Mid-Term Conference of the Shift2Rail JU Funded IP3 Projects

IN2SMART Presentation

Paris 24th of January 2018

Contract No. H2020 – 730539

Presentation ToC

Introduction to the project - Mr. Carlo Crovetto, Ansaldo STS

Introduction to the Intelligent Asset Management System (IAMS) Decision and Activities Flowchart - Mr. Federico Papa, Ansaldo STS

IAMS Data Architecture - Mr. Federico Papa, Ansaldo STS

IAMS monitoring systems - Mr. Roald Lengu, Ansaldo STS

IAMS asset management procedures - Mr. Henk Samson, Strukton Rail

IAMS story boards and use cases - Mr. Benoit Guyot, SNCF and Andy Kirwan, NR as storyboards referents

Conclusions - Mr. Carlo Crovetto, Ansaldo STS

Introduction to the project

Mr. Carlo Crovetto

(Project coordinator)

Ansaldo STS

PROJECT QUICK OVERVIEW AND KEY DATA

Official Start of the project: 01/09/2016
Kick of Meeting: 15/09/2016

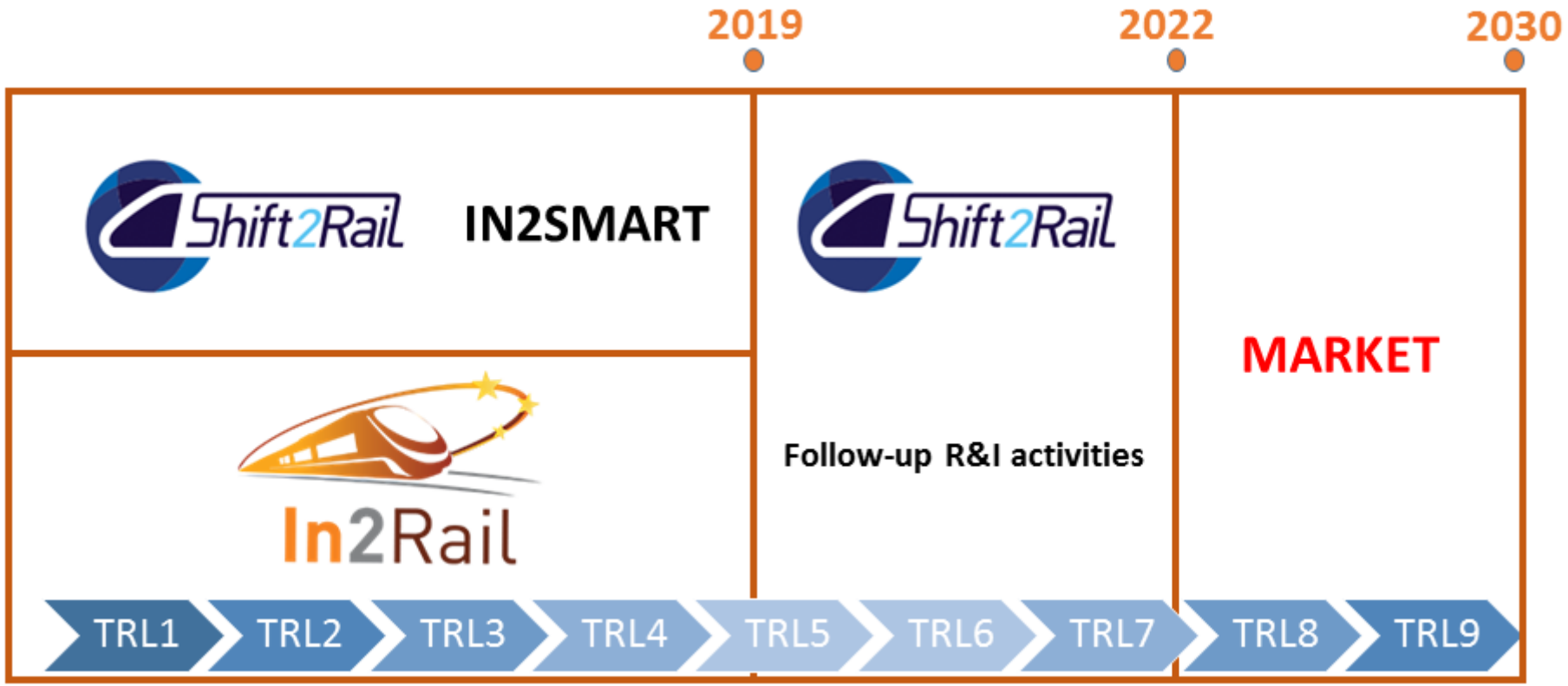
Project's duration : 36 months

Project's Coordinator : ASTS

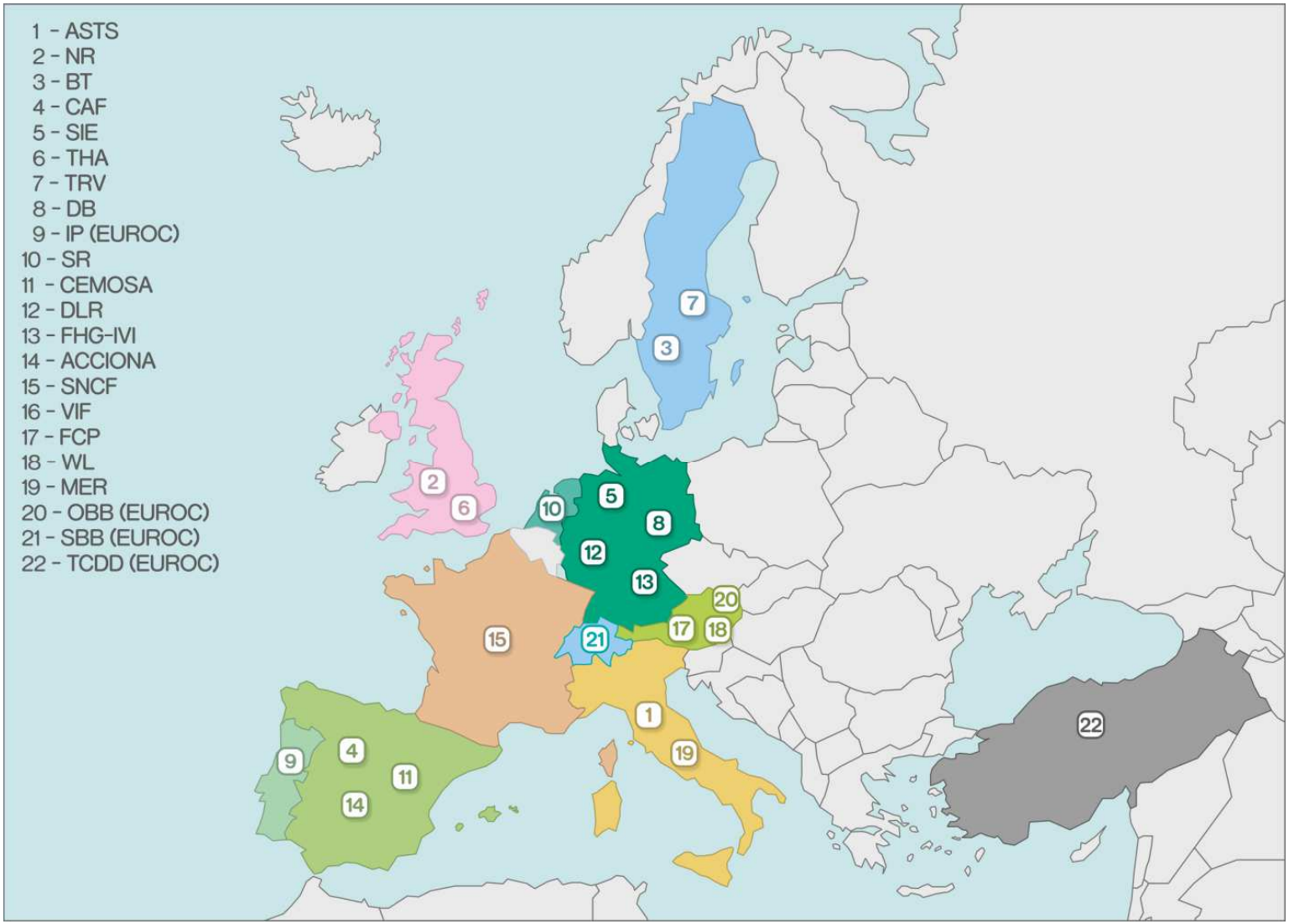
Global Project's budget: 16.405.562,5€

Funded Project's budget: 7.290.632,50€

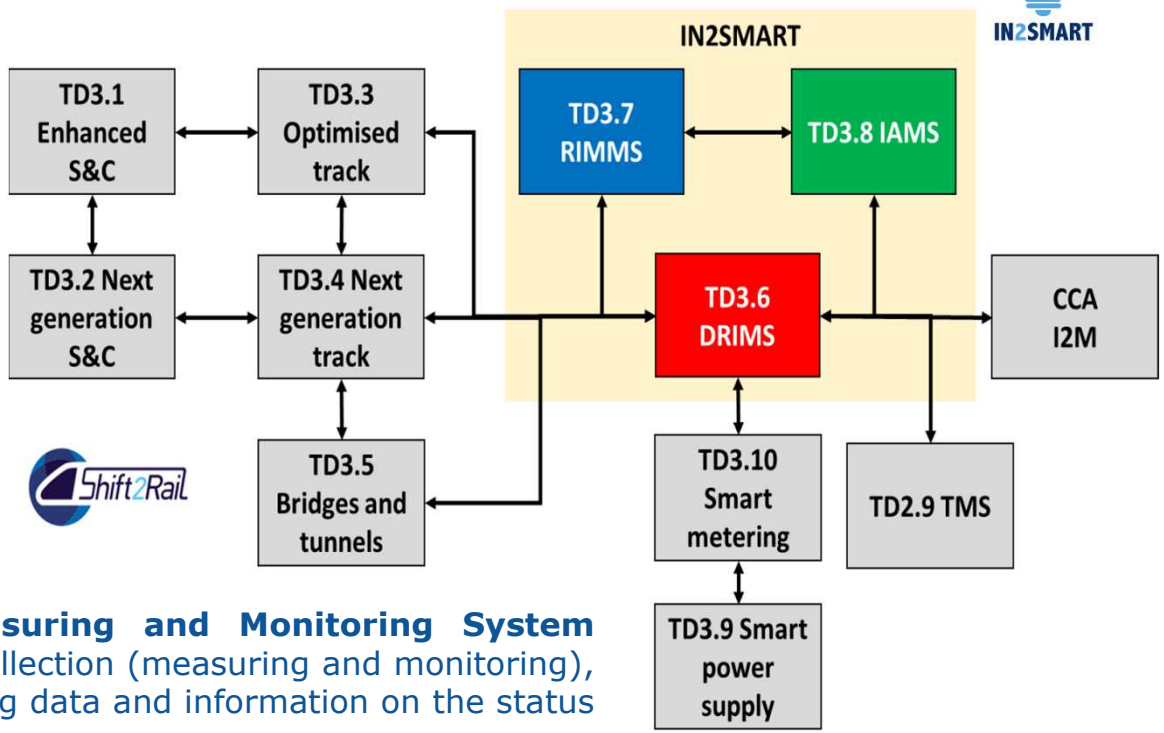
TIMELINE AND PROJECT POSITIONING



PROJECT PARTNERS



S2R IP3 TDs & IN2SMART

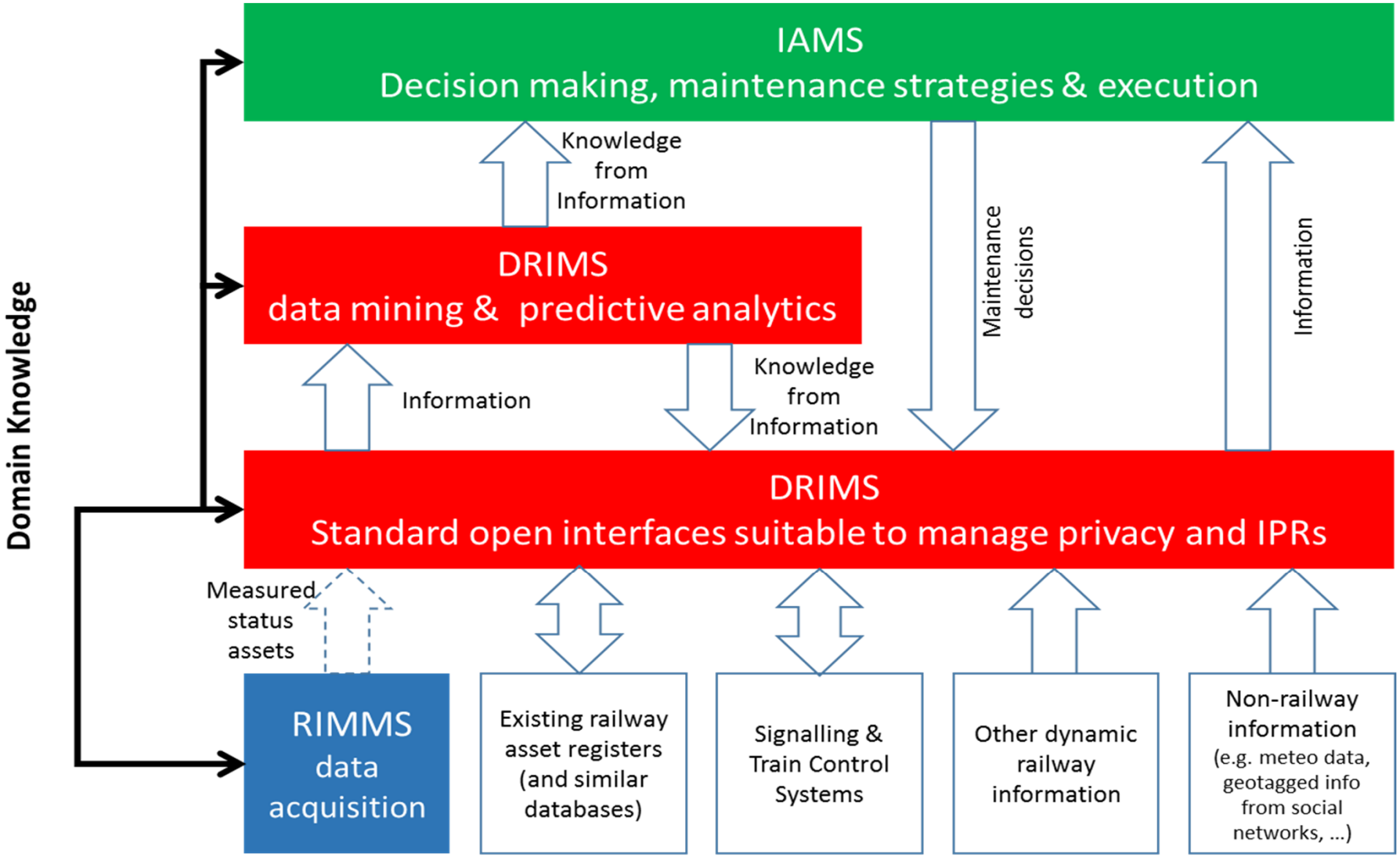


☐ **TD3.7 Railway Information Measuring and Monitoring System (RIMMS)** focuses on asset status data collection (measuring and monitoring), processing and data aggregation producing data and information on the status of assets;

☐ **TD3.6 Dynamic Railway Information Management System (DRIMS)** focuses on interfaces with external systems; maintenance-related data management and data mining and data analytics; asset degradation modelling covering both degradation modelling driven by data and domain knowledge and the enhancement of existing models using data/new insights;

☐ **TD3.8 Intelligent Asset Management Strategies (IAMS)** concentrates on decision making (based also but not only on TD3.6 input); validation and implementation of degradation models based on the combination of traditional and data driven degradation models and embedding them in the operational maintenance process based upon domain knowledge; system modelling; strategies and human decision support; automated execution of work.

IN2SMART Asset Management Architecture



IN2SMART & its relevant 2017 OCs: IN2DREAMS and MOMIT

IN2DREAMS WPs	IN2SMART WPs
WP4: Smart contracts for Railway Data Transactions	WP7 "DRIMS Open Standard Interfaces": *inputs on protocols to be adopted by IN2SMART platform* WP8 "DRIMS Data Mining and Predictive Analytics" & WP9 "IAMS Asset Management and Decision Support": *common case study applying IN2DREAMS solutions to IN2SMART use cases*
WP5: Knowledge extraction from Railway Asset Data	WP8 "DRIMS Data Mining and Predictive Analytics": *common case study to apply IN2DREAMS solutions to some IN2SMART use cases to extract knowledge from data and improve uncertainties evaluation. The results will be used also inside WP9 models.*

MOMIT WPs	IN2SMART WPs
WP4: Multi scale observation and monitoring of Rail Infrastructure Threats – Application cases and monitoring results demonstration	WP3 "RIMMS Satellites and autonomous intelligent monitoring systems" and, more in details, with the Task 3.2 "UAVs" monitoring application (Leader: SNCF Partners: ASTS, EUROC, SR and ACCIONA).

Introduction to the Intelligent Asset Management System (IAMS) Decision and Activities Flowchart

Mr. Federico Papa

(Project TMT leader)

Ansaldo STS

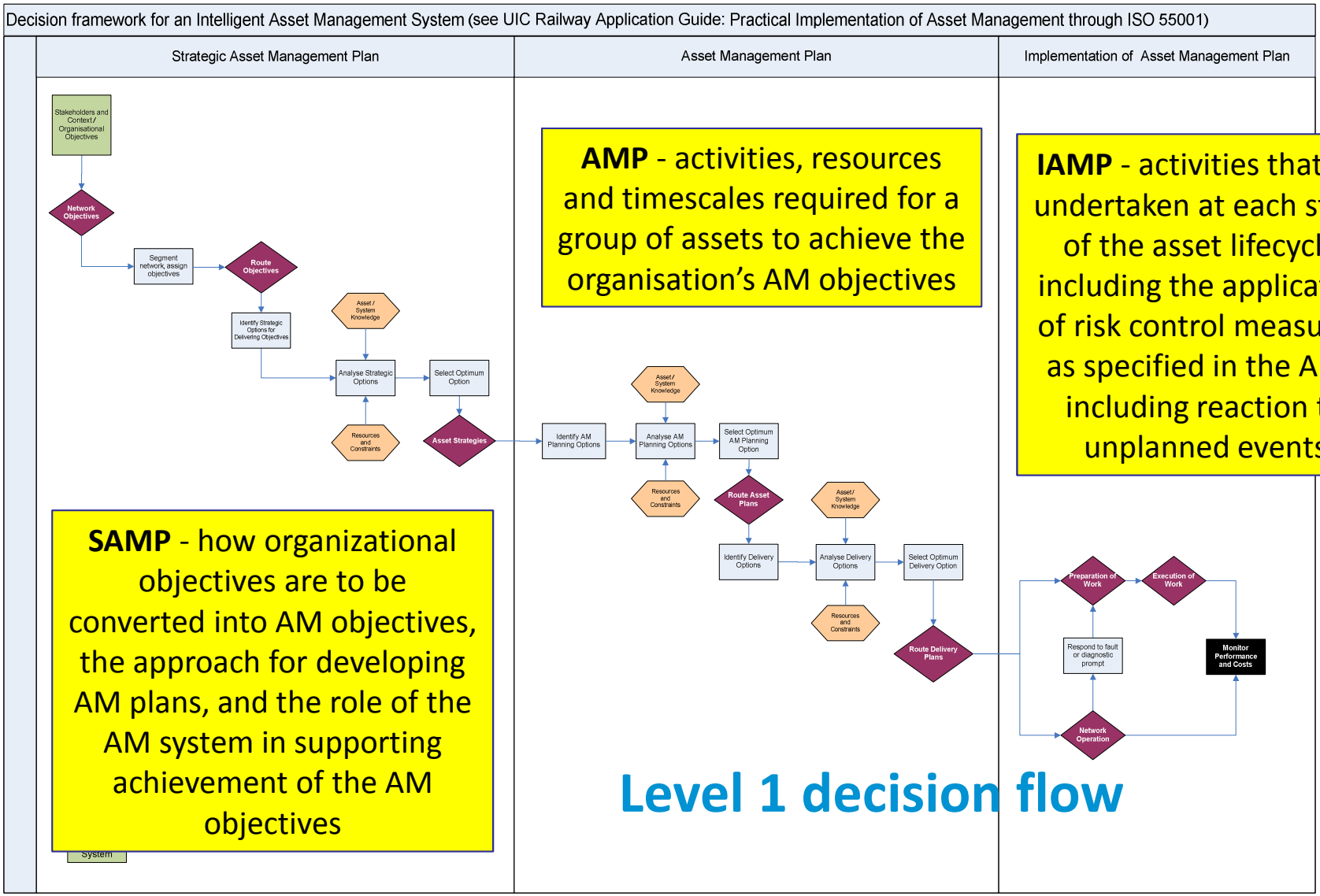
IAMS Flow Chart

Although there is not an established definition of an IAMS, the terms *Asset*, *Asset Management* and *Management System* are all defined in ISO 55001 and these provide a good foundation for a common interpretation of the IAMS for a railway implementation.

