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ARE QUANTITATIVE SAFETY TARGETS FOR RAILWAYS USEFUL FOR DISRUPTIVE TECHNOLOGIES?

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Acknowledgement of Country

Acmena acknowledges Aboriginal and Torres Strait Islander peoples as the First Australians. We recognise their cultures, histories and diversity, and their deep connection to the lands, waters and seas.

Jagera people and the Turrbal people of Meanjin

I would like to pay my respects to their elders, past, present and emerging.

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01

CHALLENGE

Are quantitative safety targets for railways useful for disruptive technologies?

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ONRSR Recommends:

4.4 Quantitative safety limits

Quantitative safety limits sets a clear framework within which major projects can assess safety risk and understand those risks that are unacceptable, tolerable or broadly acceptable.

The use of such limits provides guidance as to the acceptability of risk, but fundamentally all safety risk must still be managed SFAIRP.

As a minimum, ONRSR expects:

> major projects to document the upper limit for individual or collective risks of equivalent fatality, and

> major projects to ensure documented limits are consistent with the relevant RTO's SMS.

Traditionally this is done through

- Fatality Weighted Injuries (FWI)
- Tolerable Hazard Rates (THR)/Tolerable Functional unsafe Failure Rates (TFFR)
- Safety Integrity Level (SIL)

CHALLENGE

Can we really use traditional quantitative safety targets for disruptive technologies?

Question:

- Are quantitative safety targets for railways useful for disruptive technologies such as Artificial Intelligence?

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QUANTITATIVE SAFETY TARGETS

Traditional Techniques - FWI, THR/TFFR, SIL

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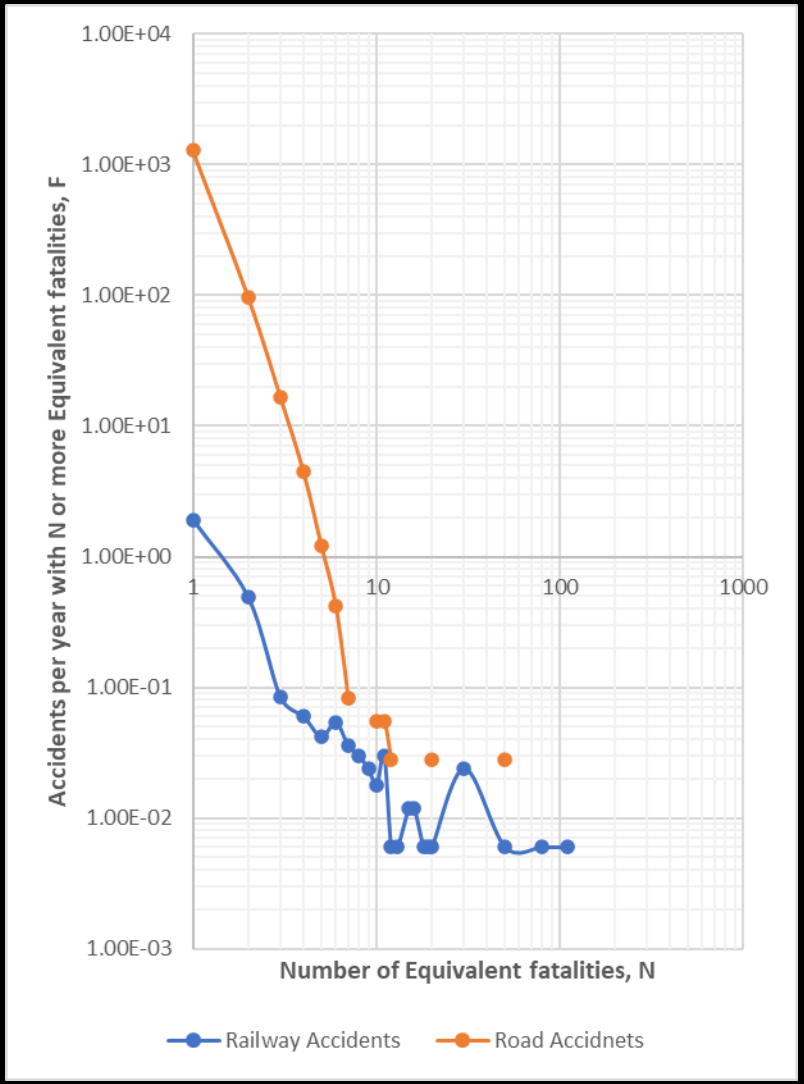
Definition

Fatality Weighted Injuries uses weightings to equate injuries of differing degree with a fatality, which allows all of the risk on the railway to be totalled and contrasted in comparable units.

