General Project Overview

Final Project Workshop
Vienna 17.04.18 – TRA 2018 Conference

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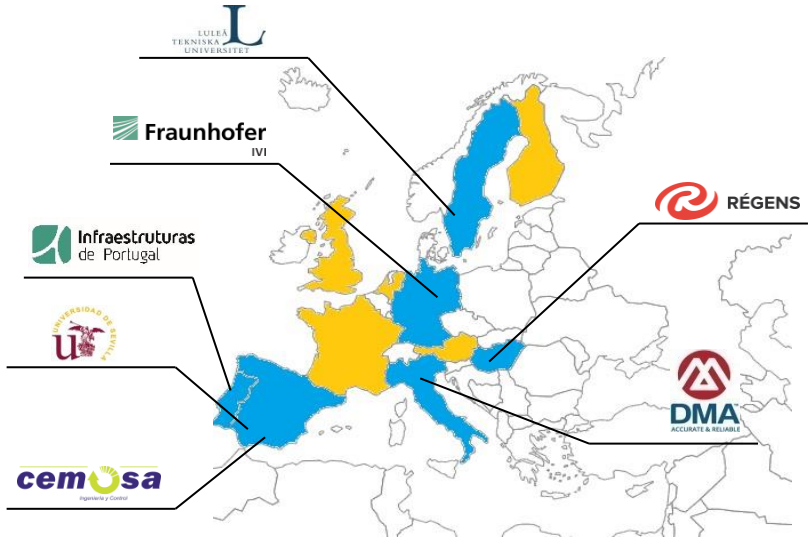
Facts & Figures

- 7 partners from 6 EU countries
  - 3 research organisations:
    Fraunhofer IVI, University of Seville,
    University of Lulea
  - 2 technology SMEs: Régens, DMA
  - 1 Industry: CEMOSA
  - 1 public body:
    Infraestruturas de Portugal



- Duration: 36 months
- Budget: 3M€
- Funded by H2020 Programme
- 2 real pilots for validation

Motivation: transport systems and social and economic development

Transport systems is core in socio economical development






Motivation: European transport networks

- Our transport networks are well developed

Size in thousands Km (2012)	EU 28	USA	Japan	China	Russia
Road Network (paved)	5,000	4,258	983	3,610	1038
Motorway network	73.2	92	8.1	96.2	50.9
Rail network	2,153	205.5	20.1	97.6	85.6

Source: ERF Statistics Year Book 2016

- but our **transport demand is already higher than our capacity** → **Congestion** problems (high economic, social, environmental costs)
- and **will keep on increasing** as so requires our 'growing' (hopefully) economies

Motivation: European transport networks

The problem: Our modern societies demand **growing transport capacity**

- But…**budget** and land restriction
- Besides…as our transport network is reaching its limit capacity, **maintenance need increases** while the **time slots** for such maintenance interventions **decrease**

The Challenge

Increase transport capacity at reduced budget and land availablity

Optimise the performance of existing infrastructure **to enhance its capacity** to meet society needs