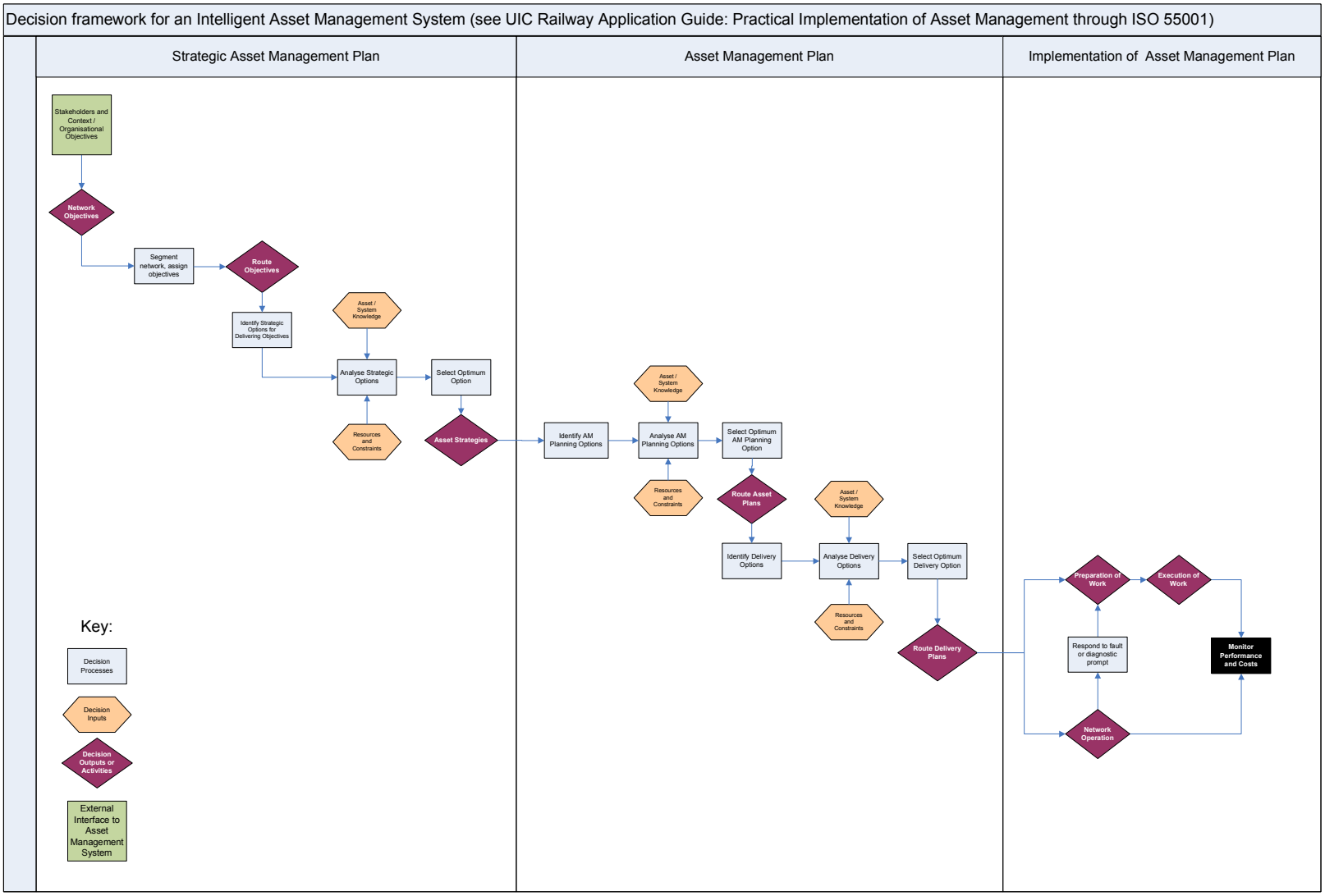
By adopting ISO 55001, a number of principles emerge which influence the scope of application of the IAMS, including:

- *Asset Management* is much broader than maintenance – additionally it includes the operation, renewal and upgrade of the railway assets (possibly including also those that are used to maintain and/or monitor the railway).
- The *Asset Management System* is inclusive of, but comprises more than, an IT system – it is the complete set of interrelated elements that enable an organisation to take better decisions and implement them efficiently and effectively.

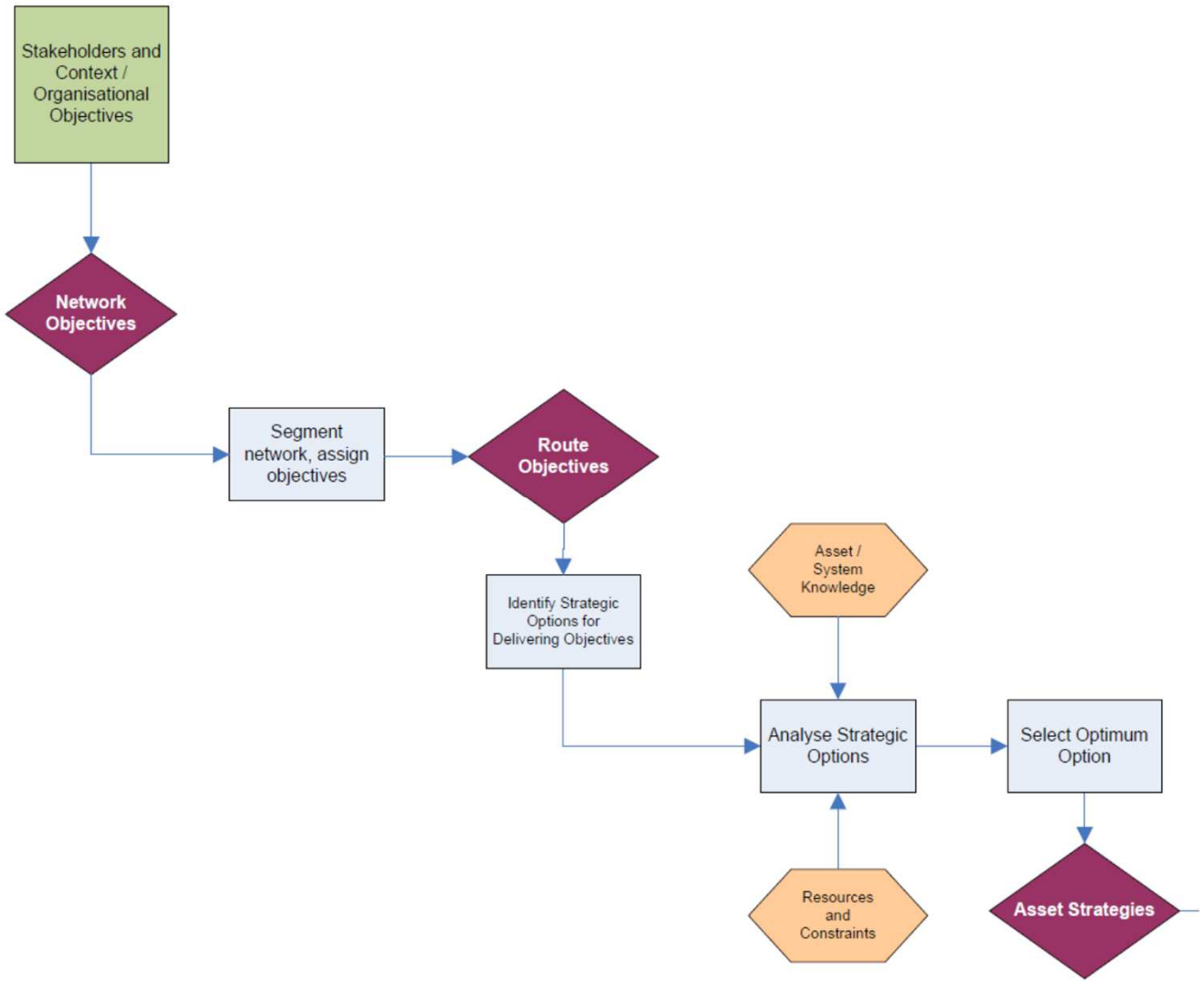
IAMS Flow Chart (ISO55000)



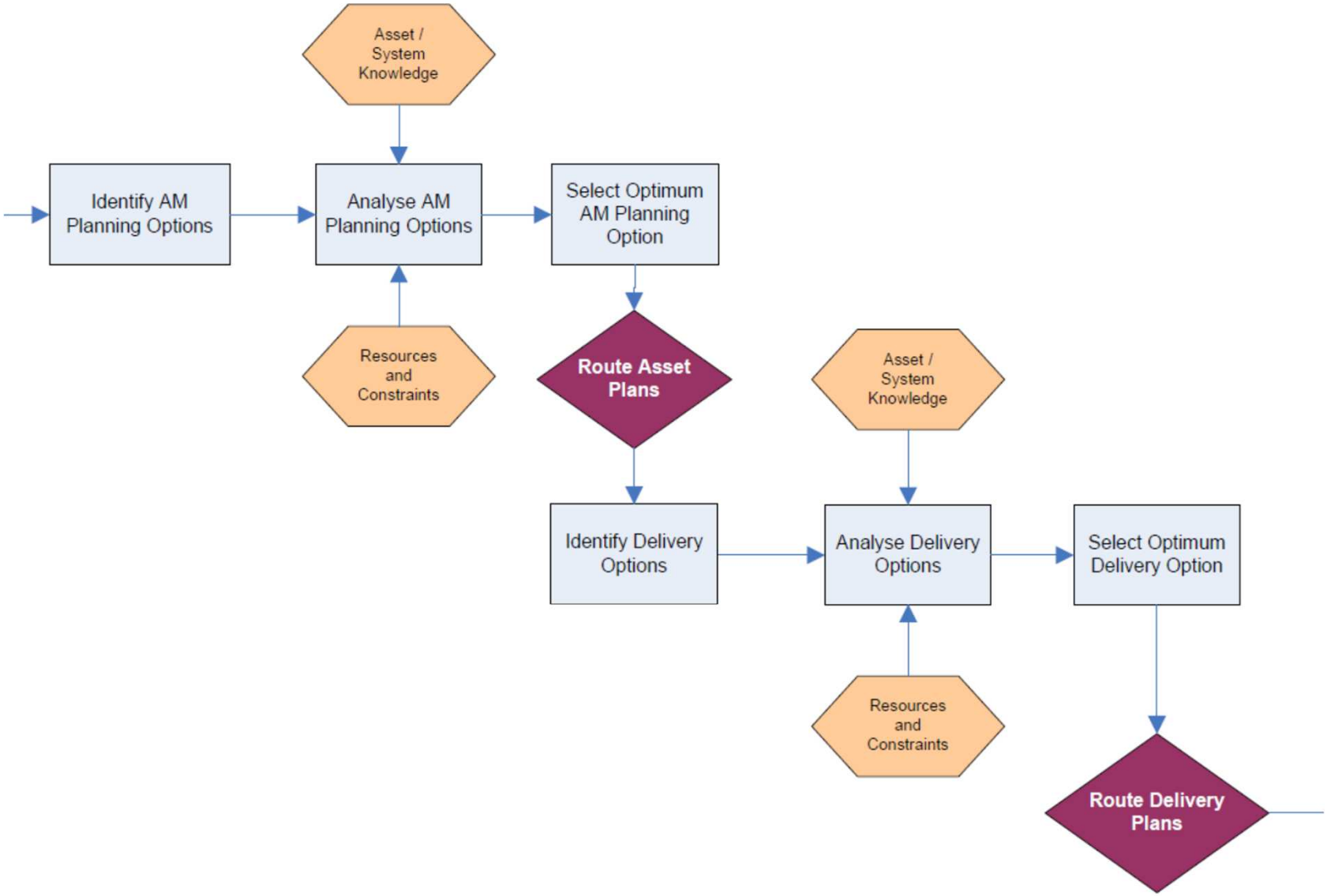
IAMS Flow Chart



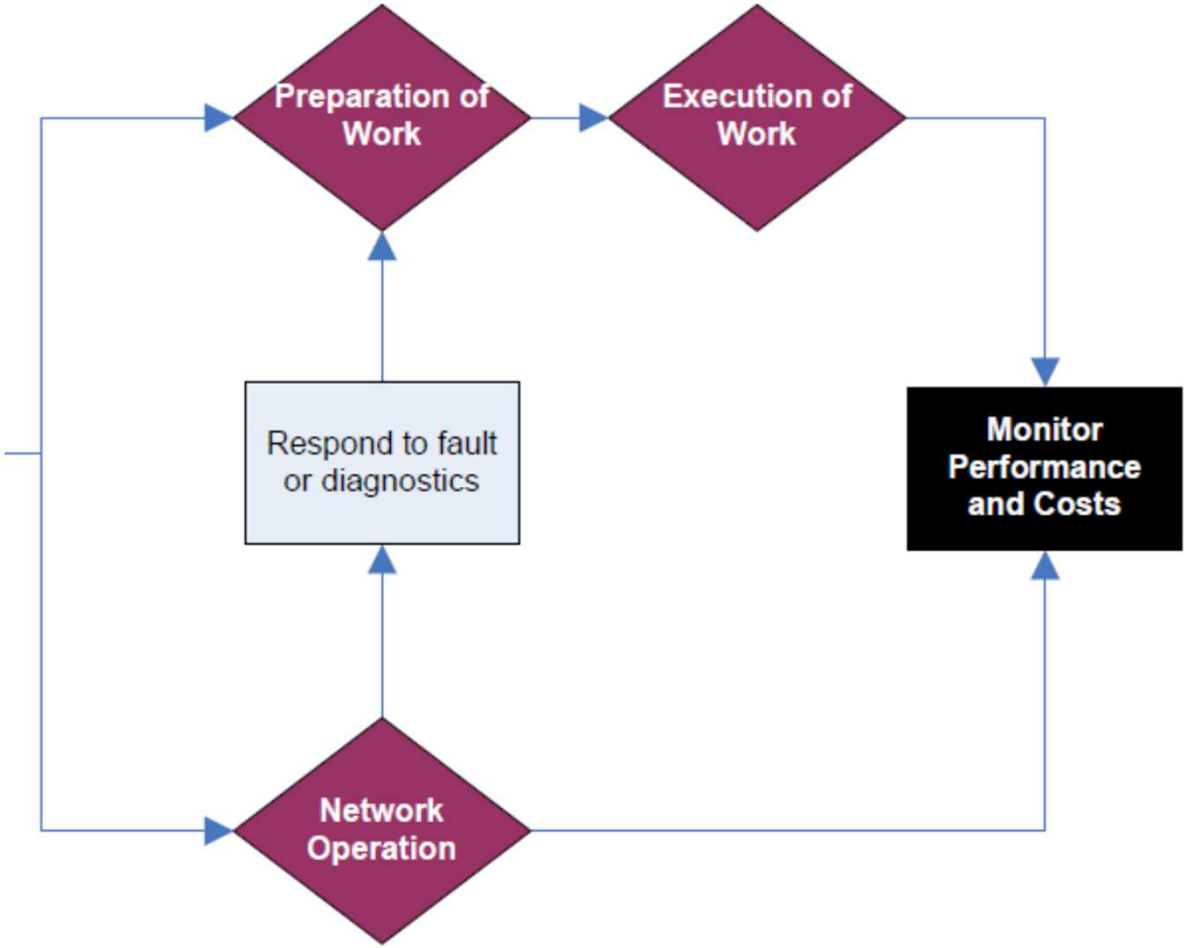
IAMS Flow Chart



IAMS Flow Chart



IAMS Flow Chart



IAMS Analysis Process

IAMS decision and activity flowchart – Level 1

comprehensive view of the wide range of decisions and activities taken by IMs, from SAMP to AMP to IAMP

IAMS Decision and Activity Flowchart – Level 2

a further level of detail to describe the key parameters associated with each component in the Level 1 Flowchart

IAMS Analysis Process

From AMS to IAMS

adoption of breakthrough methods and technologies that are transforming other domains and have the same potential to do so in rail

IAMS Analysis Process

UML description of IN2SMART IAMS function

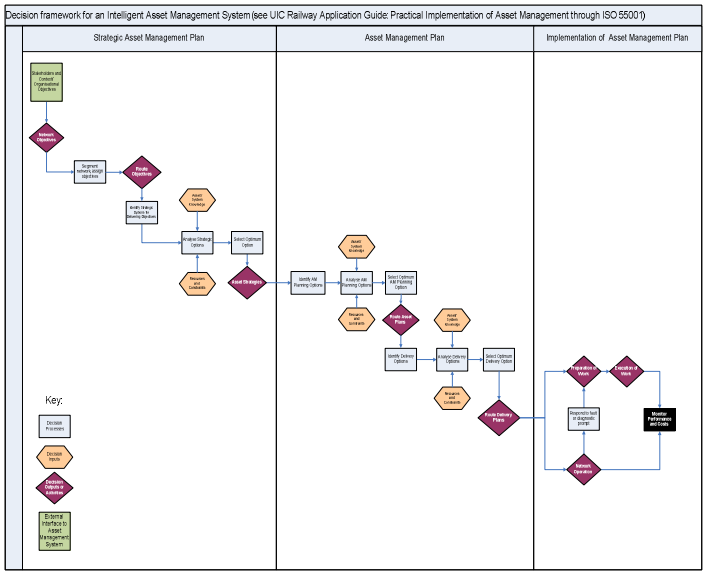
the transitions between the IAMS Level 1 and Level 2 approaches and what to implement in IN2SMART using UML representation

IAMS Analysis Process

Requirements

86 requirements from Level 1, Level 2 and UML diagrams

The way forward



- Requirements
- Developments Guidelines
- Integrated Technological Demonstrators (ITD) Architecture

IAMS Data Architecture

Mr. Federico Papa

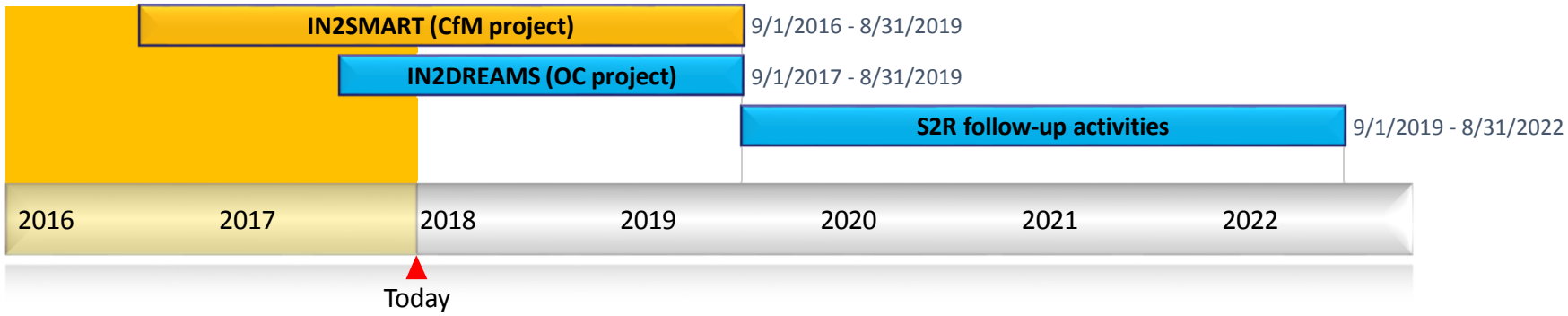
(on behalf of Milena Garresio, DRIMS-TD3.6 leader)

Ansaldo STS

DRIMS objective from MAAP

Defining an innovative approach to existing railway data management, processing and analysis to support intelligent asset management without the need of developing either a new database or yet another asset register.

