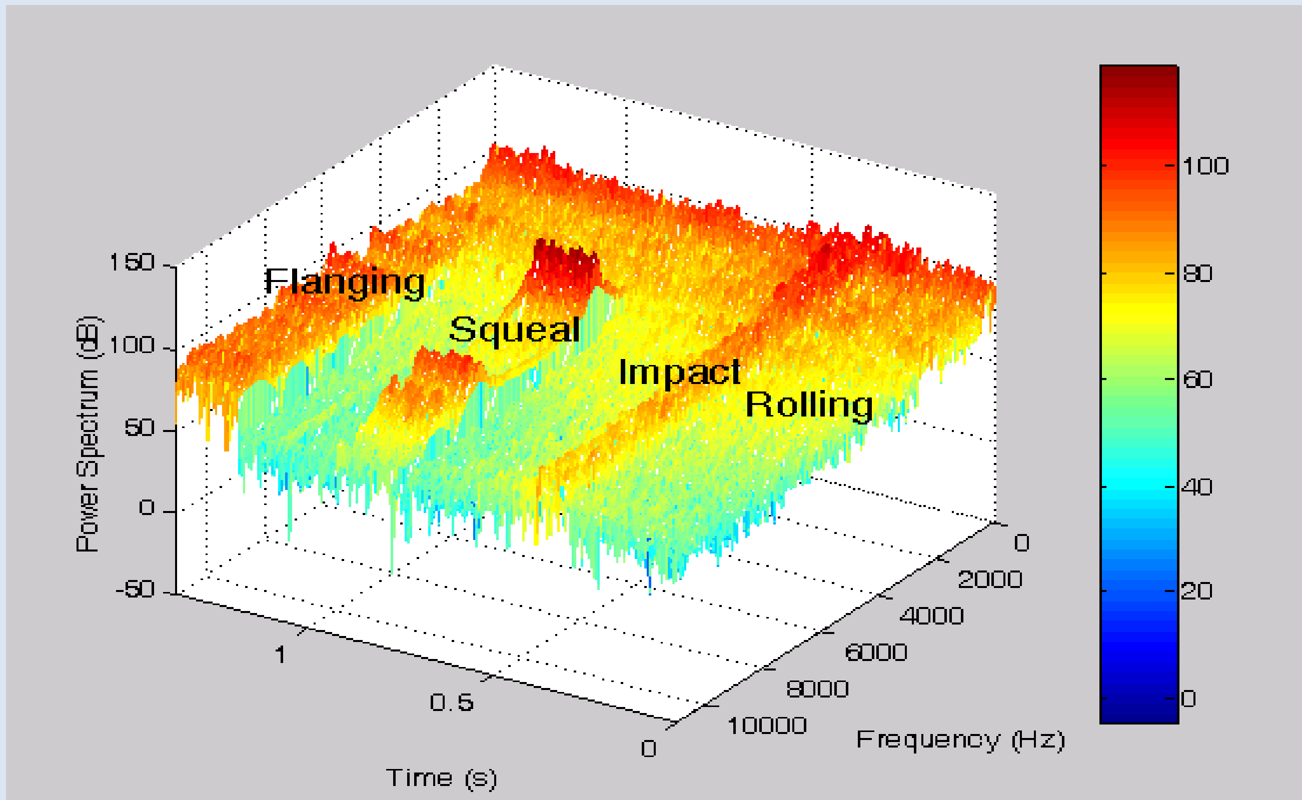


Figure1: Rail roughness measurement using the Corrugation Analysis Trolley

squeal | flanging | impact | rolling



Kaewunruen and Remennikov (2015) Australian Journal of Civil Engineering

PRACTICAL PROBLEMS

Concrete Damage Repair

Carbonation
Chloride contamination
Corrosion

Kaewunruen et al. (2014) Frontiers in Materials

PRACTICAL PROBLEMS

OWH Structure Damage

Longitudinal cracks

Corroded bolts

Corrosion

REALITY CHECK!

- ❑ Railway is complex by nature. Construction of railway thus emits significant carbon footprint.
- ❑ Sus-systems and their components deteriorate under interdependent systemic functions.
- ❑ Corrective and preventative maintenance is often required, depending on situation.
- ❑ Unplanned maintenance can cause excessive financial penalties.

