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Towards AIaaS for the networks of the future: reusable and interoperable data-based models in Railway scenarios

Alessandro Capuozzo

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Introduction

Alessandro Capuozzo

Innovation Manager & Head of AI Hitachi Rail GTS, Italy

- 18+ years in embedded systems
- System Architecture
- Artificial Intelligence
- Physical AI
- Railway Digital Transformation
- European Research & Innovation

AI is moving from standalone models toward interoperable intelligent services that can operate across systems, domains and physical assets.

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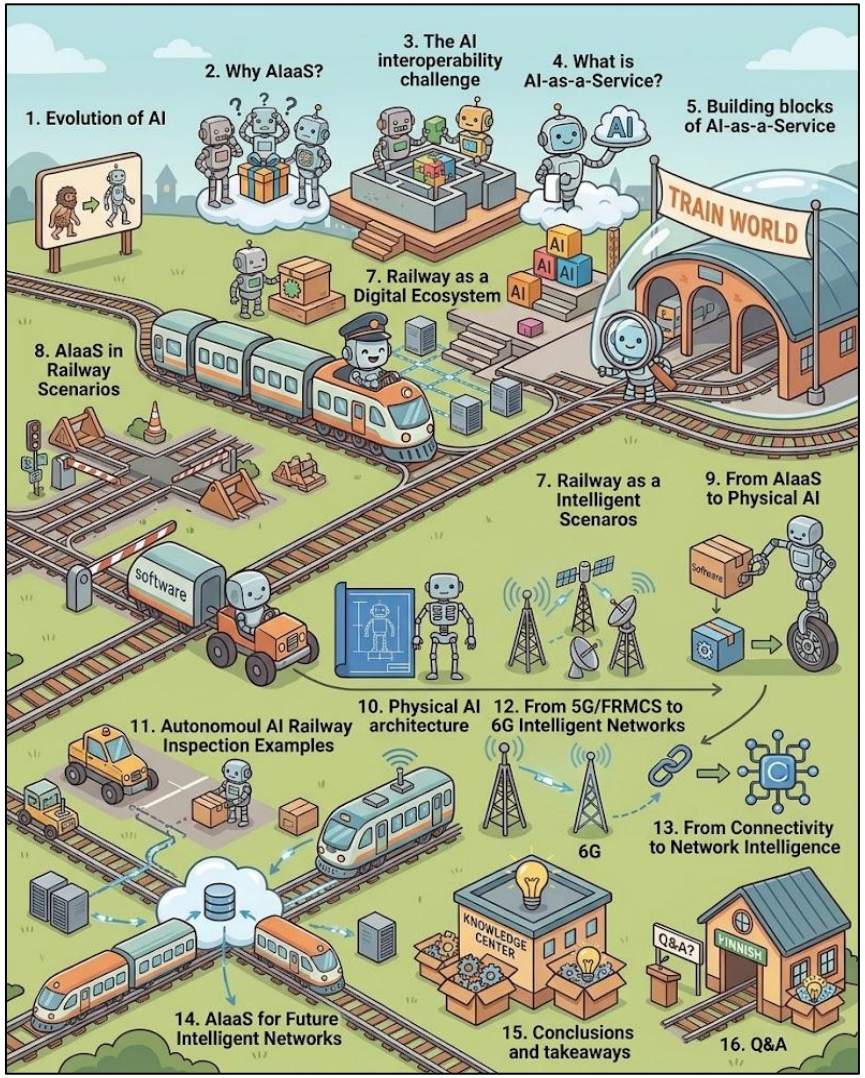
Agenda

1. Evolution of AI
2. Why AIaaS?
3. The AI interoperability challenge.
4. What is AI-as-a-Service?
5. Building blocks of AI-as-a-Service
6. Railway as a Living Laboratory for AIaaS
7. Railway as a Digital Ecosystem
8. AIaaS in Railway Scenarios
9. From AIaaS to Physical AI
10. Physical AI architecture
11. Physical AI Railway Examples
12. From 5G/FRMCS to 6G Intelligent Networks
13. From Connectivity to Network Intelligence
14. AIaaS for Future Intelligent Networks
15. Conclusions and takeways
16. Q&A



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Evolution of AI.

AI 1.0
Rule-Based systems

AI 2.0
Machine Learning

AI 3.0
Deep Learning &
Foundation Models

AI 4.0
AI-as-a-Service

AI 5.0
Physical AI

AI is evolving from standalone software artifacts to reusable, interoperable and ultimately embodied intelligence.

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Why AIaaS?

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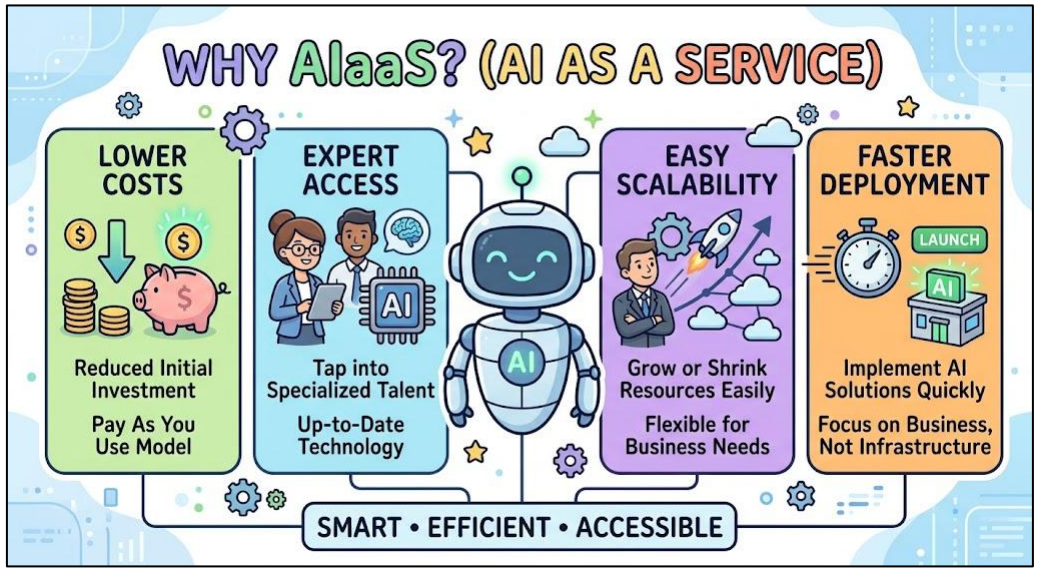
Today's reality

- ✅ More data
- ✅ More AI models
- ✅ More computing power
- ✅ More AI investments



Yet...

