

# Research on Safety Leading KPI Application in Railway Industry

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# Ricardo Rail

Experts in critical and complex railway systems

**Ricardo** – a global, multi-discipline consultancy and niche manufacturer of high-performance products.

**Ricardo Rail** – rail industry specialists within the Ricardo group working to ensure that communities around the world are served by safe, resilient, high-performance railways.

Over 3,000 engineers  
consultants and scientists  
across 20 countries



## Systems engineering

Multi-disciplinary expertise that cuts across traditional industry silos.

## Design and analysis

Expertise in producing cost-efficient responses to complex engineering

## Asset management and optimisation

Specialist processes and technologies to improve efficiency across rail

## Independent assurance

Timely approvals for rail components, products and entire systems.



# Safety KPIs – Railway Regulator & Authority



- Cost of railway accidents
- Accidents and their outcomes
- Major accidents
- Trends in accident and casualty rates and their variations
- Railway and passenger fatality rates
- Safety in different transport modes
- Worldwide railway safety
- Achievement of safety targets
- Significant accidents
- Accidents and incidents involving transport of dangerous goods
- Casualties from significant accidents
- Suicides and trespasser fatalities
- Railway suicides versus overall suicides
- Railway workers safety
- Level crossing safety
- Precursors to accidents
- Accidents investigations
- Deployment of train protection systems on railway lines
- Deployment of level crossing protection systems
- Safety certification

We use industry information about actual harm and modelled risk to measure health and safety performance on Britain's railways:

- **actual harm** caused to individuals, which is measured using the fatalities and weighted injury index (FWI).
- **modelled risk**, which uses historic data to periodically quantify the frequency and potential average consequence from a particular set of circumstances that could lead to a safety incident. The RSSB Safety Risk Model (SRM) periodically takes a snapshot of all significant risks on the mainline and their monthly Precursor Indicator Model (PIM) tracks trends in key catastrophic precursor train accident risk. London Underground (LUL) and the tramway sector use similar approaches with sector specific safety risk models.

## ORR, UK

Driver error SPAD
Fatality
Fire - on train
Level crossing collision with person
Level crossing collision with road vehicle
Level crossing near miss with person
Level crossing near miss with road vehicle
Running line collision - between trains or rolling stock
Running line collisions - trams
Running line derailment
Serious Injury

## ONRSR, Australia

**Accident Frequency Rate (AFR) :**  
**Accident Severity Rate (ASR) :**  
 Near Miss

## LTA, Singapore

## ERA, Europe

# Safety KPIs – Railway Operator



Passenger Safety (TARR)  
 Workforce fatalities and weighted injuries  
 Personal accountability for safety

**Network Rail, UK**

Workers representation in formal joint management worker health and safety committees  
 Types of injury and rates of injury, occupational diseases, lost days, and absenteeism, and number of work-related fatalities  
 Workers with high incidence or high risk of diseases related to their occupation  
 Health and safety topics covered in formal agreements with trade unions

**Deutsche Bahn, German**

NR(HS) monitors route and stations safety performance against 20 proactive and reactive safety KPIs. Reactive indicators cover RIDDOR-reportable and lost time accidents for staff and contractors and passenger accidents. Proactive indicators cover the number of safety tours and T3 checks and close out of resulting actions, safety briefings, audits, voice communications and dissemination of recommendations from accident and incident investigations.

**HS1, UK**

Number of reportable events<sup>A</sup>  
 Reportable events per million passengers carried<sup>A</sup>  
 Number of staff and contractors' staff accidents<sup>A</sup>

**MTR, Hong Kong, China**

Disclosures on Management Approach

Percentage of total workforce represented in formal joint management-worker health and safety committees that help monitor and advise on occupational health and safety programs

Type of injury and rates of injury, occupational diseases, lost days, and absenteeism, and total number of work-related fatalities, by region and by gender

**KORAIL, Korea**

Train accidents	Train collisions, derailments, and train fire
Accidents at rail crossings	People or automobiles being hit by trains
Fatalities or injuries	People killed or injured by train operation excluding suicide
Physical damage to property	Accidents causing more than 5 million yen damage to property by train operation