Construction

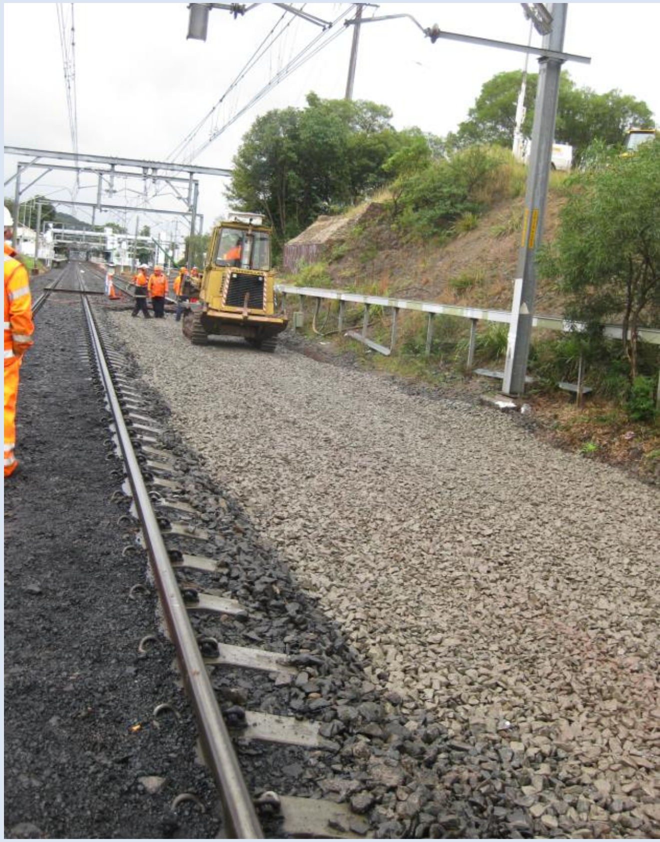
- 2 Types of Constructions
  - Greenfield = new construction of infrastructure (new asset)
  - Brownfield = renewal, retrofit, refurbishment or reconstruction of infrastructure (existing asset)

Construction

- **Construction of a New Track:**
  - **Surveying**

Construction

- **Construction of a New Track:**
  - **Ballasting (video)**



Construction

- **Construction of a New Track:**
  - **Rail and Sleeper laying**

Construction

- **Construction of a New Track:**
  - **Rail and Sleeper laying**

Construction

- **Construction of a New Track:**
  - **Resurfacing ([alignment adjustment])**

Construction

- **Construction of a New Track:**
  - **Tamping (video)**

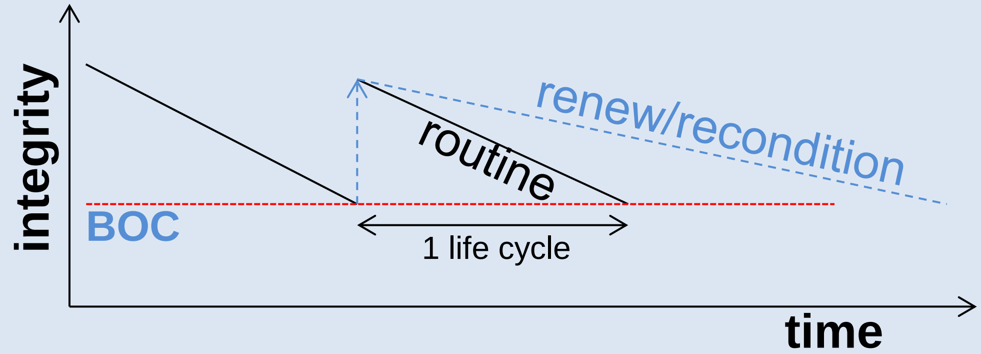
Construction

- **Construction of a New Track:**
  - **Regulating & Blooming (video)**

Construction

- **Construction of a New Track**:
  - **Stabilising (0.1-0.5MGT) (video)**

Maintenance



- **Railway Assets**:
  - Tracks
  - Special Trackwork (Turnouts, Yards/Sidings)
  - Signals, Controls & Communications System
  - Overhead Wiring Structures (OHS)
  - Platforms / Stations
  - Bridges & Viaducts
  - Tunnels
  - Airspace Development (Shopping Centre, Busway)
  - Billboards; Buildings; etc.