Fatalities	Major Injuries	Minor Injuries
1	10	200

Sources

- Accident and Incident Reports
- National Safety Databases (E.g., ONRSR Rail Safety Report)
- Operational Data from Rail Operators



F-N Curve for Rail and Road Accidents in Australia

QUANTITATIVE SAFETY TARGETS

Traditional Techniques - Fatality Weighted Injuries (FWI)

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Definition

Maximum allowable frequency of hazardous events within a rail system, based on historical data, regulatory guidelines, and industry good practices.

Sources

Piece Part Predictions

- MIL-STD-217F
- Telcordia
- IEC 61709
- …

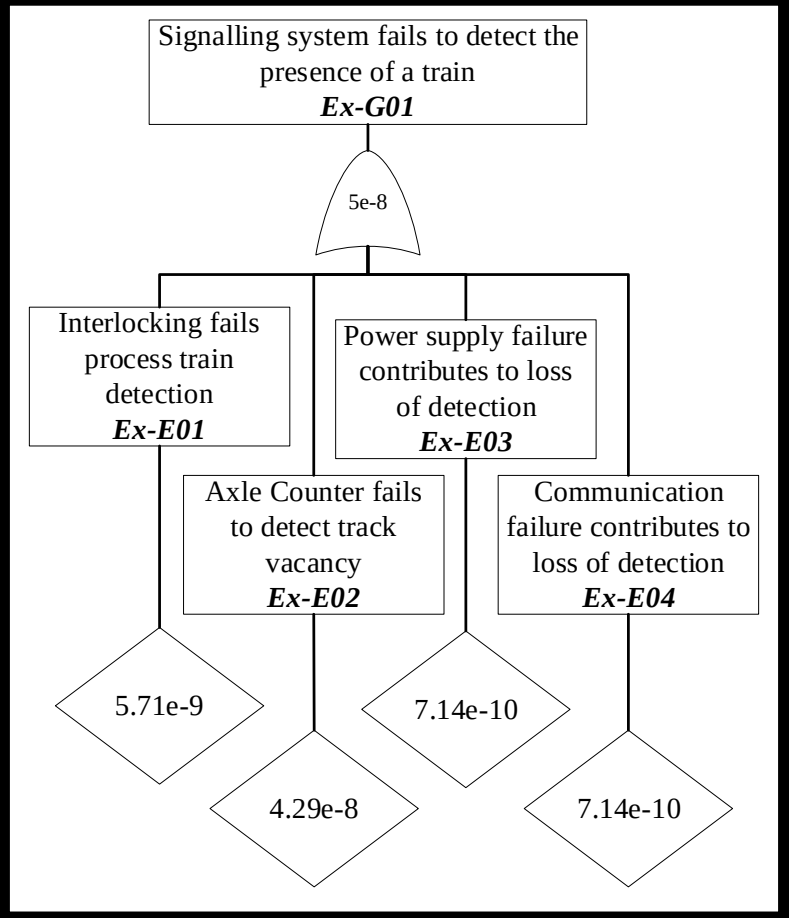
Databases

- NPRD
- EPRD

Other Methods

- Human reliability -> Railway Action Reliability Assessment (RARA)

Example - FTA



Assuming – 70 Units (8 Interlocking units, 60 Axle counter units, 1 Power Supply, and 1 Communication equipment)

QUANTITATIVE SAFETY TARGETS

Traditional Techniques – THR/TFFR

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Definition

Safety Integrity - ability of a safety-related system to achieve its required safety functions under all the stated conditions within a stated operational environment and within a stated duration (EN50126)

Safety Integrity Level (SIL) one of a number of defined discrete levels for specifying the safety integrity requirements of safety-related functions to be allocated to the safety-related systems (EN50126)

Source

Standards

- EN50126, EN50128/EN50716, EN50129

Table 2 — SIL quantitative and qualitative measures

TFFR [h^{-1}]	SIL attribution	SIL qualitative measures
$10^{-9} \leq TFFR < 10^{-8}$	4	Defined in sector-specific standards
$10^{-8} \leq TFFR < 10^{-7}$	3	
$10^{-7} \leq TFFR < 10^{-6}$	2	
$10^{-6} \leq TFFR < 10^{-5}$	1	

Example – FTA (from previous slide)

- TFFR per unit = 5E-8/70 = 7.14E-10 events per hour
- TFFR equivalent to SIL4
- Interlocking (8 units): THR = 5.71e-9 events per hour