Fewer, faster and better planned interventions

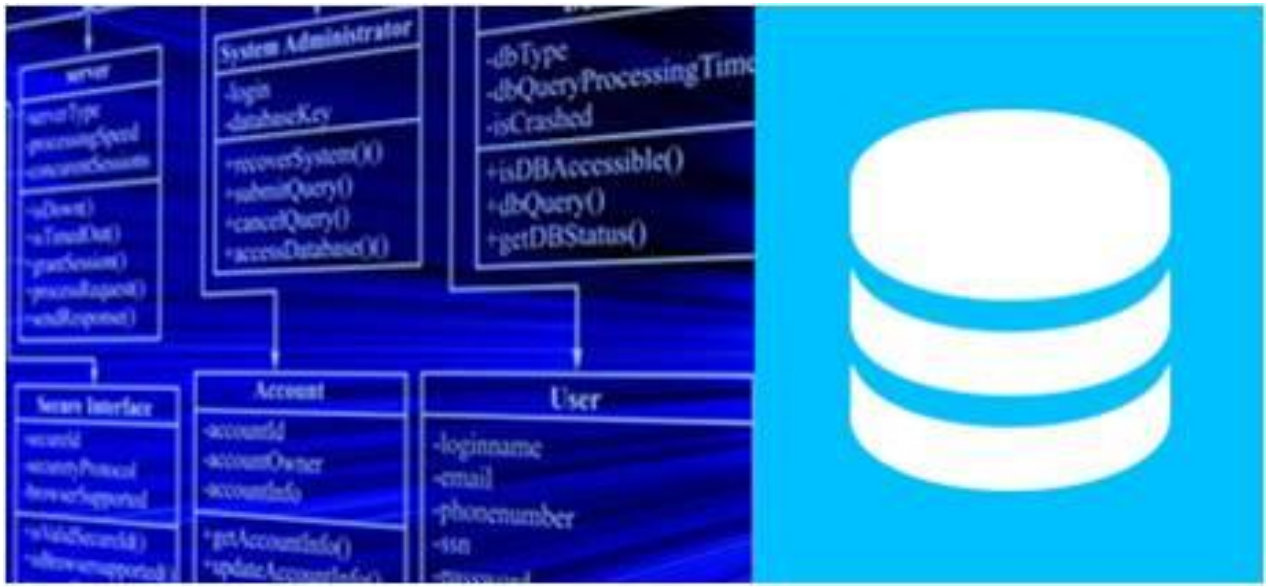
Target

STARTING POINT:

- ✓ Avalilable information on historical **infrastructure condition and maintenance** interventions

STATE OF ART

- Right now the main issue is NOT data availability, but the creation of a system, as well as an efficient database, good enough to obtain the maximum from such information, starting from a consistent data repository, available for data consumers in a cloud computing environment.



STATE OF ART

- As said, nowdays data availability is not an issue, that's because the use of actual measurement systems makes possible the collection of huge amount of data (we are talking about TBs) in every measurement session.
- The open question is how to take advantage from them, integrating all information in order to enhance the quality of interventions carried out on infrastructures.

DATA FARM

- This is possible starting with the creation of an innovative Data Farm, able to store all data coming from the physical infrastructures (even big dimensions ones) in an organised structure that makes them easily retrievable.

Target

STARTING POINT:

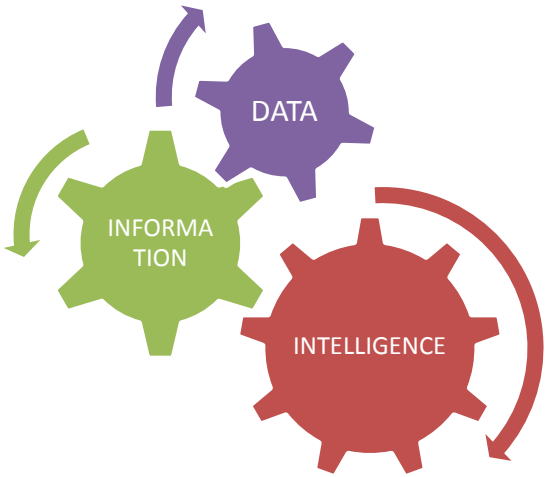
- ✓ Avalilable information on historical **infrastructure condition and maintenance** interventions

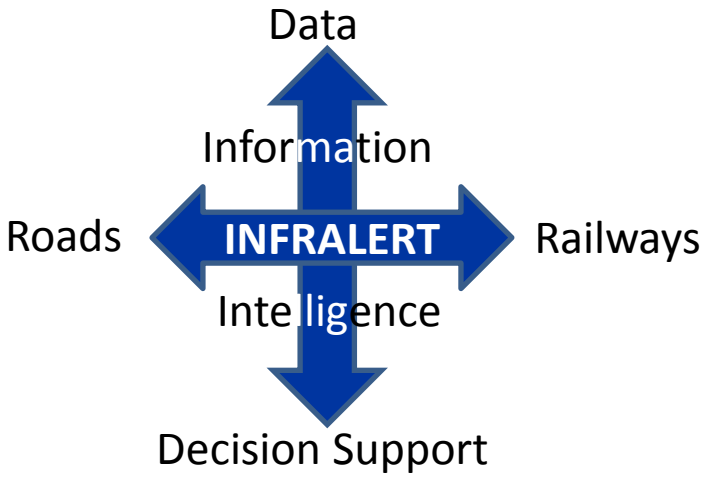
MAIN GOAL

- ✓ To develop and **expert based information system** to support and automate infrastructure management
- ✓ From **measurements to maintenance**
- ✓ Suitable for linear infrastructure and applied in particular to **roads and railways**