Track Services

Track Inspections

- Engine Ride
- Track Walking
- Detailed Track Patrol
- Track Inspection Vehicle (Geometry)
- Rail surface testing
- Crossing Inspection
- Crossing Ultrasonic testing
- Survey Mark Review
- Clearance Review
- Rail Creep Measurement
- Bridge Inspection
- Overhead wiring inspection
- Wayside detection systems
- Ride comfort (Customer Experience)
- Etc…..

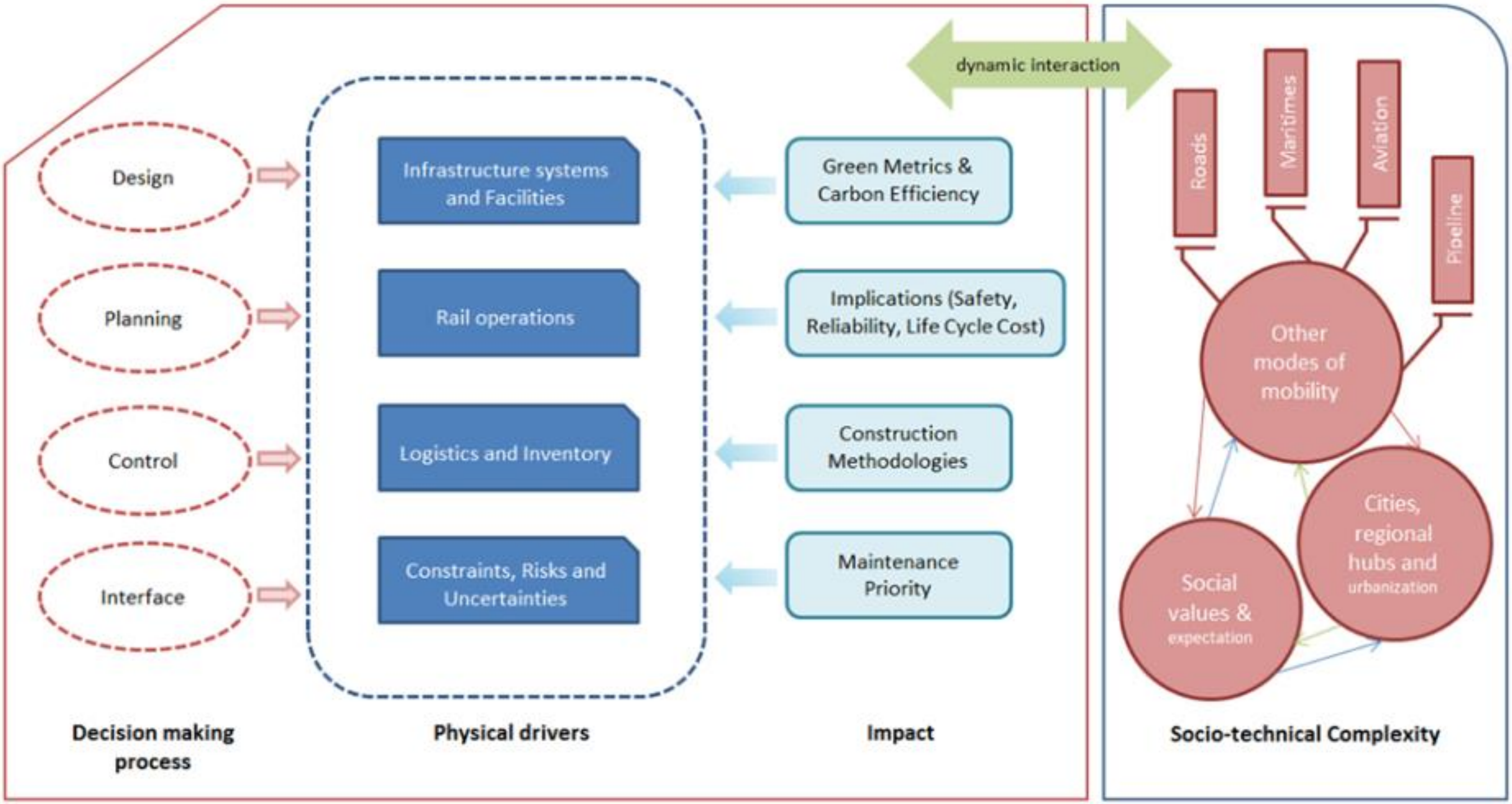
Track Data Analysis

- Operational Analysis
- Prioritisation
- Assurance & Audit
- Condition Monitoring & Maintenance Analysis
- Scheduling