- ❌ Intelligence remains fragmented
- ❌ Models are difficult to reuse
- ❌ Knowledge transfer is limited
- ❌ AI deployment does not scale efficiently

How can we transform AI from isolated models into reusable and interoperable intelligence services?

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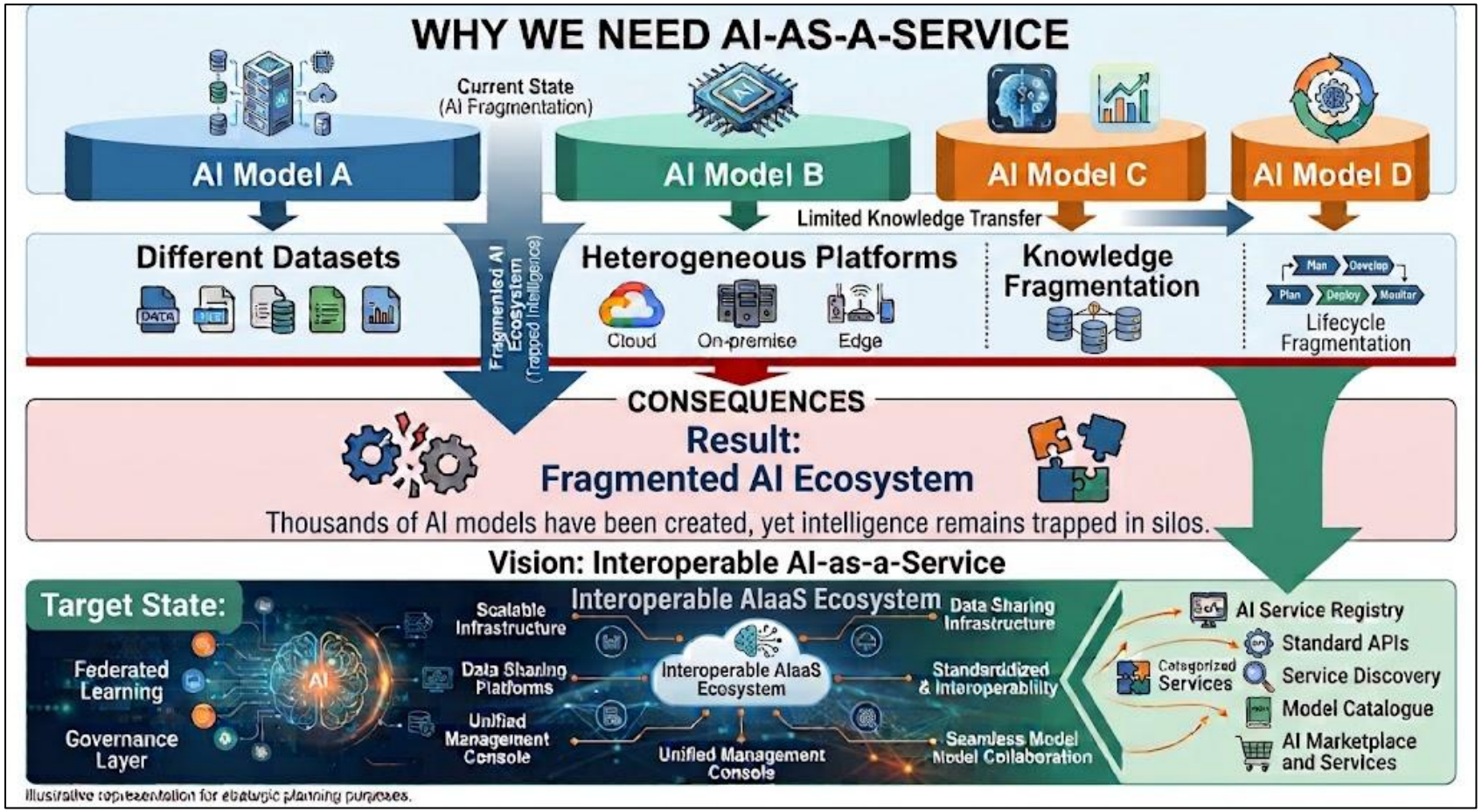
The AI interoperability challenge.



The challenge is no longer building AI. The challenge is making AI reusable.

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What is AI-as-a-Service?

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AI-as-a-Service (AIaaS) transforms AI capabilities into discoverable, reusable, interoperable, and scalable services that can be deployed and consumed across domains and heterogeneous environments.

CORE CAPABILITIES

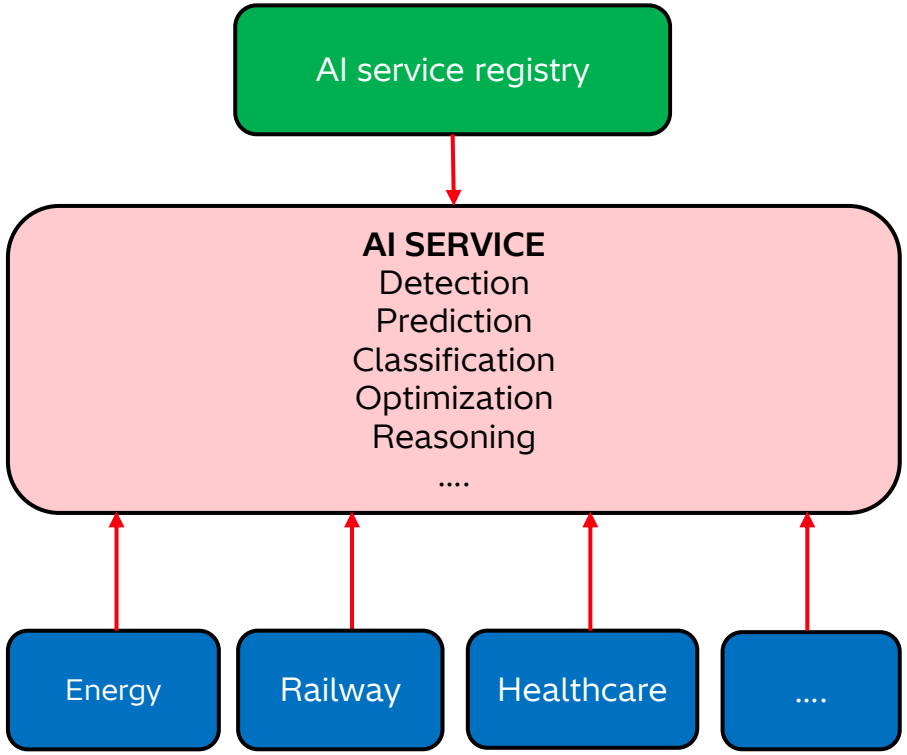
🔍 **Discover:** Find existing AI capabilities;

♻️ **Reuse:** Avoid rebuilding AI capabilities from scratch;

🔗 **Interoperate:** Integrate AI services through standard APIs;

🚀 **Deploy anywhere:** Cloud, edge, on-premise, embedded systems;

📈 **Scale:** Deploy, manage and evolve AI service across applications.



