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IRSC 2025

**Advancing Railway Safety through
Innovations and Collaborations**

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Reimagining Rail Safety: Adaptive Safety Learning and Safety Intelligence in Complex Socio-Technical Systems

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Reimagining Rail Safety



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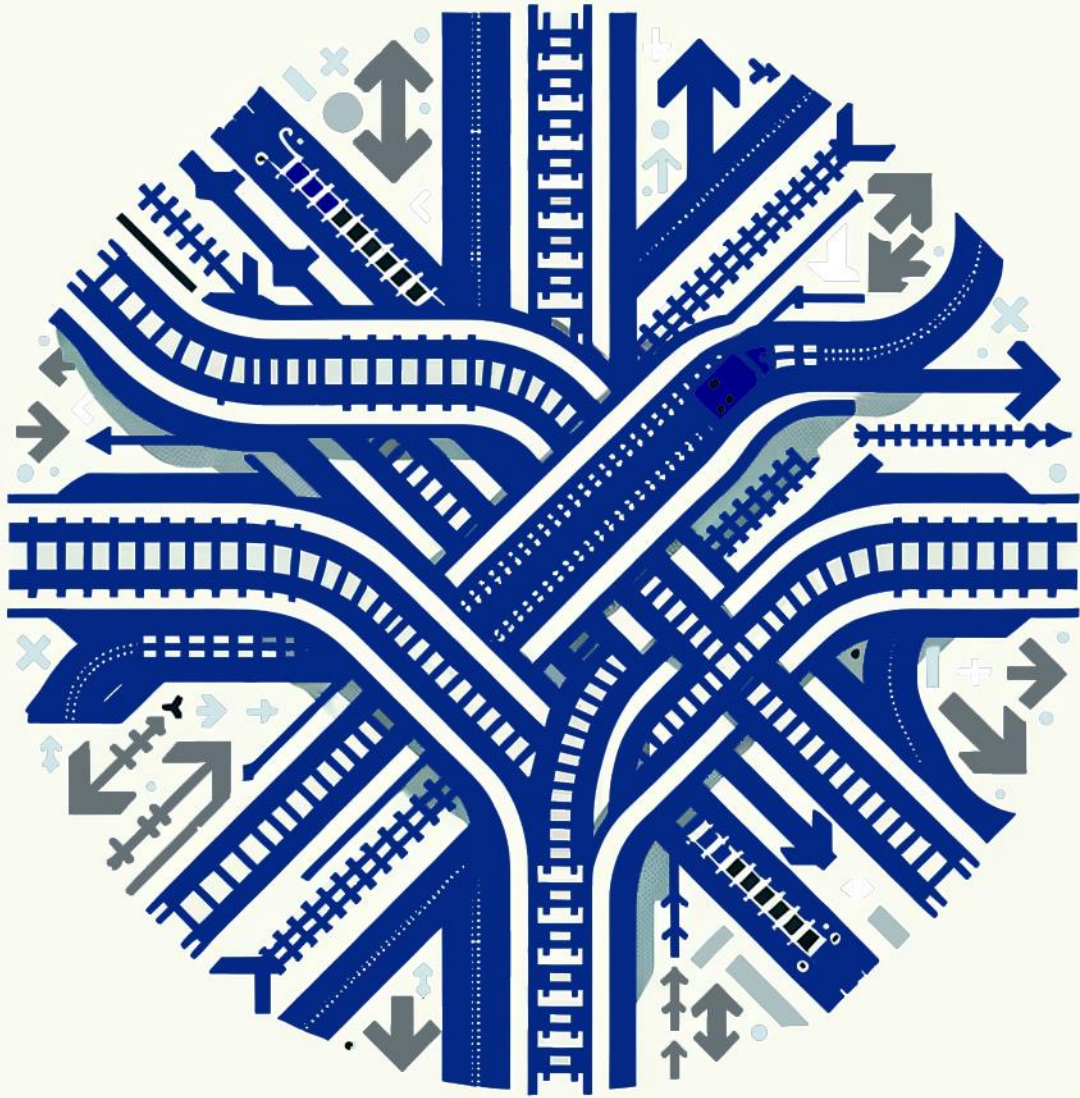
Dr. Pete McCarthy



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Rail Safety Challenge: The Case for Change



- The rail industry faces increasing complexity, driven by new technology, higher passenger expectations, and workforce pressures.
- Conventional safety models (compliance, post-incident fixes) struggle to manage variable and unpredictable operations.
- Need to shift from reactive, hindsight-driven safety to adaptive, intelligence-led approaches.