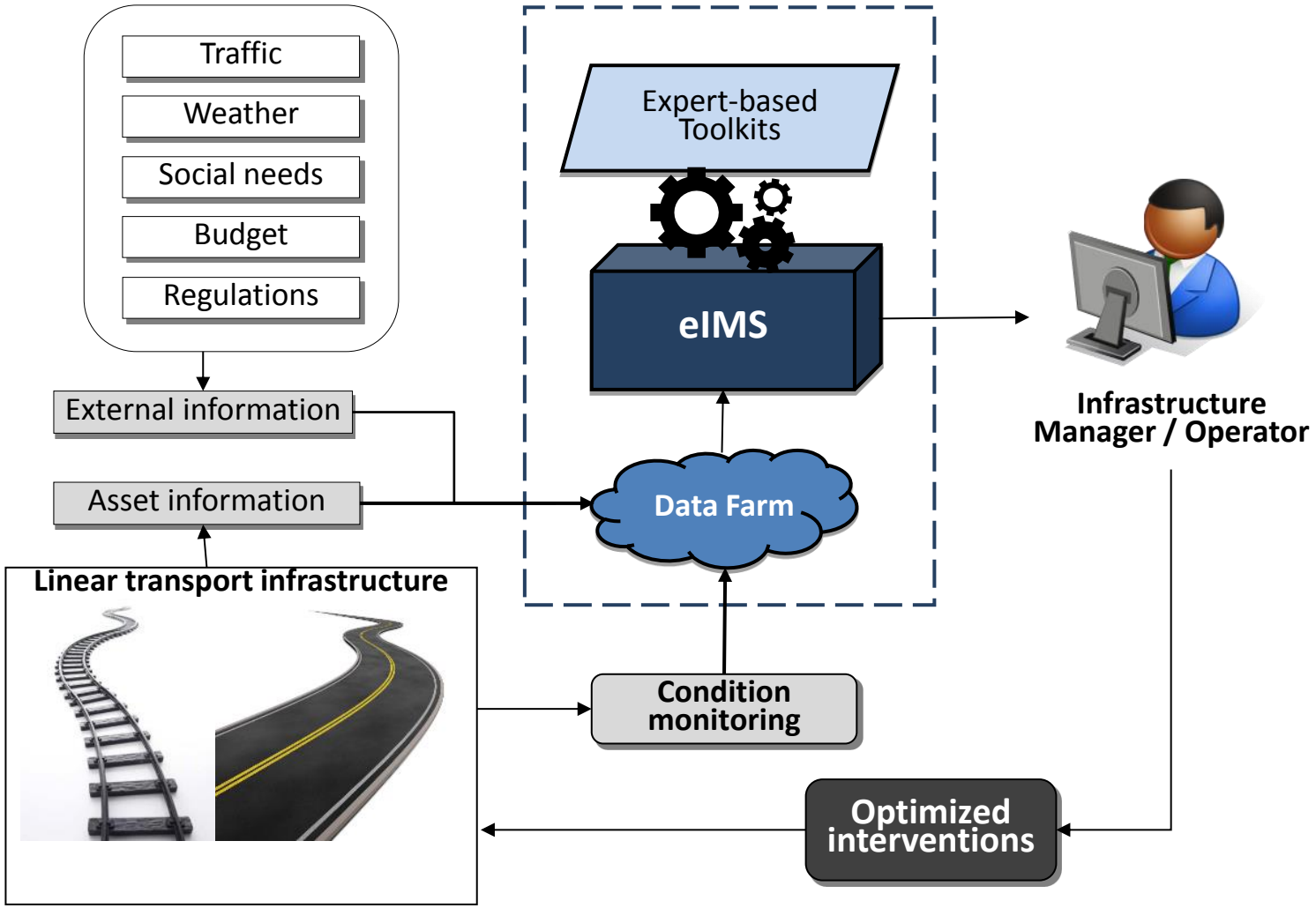
Major Challenges

- Developing the **information technologies** and **standard procedures** applicable to linear transport systems in general
- Developing **expert-based toolkits** built on artificial intelligence and optimisation techniques to **support decision making** in maintenance planning, renewal and new construction of infrastructures
- Integrating all previous models and tools in a **cloud-based framework compatible** with existing **asset management** systems