Transforming AI from isolated models into shared intelligence services.

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Building blocks of AI-as-a-Service

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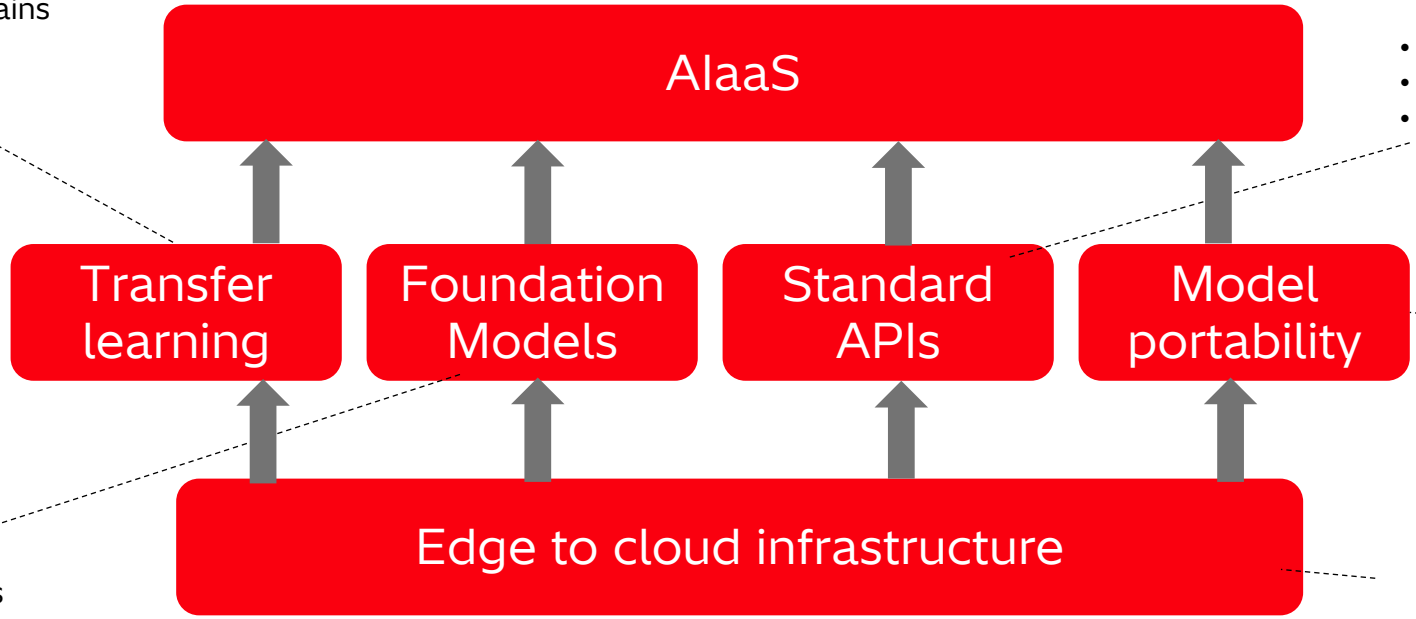
- Reuse knowledge across domains
- Reduce data requirements
- Accelerate deployment



- Service interoperability
- Service discovery
- Integration across ecosystems

- Deploy across Cloud, Edge and Embedded platforms
- Hardware-independent execution

- Shared intelligence layer
- Adaptable to multiple use cases
- Basis for scalable AI services

- Distributed intelligence
- Low latency processing
- Scalable infrastructure

AIaaS is enabled by technologies that make intelligence transferable, portable, interoperable and scalable.

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Railway as a living laboratory for AIaaS.

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Railway systems provide an ideal environment to validate reusable, interoperable and scalable AI services.

Intelligent infrastructure
- Trackside Monitoring
- Smart Stations
- Intrusion detection
- Asset inspection

Connected assets
- Trains
- Video systems
- IoT Sensors
- Communication networks

Distributed Intelligence
- Cloud AI
- Edge AI
- Real-Time analytics
- Decision Support System

Key characteristics:
- Safety-critical operations;
- Heterogeneous data sources;
- Long asset lifecycles;
- Large-scale distributed infrastructure;
- Strong requirements for reliability and explainability.

Railways combine physical assets, distributed intelligence and safety-critical operations, making them an ideal testbed for AI-as-a-Service.

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Railway as a Digital ecosystem

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Railway systems are evolving into interconnected digital ecosystems where data, AI services, networks, and physical assets continuously interact to improve safety, efficiency, and operational performance.

Railway Ecosystem components

Physical assets

- Rolling stock
- Signalling systems
- Stations
- Trackside equipment
- Inspection vehicles

Connectivity

- FRMCS
- 5G networks
- IoT Communications
- Operational networks

Data & Digital Platforms

- Digital Twins
- Data lakes
- Asset management systems
- Operational data platforms

AI Services

- Intrusion Detection
- Predictive Maintenance
- Video analytics
- Energy optimization
- Decision Support