QUANTITATIVE SAFETY TARGETS

Traditional Techniques – SIL

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DISRUPTIVE TECHNOLOGY - AI

Applications and Adoption

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A Definition

'A computerized system that is able to perform physical tasks and cognitive functions, solve various problems, or make decisions without explicit human instructions'

AI Application in Railway Industry:

- Maintenance and Inspection
- Safety and Security
- Autonomous Driving and Control
- Traffic Planning and Management
- Passenger Mobility

Summary:

- Maintenance and Inspection domain is the most advanced in AI application
- Limited integration of AI in safety-critical domains
- **Challenges**
  - Non-stable behaviour
  - Opacity of certain AI approaches
  - Data Scarcity

DISRUPTIVE TECHNOLOGY - AI

Applications

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Dubai Metro

- In 2021, Dubai's Road Transport Authority (RTA) began trailing AI and simulators to reduce passenger waiting times and manage crowds during peak hours by analysing Nol card data.
- This approach successfully reduced congestion by 40-60% and cut waiting times to just 30 minutes.

- *No Updates since 2021.*

Copenhagen Metro

- The S-bane network is being upgraded to become the world's longest automated urban railway, utilizing Siemens' GoA4 technology.
- This AI-driven system aims to enhance efficiency, increase train frequency, and maintain high punctuality by automating functions such as speed control, braking, and incident management.
- The upgrade is expected to be completed by 2030.

- *Siemens official website does not confirm the above AI application.*

DISRUPTIVE TECHNOLOGY - AI

Adoption

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CASE STUDY

Considering application of AI in a typical signalling system

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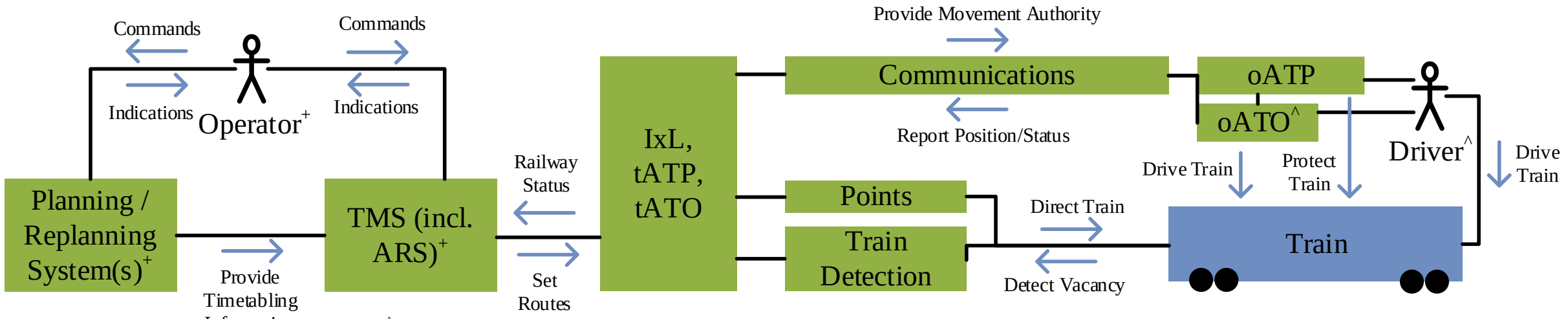

Note ^ : The extent of the automatic train operation depends on the grade of automation. At the highest level the driver is removed.
Note + : The extent of operator control depends on the degree of automation afforded by the planning system the automatic route setting system. Typically, the operation continues to be engaged in some level of supervision.

CASE STUDY

'Typical' Signalling System

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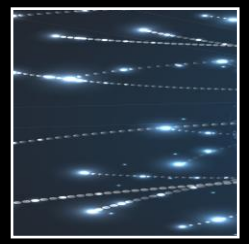

Learning (limited memory AI)

Non-Learning (reactive machine AI)

CASE STUDY

Uses of AI

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CASE STUDY

Use of AI in Development Aids

Reviews

- Summaries
- Efficiencies
- Trust?

Test Environment

- Test Cases
- Efficiencies
- Complete?

Code Generation

- Efficiencies
- Enabling
- Correct?

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CASE STUDY

Use of AI in Development Aids

Requirements Management Tool

In the future AI is likely to help analyse and draft new requirements. This will introduce new avenues for the tool to contribute to the failure mode and increases the need for full formal reviews.