**JR East, Japan**

Number of passenger injuries <sup>(1)</sup>  
 Incidents per million passengers carried  
 Number of staff injuries <sup>(1)</sup>  
 Incidents of staff per 200,000 working hour  
 Number of contractors' staff injuries <sup>(1)</sup>  
 Incidents of contractor per 200,000 working hour

**BTS, Thailand**

# Lagging KPIs VS Leading KPIs



Lagging

Leading



## Lagging Indicator

Reactive measures safety incidents that happened in the past, and how severe the injuries or illnesses were

## Leading Indicator

Proactive, preventive, and predictive measures that provide information about the effective performance of the health and safety activities

*The leading indicator identifies failings or 'holes' in vital aspects of the risk control system discovered during routine checks on the operation of a critical activity within the risk control system. (HSE, 2006)*

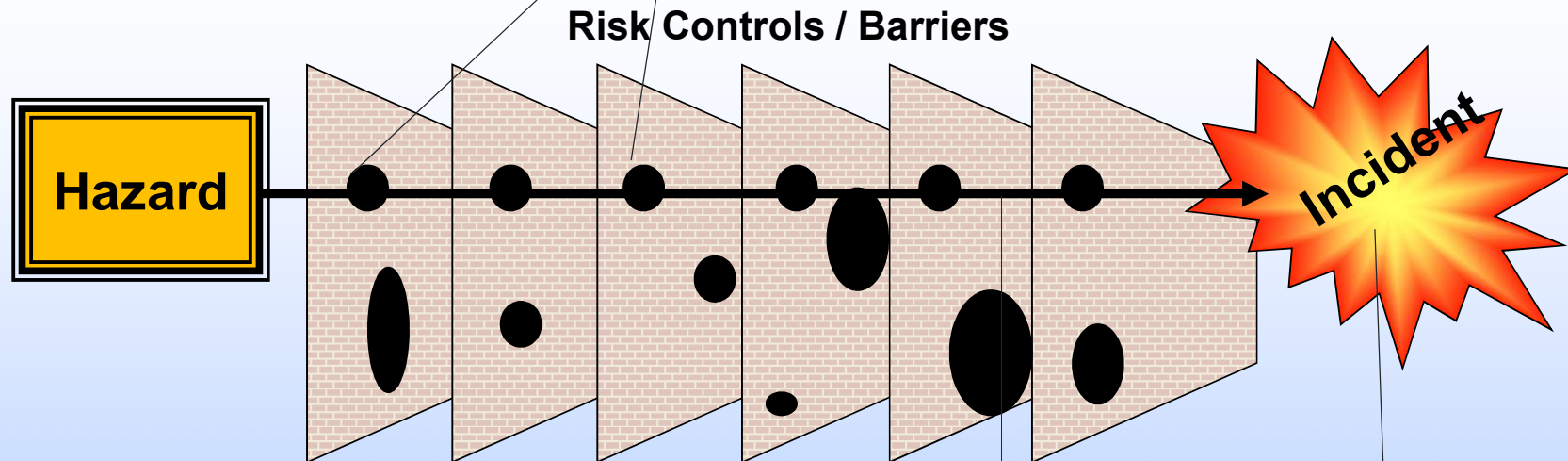


# What are leading and lagging safety KPIs measuring?

Using Swiss Cheese Model to illustrate...