Safety Intelligence

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Evolving Safety Science: From Hindsight to Foresight

- Modern safety science (Safety-II, resilience engineering) emphasises learning from normal work.
- Cross-industry evidence (aviation and healthcare) shows proactive learning yields greater resilience and fewer surprises.
- Just culture and psychological safety are essential for capturing frontline insights to drive continuous improvement.



Adaptive Safety Learning

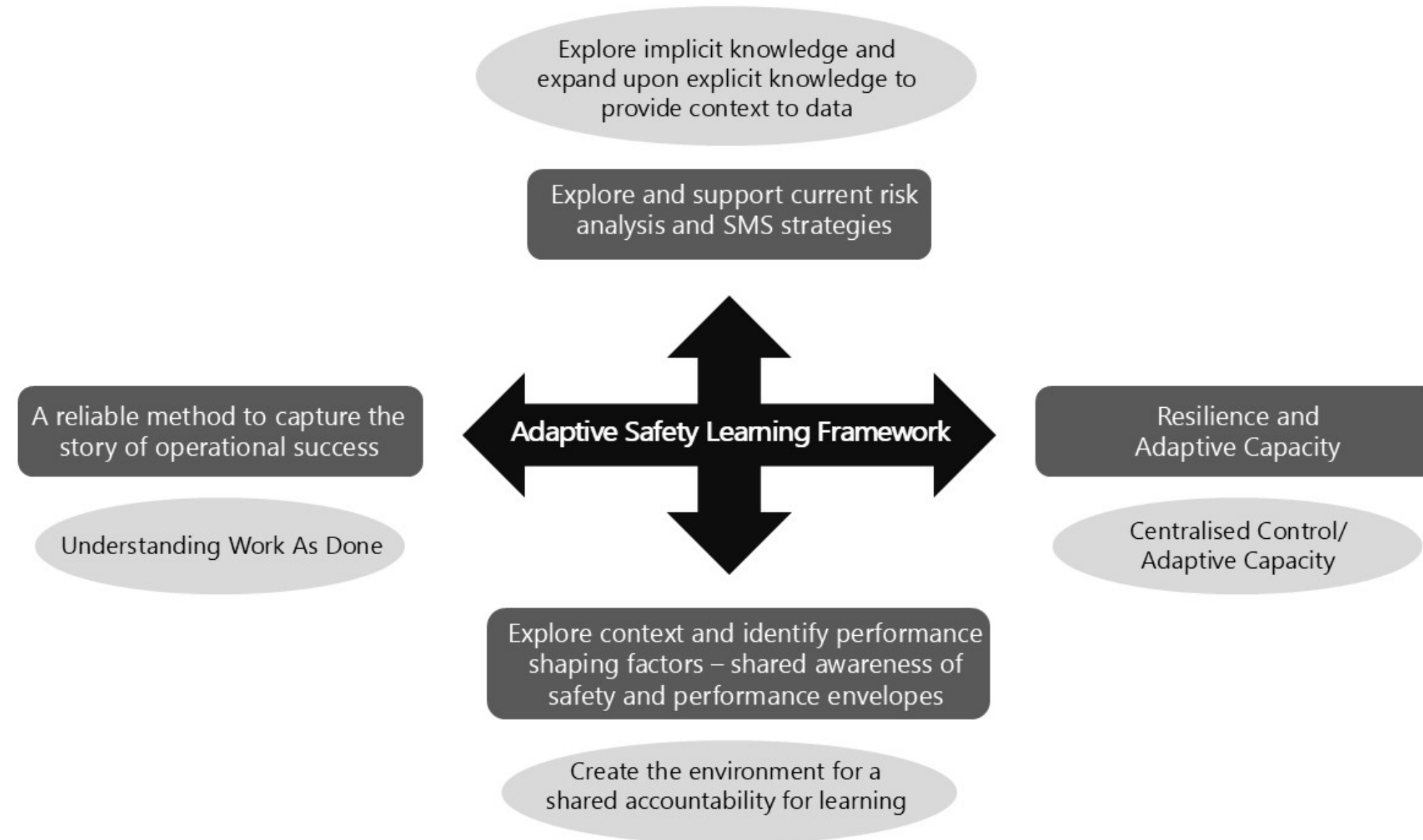
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Safety Intelligence and ASLF: A New Framework