Track Maintenance

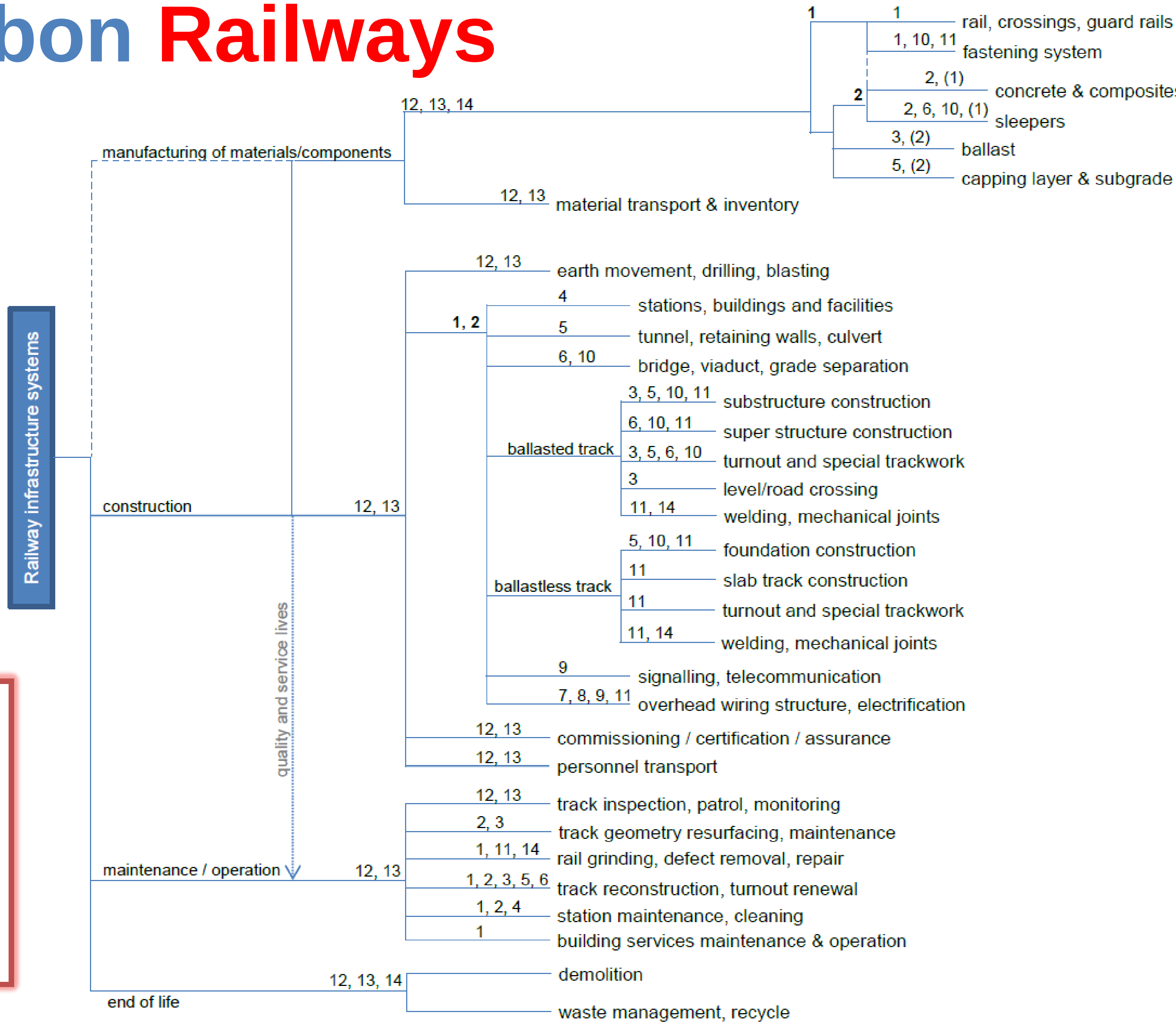
- Planning & Re-Design
- Operations Management
- Logistics and resources
- Maintaining assets:
  - Renew & Repair
  - Restoration
- Commission and Report