Leading KPI measures (activities):

- 1) No. of risk controls / barriers
- 2) Strength and effectiveness of risk controls / barriers (size of the "holes")

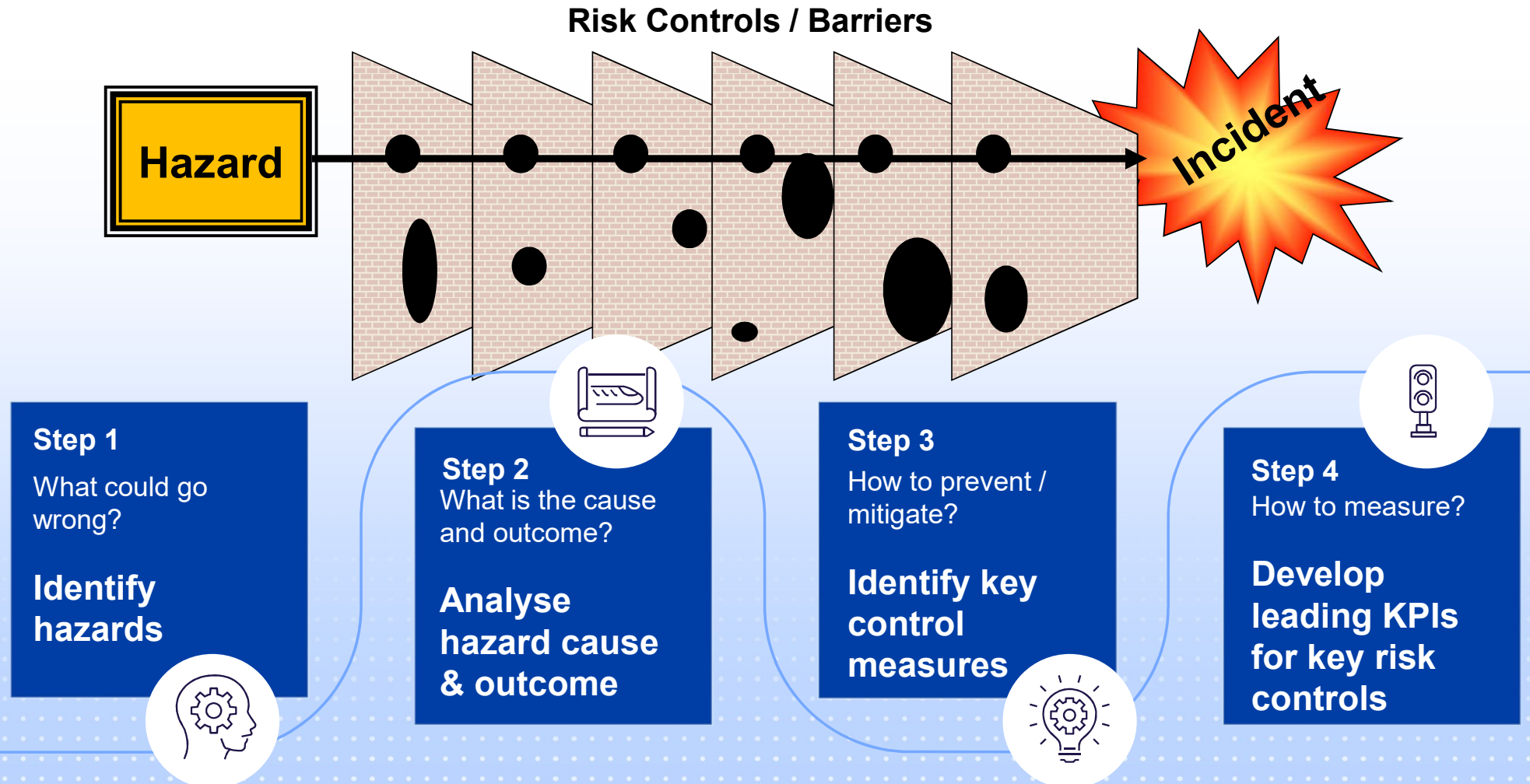


Lagging KPI measures (events / outcome):

- 1) Failures / faults following series of holes (precursors)
- 2) Incident / accident if all risk controls are failed

# How to develop leading KPIs?

An approach focus on risk control system



# Application of leading safety KPIs

A pilot study with railway operator in Asia



Build a scalable assessment model / tool to **evaluate proactive safety management activities**



**Justify the safety investment** based on safety performance and improvement



**Interface with existing safety information management system** (safety index) and provide supplementary information

*Objectives: To develop and verify the leading safety KPIs system through pilot application*



