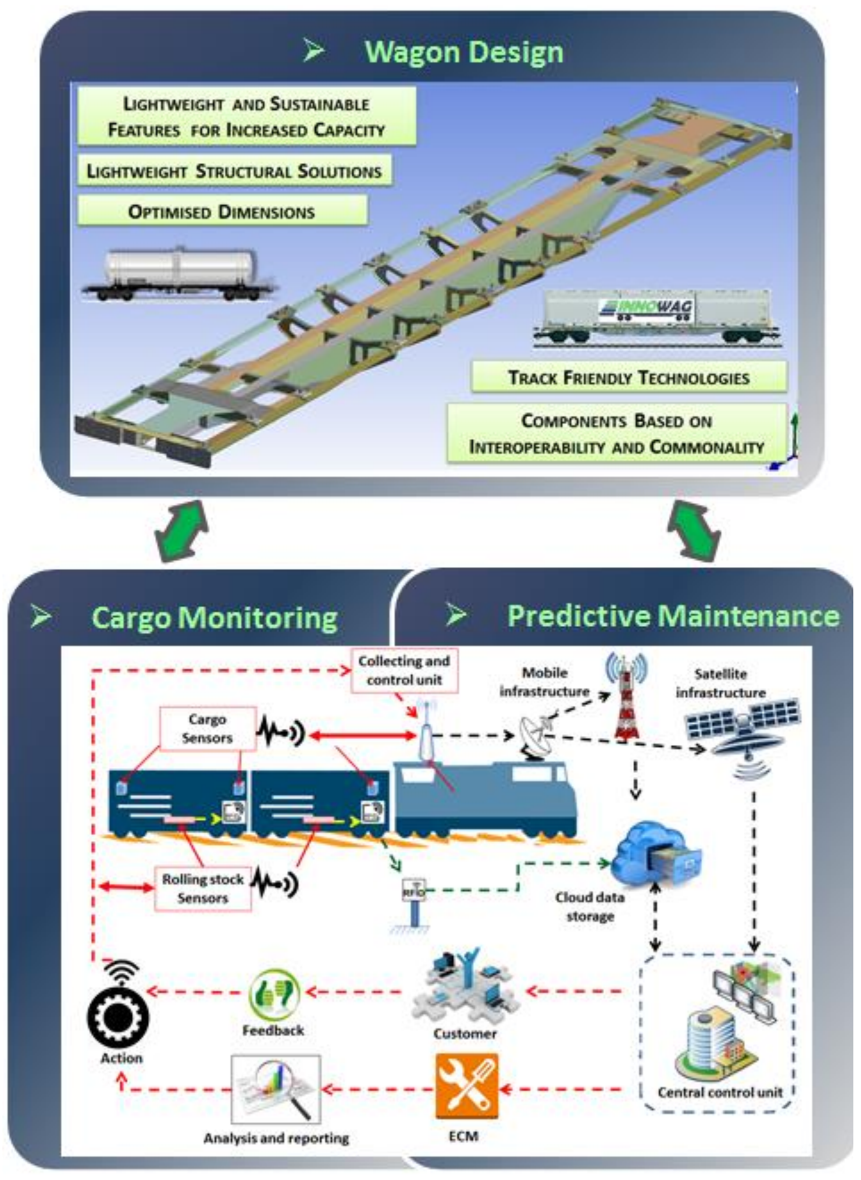
Innovative monitoring and predictive maintenance solutions on lightweight wagon

Horizon 2020
European Union Funding
for Research & Innovation

THE INNOWAG PROJECT

Project coordinator: Newcastle University
Total Budget:1.5M
Duration: 01/11/2016 – 30/06/2019
Call addressed: *S2R-OC-IP5-03-2015*
Complementary CFM project: *S2R-CFM-IP5-01-2015 - FR8RAIL*

The INNOWAG project aims at developing a rail freight service that fits the needs of modern manufacturing and supply chain, through its following **specific objectives:**



- ***Increase freight rail capacity*** by optimising and lightweighting the wagon design for increasing the ratio payload/wagon tare;
- ***Increase freight logistic capabilities*** by:
  - ***i.*** *offering real time data on freight location and condition through a smart self-powered sensor system and communication technologies;*
  - ***ii.*** *optimised wagon modular design capable to transport various types of goods; and*
  - ***iii.*** *improved availability to freight customers, enabled by a safer and more reliable and interoperable freight service;*
- ***Increase RAMS and reduce LCC*** by implementing modern and innovative predictive maintenance analytics, models, and procedures.