Safety Intelligence

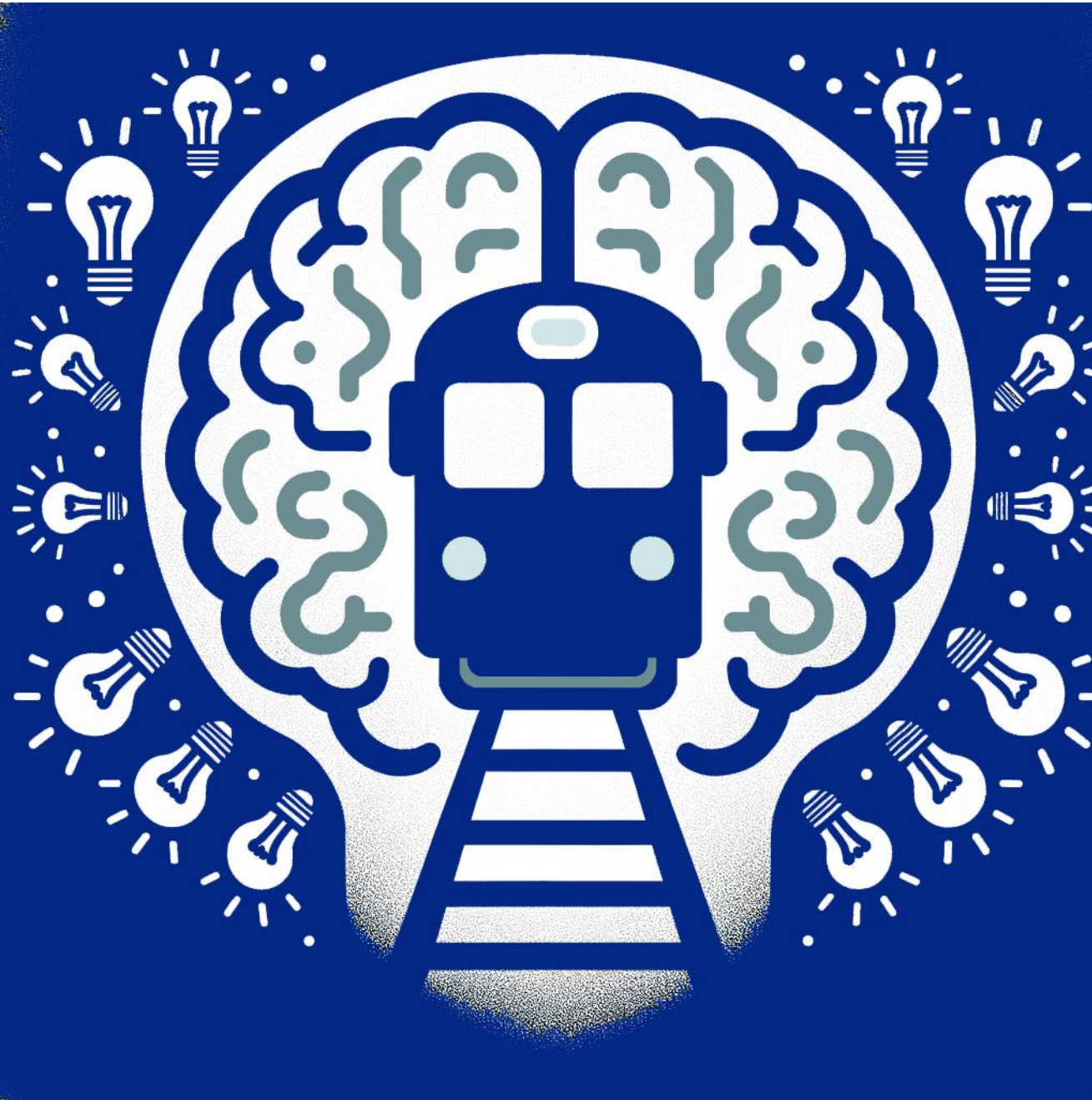
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Safety Intelligence and ASLF: A New Framework



- Adaptive Safety Learning Framework (ASLF) – a model to continuously learn from everyday operations and incidents.
- ASLF embeds **safety intelligence** – the collective ability to gather, analyse, and act on safety knowledge proactively.
- Key elements: harness tacit frontline knowledge, enable open information flow, and turn lessons into preventive action.