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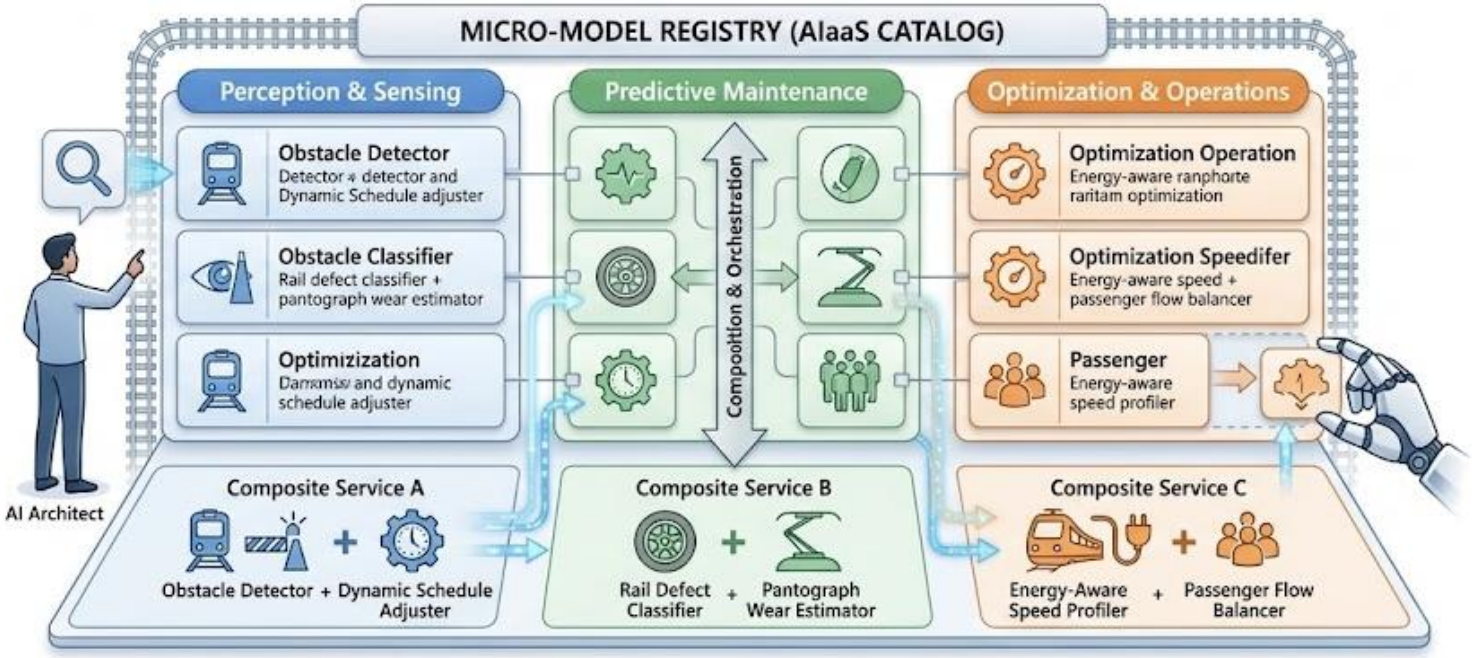
AIaaS Micro-Model registry



- AIaaS breaks down complex AI into lightweight, domain-specific micro-models that can be dynamically discovered, composed, and reused.
- Modular micro-models act as standardized building blocks, enabling rapid composition of railway AI services without retraining from scratch.

Build once. Compose many times. Reuse everywhere.

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AIaaS in Railway Scenarios.

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Trackside & Obstacle Monitoring

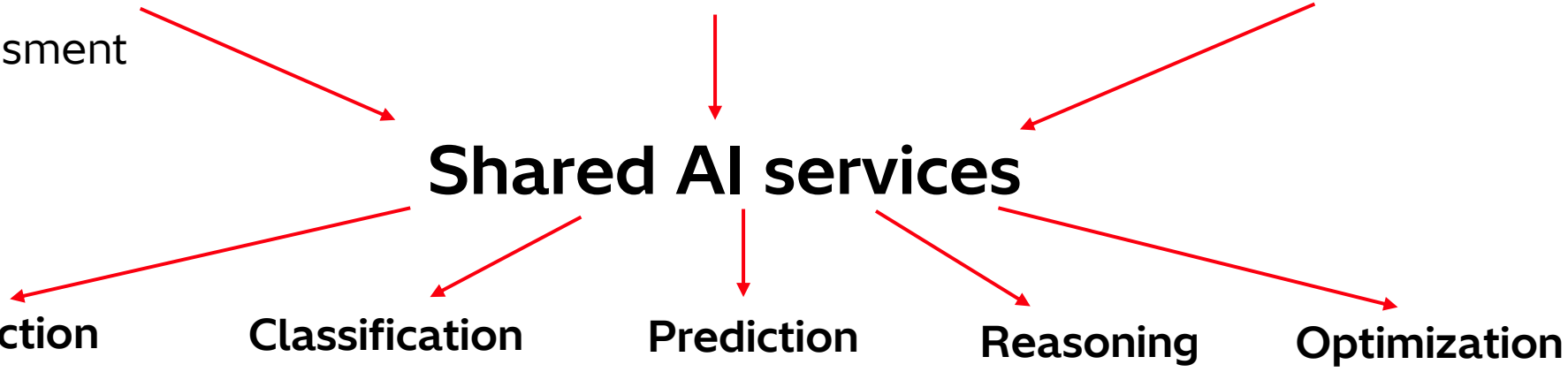
- Object detection
- Classification
- Tracking
- Risk Assesment

Predictive maintenance

- Anomaly detection
- Condition monitoring
- Failure prediction
- Asset Health Assessment

Video analytics

- Passenger Monitoring
- Crowd detection
- Safety analytics
- Operationalinsights



The same AI capabilities can be discovered, reused and deployed across multiple applications through an AIaaS ecosystem.