# Develop and verify leading safety KPIs



## Key concepts and key tasks



Cover specific operational safety hazardous events



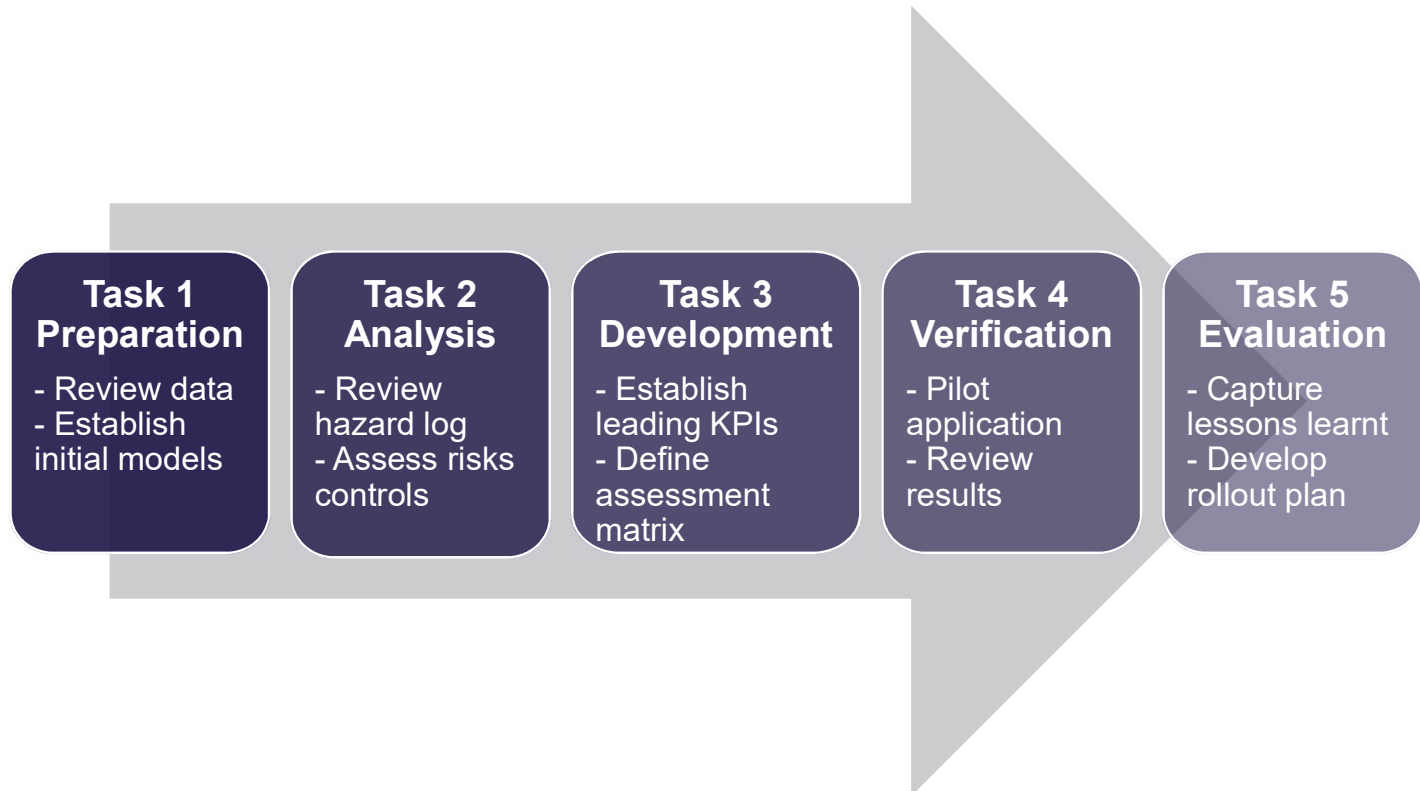
Review risk causation factors and consequences