Sub-theme:

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Methodology: Cross-Sector Learning Approach



Methodology

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Psychological Safety: a culture of trust

- Non-punitive just culture: employees report errors and near misses without fear, turning mistakes into valuable lessons.
- Psychological safety lets hidden risks surface: teams speak up about concerns, revealing issues before they escalate.
- Balance accountability with empathy: a fair response to errors builds trust, ensuring honesty while correcting unsafe behaviours.



Safe enough to speak up, strong enough to learn

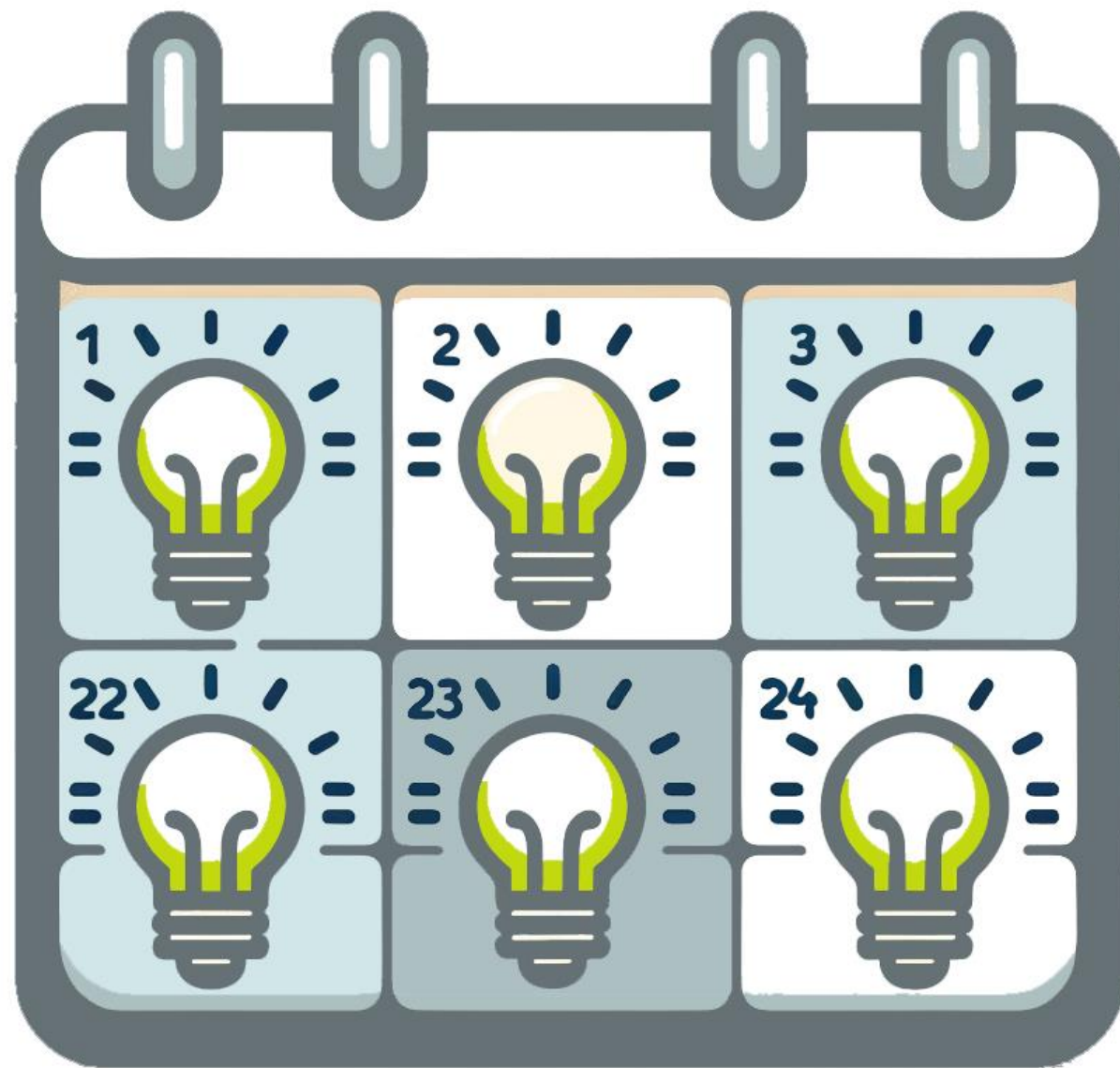
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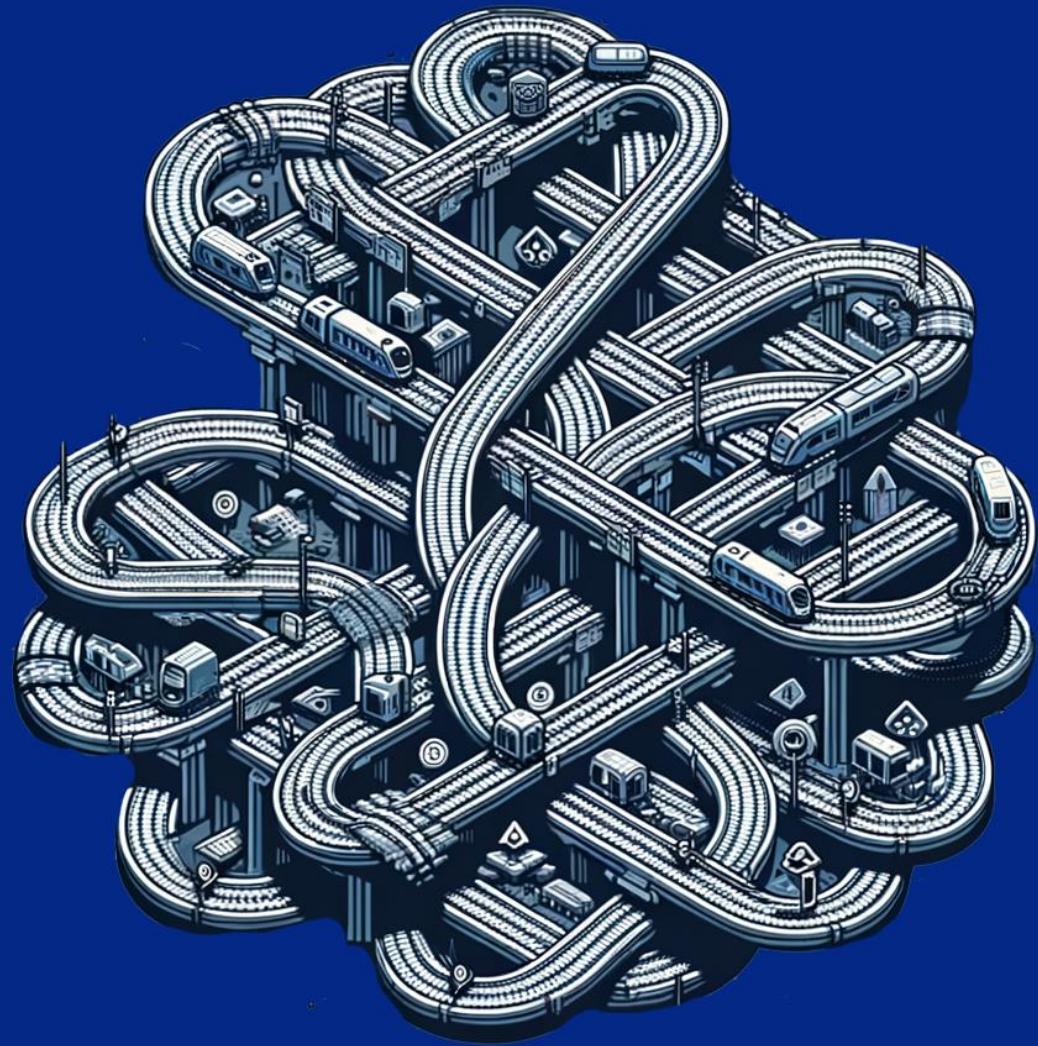


Operational Learning: Learning from Everyday Work



- Beyond reactive fixes: learn continuously from daily operations and small glitches, not just major incidents.
- Learning teams and debriefs engage staff to analyse “work-as-done,” revealing adaptive practices and improvement ideas.
- Feedback loop: Insights from everyday work inform training and procedures, preventing issues before they escalate.