WAGON DESIGN

Specific objectives and subsequent **approach**:

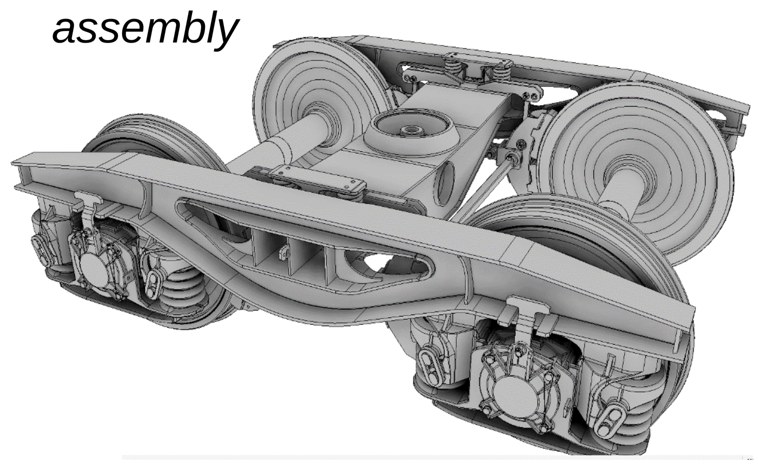
- Development of a novel concept of modular and lightweight wagon through:
  - *Analysis and selection of lightweight materials;*
  - *Optimised structural design;*
  - *Modular components and/or sub-assemblies;*
- Structural strength and fatigue analysis of critical sub-assemblies;
- Validation of design concepts through specific laboratory tests.

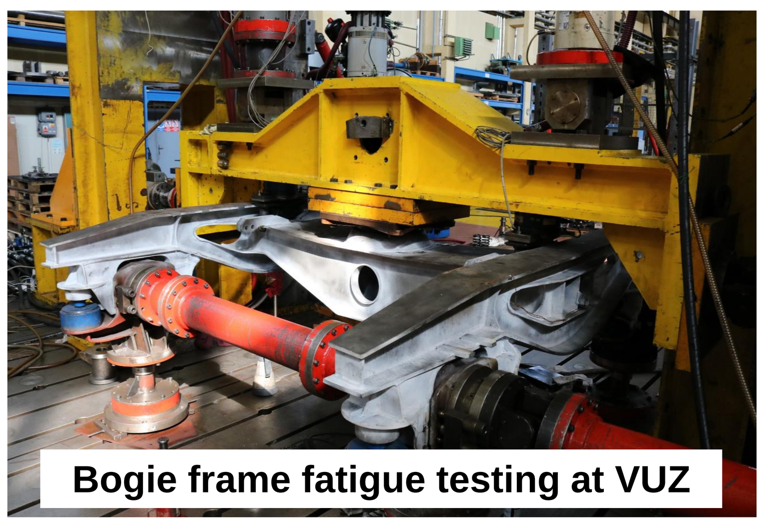
INNOWAG lightweight concepts:

Lightweight Y25 bogie design

(17% mass reduction)

- *HSS bogie frame & optimised design*
- *lightweight wheelsets and brake assembly*



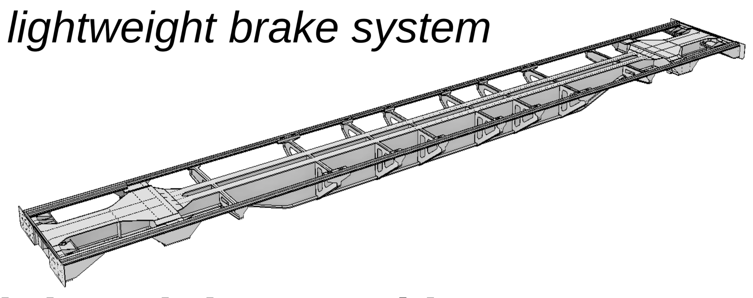


Bogie frame fatigue testing at VUZ

Lightweight 60' container wagon

(22% mass reduction)