Based on bow-tie models

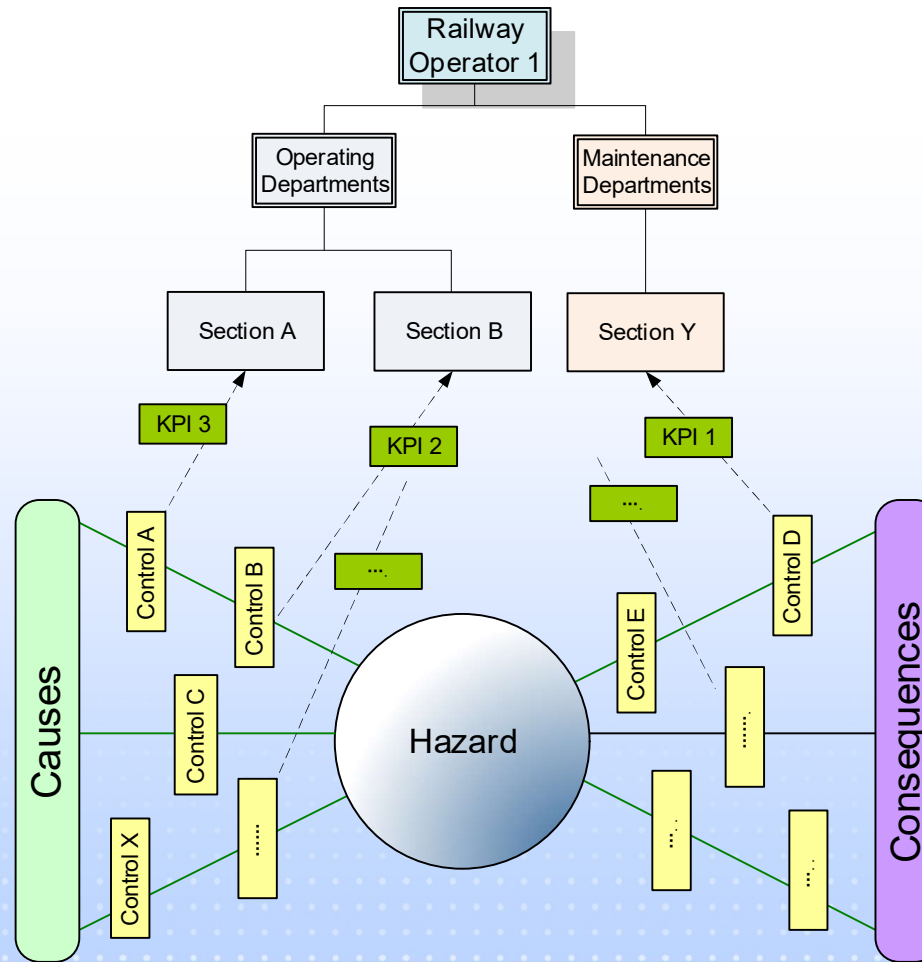


Establish leading KPIs on key risk controls



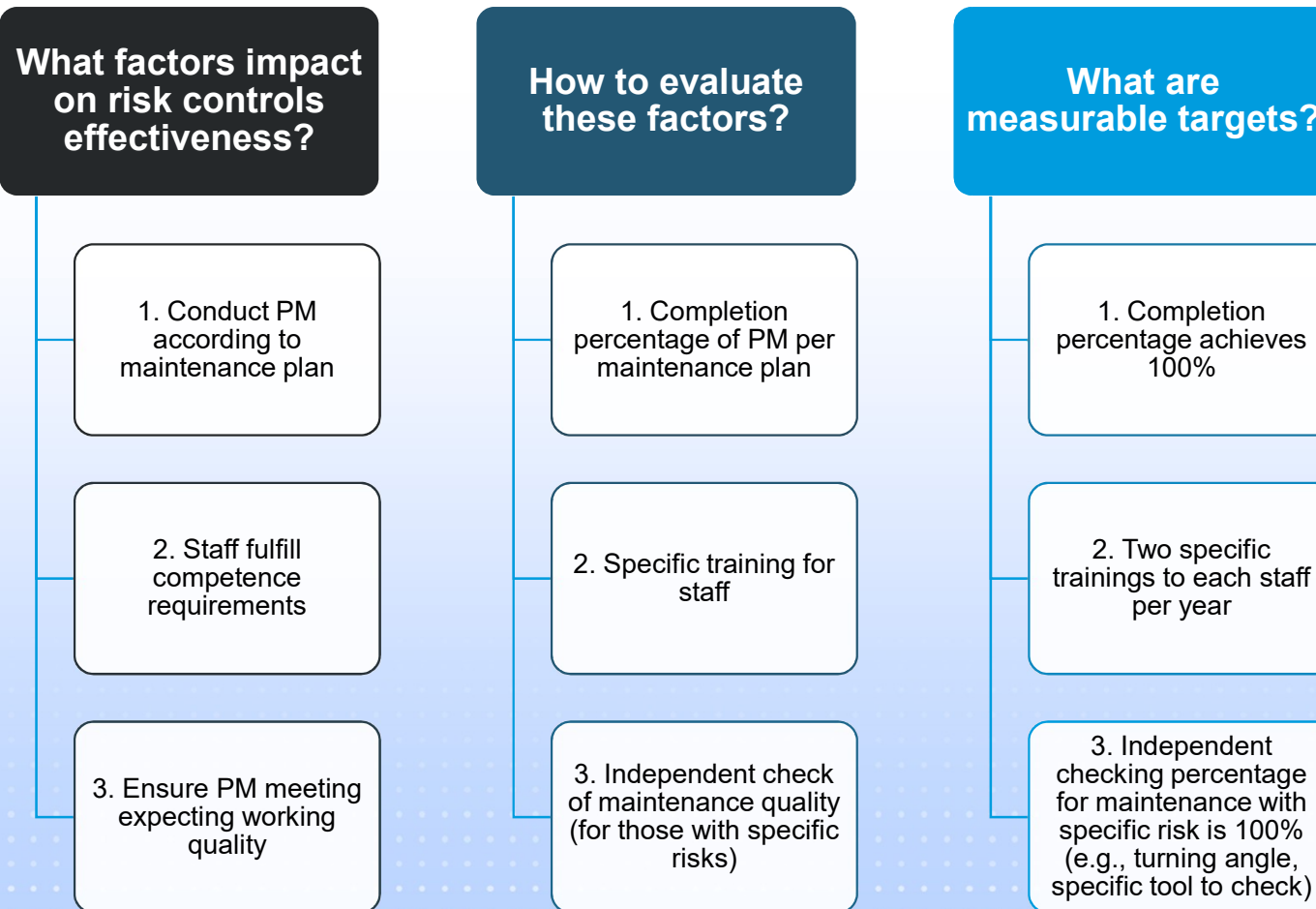
# Establish safety assessment model

Develop bow-tie models