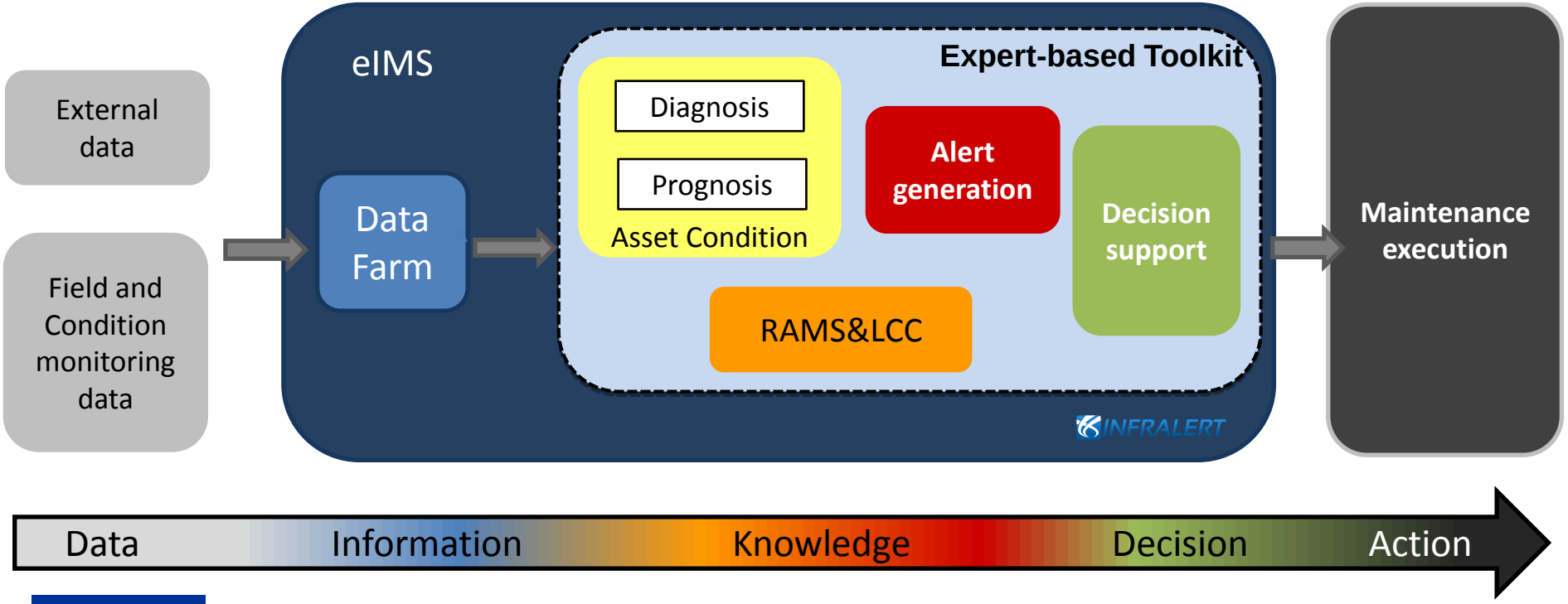


The concept

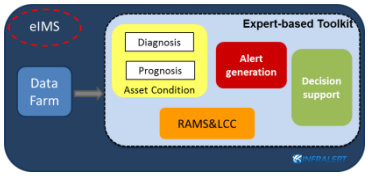

Traffic
Weather
Social needs
Budget
Regulations
External information
Asset information
Linear transport infrastructure
Expert-based Toolkits
eIMS
Data Farm
Condition monitoring
Infrastructure Manager / Operator
Optimized interventions

The concept

INFRALERT develops an **expert-based Infrastructure Management System** which **coordinates and integrates** all the processes from measurements to **Maintenance & Renewal** and support long term strategic investment decisions