DRIMS DEVELOPMENT THROUGOUT SHIFT2RAIL PROGRAM



TD3.6 DRIMS Process Steps

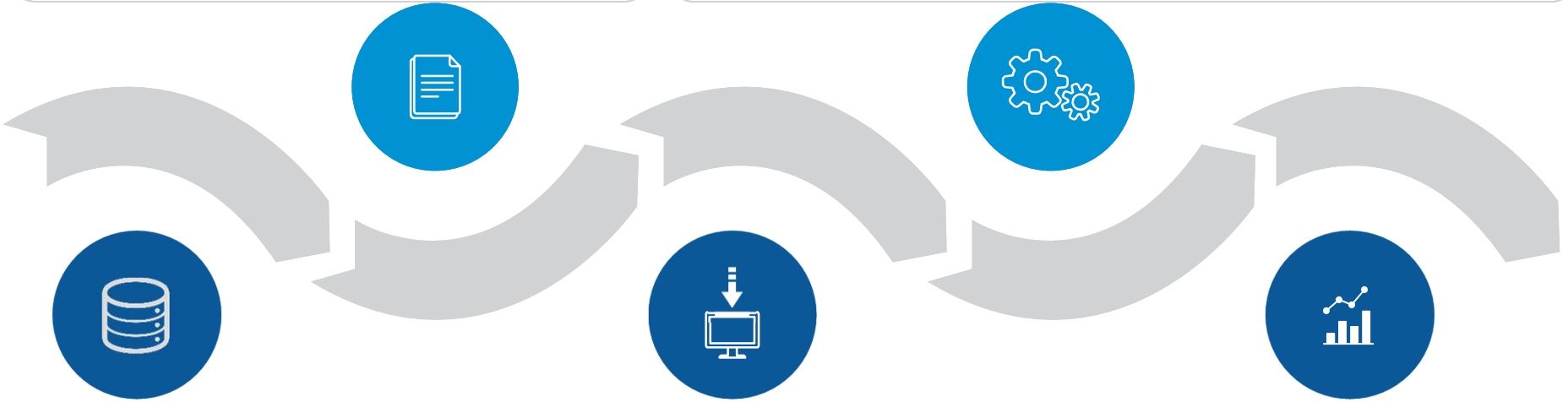
Anomaly detection

Process mining

Asset decay forecasting

Develop of an Open standard Interface for Maintenance Data

Design of Data mining and Big data Analytics for extracting knowledge from data



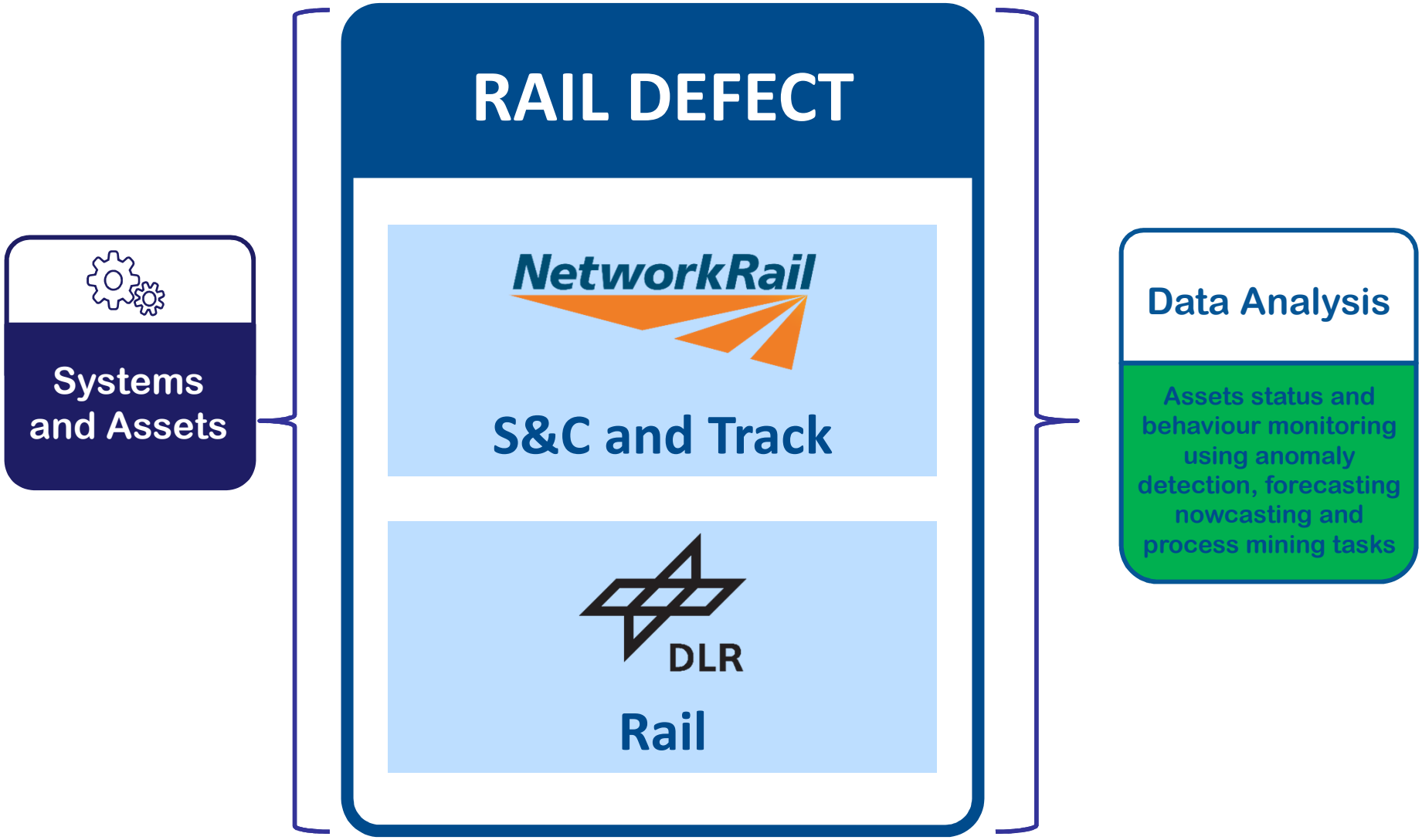
Heterogeneous Data Sources

Data Collection on IT Architecture

Real-time and Online Analytics for assets status and behaviour modelling

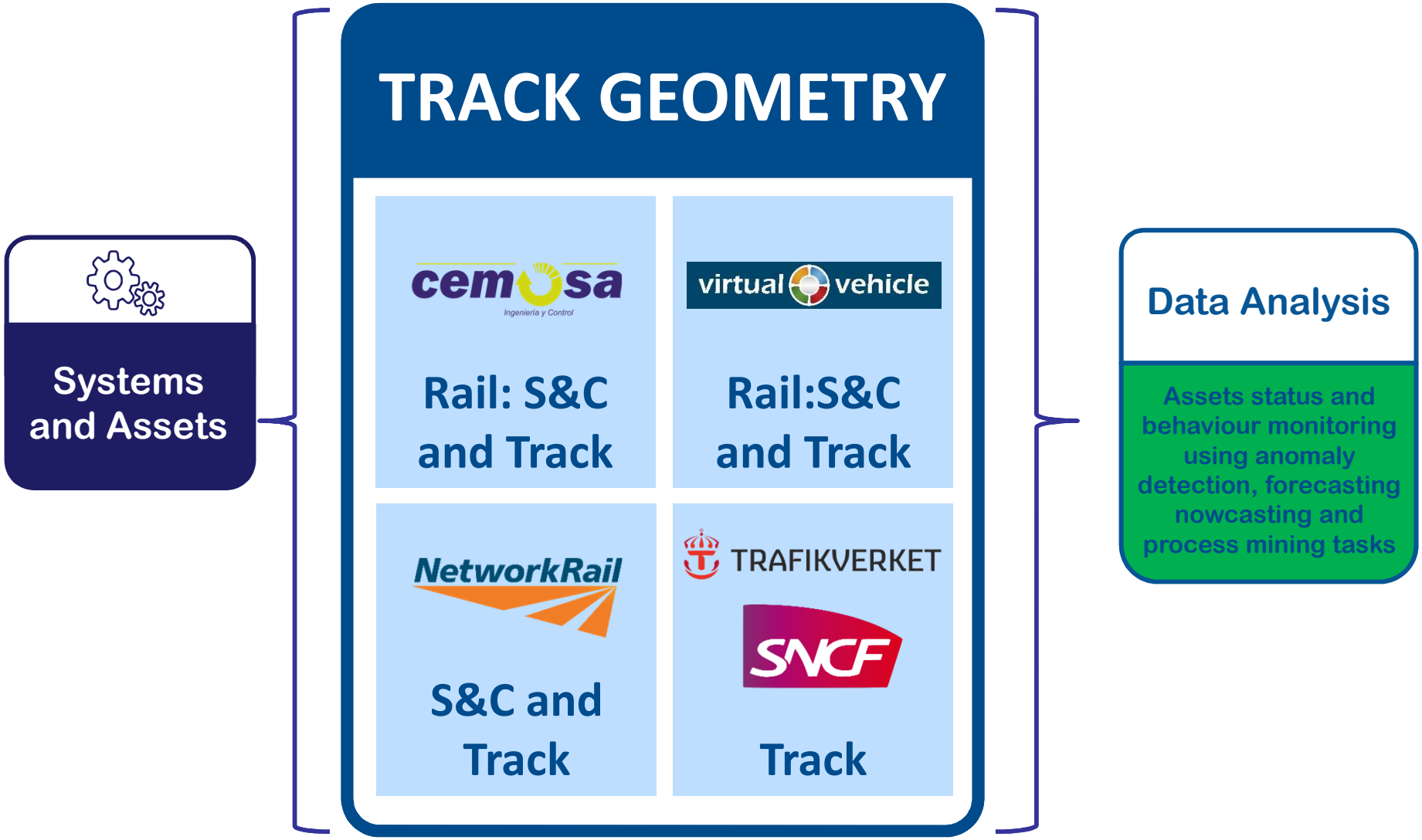
Data Collection

Use-cases Defintion



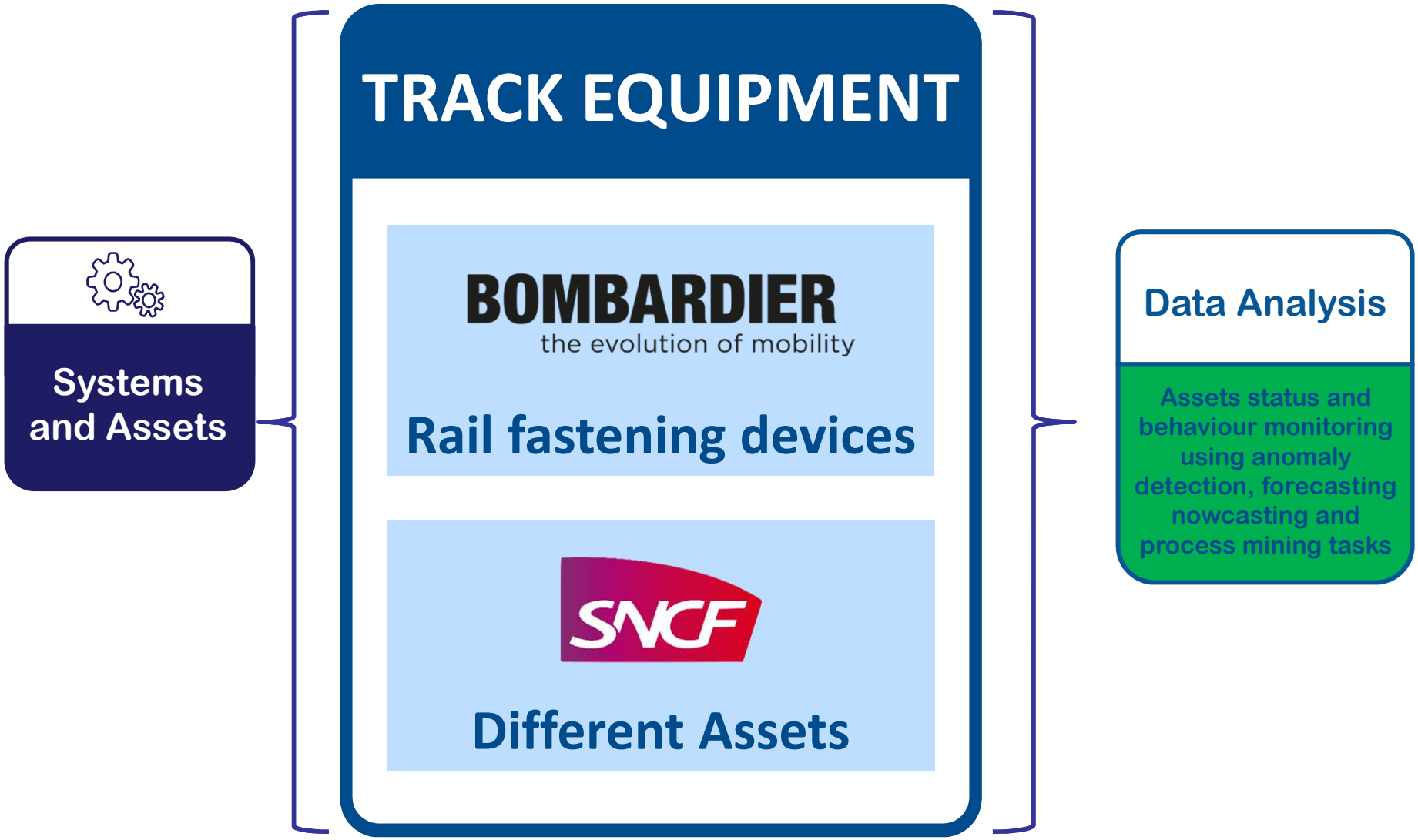
Data Collection

Use-cases Defintion



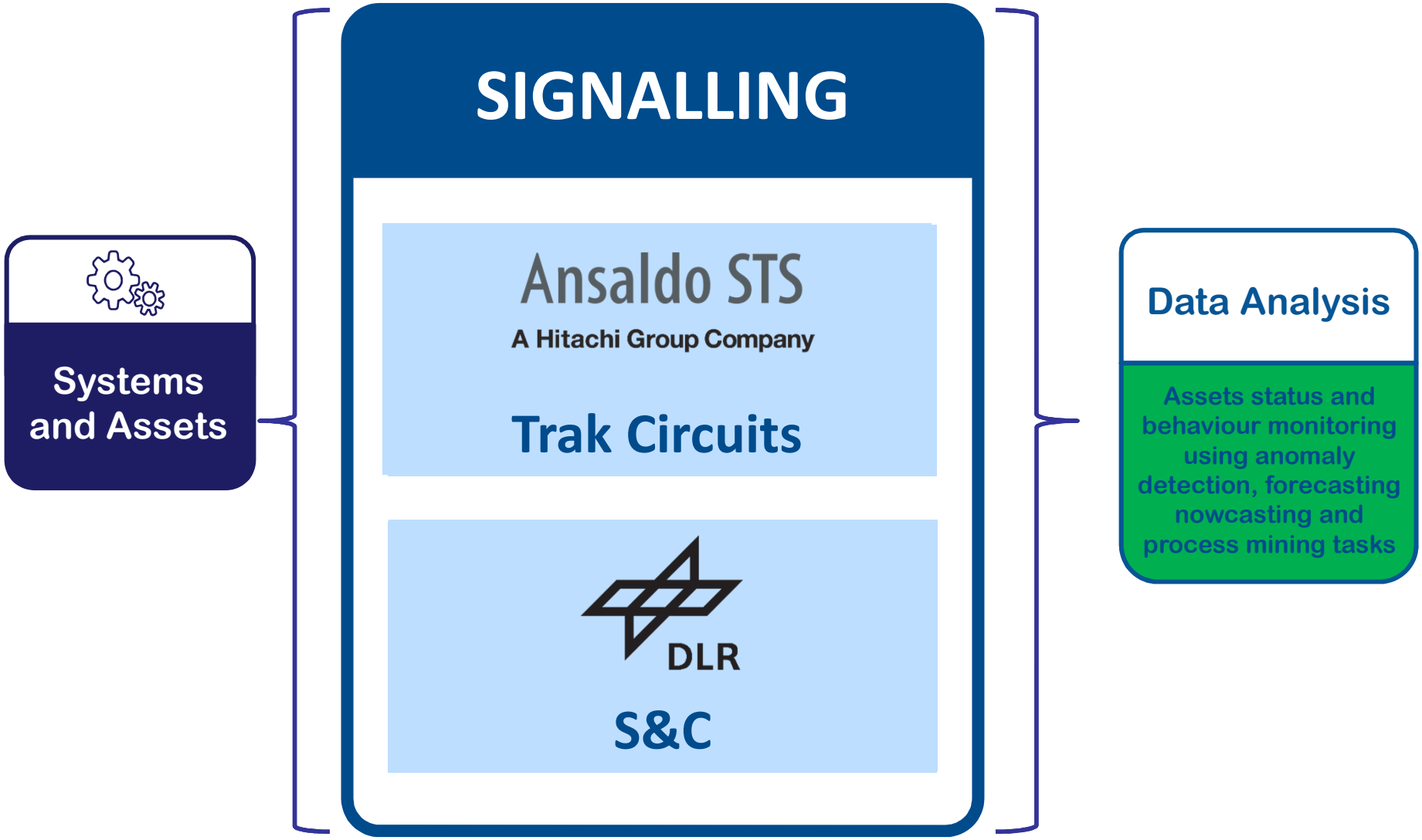
Data Collection

Use-cases Defintion



Data Collection

Use-cases Defintion



Data Collection

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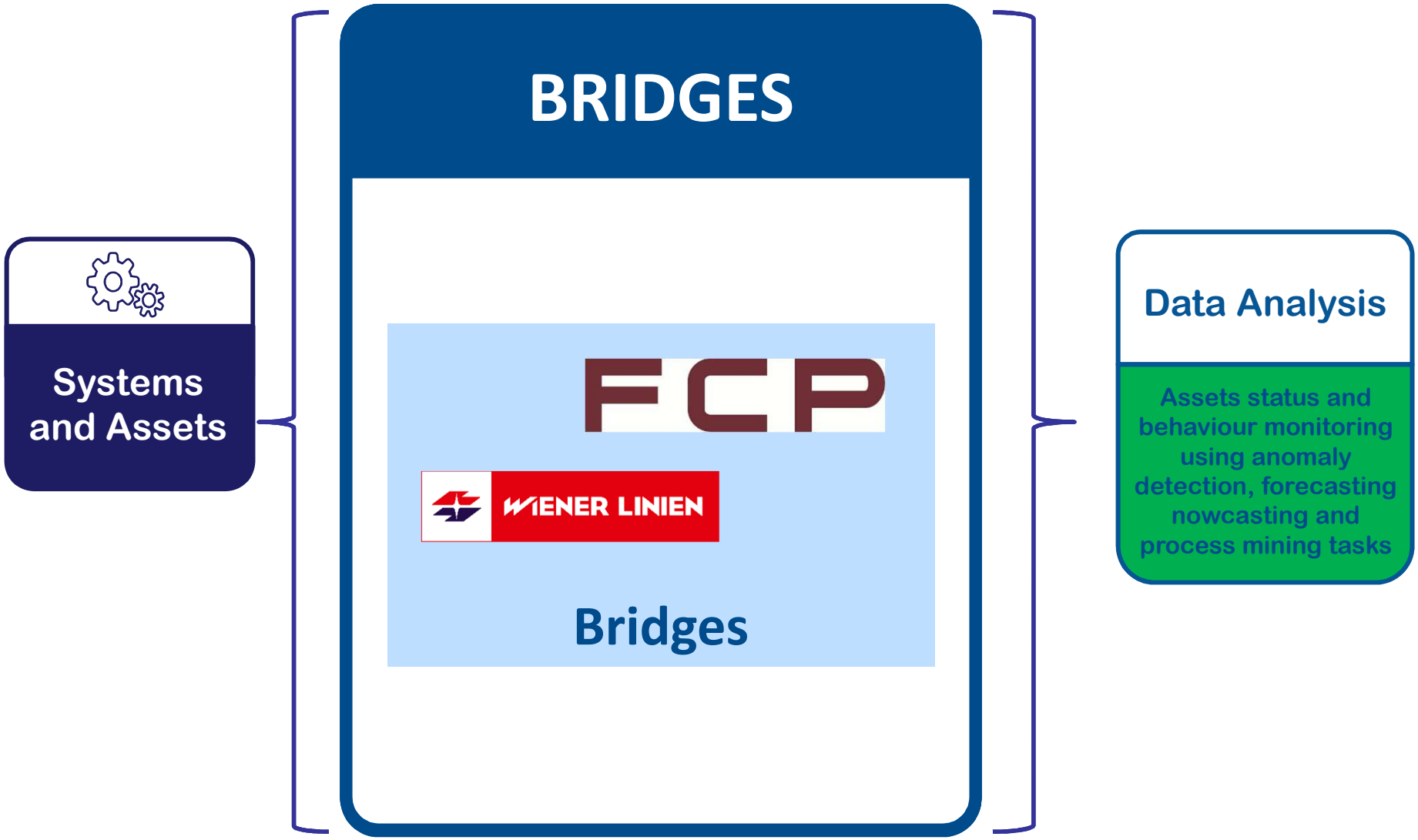
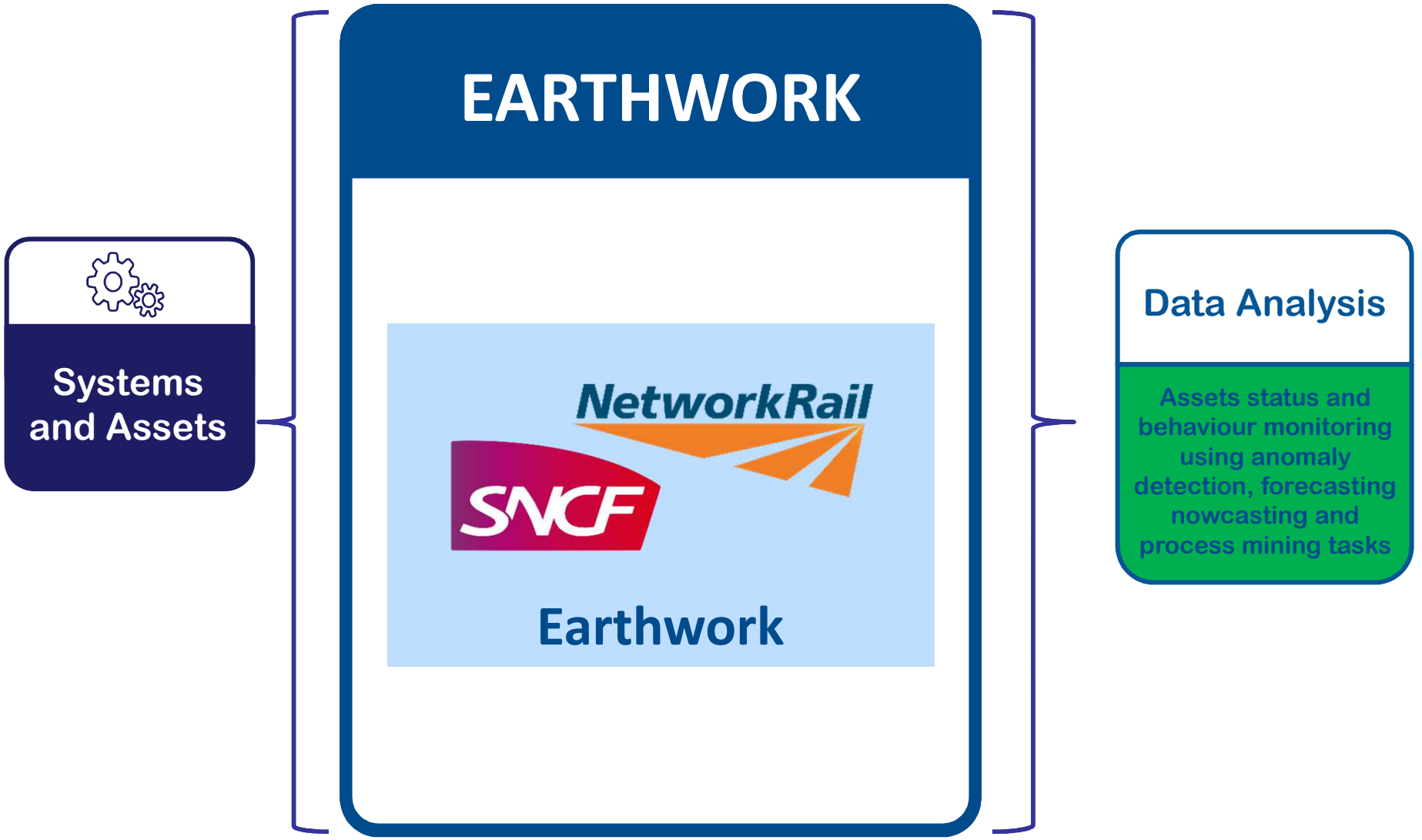


Data Collection

Use-cases Defintion



Data Analysis

Data Analysis

Assets status and behaviour monitoring using anomaly detection, forecasting nowcasting and process mining tasks

Rail defect

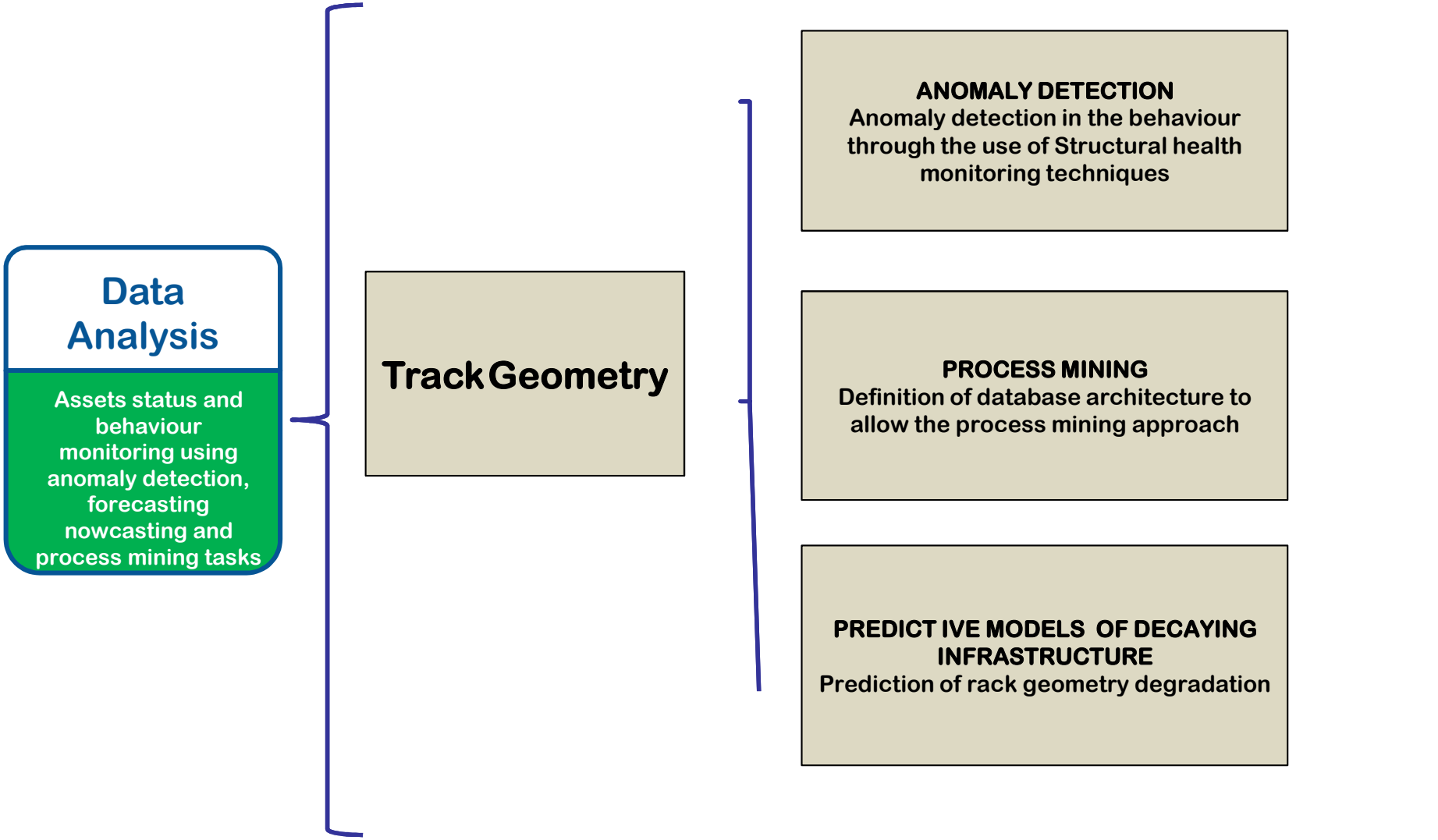
ANOMALIES DETECTION

These measurements are performed on a regular basis (one / twice a year) with a special measurement train, or during ad-hoc inspections at certain locations. Existing data analytics techniques will be applied to detect anomalies in the data sets in an early stage, which can be used to trigger specific maintenance activities. Anomalies can be found by either deviations from standard values (within a certain range) or by a-typical evolution of the values over time.