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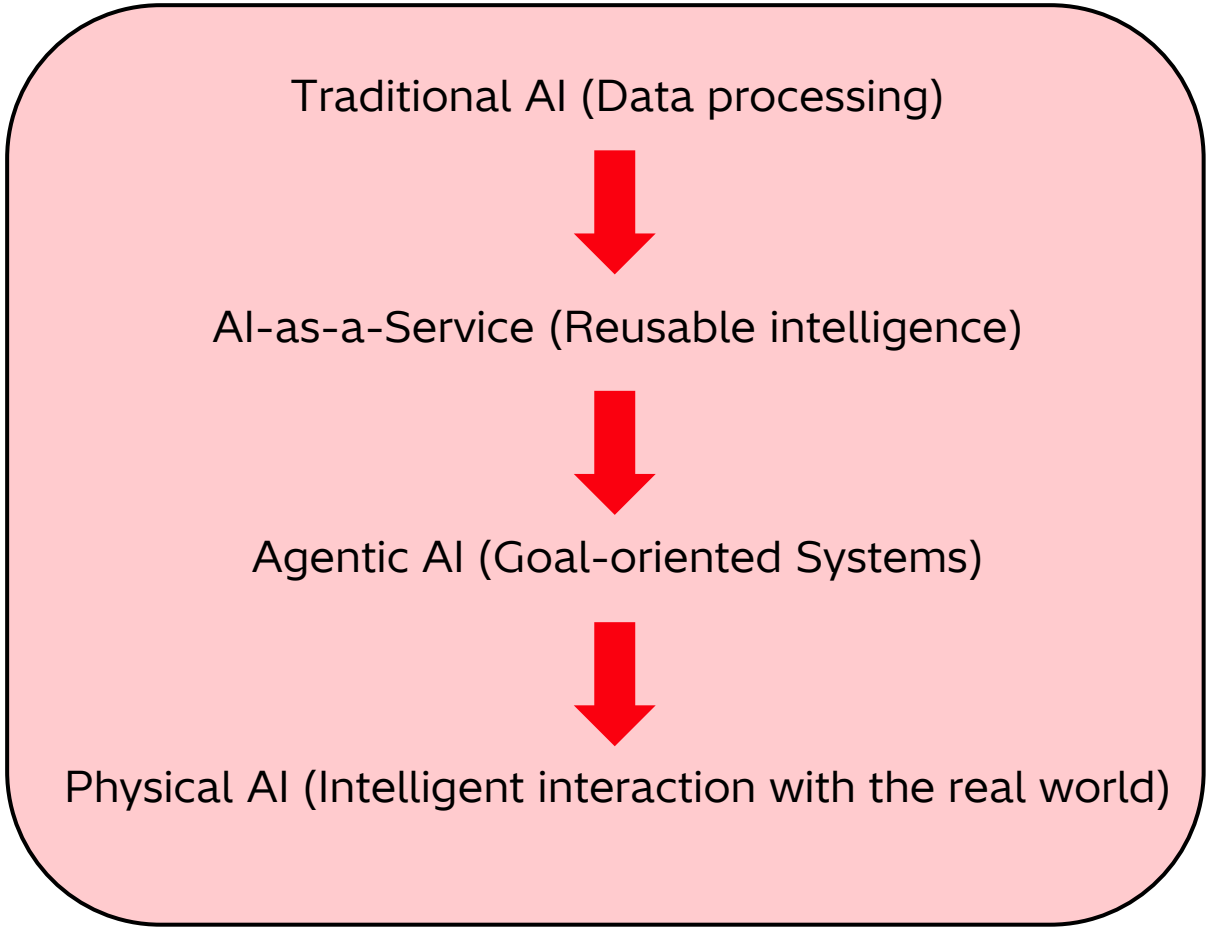
From AIaaS to Physical AI.



Physical AI examples

- 🚆 Autonomous inspection systems
- 🤖 Maintenance robots
- 🚁 Infrastructure monitoring drones
- 📷 Intelligent trackside systems
- 🚦 Adaptive railway operations

AI is no longer limited to understanding the world. It is becoming capable of interacting with it.

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Physical AI architecture.

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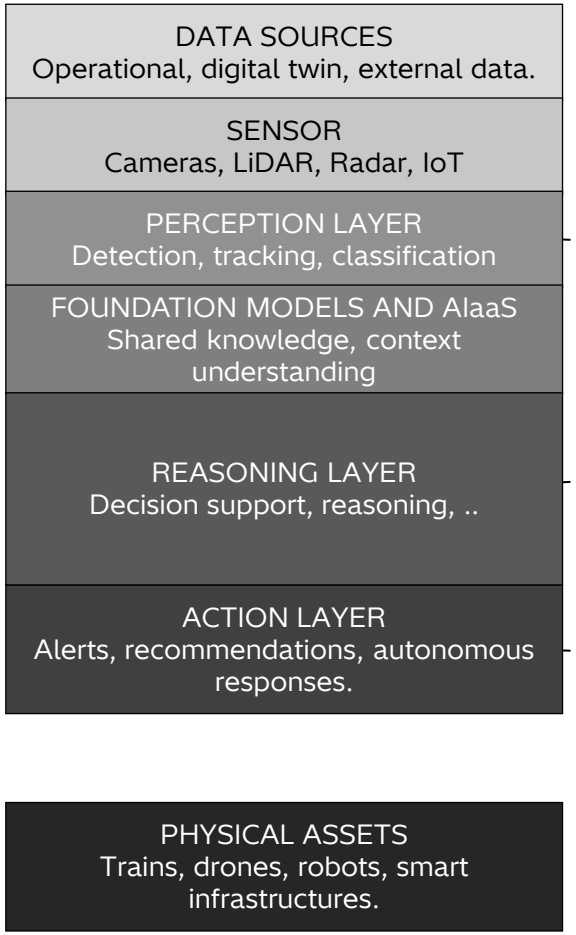

Physical AI extends AI beyond data analysis by enabling perception, reasoning, decision-making and interaction with physical systems.

- Understand the environment
- Detect objects and events

- Interpret context
- Assess risks and priorities

- Generate recommendations
- Support interoperable decisions

Closed-loop learning enables continuous adaptation and operational improvement.

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Physical AI railway examples

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Use Case	Perception	Reasoning	Action
Intrusion Detection	Cameras, LiDAR	Threat Assessment	Operator Alert
Infrastructure Inspection	Drones, Vision AI	Defect Analysis	Maintenance Planning
Predictive Maintenance	Sensors, Telemetry	Failure Prediction	Work Order Generation
Smart Stations	Video Analytics	Crowd Assessment	Adaptive Operations

Physical AI closes the loop between sensing, intelligence and operational action.

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What is an inteligent native ecosystem?