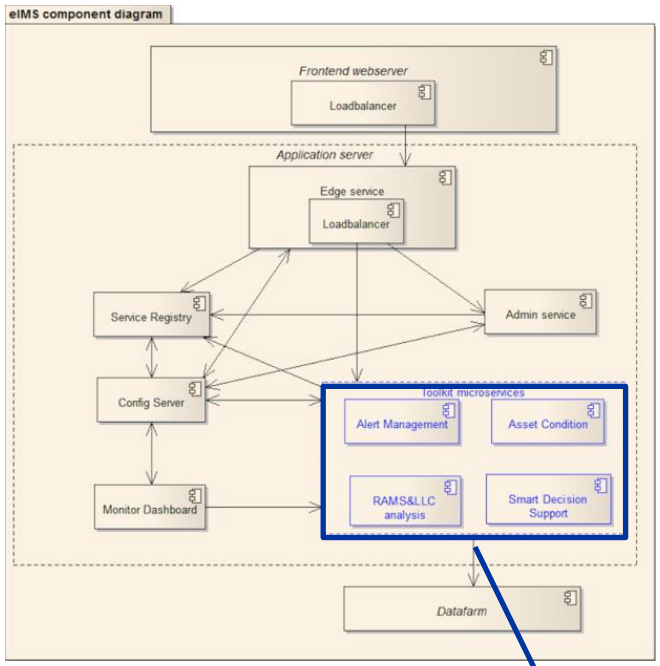


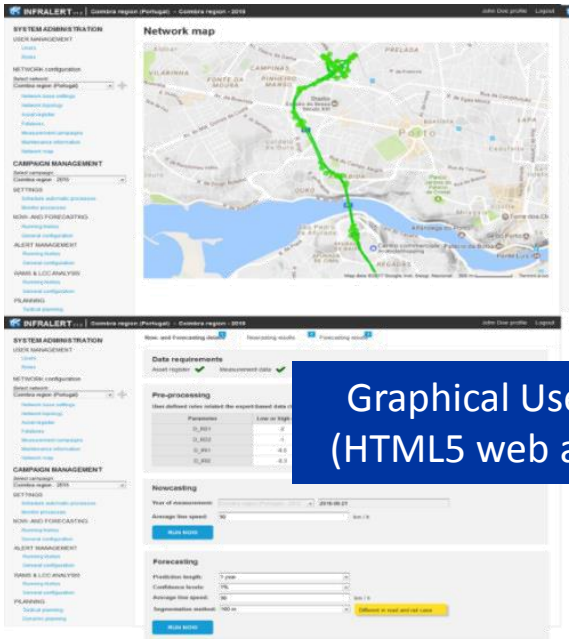
Expert-based Infrastructure Management System (eIMS)

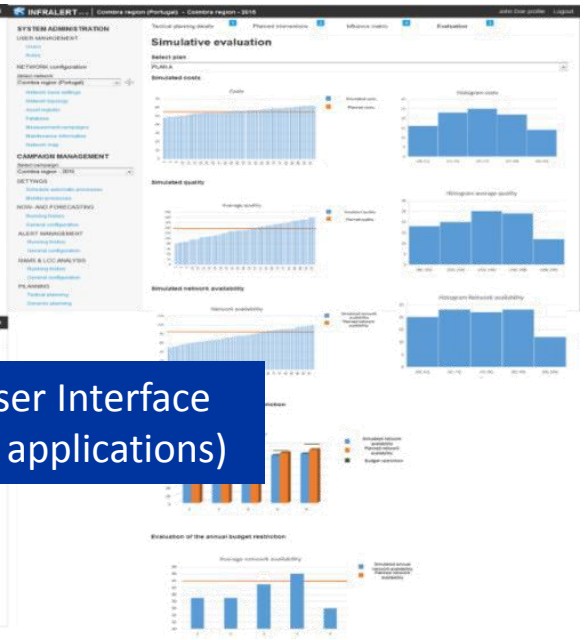


eIMS is the shell that allocates expert based toolkits

- Open, cloud based, multi tier environment
- Modular-based easily scalable microservices in the middle ware
- Frontend webserver