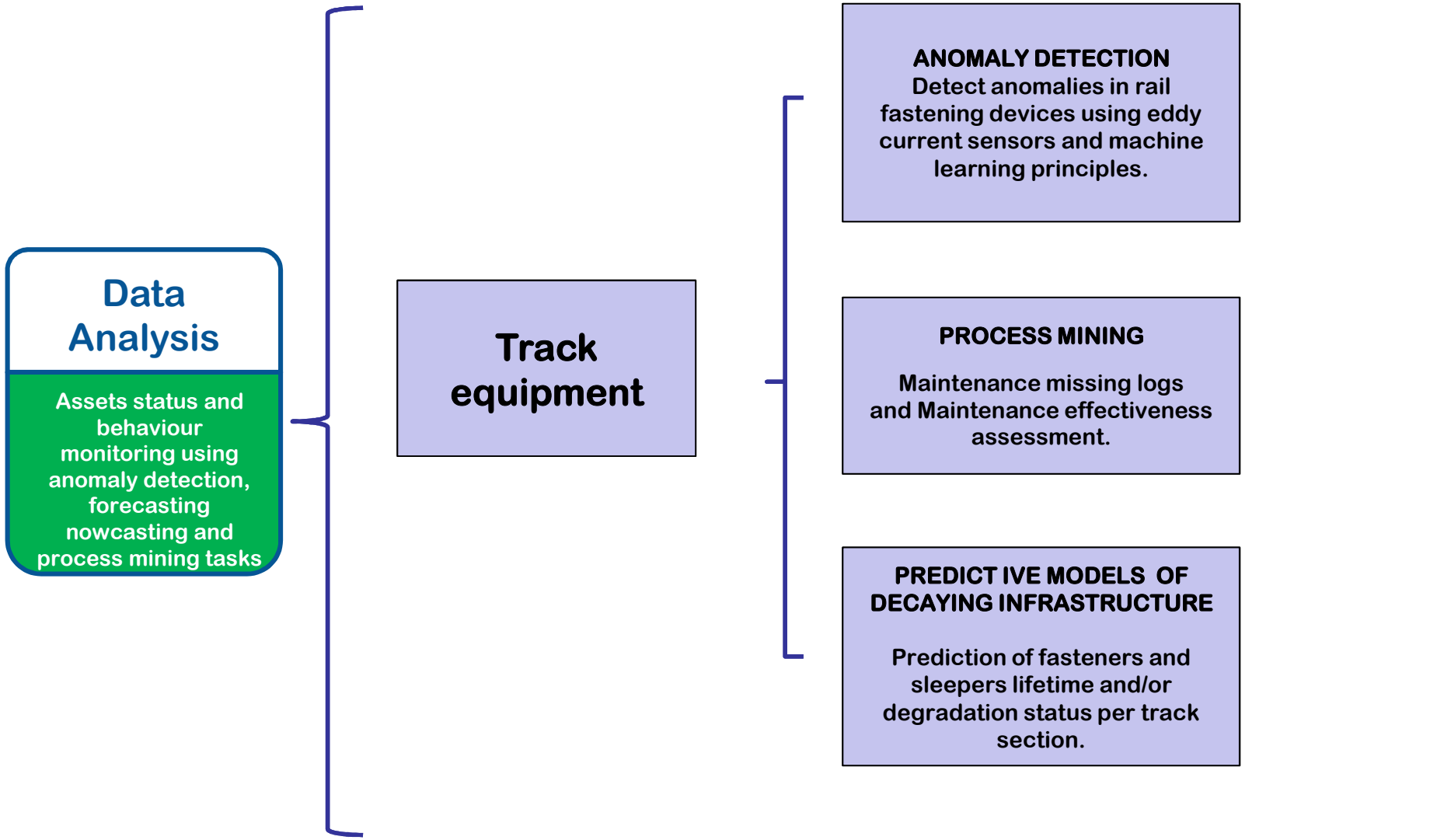
PREDICT IVE MODELS OF DECAYING INFRASTRUCTURE

these models are being developed in a parallel project, and will be used to understand the origin of detected anomalies. In that sense, data-driven and model-based approaches for detection and prediction of rail track failures will be connected.

Data Analysis



Data Analysis



Data Analysis

Data Analysis

Assets status and behaviour monitoring using anomaly detection, forecasting nowcasting and process mining tasks

Signalling

ANOMALY DETECTION

Detection of anomalies related to track circuits, with a fully data-driven approach: 1) collection of relevant data, 2) raw data cleaning and first exploratory data analysis, 3)data wrangling in order to obtain a usable dataset to feed the selected algorithm, 4) development of anomaly detection data-driven model(s), 5) model validation by exploiting part of the historical data.

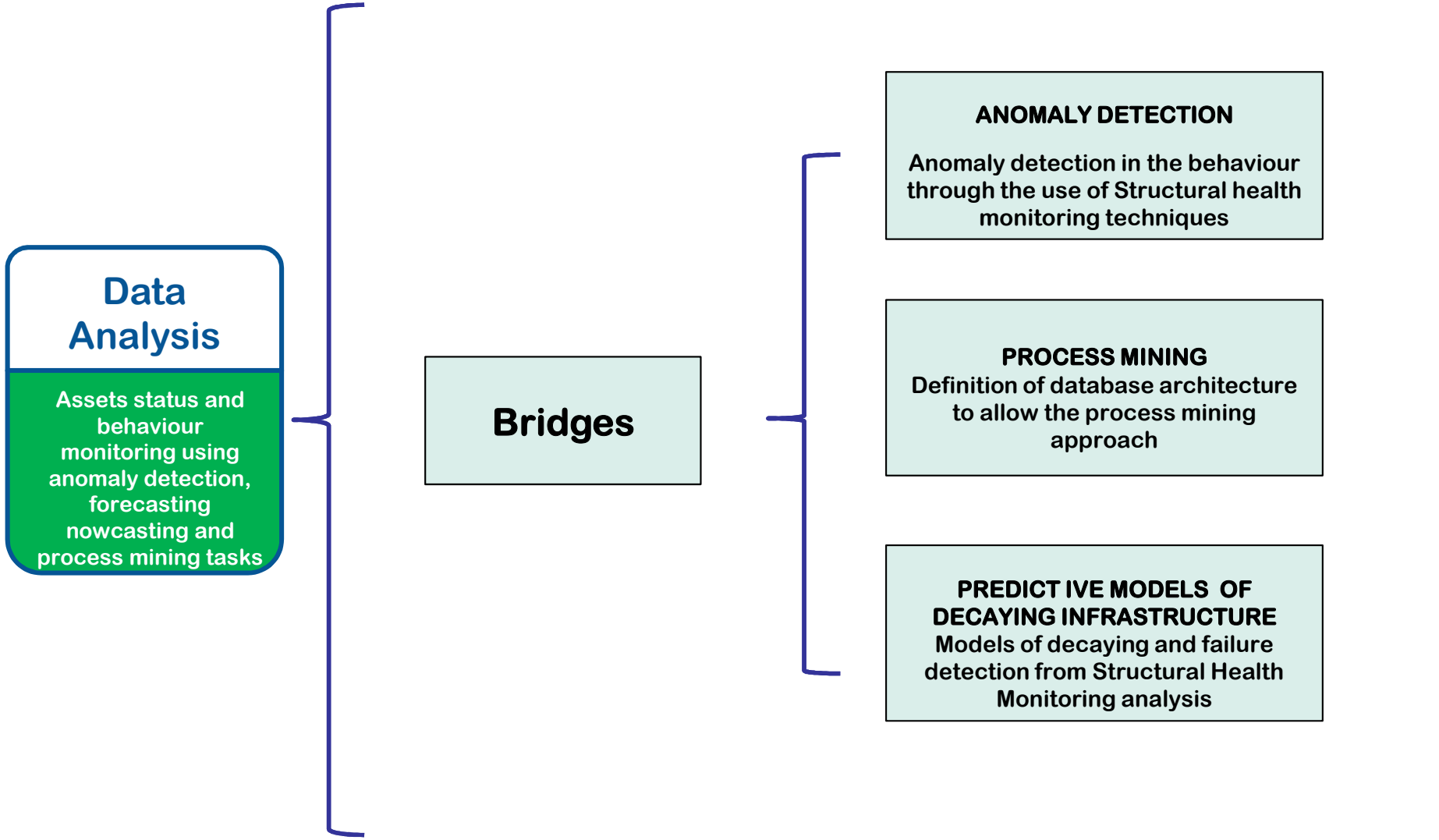
PROCESS MINING

process mining of switch maintenance for enhanced efficiency. Approach: identify available and missing information on the maintenance process to create complete event logs exploitable for process mining. approaches.

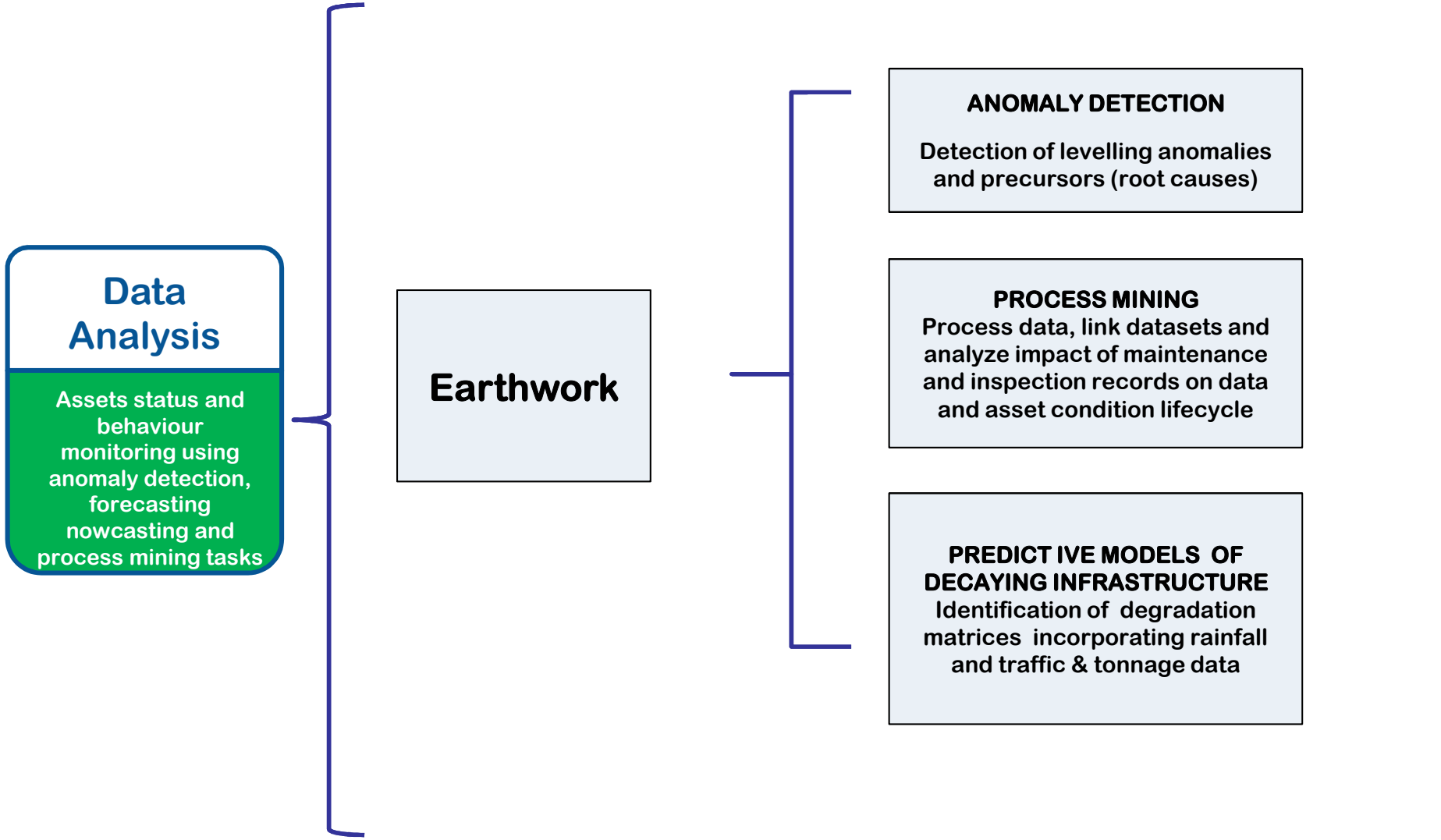
PREDICT IVE MODELS OF DECAYING INFRASTRUCTURE