Low Carbon Railways



Kaewunruen et al. (2015) Frontiers in Environmental Sciences

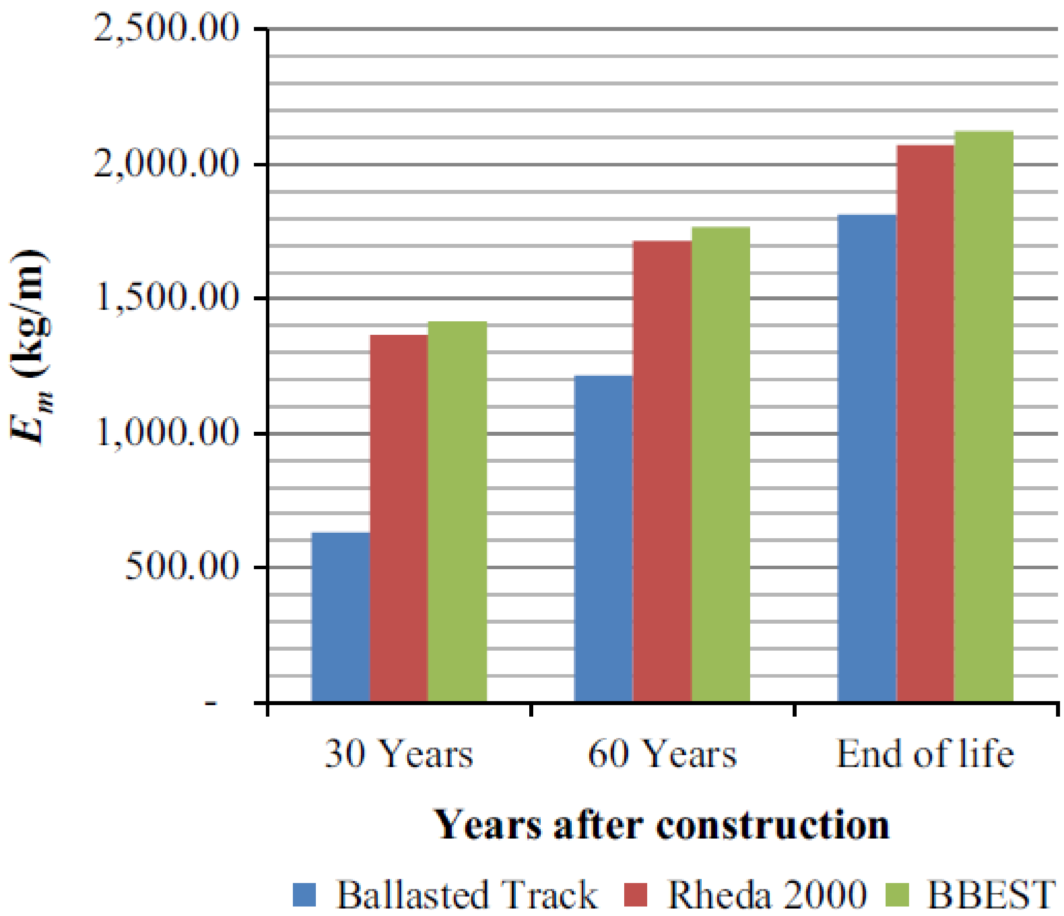
Low Carbon Railways



Greenhouse gas contributors:

1. Steel embodied carbon
2. Concrete embodied carbon
3. Gravel embodied carbon
4. Brick embodied carbon
5. Soil and bed material embodied carbon
6. Timber embodied carbon
7. Aluminium embodied carbon
8. Copper embodied carbon
9. Insulator embodied carbon
10. Polymer/Rubber embodied carbon
11. Other materials (chemical, synthetics)
12. Fuel Consumptions
13. Electricity
14. Other energy sources (e.g. gas, etc.)