Change Management Tool

In the future it is conceivable that AI will be used to raise, triage, and even assess change request. Meaning that it may be harder to catch corruption caused by the AI which may generate reasonable but possibly incorrect information.

Configuration Management Tool

AI may be used to support reviews and audits in configuration management. Care should be taken so that the AI does not corrupt or incorrectly interpret the data captured.

Compiler Tool

There are plenty of tools available where AI is being used to detect bugs, review code, document code, refactor code, generate code, and explain code all which contribute to the example failure modes and require diligence to review / check prior to use and may require some proving in and of themselves.

Software Test Tool

There are already tools available using AI to test software. While this when used in addition to (or prior to) traditional methods may add significant benefit. Care needs to be taken to monitor the reliance made on one test method.

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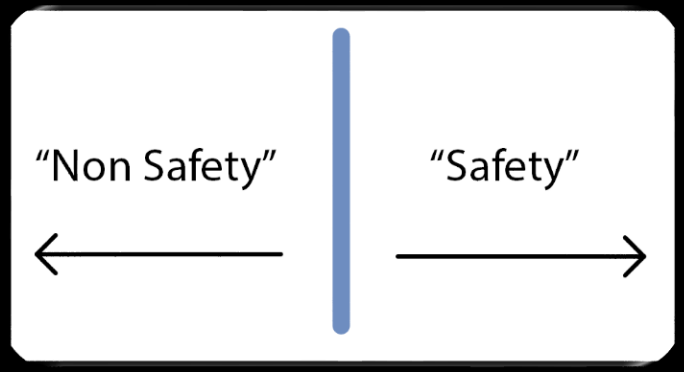
Planning/Replanning Systems

Traffic Management Systems



CASE STUDY

Use of AI in Non-Safety Systems

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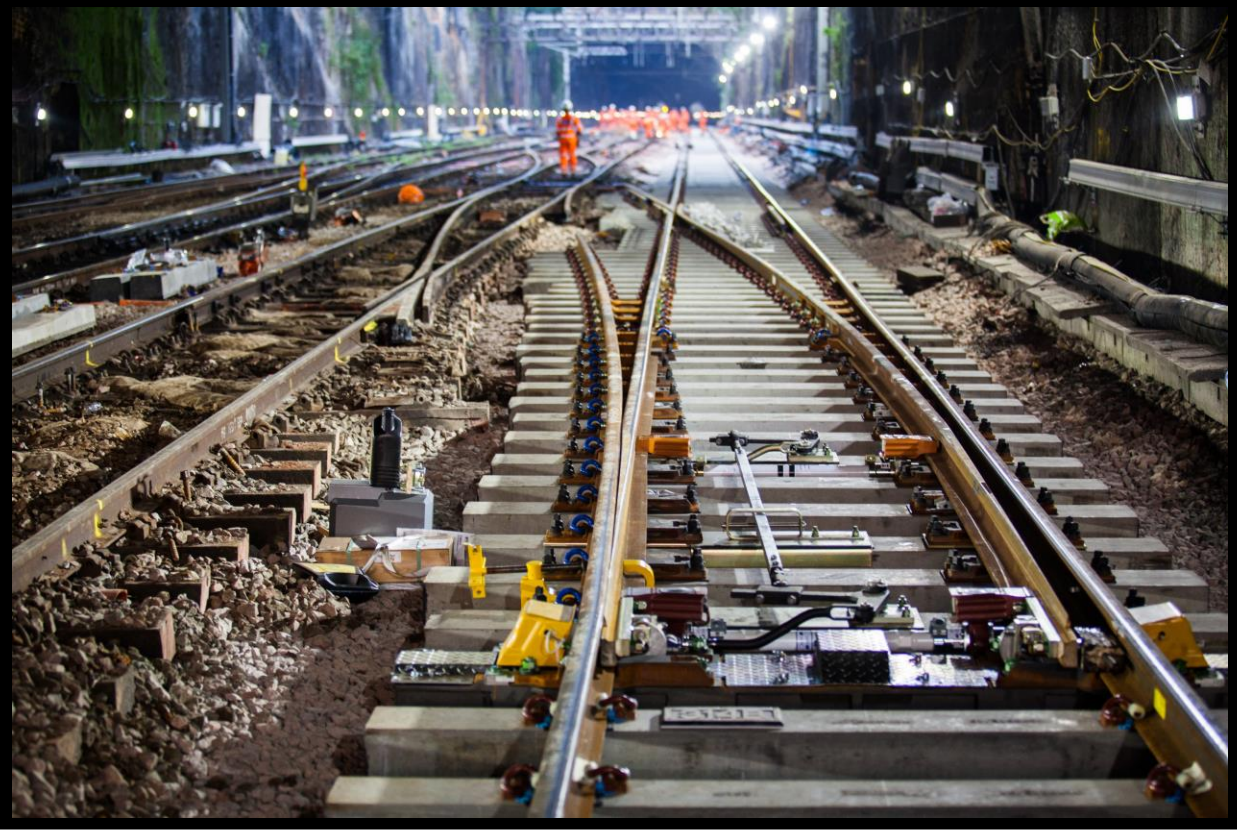
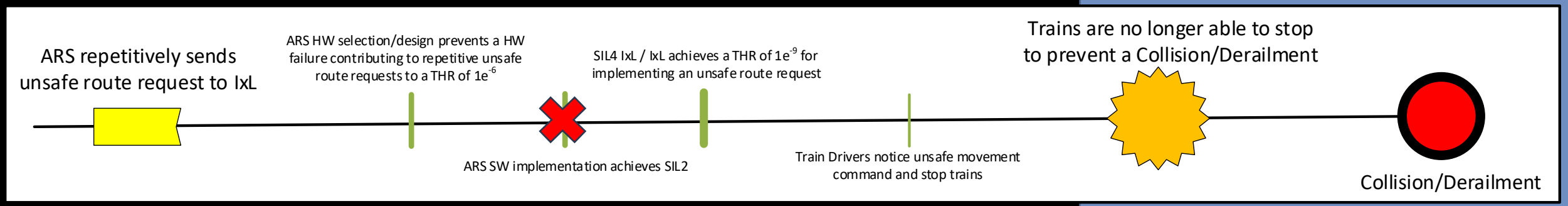