Embracing Complexity: Systems Thinking in Safety



- Rail as a complex socio-technical system: many interacting elements mean small changes can have unpredictable effects.
- One-size-fits-all rules fall short in complexity; safety needs real-time adaptation and systems thinking.
- Multiple defences & perspectives: build redundancy and use diverse expertise to catch issues early in unpredictable conditions.



Safe enough to speak up, strong enough to learn

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Adaptive Capacity: Building Resilience

- Adaptive capacity – the ability to anticipate, absorb, and adapt to sudden changes before they become crises.
- Empower agility: Frontlines are trusted to adjust and innovate in real-time when conditions shift unexpectedly.
- From hindsight to foresight: analyse weak signals and trends so the organisation can act before an accident occurs.



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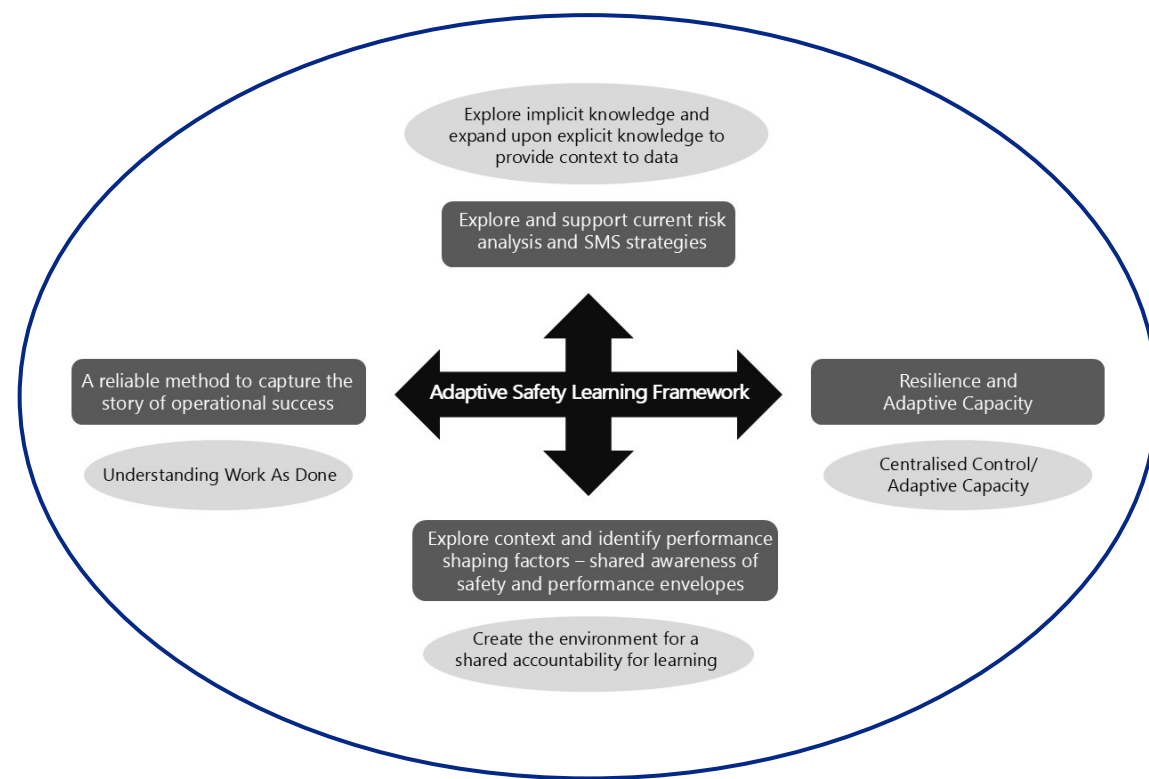
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Practical Implications: From Theory to Practice



- Implement ASLF: hold regular learning sessions, encourage open reporting, and share insights across departments.
- Break silos: exchange safety data and lessons with other industries to spur innovation and mutual learning.
- Lead by example: leadership champions just culture and continuous improvement, making adaptive learning “how we operate.”
- Track leading indicators (near-misses, fixes implemented) to gauge safety intelligence and drive ongoing improvement.



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Conclusion & Future Directions:

Towards Intelligent Safety



- From reactive to intelligent safety: commit to a proactive learning culture that evolves with growing complexity.
- ASLF and safety intelligence give rail a path to enhance safety and performance in tandem.
- Future vision: high-reliability industries sharing safety intelligence, learning together to stay ahead of emerging risks.



Safety Intelligence

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