# Establish leading safety KPIs

Using rolling stock preventative maintenance as example

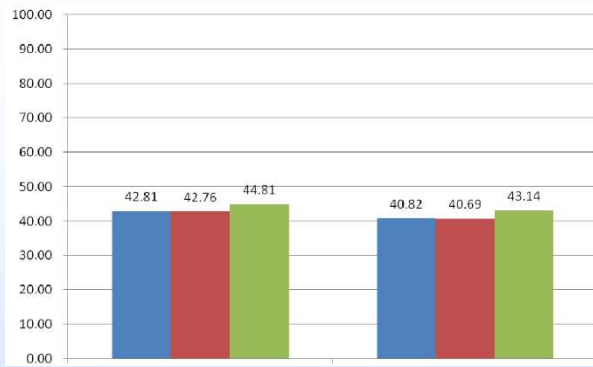




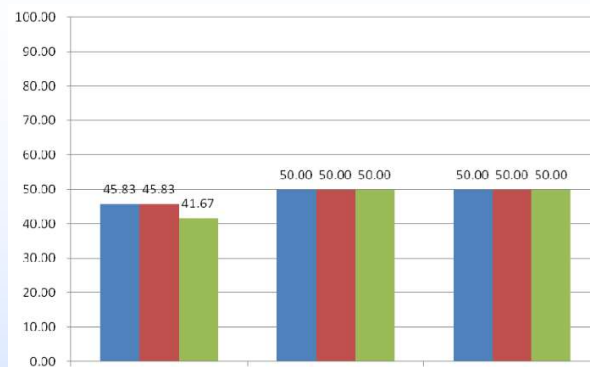
# Verification of safety assessment model