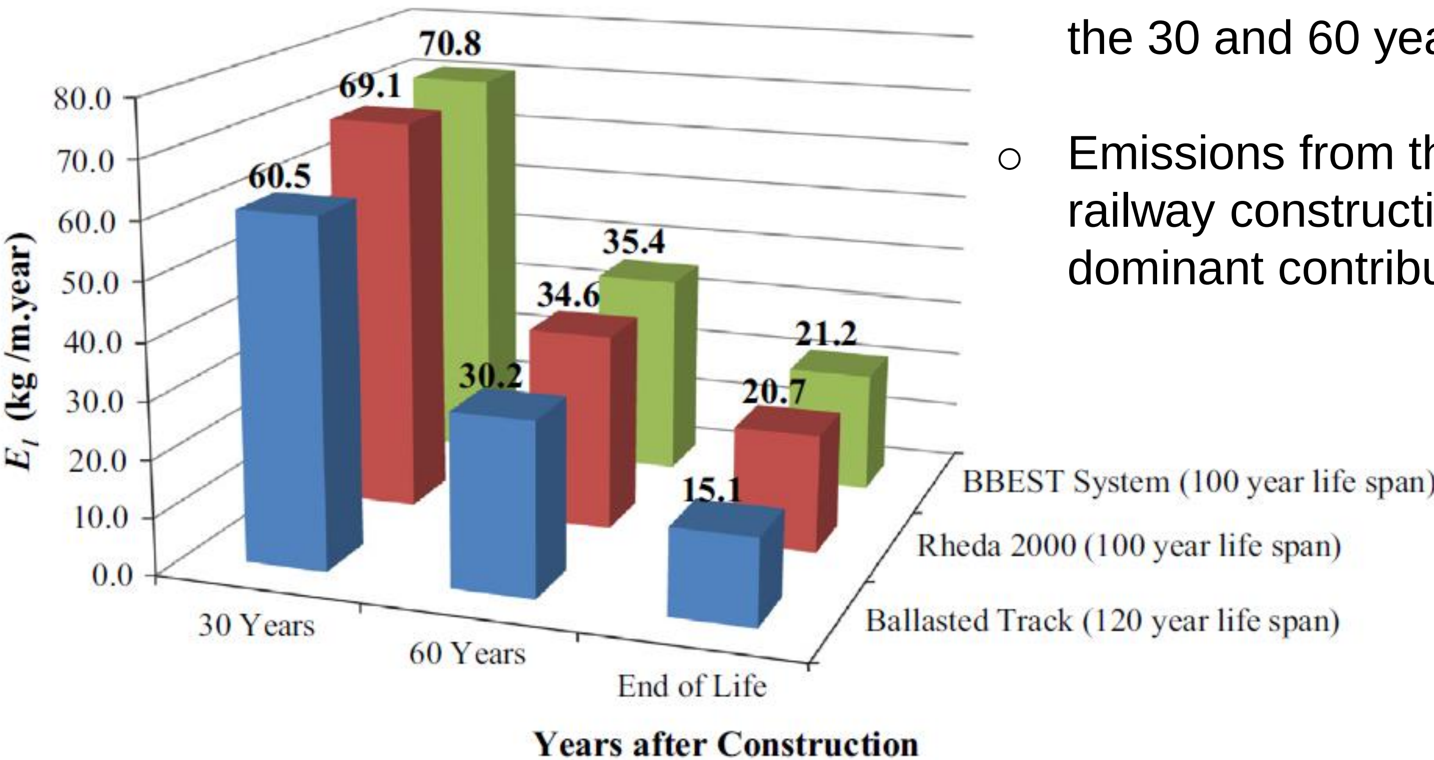
Systems-based strategy to achieve carbon-efficiency (i)



- Extensive monitoring and measurements of railway construction management practices were conducted.
- Life cycle carbon emission from plain-line railway renewal activities are assessed.
- Field data suggests the carbon footprint due to ballasted track construction and maintenance is less than that of ballastless tracks over the lifespan.