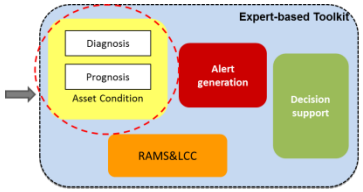




Graphical User Interface (HTML5 web applications)

4 toolkits integration in the system architecture

Expert based toolkit: Asset Condition



The "Asset Condition system" analyses/uses:

- **Condition data**

+

- Asset register

→ **Assessment** of **current** and **forecasted** condition

INPUT

Condition Data

Feature limits

Asset Condition Toolkit

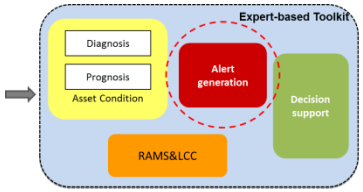
OUTPUT

Nowcasting & Forecasting of individual segments

Maintenance and operator knowledge **(heuristic models)**

Other User's settings:
- Level of confidence
- Prediction length

Expert based toolkit: Alert Generation



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The "Alert management system" analyses/uses:

- **forecasted** asset **condition data**

+

- **historical maintenance** interventions

→ to estimate/predict **maintenance alerts**.

INPUT

Nowcasting & Forecasting

Features' limits

Alert Generation (ALERT MANAGEMENT)

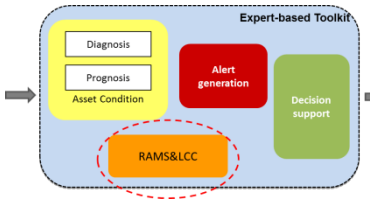
OUTPUT

Alerts and Most Probable Maintenance Intervention

Historical database with maintenance **interventions**

Other User's settings and data:
- Level of confidence γ
- Measurements

Expert based toolkit: RAMS & LCC



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The "RAMS & LCC tool" analyses **maintenance records** (cost and interventions) to:

- Calculate the **performance** of the system in the form of **RAMS**
- Calculate **maintenance costs** and how they **depend on the RAMS** and other factors

INPUT

Maintenance Cost (material, labour, equipment, …)

Maintenance interventions (type, times, actions)

RAMS & LCC

OUTPUT

Failure probability characterization:

- **Failure/Repair rate**
- **MTTF / MTBF / MTTM**
- **Probability distributions**

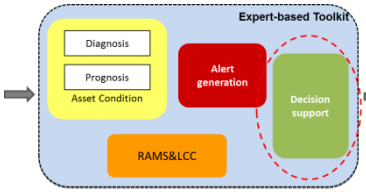
Stochastic cost assesment:

- **Uncertainties in LCC due to RAMS**
- **Relevant drivers affecting LCC**
- **Probability distribution of costs**

Cost models

RAMS statistical models

Expert based toolkit: Decision Support Tool



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The "Decision Support" provides capabilities for the optimised planning of maintenance:

- Algorithmic handling of **uncertainties in planning** (e.g. future conditions, alerts, reliability)
- Provides alternative solutions to **support decision-making** in maintenance planning