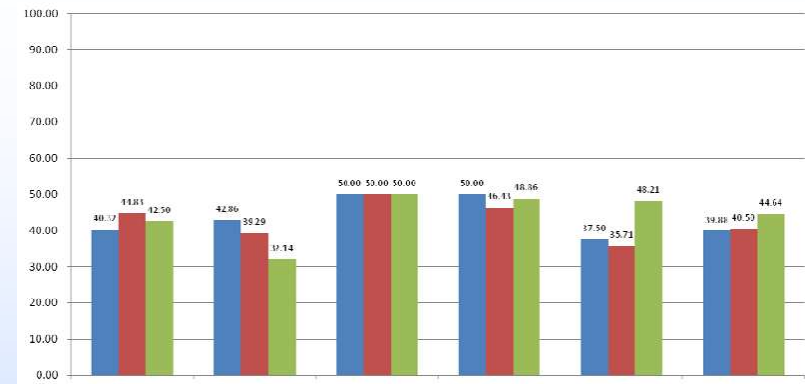
Pilot study for 3 months and review of monthly assessment results



Reporting based hazardous events



Reporting based key risk controls



Reporting based on various departments

# Evaluation and lessons learnt

What's working and what to improve?



## Establishing KPIs

- Inadequate understanding of risk causation models
- Different views on key risk controls
- Different views on measurement and target setting, and level of details



## Tracking KPIs

- Inconsistent reporting on KPIs
- Lack of integration to existing database / monitoring platform
- Different understanding of measurement and evaluation criteria on KPIs



## Integrate with wider SMS

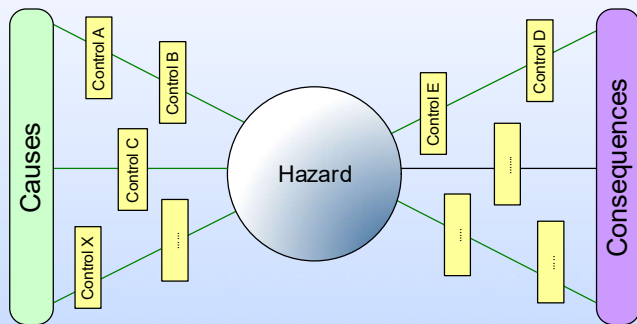
- KPIs established not fully align with safety management maturity
- Perception on KPIs and not fully supported by organisational safety culture



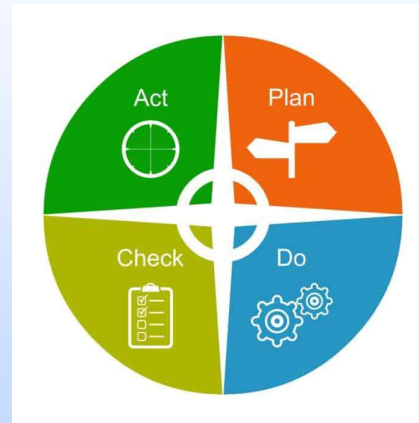
Safety leading KPIs <> Organisational Safety Culture

# Conclusion

Understanding of risks



Integrate with SMS



Support by Safety Culture





The background of the slide is a long-exposure photograph of a train tunnel. The train tracks recede into the distance, illuminated by warm, golden light. On the right side, there are horizontal light trails from lights outside the tunnel, suggesting motion and speed. The overall color palette is dark with warm highlights.

**THANK YOU**