Krezo et al. (2016) Transportation Research Part D: Transport & Environment

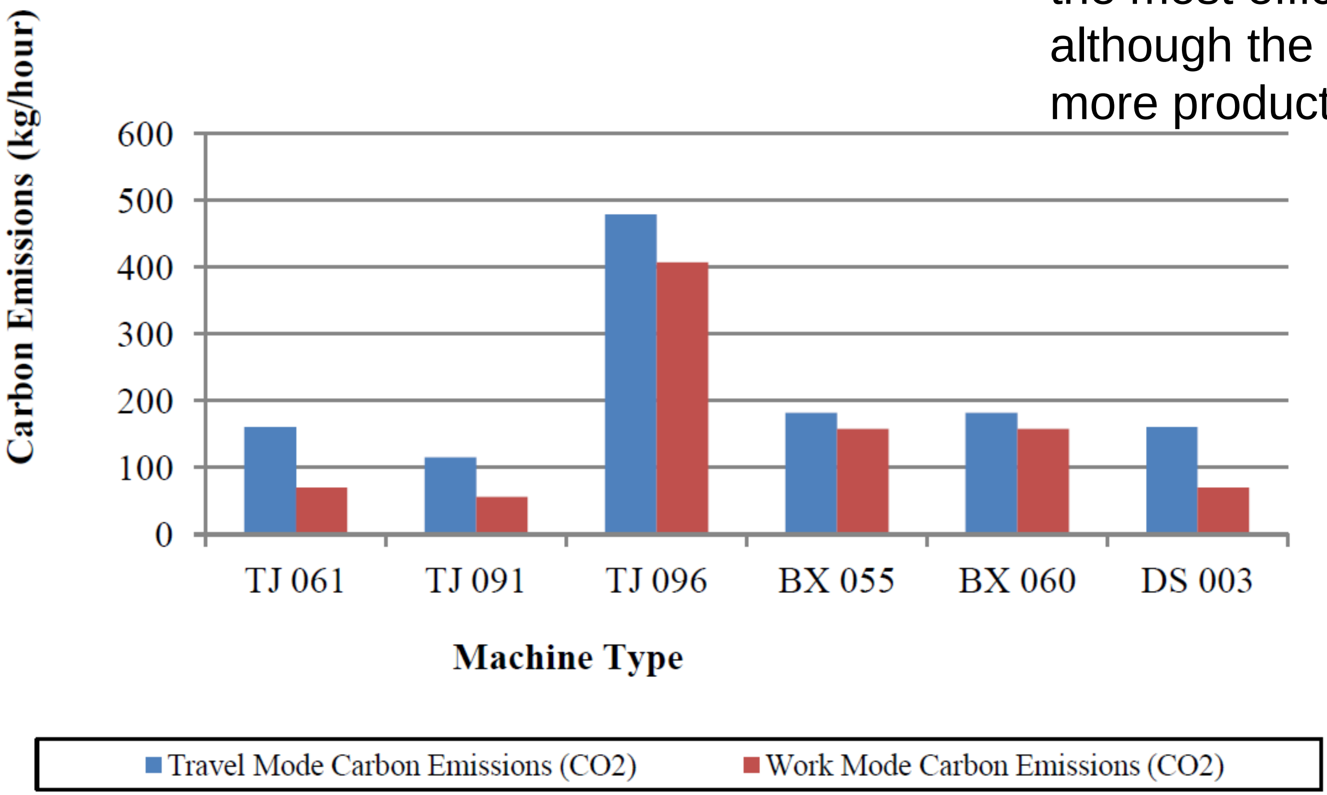
Systems-based strategy to achieve carbon-efficiency (ii)



- Significantly more maintenance emission in ballastless track bed can be observed at the 30 and 60 year interval.
- Emissions from the embodied carbon of railway construction materials are the dominant contributor.
- Prolonging the reconstruction frequency by optimal routine maintenance activities is the key to reducing lifecycle CO_2-e emissions.

Krezo et al. (2016) Transportation Research Part D: Transport & Environment

Systems-based strategy to achieve carbon-efficiency (iii)



- Resurfacing machine TJ061 and TJ091 are the most efficient tampers. It is found that although the dual head tamper (TJ096) is more productive, it is not carbon-efficient.
- By adopting the right combination of work equipment, carbon efficiency can be optimised through appropriate use of resurfacing machines.