Predictive maintenance on track circuits

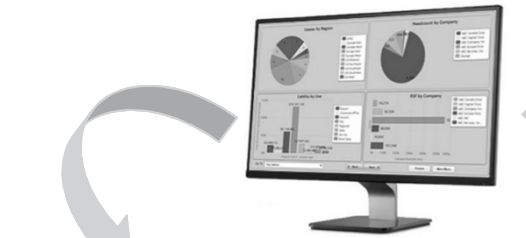
Data Analysis



Data Analysis



Final Process



Decision Making

Predictive, risk- and condition- based, reliability centered, integrative maintenance decision support

Data Analysis

Assets status and behaviour monitoring using anomaly detection, forecasting nowcasting and process mining tasks

Systems and Assets

Data Collection

Periodic/Real-time acqusition of System Data with **Standardized Format**

IAMS monitoring systems

Mr. Roald Lengu

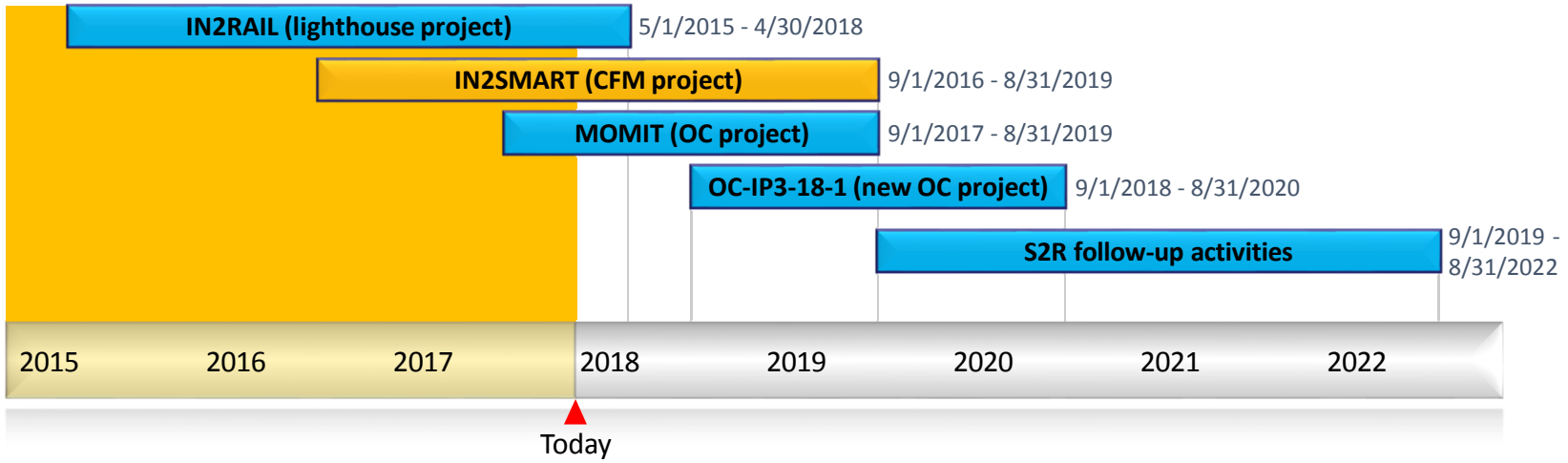
(TD3.7 leader)

Ansaldo STS

RIMMS objective from MAAP

Defining an integrated set of **cutting-edge on-board** and **wayside** asset-specific **measuring** and **monitoring** sub-systems in order to collect and deliver the status data of the railway system (infrastructure and rolling stock).

RIMMS DEVELOPMENT THROUGOUT SHIFT2RAIL PROGRAM



TD 3.7 structure

- Track and S&C Monitoring Solutions

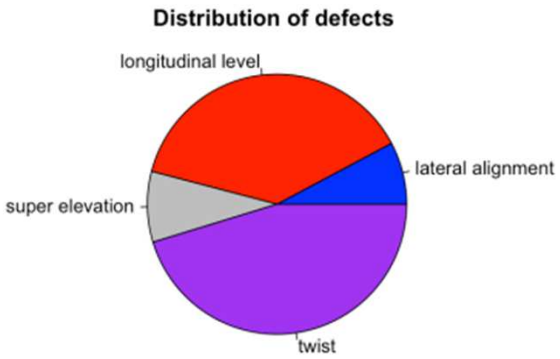
- Signalling Systems Monitoring

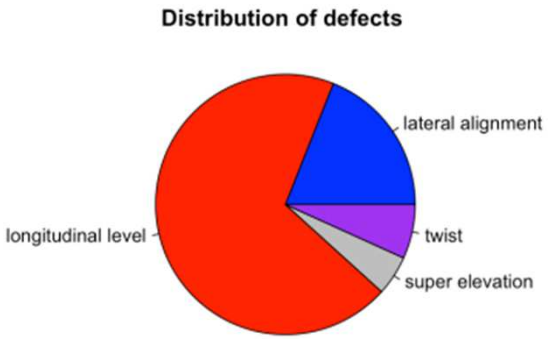
Font: Arcadis

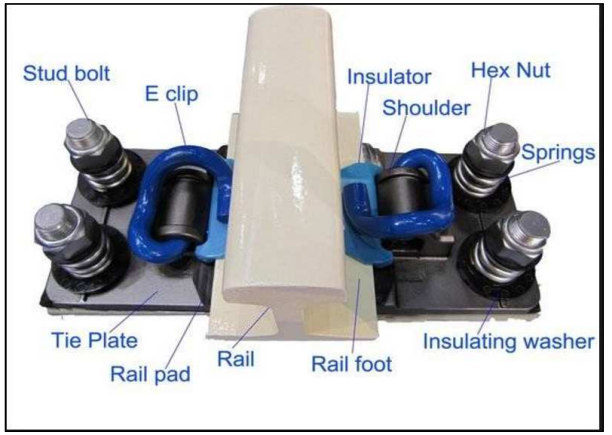
- Operations

Track and S&C Monitoring Solutions

- Track Geometry Monitoring
  - Current Objective: To develop calibrated prototypes of integrated monitoring systems for track and S&C which can be installed on inservice trains
  - S2R Projects: IN2RAIL WP5, IN2SMART WP4, Planned S2R following activities
  - Defined relevant parameters to be monitored
  - Selection of low-cost commercial components and architecture definition

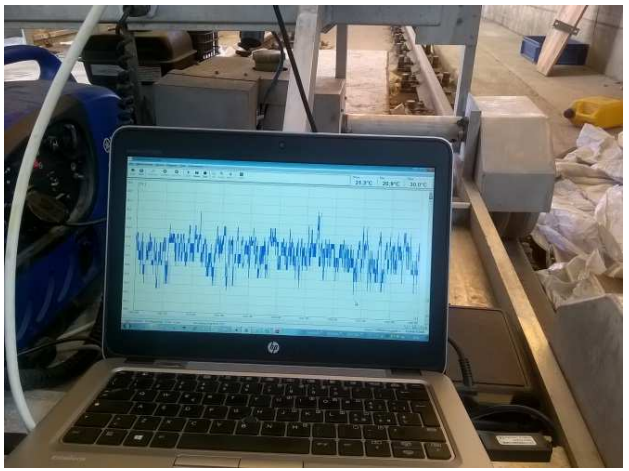






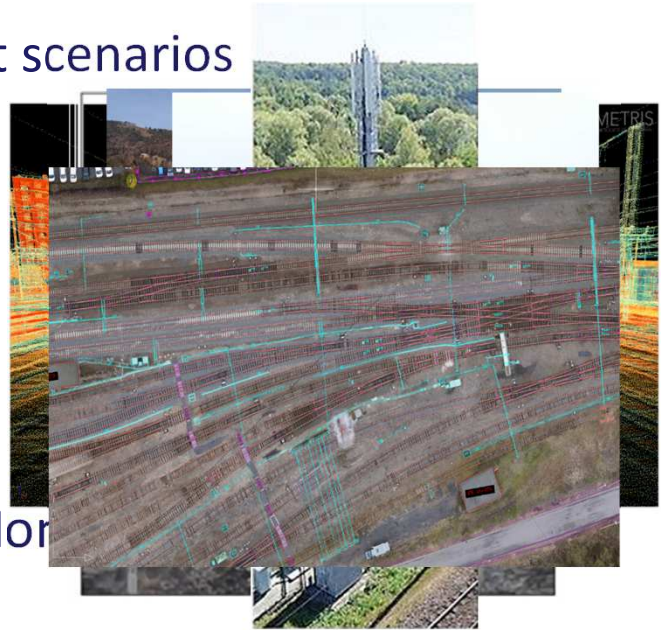
Track and S&C Monitoring Solutions

- Rail Temperature stress monitoring
  - Current Objective: The monitoring of thermal stresses in rails aims to prevent the risk of track buckling, at high temperatures and railbreaks at low temperatures.
  - S2R Projects: IN2RAIL WP5, Planned S2R following activities
  - Defined low-cost commercial components and system prototype architecture
  - Defined in field test architecture and performed tests



Track and S&C Monitoring Solutions

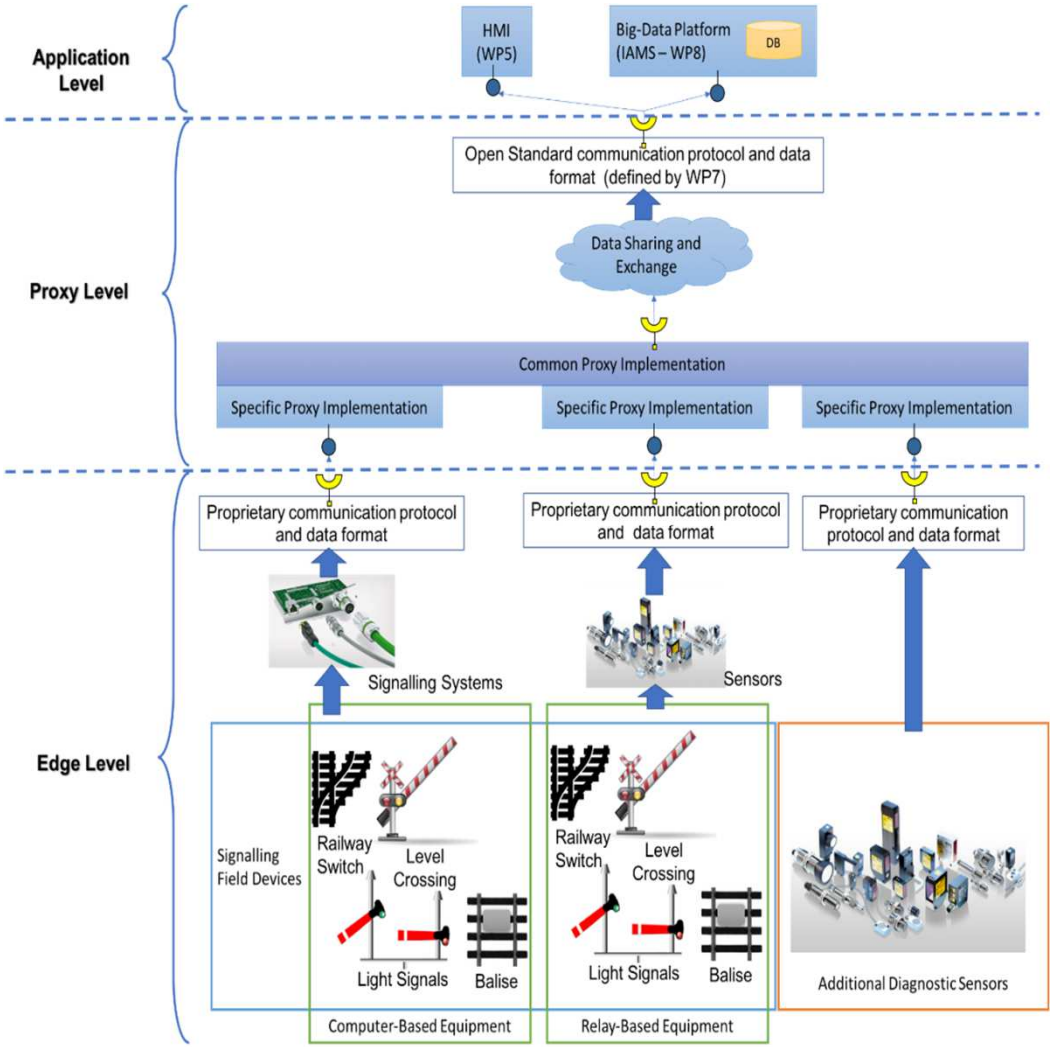
- Drone and Satellite monitoring
  - Current Objective: carry out a feasibility study for autonomous measuring systems based on UAV's, satellites or unmanned/robot vehicles to monitor railway infrastructure assets and the environmental condition near them.
  - S2R Projects: IN2SMART, MOMIT OC, Planned S2R following activities
  - Defined systems, use cases and test scenarios
    - Track inspection
    - Civil engineering
    - Natural hazards
    - Signalling and telecommunication
    - Power supply systems
    - Asset monitoring
  - Definition of collaboration with Mor



Signalling Systems Monitoring

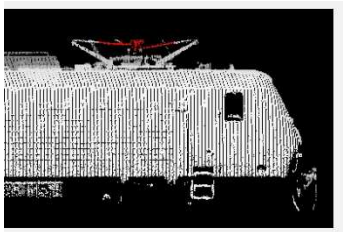
- Current Objective: Develop a framework toolset to be used by any party to develop a converter proxy for diagnostic data into a defined format
  - Data collection by either embedded or remote systems
  - Reduce the risk of violating the safety case
  - S2R Projects: IN2SMART, OC-IP3-18-1, Planned S2R following activities
- 2 main scenarios:
  - Existing Signalling and Telecomm
  - New Signalling and Telecomm
- Defined requirements and proxy architecture
- Hazard analysis ongoing

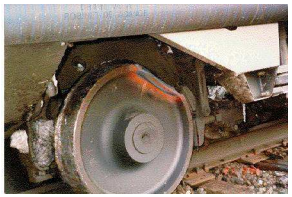
Signalling Systems Monitoring

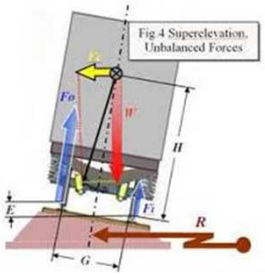


Operations

- Current Objective: Achieve an integrated solution for monitoring the trains and their impact on the infrastructure which must be standardized, easy to be installed, low cost and compliant with the maintenance process proposed by the S2R project.
    - S2R Projects: IN2SMART, OC-IP3-18-1, Planned S2R following activities
- Train impact on infrastructure



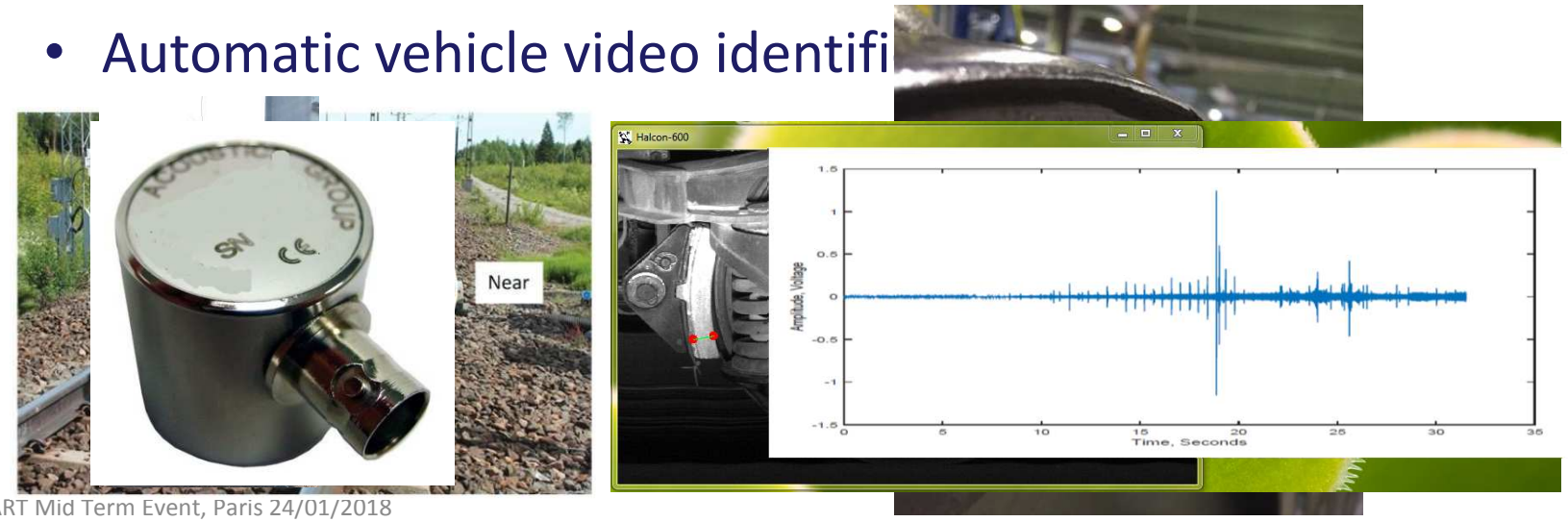




Operations

Started developments on relevant use cases

- Video monitoring for wayside vehicles defects detection
- Track based video monitoring for wheel defects, profiles and equivalent conicity
- Acoustic Emission sensors for wheel flat detection
- MEM technology and Brillouin scattering for static and dynamic wheel-rail contact force assessment
- Automatic vehicle video identifi



IAMS asset management procedures

Mr. Henk Samson

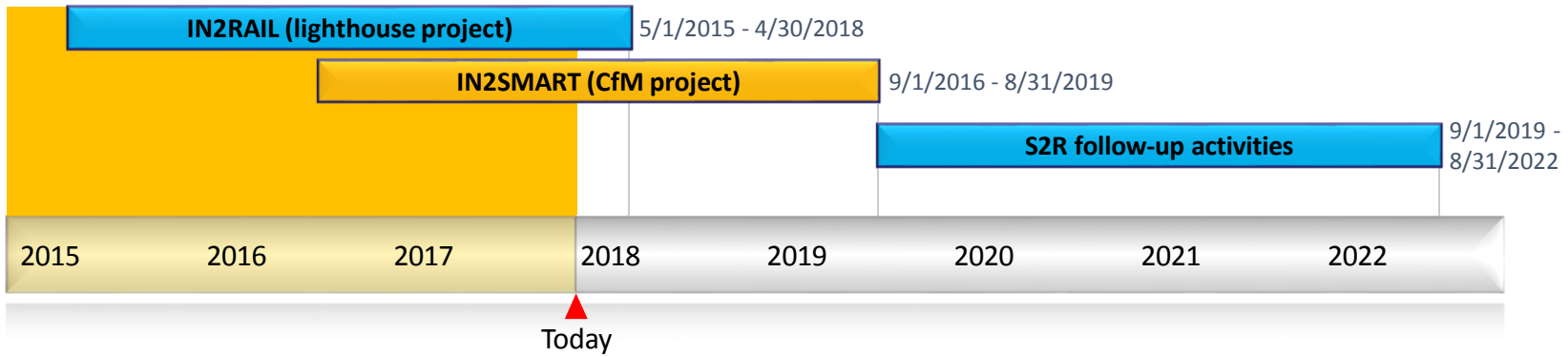
(TD3.8 leader)