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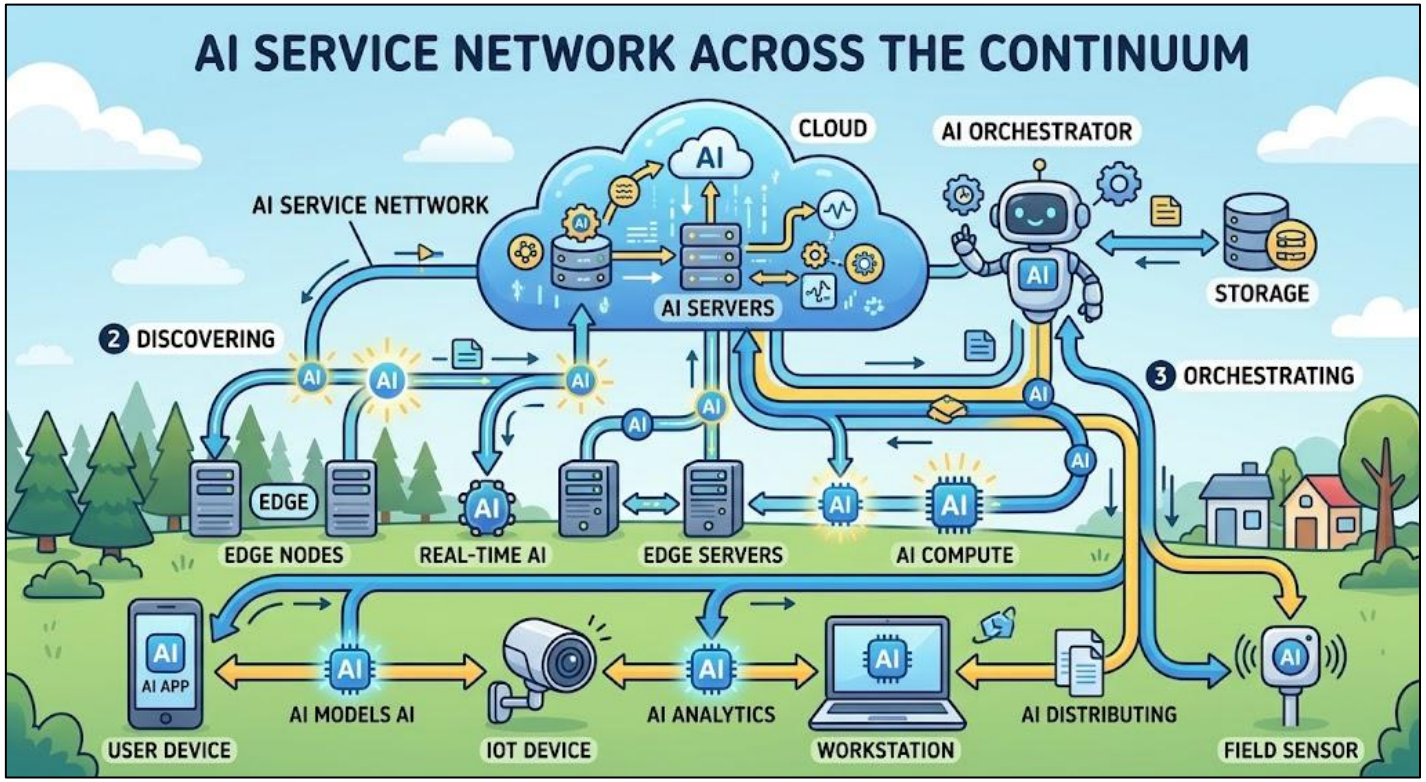
Traditional Network

- Connectivity;
- Data transport;
- End-to-end communication.

Intelligent native ecosystem

- Connectivity;
- Compute;
- Storage;
- AI Services;
- Orchestration.



An intelligent native ecosystem combines connectivity, computing, storage and AI services to dynamically orchestrate distributed intelligence across cloud, edge and physical assets.

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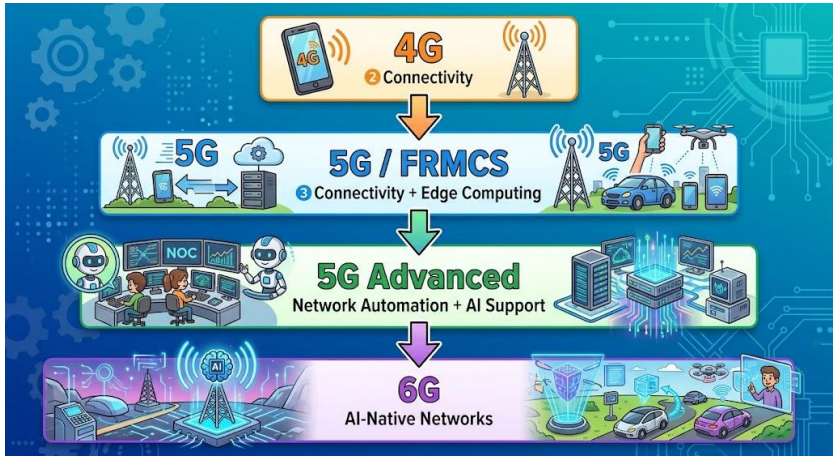
From 5G/FRMCS to 6G



6G provides the foundation for distributed AIaaS ecosystems.

Railway Perspective

Today (FRMCS)

- Broadband communications;
- Low-latency connectivity;
- Train-to-ground communications;
- Edge computing support.

Tomorrow (6G)

- AI-native networking;
- AI-as-a-Service;
- Distributed intelligence;
- Autonomous orchestration;
- Network digital twins;
- Integrated sensing and communications;
- Agentic & Physical AI support.

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From 3C Networks to Intelligence-Native Ecosystems

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European 3C vision

Connectivity
+
Compute
+
Coordination

Intelligent native ecosystem

Connectivity
+
Compute
+
Coordination
+
Intelligence

AIaaS extends the 3C paradigm by introducing reusable, discoverable and orchestrated intelligence services.

Future ecosystems will not only interconnect resources. They will discover, share and orchestrate intelligence.