INPUT

Alerts & Most probable maintenance interventions

RAMS & LCC

IM objectives & constraints

Decision Support

OUTPUT

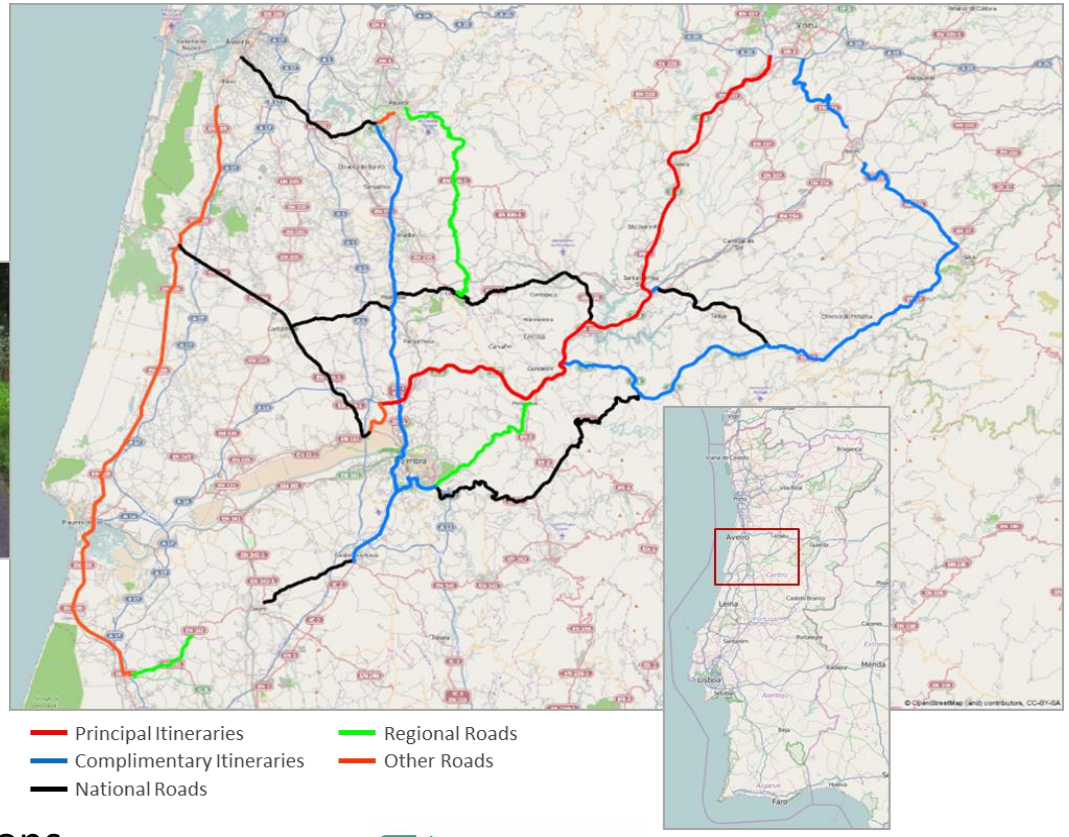
Maintenance plan:

Operational
Tactical

Optimisation Algorithms

The demonstration pilots

Meshed road network in Portugal under the management of **Infraestruturas de Portugal**: **541 km**



Heterogeneous network in terms of traffic demand, road hierarchy and age

Tactical planning (5 yrs):

- Major maintenance interventions
- Min cost & max overall network quality

	IP network	INFRALERT network	
Network length (km)	13 577	541	4%

The demonstration pilots

A rail corridor in Sweden: Malmbanan - Iron ore line

- 2 lines of 135 Km and 165 Km resp.
- Heavy-haul railway trains (maximum axle load of 30 tonnes).
- Mixed traffic
- Harsch climate conditions (-45ºC to +25ºC).

Planning problem features:

- Weekly operational planning
- Allocate interventions to time windows
- Minimise penalties for shifting of interventions and influence in railway service
- Consider working constraints, budget and available time

Conclusions

- INFRALERT is a platform to **support decision making** in the field of **optimal plannning for maintenance interventions for rail and road networks**
- Its architecture is **modular** based on the development of **several expert tools** allocated on a common shell: the ***expert based Infrastructure Management System platform (eIMS)***
- ***Cloud*** *Web based application*
- The **expert based toolkit** include:
  - ❑ **Asset condition** tool
  - ❑ **Alert generation** tool
  - ❑ **RAMS & LCC** tool
  - ❑ **Decision Support tool**
- Demonstrated for **rail & road** networks

The Impact

- **Reduction** of recurrent **cost for maintenance** interventions
- Overall **increase** of the **availability** of the infrastructure
- Enhance of the **reliability**
- Reduction of **traffic disruption**
- Improve **comfort and safety**
- Enhance the **flexibility** and quality of interventions planning
- Extension of life span of asset and **reduction of LCC**

Results of the validation in the rail & road pilot will be shown after lunch.

Wait and see!