Strukton Rail

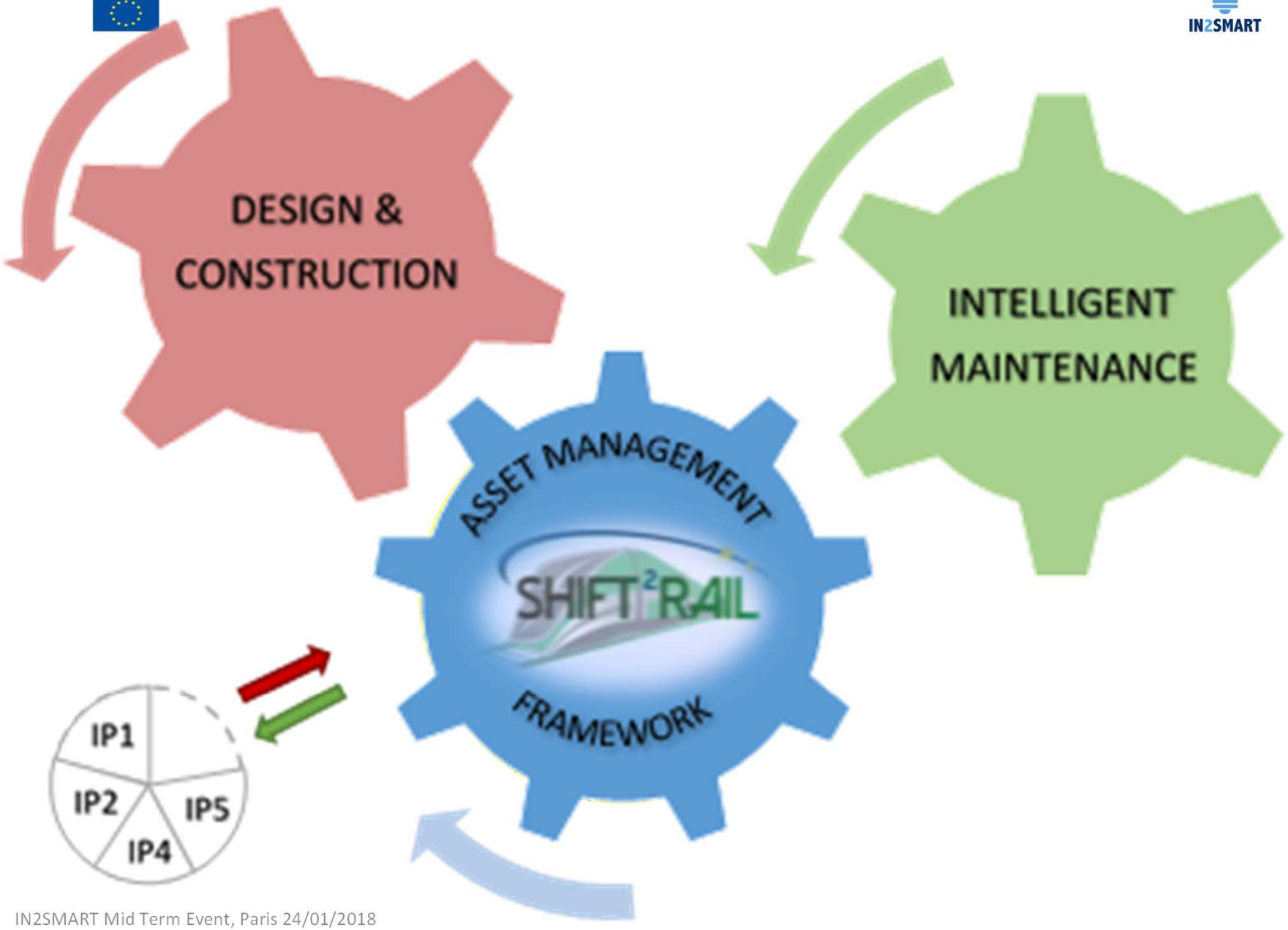
IAMS objective from MAAP

Defining concepts for maintenance planning and decision support; implementation of risk- and condition-based maintenance strategies; decision support tools and system architectures for maintenance management, resource planning and deployment (including skilled staff, plant and possessions) and for LCC based maintenance or system improvement including state, age of asset and root causes for maintenance – supported by DRIMS. A second stream of technical objectives is related to new and advanced working methods, tools and equipment and logistics solutions, supporting the LEAN execution of intelligent maintenance processes.

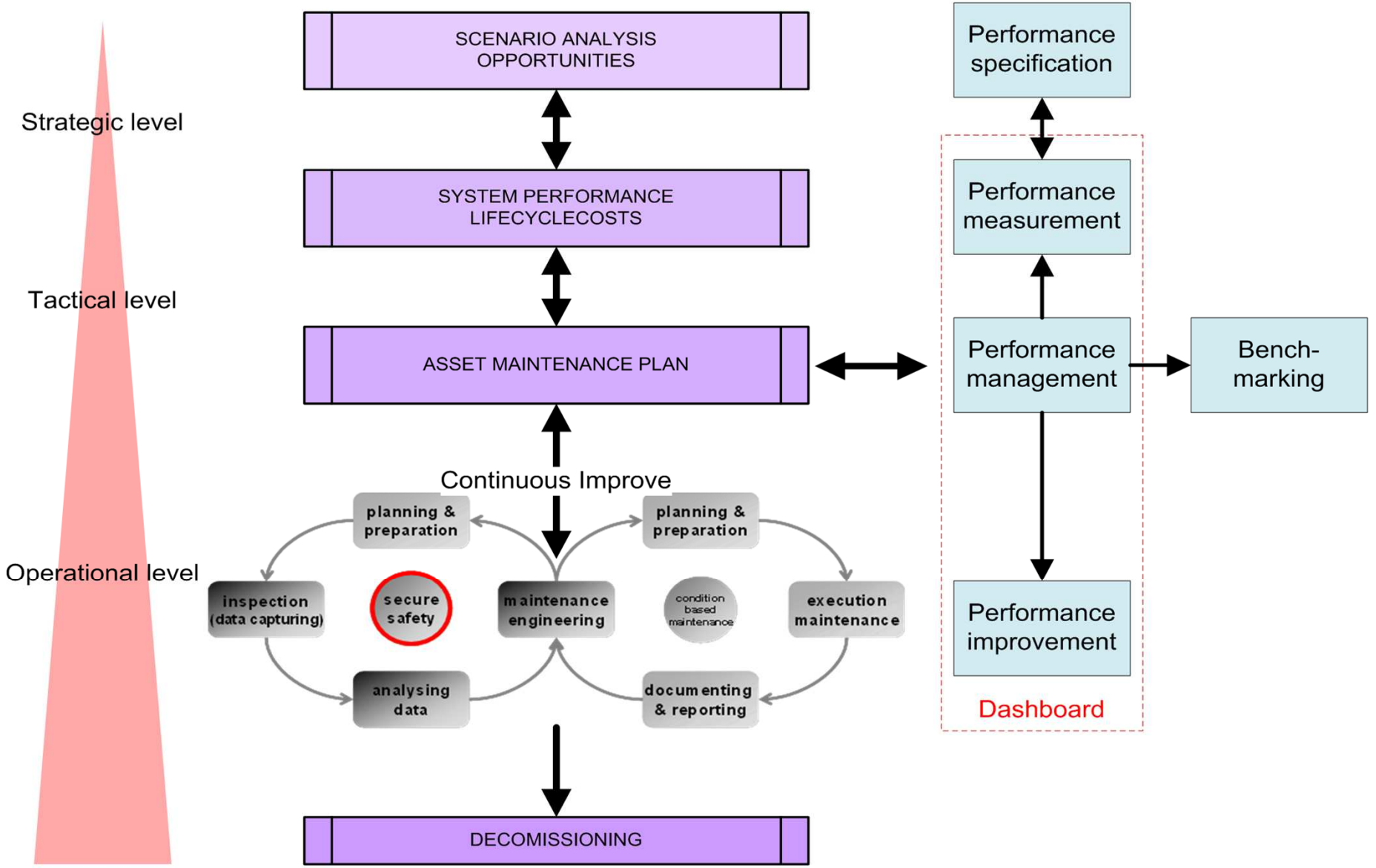
IAMS DEVELOPMENT THROUGOUT SHIFT2RAIL PROGRAM