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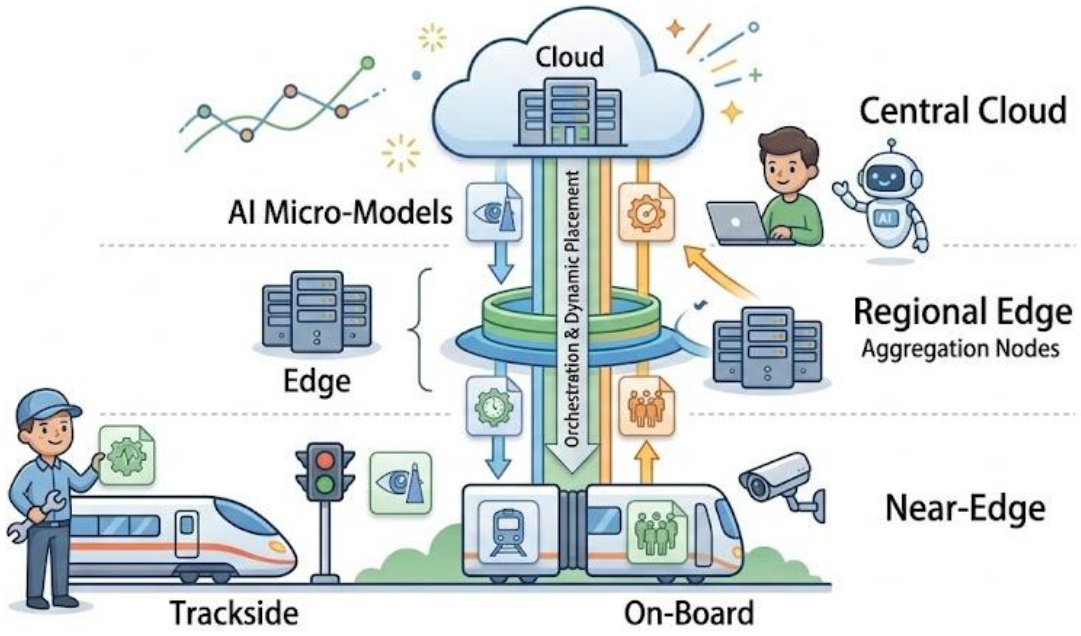
AIaaS at the Network Level: Dynamic Edge-to-Cloud orchestration



Future railway networks do not merely transport data: they dynamically orchestrate, place, and execute AI micro-models where compute and latency demand it.

- **Near-Edge Deployment (Trackside & On-Board):** Ultra-low latency execution (<10ms) for time-critical safety and obstacle detection.
- **Regional Edge Aggregation:** Local data processing and intermediate inference for predictive maintenance and regional coordination.
- **Central Cloud Governance:** Heavy compute model training, cross-domain analytics, and global AI micro-model registry management.
- **Network Slicing & Orchestration:** Guaranteed bandwidth and dynamic resource allocation for mission-critical railway AI services.

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DEMO

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Video Analytics — platform person count

People detected on platform

7

Predictive maintenance

Simulate incident

Vibration

3.4

Temperature °C

47.56

No anomaly in progress

Live vibration history

Telecom network quality (FRMCS/5G)

Signal %

96.6

Latency ms

27.7

Network coverage within normal range

Passenger assistant

Ask a question

Are there some delays?

Send question

Network quality along the line is temporarily degraded: real-time schedule updates may arrive with a delay.

Shared context event log

```
[2026-09-23T17:34:09.055725+00:00] network_quality_service -> coverage_restored: {}
[2026-09-23T17:34:03.716066+00:00] passenger_assistant_service -> passenger_question: {'
[2026-09-23T17:33:56.522290+00:00] network_quality_service -> coverage_degraded: {'signa
[2026-09-23T17:33:41.341498+00:00] maintenance_service -> probable_fault: {'track_sectio
[2026-09-23T17:33:38.188714+00:00] maintenance_service -> probable_fault: {'track_sectio
[2026-09-23T17:33:33.822436+00:00] network_quality_service -> coverage_restored: {}
```


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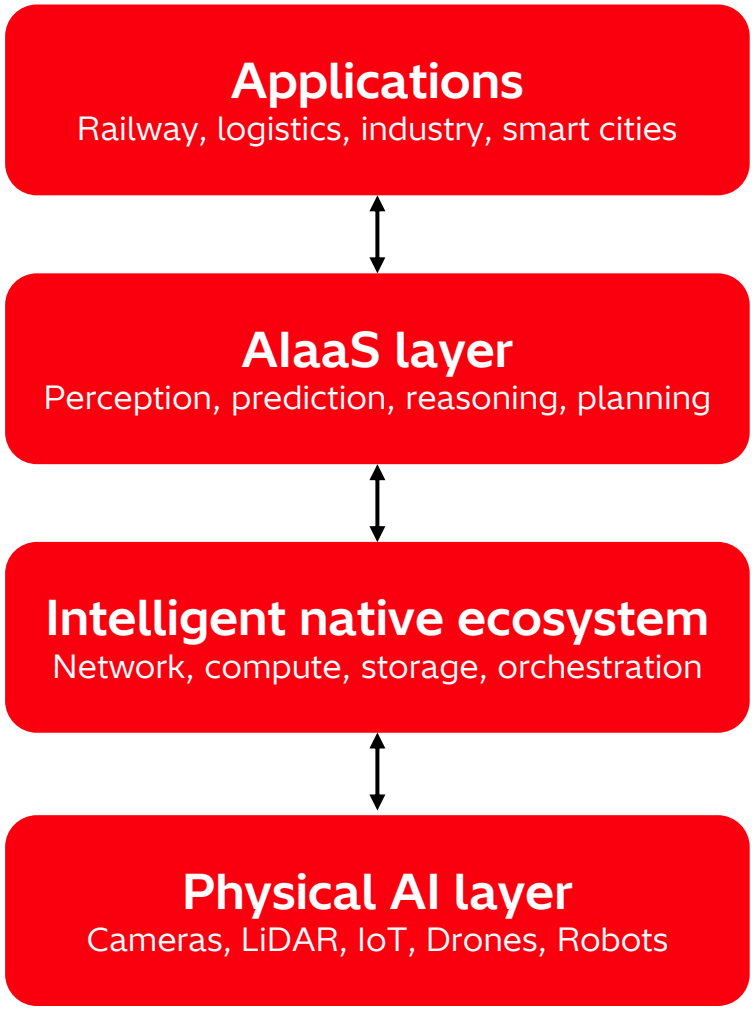
AIaaS for Future Intelligent Networks



A distributed infrastructure that combines connectivity, compute, storage and AI services to deliver intelligence across cloud, edge and physical assets.

Network Native Capabilities

- Connectivity
- Computing
- Storage
- AI Services
- Orchestration

Future networks will evolve from connecting devices to orchestrating distributed intelligence.

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Conclusions and takeways

1. AI is evolving
From rule-based systems and standalone models to reusable, interoperable and embodied intelligence.

2. AIaaS enables intelligence reuse
AI capabilities can be discovered, shared and deployed across domains through interoperable services.

3. Railways are an ideal AIaaS testbed
Safety-critical operations, distributed assets and heterogeneous data sources make rail a unique validation environment.

4. Physical AI is the next step
AI is moving beyond data analysis towards perception, reasoning and interaction with the physical world.