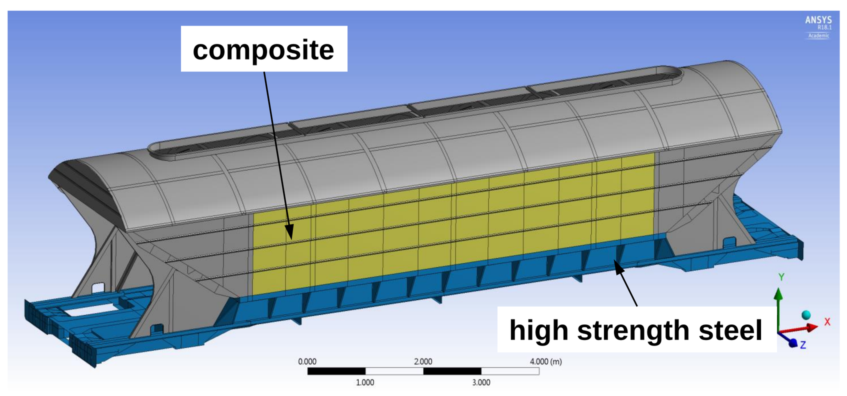
- *HSS underframe & optimised design*
- *lightweight brake system*



Lightweight cereal hopper wagon

(21–27% overall mass reduction;
51% carbody mass reduction)

- *HSS underframe and bottom*
- *composite (GFRP) side wall panels*
- *lightweight bogies*



CARGO CONDITION MONITORING

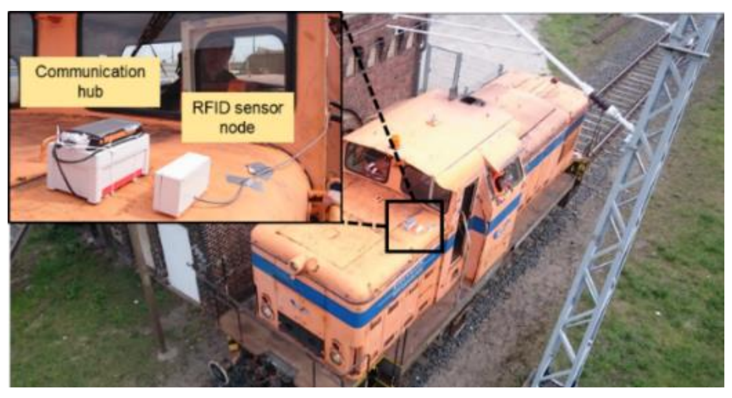
Specific objectives and approach

- Formulation of the overall measurement concept with focus on architecture design and sensor arrangement;
- Design of a power supply system based on energy harvesting technologies;
- Design of a data communication system based on WSN;
- Validation of the developed cargo condition monitoring system at TRL5.

Cargo Monitoring prototypes:

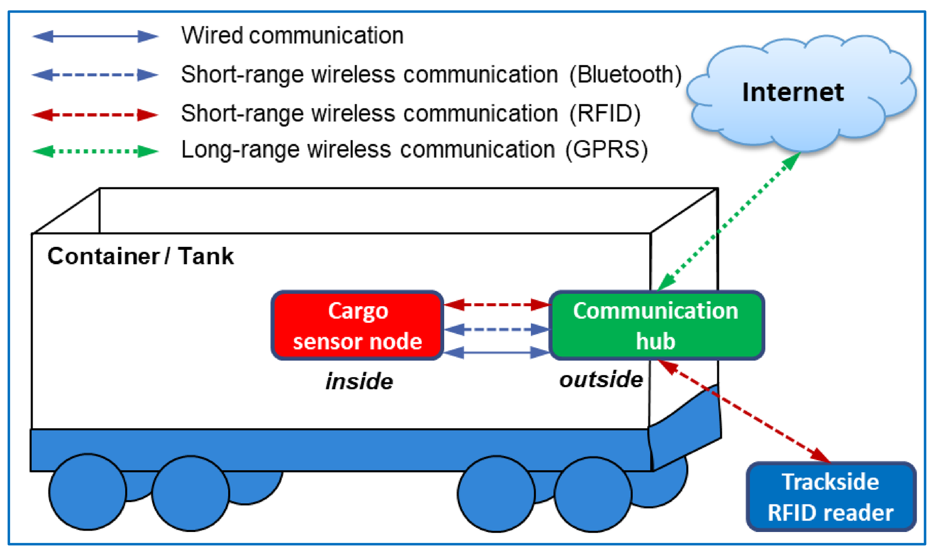
Bluetooth (BT) based prototype

Onboard RFID-based prototype

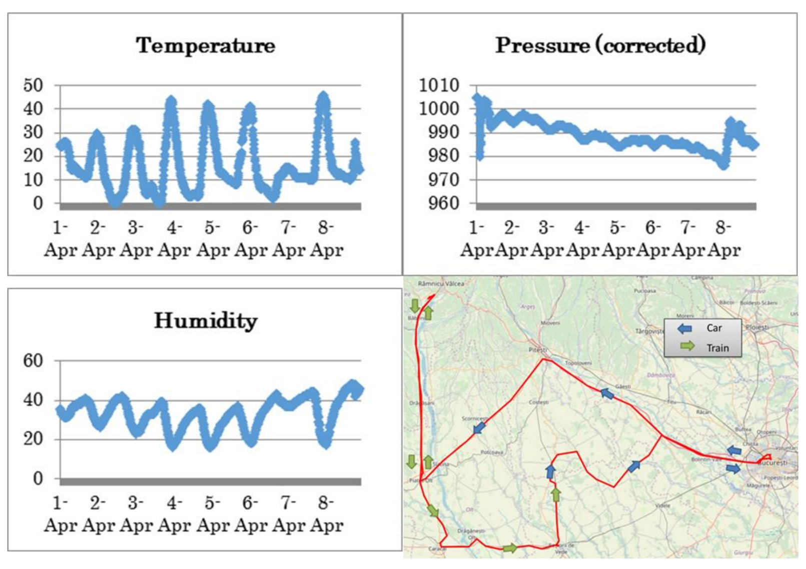


Test of trackside RFID reader for the hybrid concept (RFID+BT)

Generic system architecture:



Operational tests of BT-based prototype (supported by UVA in Romania)



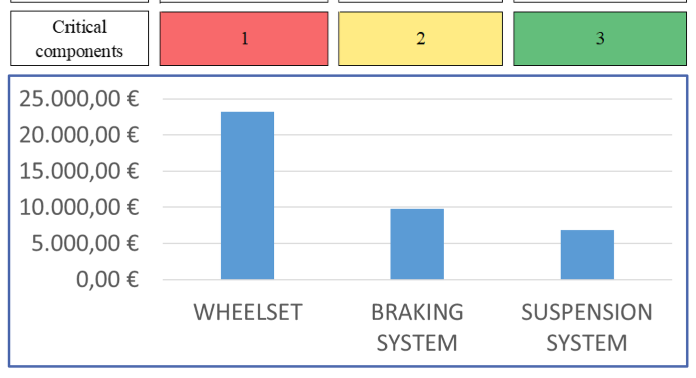
PREDICTIVE MAINTENANCE

Development of ***approaches*** to support ***predictive maintenance (PDM)*** strategy for freight vehicles:

- Cost driven analysis through *Life Cycle Cost (LCC)* model
- Reliability driven analysis through *Failure Mode and Effect Analysis (FMEA)*
- Development of a guided procedure (*Wizard Tool*) to support maintenance operators in the optimisation of the maintenance policy on freight wagons

Example result of cost-driven analysis: Prioritisation of components based on their Life Cycle Cost