CASE STUDY

Use of AI in Safety-Related Systems

Automatic Route Setting



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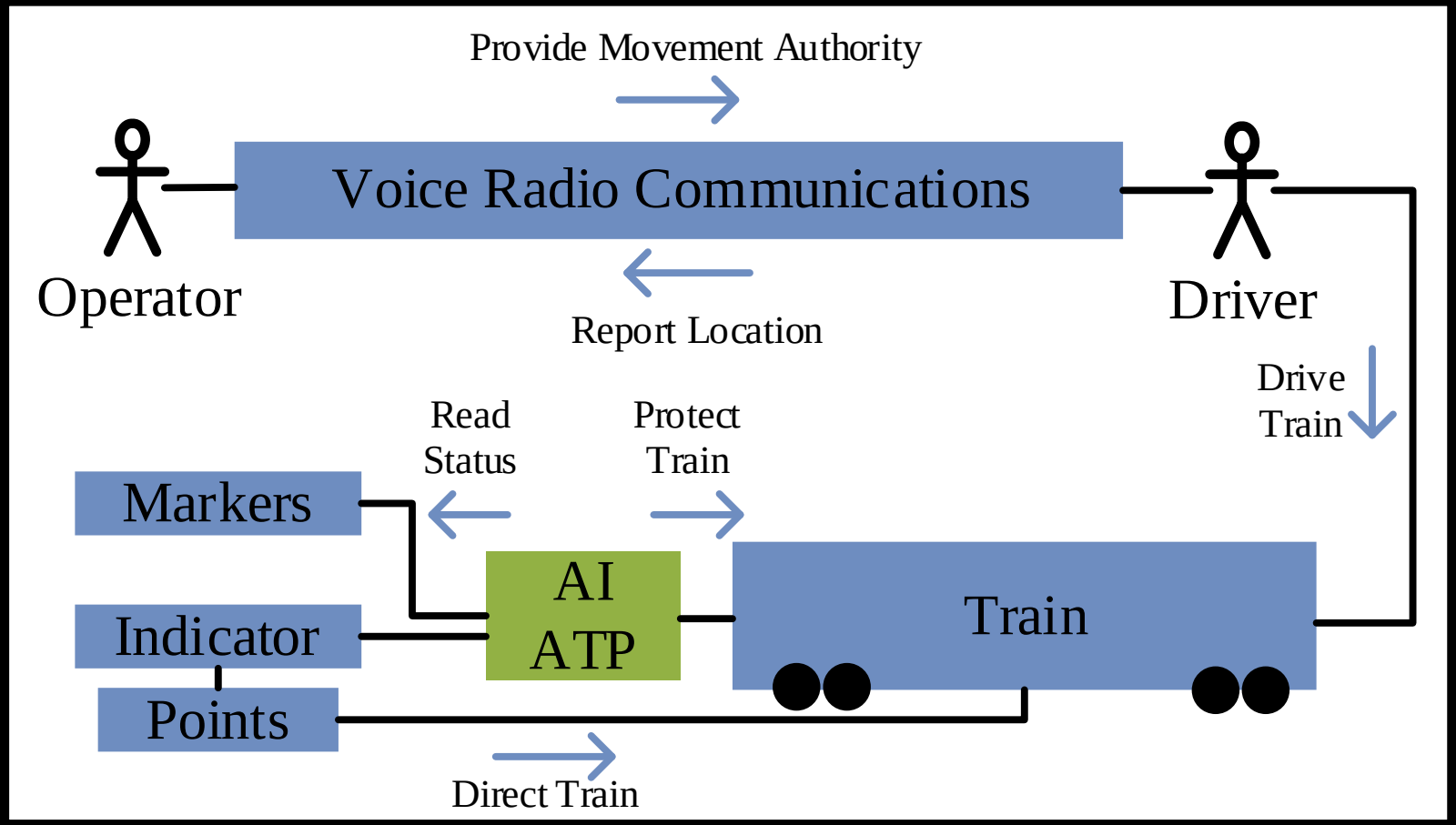
CASE STUDY