5. Future networks will orchestrate intelligence
Networks will provide not only connectivity, but also computing, storage, AI services and orchestration capabilities.

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Thank You

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Q&A

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BACKUP

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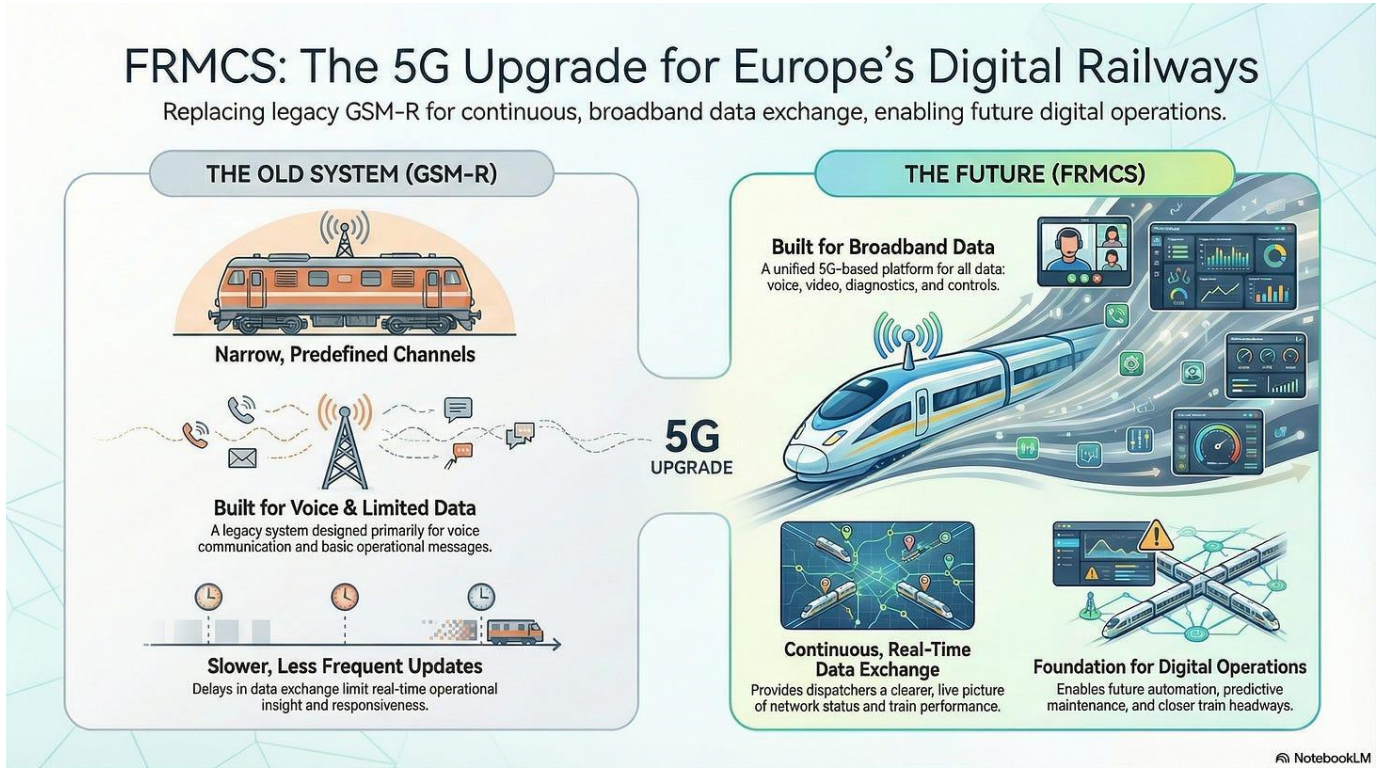
The 5G upgrade for Europe’s digital railways



https://www.therailagenda.com/p/how-frmcs-works-and-why-it-will-redefine

FRMCS is Europe’s next railway communication system: a 5G-based platform that replaces GSM-R and enables continuous data exchange between trains, infrastructure and control centres.

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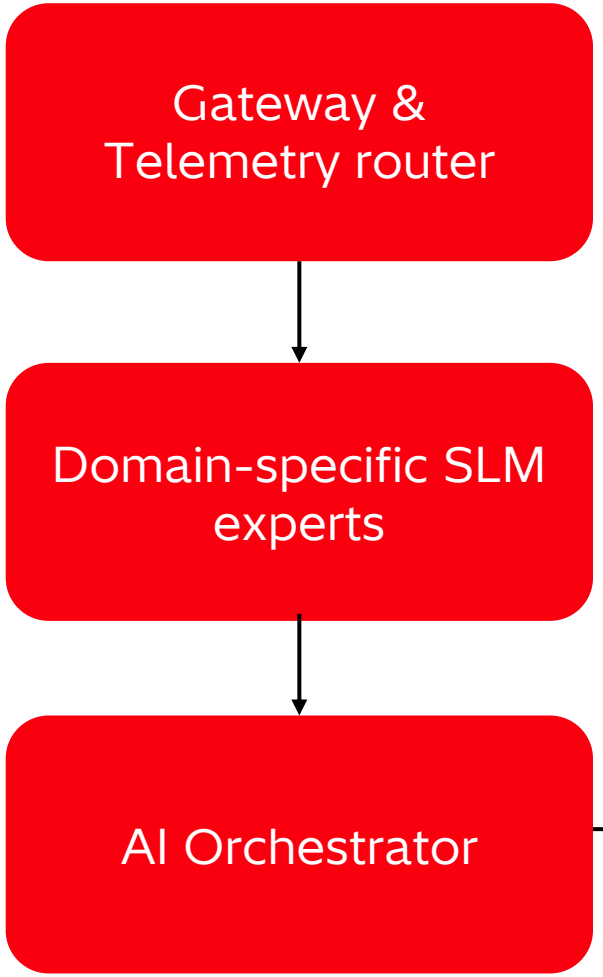
AI-Native network orchestration example



- Collects network KPIs (RSRP, RSRQ, SINR);
- Monitors operational context;
- Routes requests to domain experts

Channel expert: Radio propagation/prediction/Tunnel shadowing prediction

Mobility expert: Handover optimization/Mobility prediction

Slicing expert: QoS management/Slice adaptation

- Aggregates expert outputs;
- Generates execution policies;
- Triggers corrective actions.

- **Operational actions**
- Predictive handover
- Resource optimization
- QoS adaptation
- Network reconfiguration

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