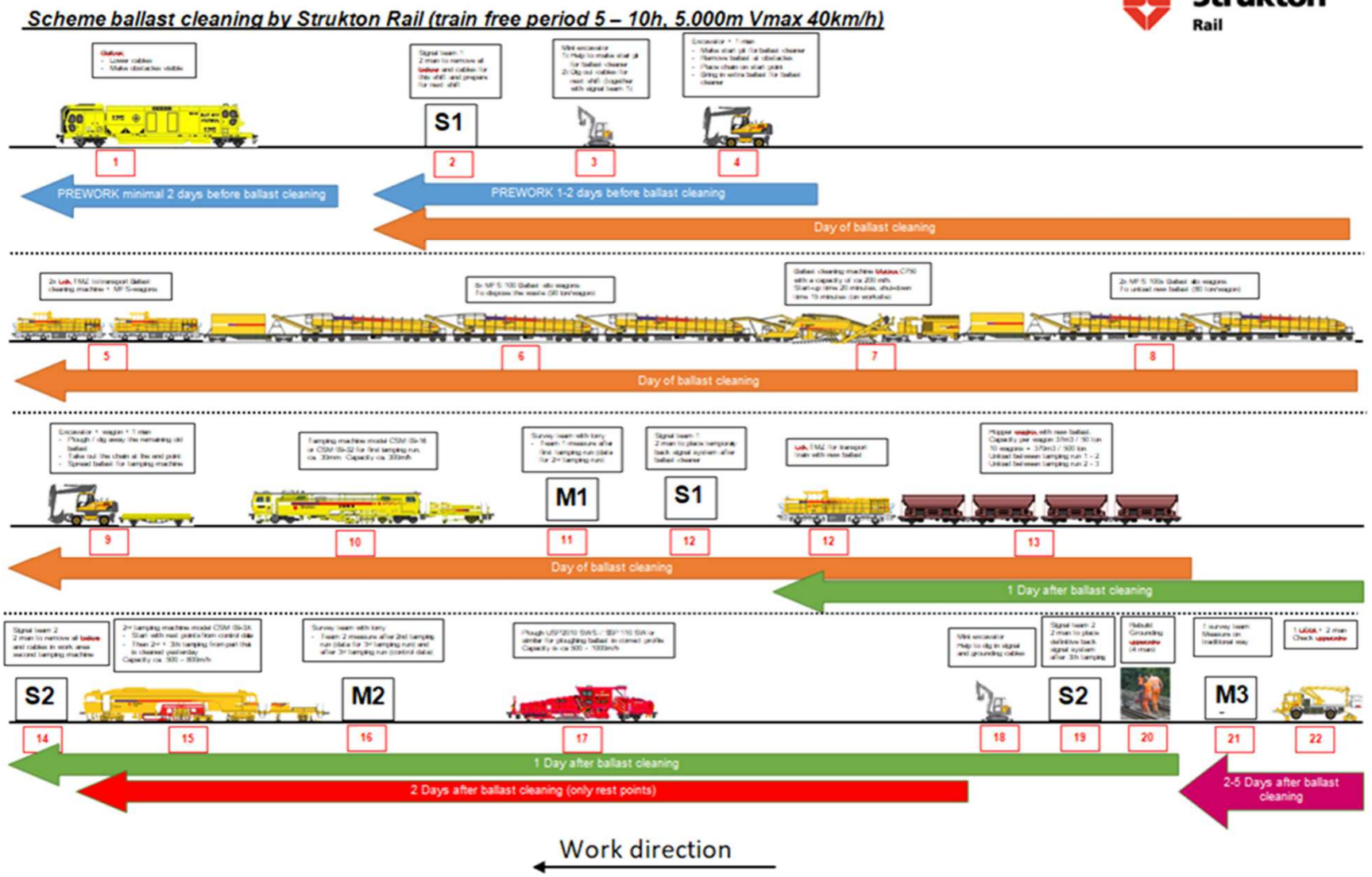
Context


DESIGN &
CONSTRUCTION
INTELLIGENT
MAINTENANCE
ASSET MANAGEMENT
SHIFT²RAIL
FRAMEWORK
IP1
IP2
IP5
IP4

Supply chain: different actors

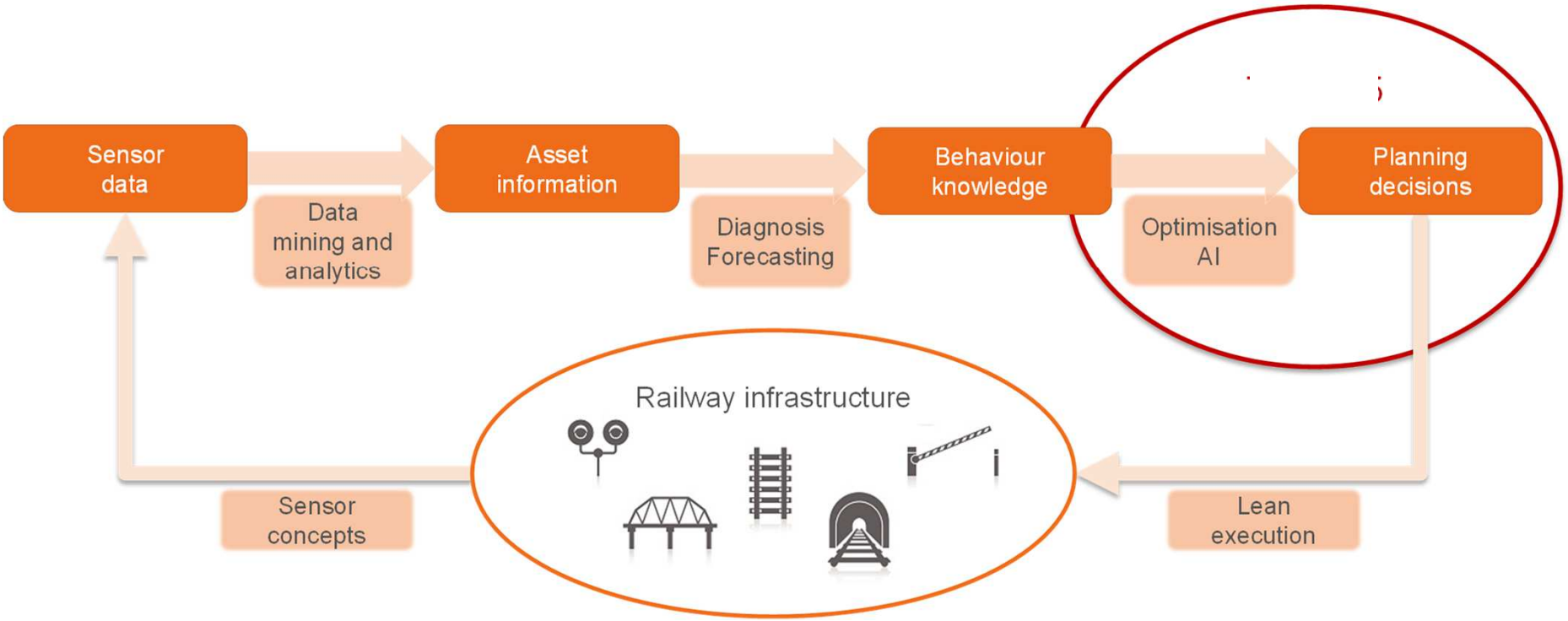


Logistic challenge rail planning

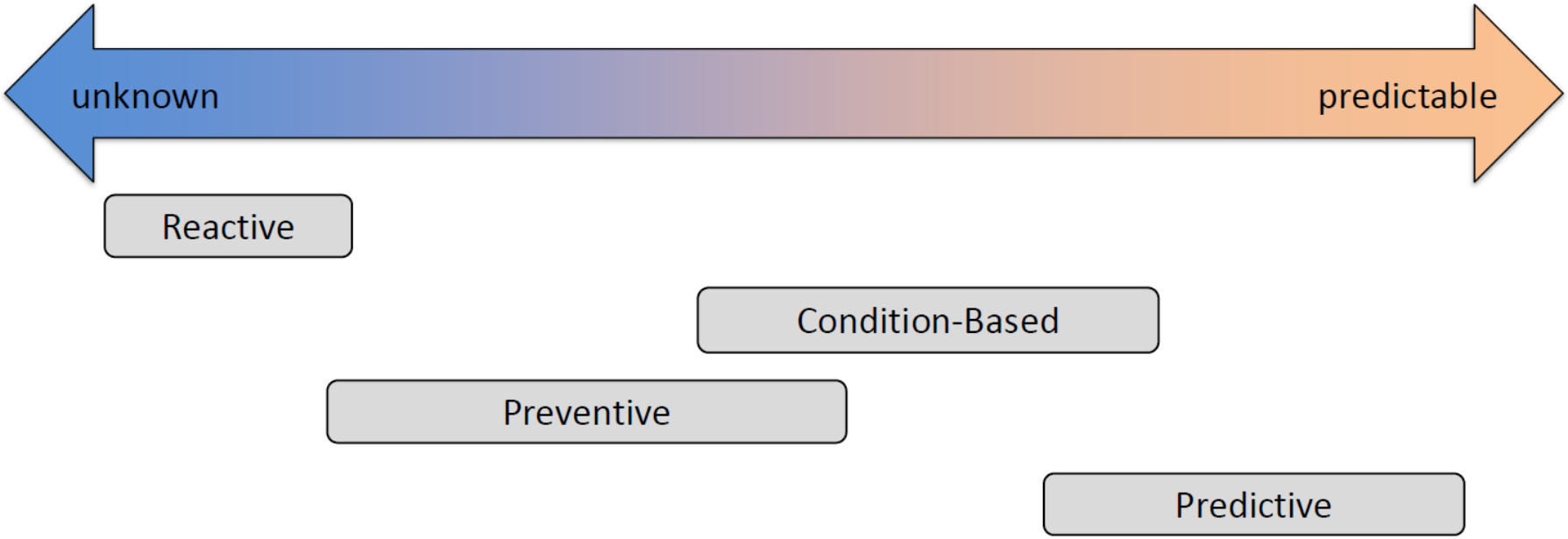


Logistic challenge rail planning

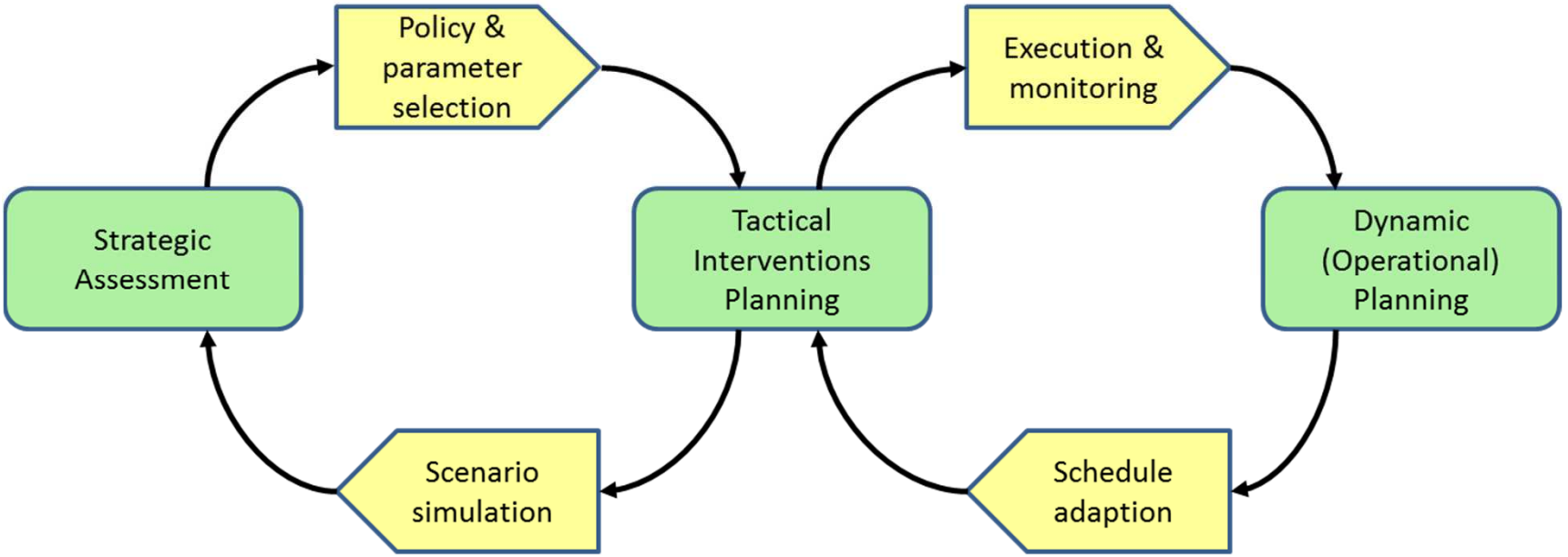
Data-driven asset management



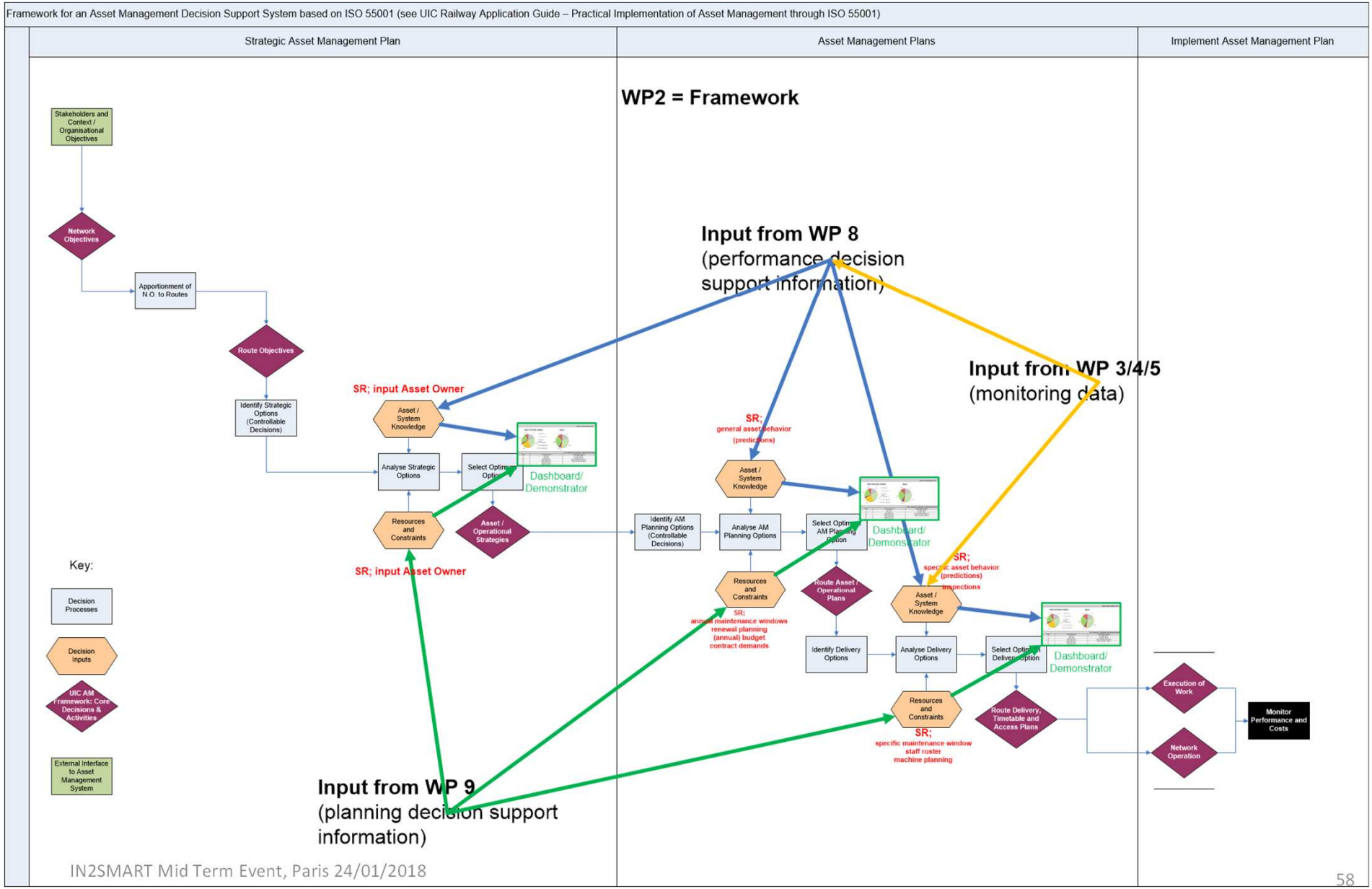
Maintenance Triggers



Nested and Adaptive Approach



Link between WPs



IAMS story boards and use cases

Mr. Benoit Guyot

(SNCF storyboard referent)

SNCF

SNCF storyboard

Optimising walking inspections
A step forward to Predictive Maintenance

Current walking inspections

Objectives

- Major contribution to Risks management, by **detecting anomalies in field**

- **Checking integrity** of the assets
  - Track, S&C, Catenary, Bridges & Tunnels, Level crossings...
  - All the assets visually accessible from the track are concerned

and their surroundings (inc. Vegetation)

- Outputs :
  - **Alarms** with direct operating impact
  - Reports in order to **provide assets status feedback and knowledge**
  - **Next Maintenance interventions scheduling**

Context

- **Huge consumption of work forces**
  - Significant OPEX , depending on traffic density on the lines

- Huge **safety issues** induced by the presence of workers in Track

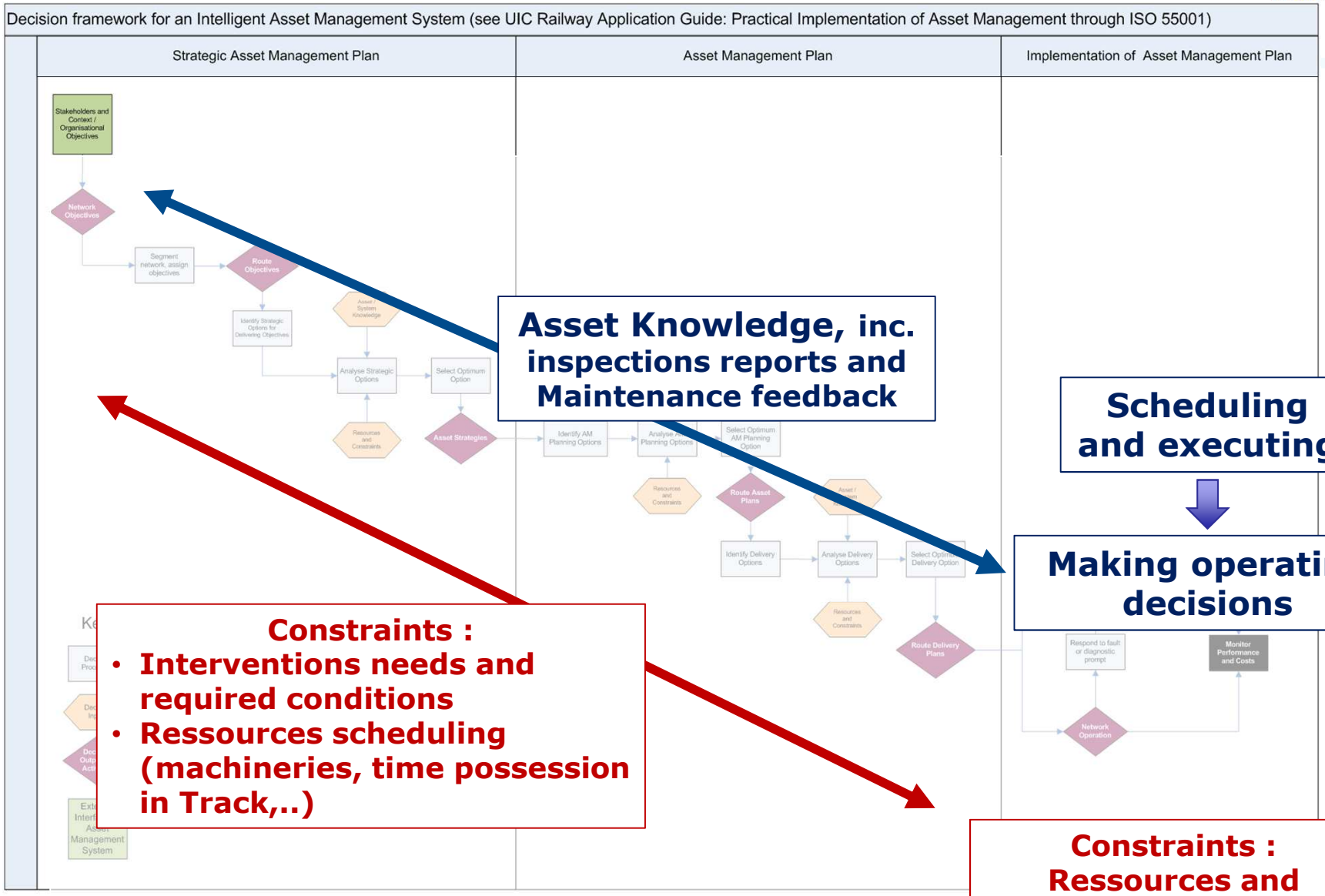
- Strong requirements concerning the **ability and skills of the maintenance operators** to detect anomalies (and faults)
  - Makes difficult to replace by technical / technological means

Current practices – SNCF

Mainly performed by maintenance operators

But integration of new monitoring systems already began

Within AM framework



Storyboard SNCF – In2SMART
Objectives and issues

3 main objectives

- Reducing **Maintenance costs and related capacity needs**
- **Increasing data gathered** during inspection based on new, reliable and efficient technologies
- Increasing the **safety of the maintenance operators**, by reducing their presence on track.

Key issues for In²Smart

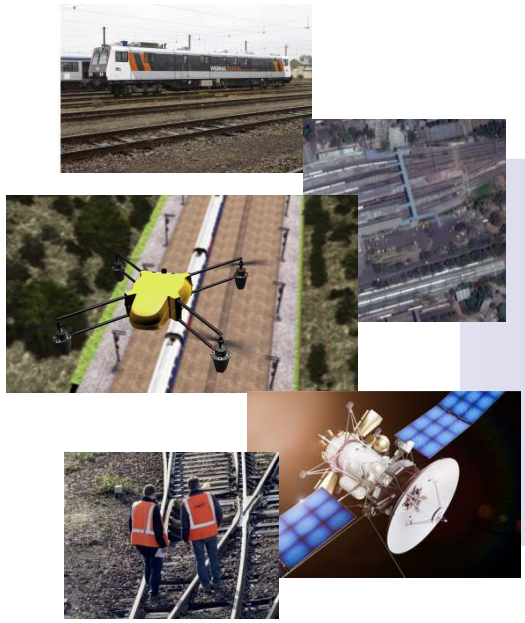
- Deeper insights concerning the **business model of new Data gathering devices** (Drones, SAT, ...)
  - Whether or not using them with an acceptable confidence
- **Intensive use of Data** (existing/new) **and Data-driven approaches**
- Testing and validating **innovative Decision-making support**

1 main constraint

- **Expected risks and safety performances** : New predictive maintenance process **at least equivalent to the current Inspection process**

Main links with In2SMART

Data gathering and storage



Multiple sources integration and mergeing

From Data to Information for Maintenance

1. Real-time **anomaly detection**, flaging possible causes
2. **Real-time whole risks assessment** (agregated from different types of assets)
3. **Prediction** of future assets status, and whole risks assessment

Data and Image processing, modelling for Maintenance

Support Decision making

1. **Assets priorization** based on **RAMS**, **risks** and **LCC** assessment and assets **criticality**
2. **Planning** use cases
   - **Multiple objectives and constraints**
   - Technical disciplines and ressources (drones, operators …)
   - Access conditions

Maintenance planning support and optimisation

Main links with TDs

RIMMS

Monitoring and Data gathering

Improving existing devices and/or development of new monitoring (autonomous) contributing to the objectives

Priorities : Track, S&C, Catenary and surroundings

DRIMS

From Data to Information & Knowledge

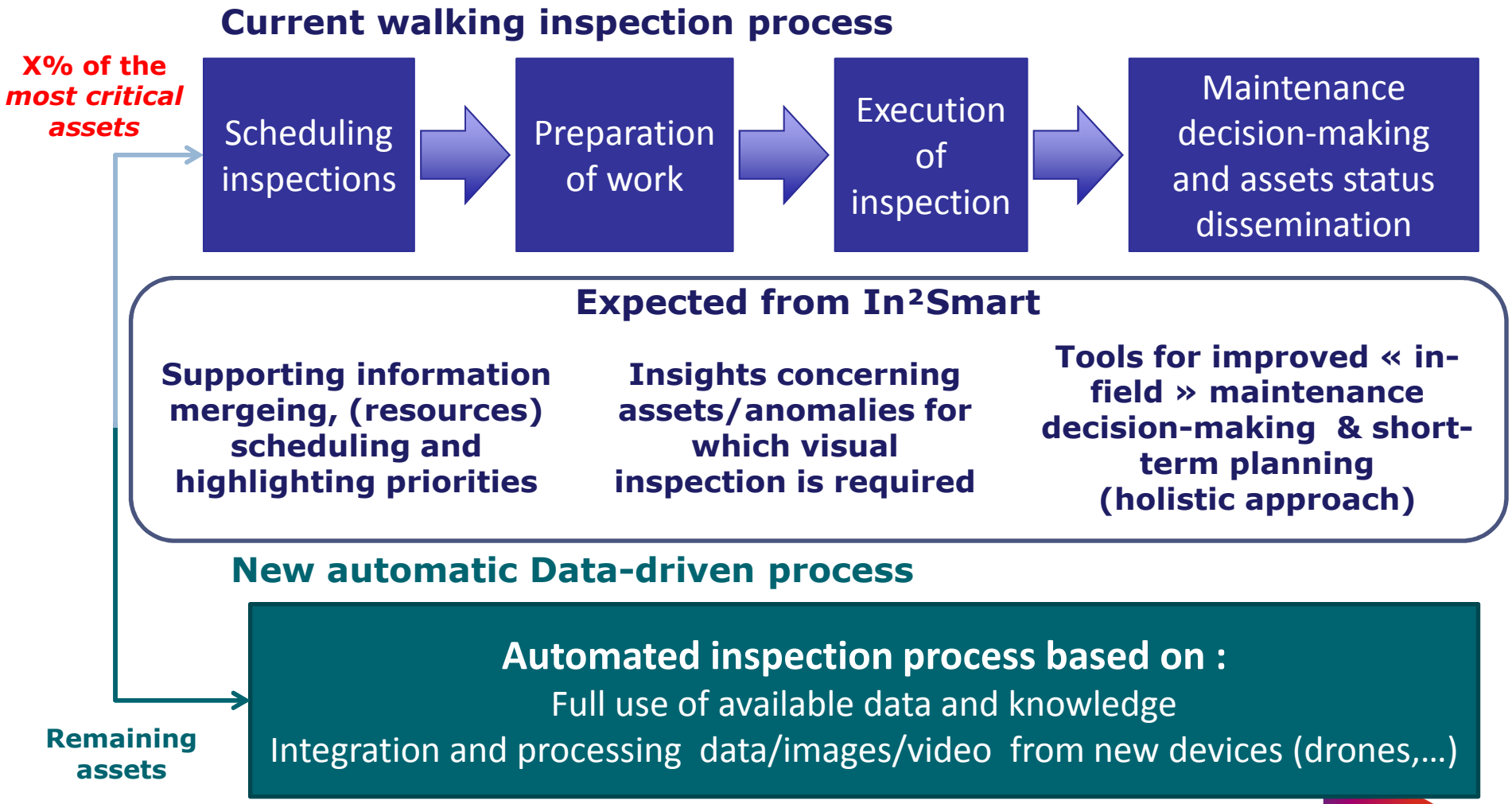
1. Open format definition in a multi-sources case
2. Development of algorithms
3. Tests Analytics tools and new approaches
4. Data Visualization for maintenance operators
   In-lab testing in operational conditions

IAMS

Support Decision making

1. Extending CRMP principles to wallking inspections
2. Implementing innovative approaches and concepts for supporting decision making
3. Testing and validating tools and methods in real cases

Storyboard objectives
Future inspection process



SNCF Use cases

Four specific use cases : sections of french rail routes

#	Network type	Routes
1	**High speed**	Paris-Lille
2	**Mass Transit**	Paris-Creil
3	**Regular line**	Troyes-Belfort
4	**Freight line**	Mohon-Thionville

Only chosen subsections will be included in use cases

SNCF Use cases

Four specific use cases : sections of french rail routes

Network type	Routes *(selected sections)*	Selected sections from these routes				
		Track length (km)	S&C	Tunnels / bridges	Catenaries (% line)	Max speed
High speed	Paris-Lille	120	37	1 / 46	100%	300
Mass Transit	Paris-Creil	72	233	0 / 61	100%	160
Regular line	Troyes-Belfort	106	75	1 / 43	100%	160
Freight line	Mohon-Thionville	84	37	3 / 37	100%	120

Families of assets concerned

1. Track
2. Switch and crossing
3. Catenaries
4. Tunnels and bridges
5. Subgrade & Surroundings

Expected improvements from In²Smart

1. New data gathering devices (on-site/embeded)
2. Anomaly detection algorithms (Image processing,…)
3. Predictive modelling – degradation and anomaly/defect occurrence
4. Decision-making tools (LCC, RAMS indicators,etc.)

IAMS story boards and use cases

Mr. Andy Kirwan

(NR storyboard referent)

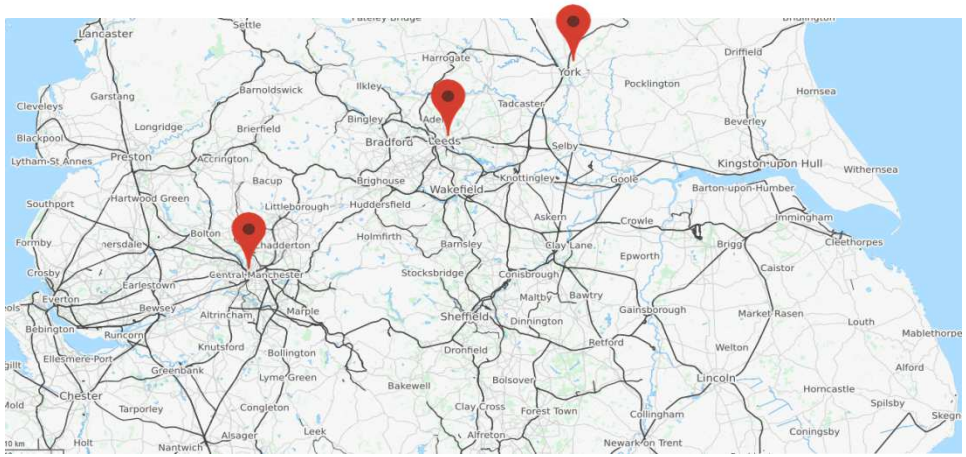
NetworkRail

Storyboard concept

- To provide IN2SMART partners with real world problems
- To make a section of railway available as a ‘living laboratory’ where solutions can be developed and evaluated
- To provide baseline of future costs and performance before implementation of solutions
- To integrate solutions to demonstrate the overall cost-benefit for the selected route

Route overview

Transpennine Route: Manchester to Leeds and York

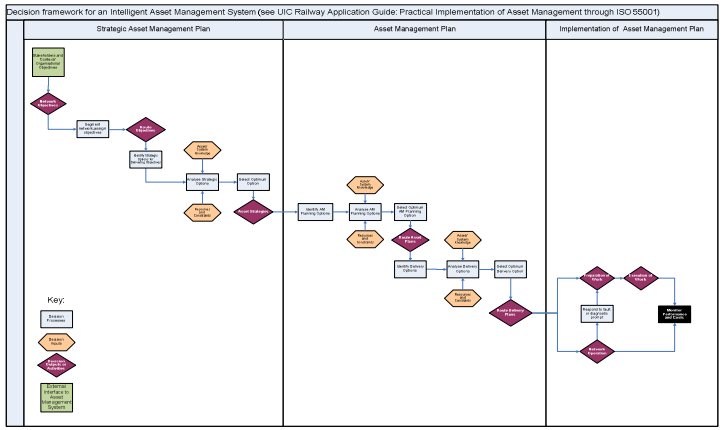


- £3bn upgrade
- Electrification
- ETCS
- Double passenger numbers by 2040
- Journey time reduction
- Completion 2022

Asset Type	Count
Track (km)	304
Switch and Crossings	236
Signal Interlocking Areas	20
Bridges	231