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www.infralert.eu

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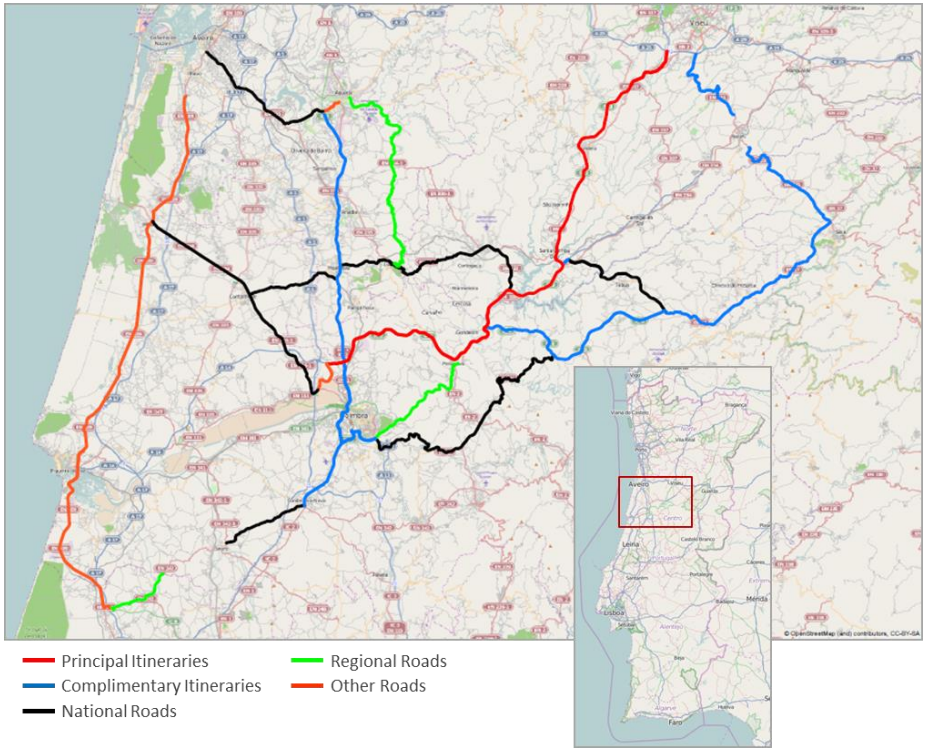
The demonstration pilots

A meshed road network in Portugal (c/o Infraestruturas de Portugal)

Planning problem features:

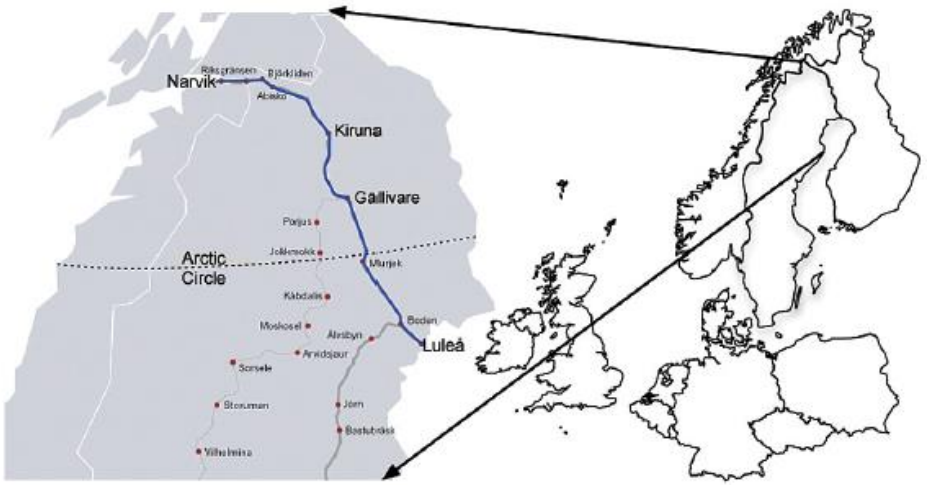
- Tactical planning (5 yrs)
- Allocation of major interventions on a monthly basis
- Min cost & max overall network quality



Infraestruturas de Portugal

The demonstration pilots

A rail corridor in Sweden: Malmbanan - Iron ore line



Planning problem features:

- Tactical planning (18 month)
- Weekly operational planning
- Allocate interventions to time windows
- Minimise penalties for shifting of interventions and influence in railway service
- Consider working shift constraints, budget and available time