Use of AI in Safety-Critical Systems

Automatic Train Protection



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CONCLUSION

Key Observations and Recommendations

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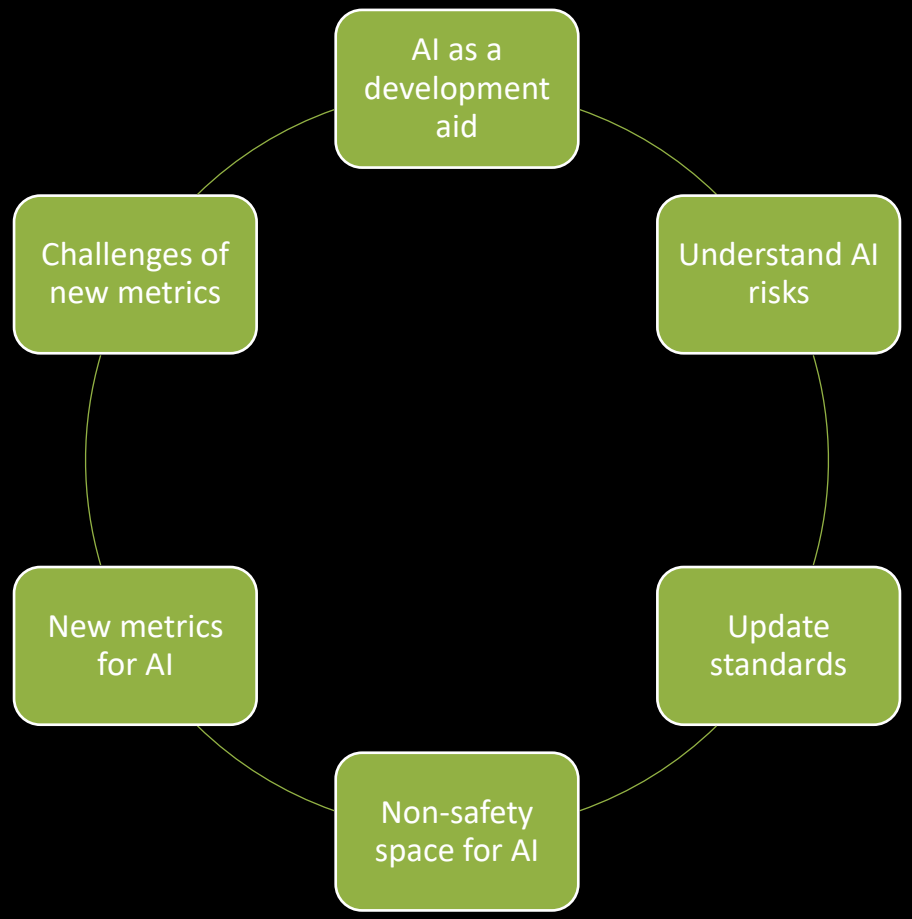
Traditional safety metrics remain relevant for monitoring rail safety, establishing tolerable risk targets (THR), and assuring traditional systems interacting with AI (SIL).

Limitations of traditional metrics for assessing disruptive technologies like AI; new metrics and guidance are necessary.



CONCLUSION

Key Observations and Recommendations

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QUESTIONS
& FOLLOW UP

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Thank You

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