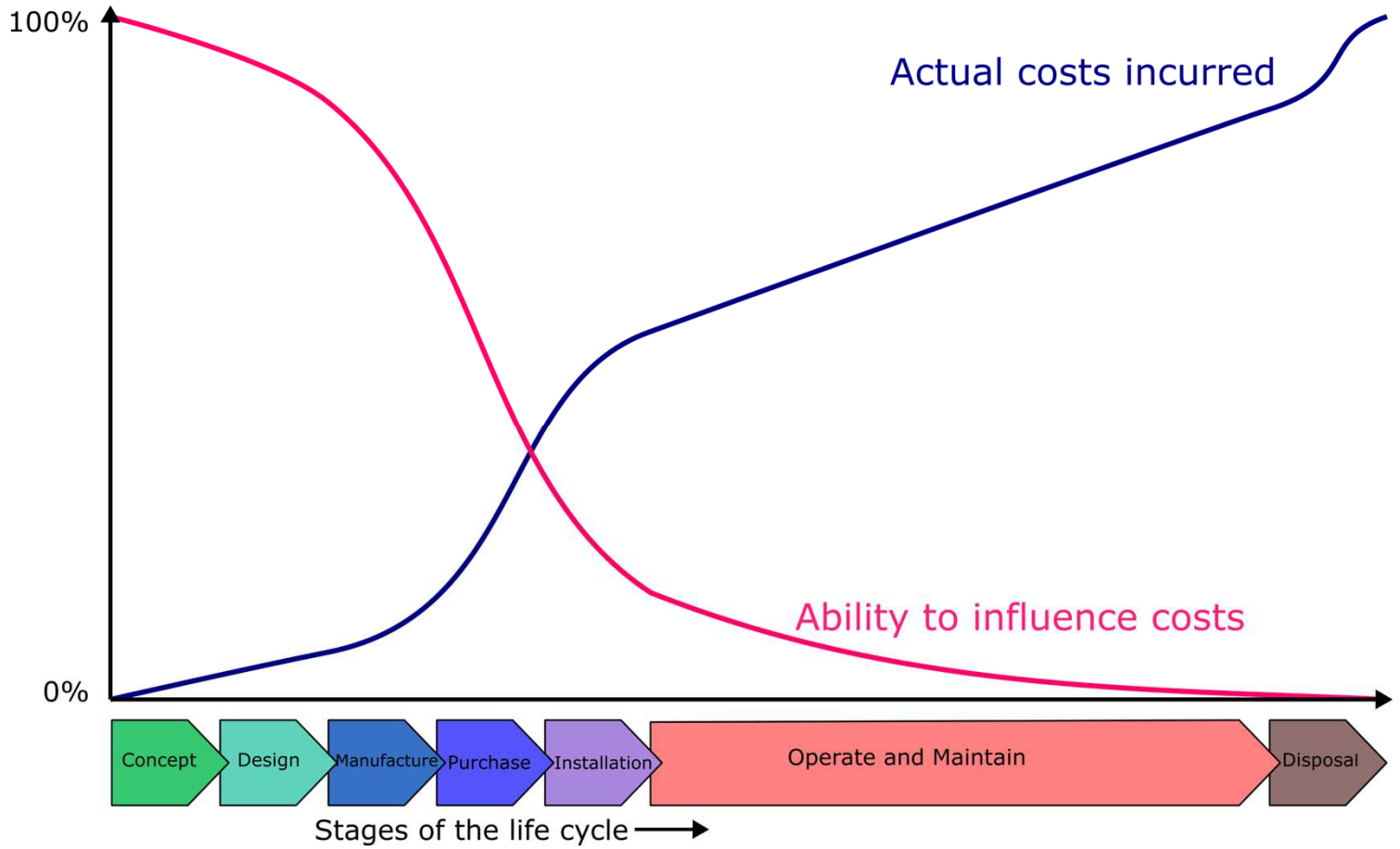
Key stages in the storyboard development

- Which components of the IAMS decision framework should the storyboard focus on?
- What is the baseline cost and performance if there are no changes to the management of the route?
- Which IN2SMART use-cases align with the storyboard?
- What other research initiatives could also be mapped to the storyboard?

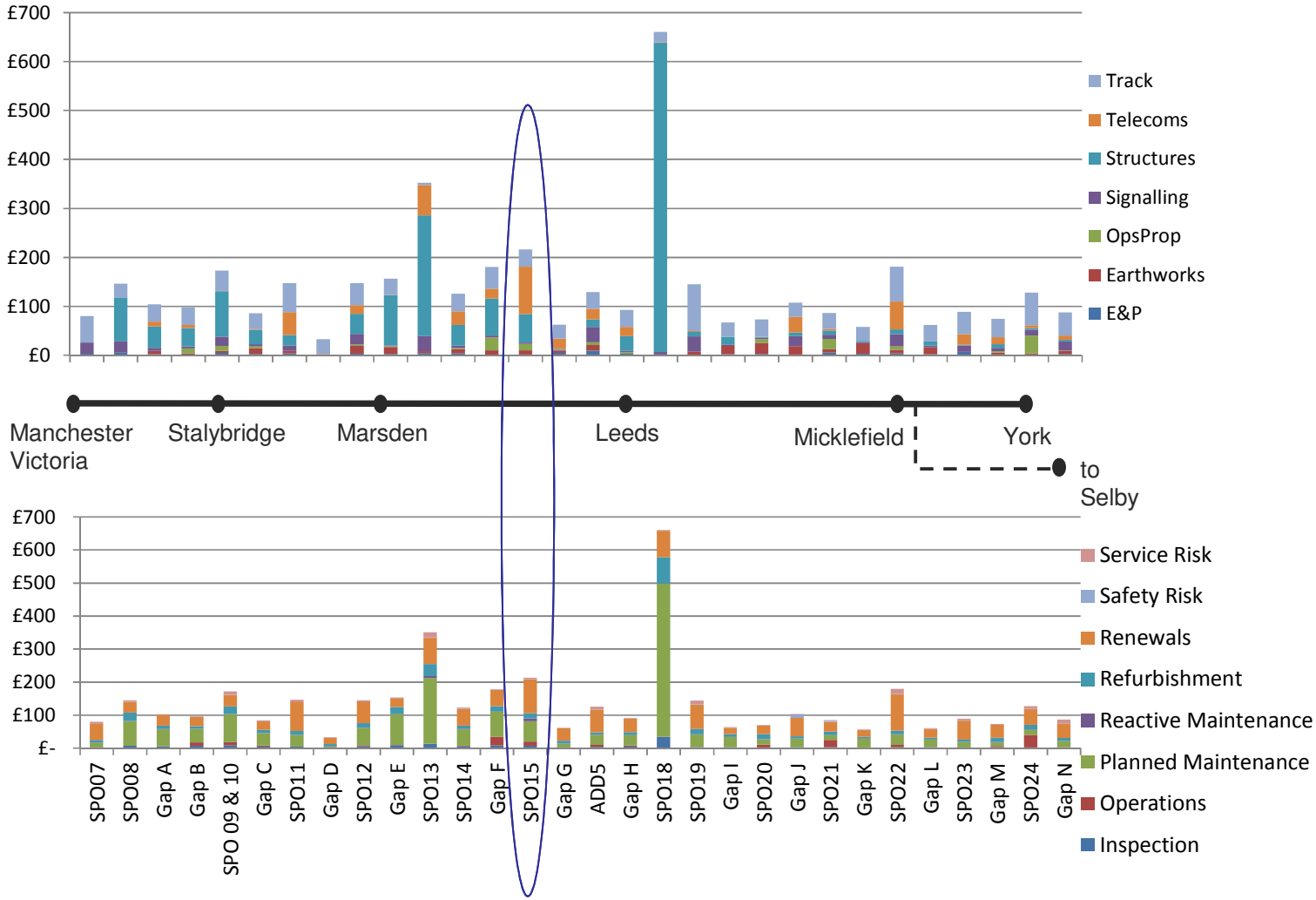


Strategy | Planning | Delivery | Operation

Initial focus on strategic decisions

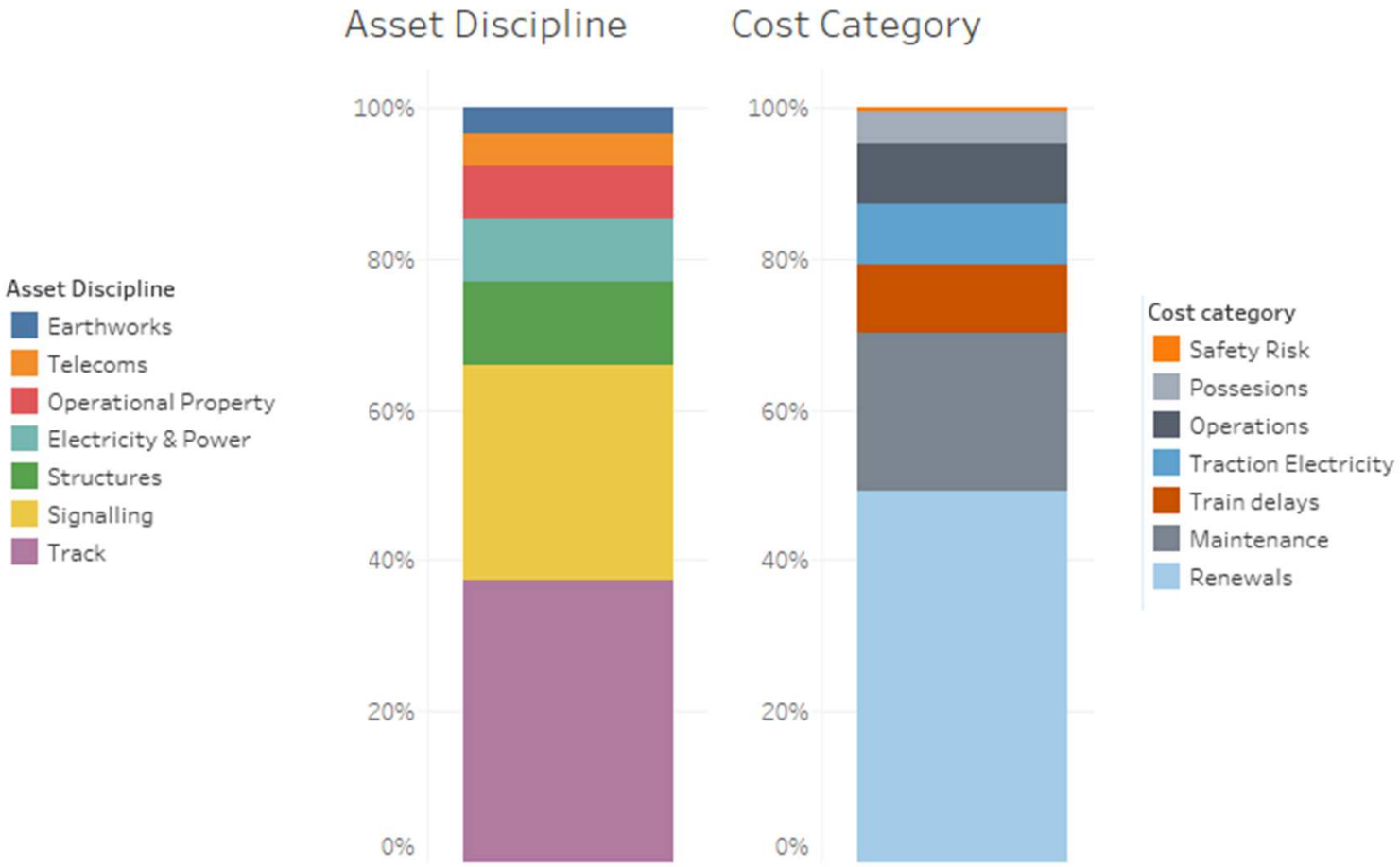


Baseline – costs and performance

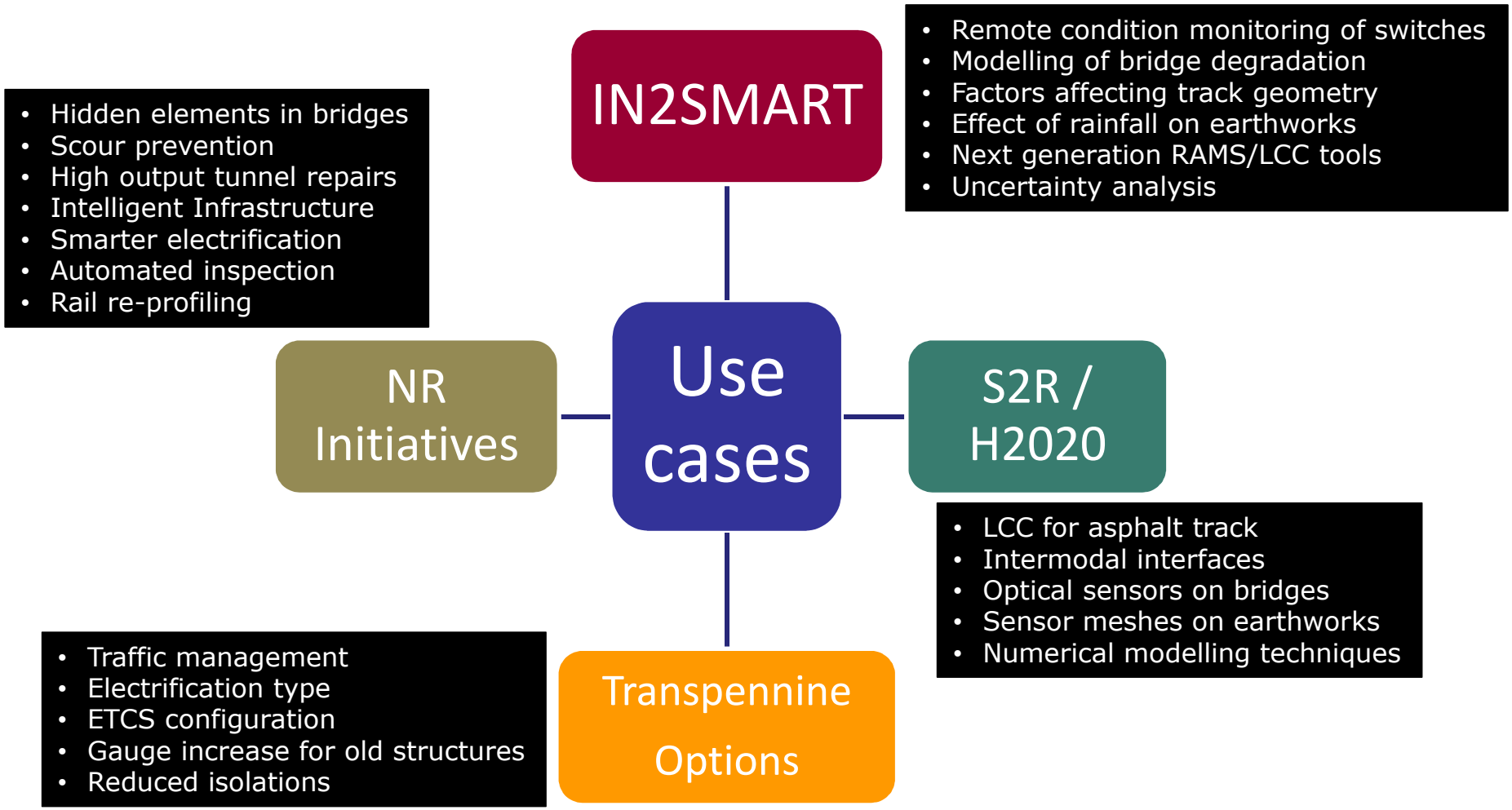


Annualised Whole Life Costs for 30 route segments (£k/track km/year)

Cost and performance breakdown



Storyboard hosting of use cases



Current status and next steps

- Good engagement established with the Transpennine Route Upgrade team
- Relevant IN2SMART use cases have been specified and linked to the storyboard
- Asset inventory (asset type, age, condition etc.) extracted from Network Rail's corporate databases and mapped to assets on Transpennine Route
- Data being provided to use case owners and progress underway in most areas

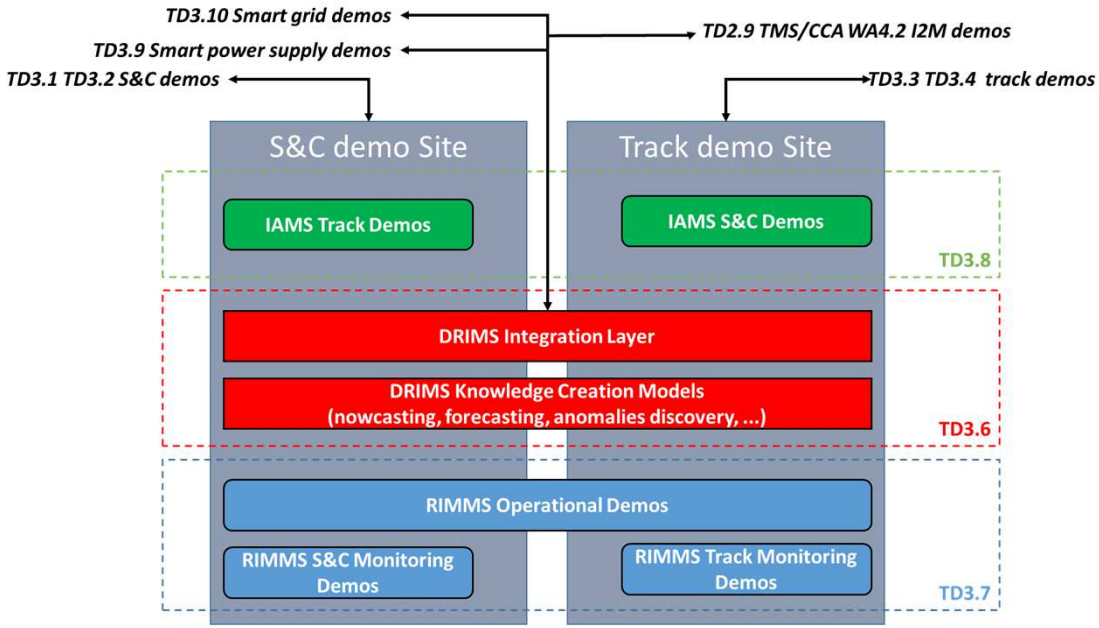
Conclusions

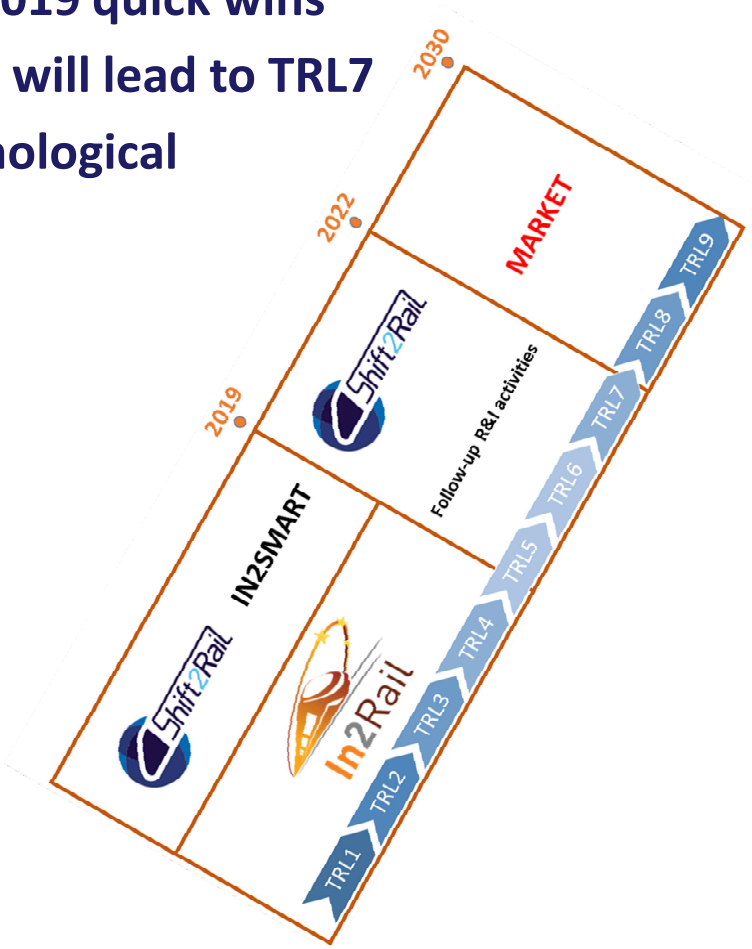
Mr. Carlo Crovetto

Ansaldo STS

IN2SMART Next steps

- Pick up all the described storyboards/use cases to a TRL4/5
- Closer connection with relevant OCs
- Provide contribution to S2R program 2018/2019 quick wins
- Pave the road for the follow up projects that will lead to TRL7
- Start the preparation of the Integrated technological Demonstrators (ITDs)





THANK YOU FOR YOUR ATTENTION

IN2SMART

Contract No. H2020 – 730539