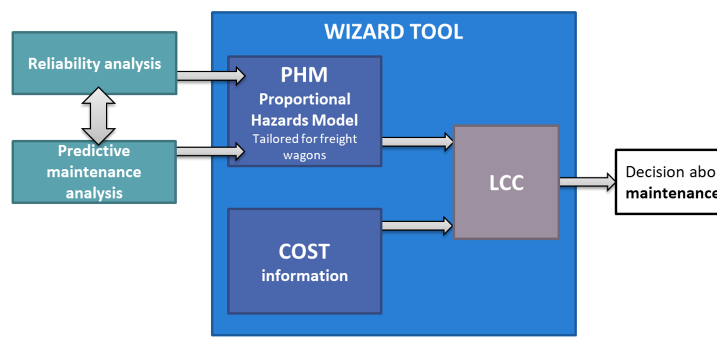
Net present value	WHEELSET	BRAKING SYSTEM	SUSPENSION SYSTEM
NPV	23.228,77 €	9.770,56 €	6.872,42 €
Critical components	1	2	3



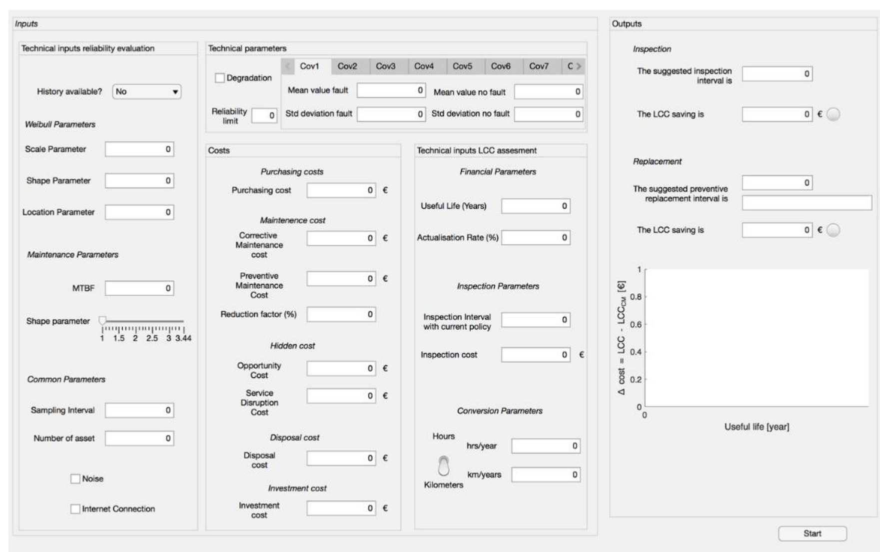
Example result of reliability-driven analysis: Prioritisation of failure modes for the wheelset based on FMEA analysis

Failure	GCU code	Nc (failure per 100 sub-assemblies)	Failure rate	Frequency rank	GCU class	GCU control criteria	Severity		Detectability		Frequency		Risk Priority Number (RPN)
axle crack	1.6.1.1	2	1.31E-06	4	5	VC	unsafe without warning	10	moderate	5	low: relatively few failures	3	200
wheel out of round	1.3.3; 1.7.2; 1.7.2.1	23	6.04E-06	6	4	M; VC/ VC	very high	8	very low	7	moderate: often there are failures	6	336
wheel crack	1.3.5; 1.3.6; 1.5	4	3.50E-07	3	4	M; VC/ VC	very high	8	very low	7	low: relative few failures	3	168
Wheel: build-up of material	1.3.4;	3	1.97E-06	4	4	M	very high	8	very low	7	moderate: seldom there are failures	4	224
wheel thermomechanical crack	1.3.5; 1.3.6; 1.5	4	3.50E-07	3	4	M; VC	very high	8	very low	7	low: relatively few failures	3	168

Logical structure of the process to support the decision maintenance (theoretical background of the Wizard tool)



Implementation of the Wizard tool



INNOWAG consortium:

Newcastle University · INERTIA TECHNOLOGY · hvle · LUCCHINI RS GROUP · New OPERA · perpetuum · POLITECNICO MILANO 1863 · TU berlin · unife THE EUROPEAN RAIL INDUSTRY · UVAiud uzina de vagoane aiud · VUZ