Krezo et al. (2014) International Conference on Railway Technology

Systems-based strategy to achieve carbon-efficiency (iv)

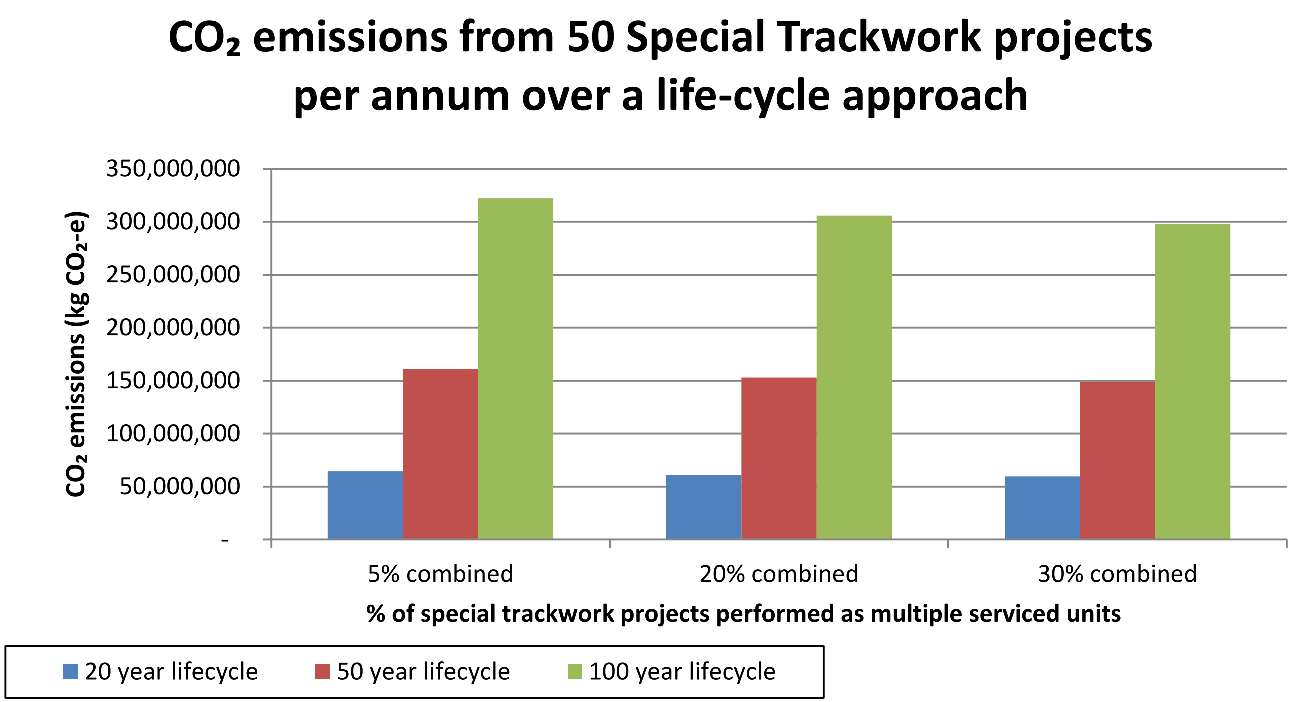
Table : E_{ij} from machineries and materials used.

Project	Total CO_2 emissions	Project duration (days)
Turnout	68,097 kg CO_2	2
Crossover	65,328 kg CO_2	2
Diamond	62,193 kg CO_2	2
Multi-unit turnouts	225,317 kg CO_2	5
Avg D	45,064 kg CO_2	1

- The overall results exhibit that similar ratios of construction methodologies and activities can result in similar amounts of CO_2 and material emissions, which are linearly dependent on the re-construction length.
- Extensive cost reviews and expert interviews also suggest a strategy that re-constructing multiple special trackworks (i.e. multiple turnout units) should be carried out simultaneously to help reduce CO_2 emissions instead of sequential unit construction.

Kaewunruen et al. (2015) Proceedings of the 20th National Convention on Civil Engineering

Systems-based strategy to achieve carbon-efficiency (v)



- The comparative results showed a 31% reduction in CO2 emissions by using this parallel construction strategy and should be considered by construction and rail transport managers to help reduce CO2 emissions from future special trackwork re-construction projects.

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Thank you for your kind attention.

Q&A