Joint Final Event

Projects coordinated by:

Mat4Rail by E. Jubete (CIDETEC)
RUN2Rail by M. Andreoni (UNIFE)
FAIR Stations by U. Battista (Stam)
PIVOT by P. Böttcher (BT)

17th September 2019
Paris

Shift2Rail JU
Driving innovation on railways

Paris, 17 September 2019

"Joint Final event PIVOT - Mat4Rail - Run2Rail - FairStations"

Robert Liskounig, Seconded National Expert at S2R JU

@Shift2Rail_JU
#Horizon2020

S2R OBJECTIVES

+50% **INCREASE** RELIABILITY & PUNCTUALITY **BY 50%**

x2 **DOUBLE** RAILWAY CAPACITY

HALVE LIFE-CYCLE COSTS OF RAILWAY TRANSPORTS

CONTRIBUTE TO **REDUCTION OF NEGATIVE EXTERNALITIES**, SUCH AS NOISE, VIBRATIONS, EMISSIONS & OTHER ENVIRONMENTAL IMPACTS

CONTRIBUTE TO THE **ACHIEVEMENT OF THE SINGLE EUROPEAN RAILWAY AREA**

S2R PROGRAMME, ABOUT € 1BLN and A NEW APPROACH TO R&I IN RAILWAY

working together & driving innovation

Shift2Rail

AN OPEN and ACTIVE ORGANISATION

28
MEMBERS

375
PARTICIPANTS INVOLVED FROM **28** COUNTRIES

101
SMEs

103
RESEARCH CENTRES AND UNIVERSITIES

[1]Data extracted from CORDA database in February, 2019

…opening up new Capabilities coming from emerging technologies or concepts!

Shift2Rail

An Innovation Programme in motion

Around 70 ongoing Projects

standardization roadmap

LP & first
S2R Projects' closing

Projects' Reviews

MAAP
Updates

CALL
2019

In September
17 Proposals
(EUR 148.6 Mio)
Selected for funding

S2R Catalogue of Solutions

Communication /Dissemination activities

AWP
2020
+
Demo Plans
(involving possible vehicle authorizations)

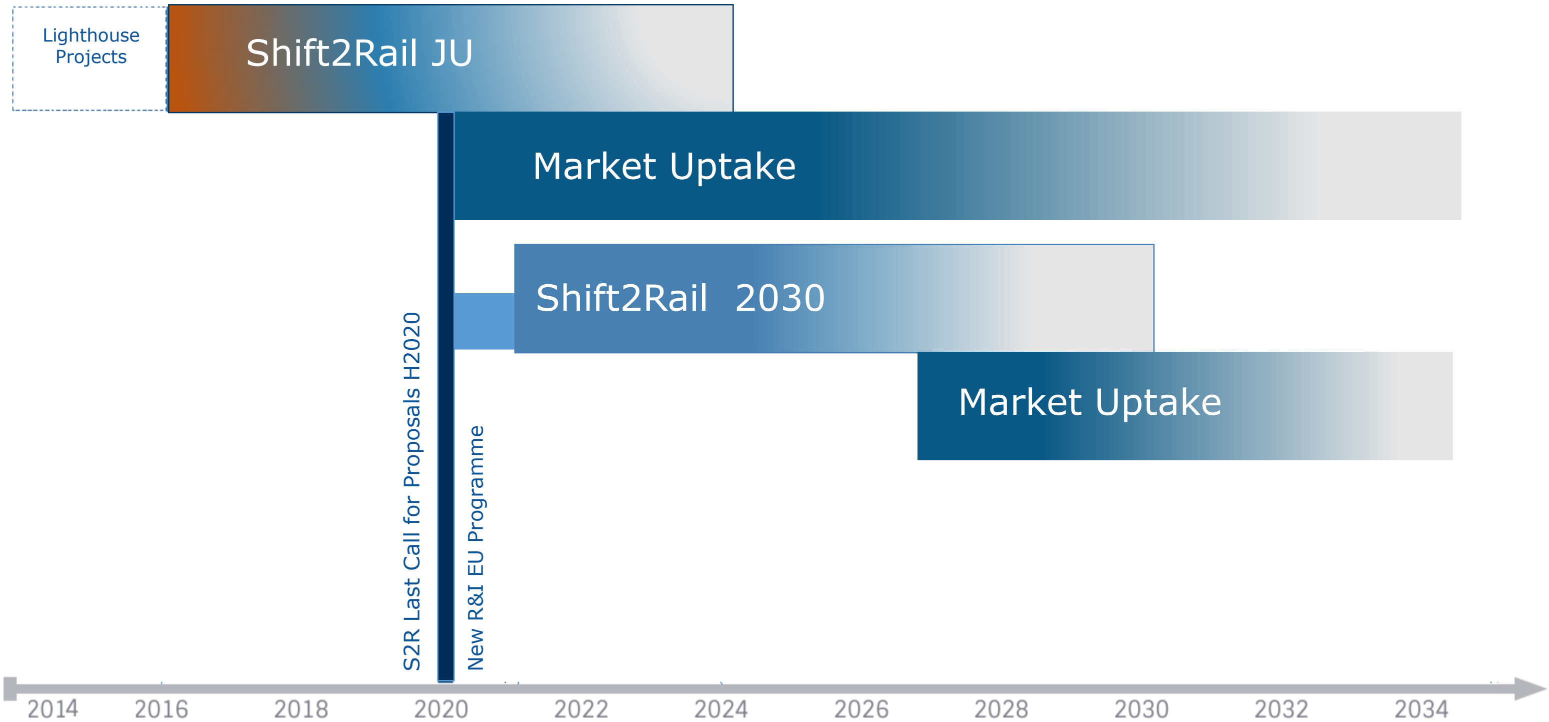
R&I BEYOND
2020

*S2R
Europe
2030*

+ infrastructure test facilities

Shift2Rail

R&I BEYOND 2020



Transforming Europe’s Rail System

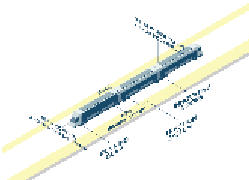
The Commission published the public consultation for a potential European Partnership “Transforming Europe’s rail system” under Horizon Europe.

Feedback will be taken into account for further development and fine tuning of the initiative.

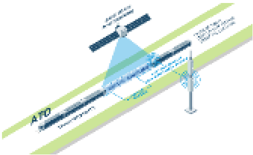
The questionnaire is available for your reply here:
https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2019-4980251/public-consultation_en

The deadline for replies is 6 November 2019.

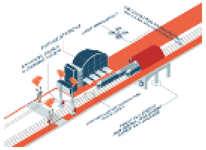
S2R solutions derived from Technical Demonstrators



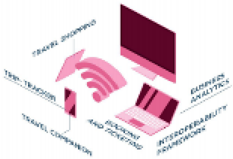
IP1 Cost-efficient and Reliable Trains, including high-capacity trains and high speed trains



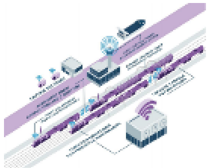
IP2 Advanced Traffic Management and Control System



IP3 Cost-efficient, Sustainable and Reliable High Capacity Infrastructure



IP4 IT Solutions for Attractive Railways Services



IP5 Technology for Sustainable and Attractive European Rail Freight

CCA Cross Cutting Activities

WHO BENEFITS?

CUSTOMERS

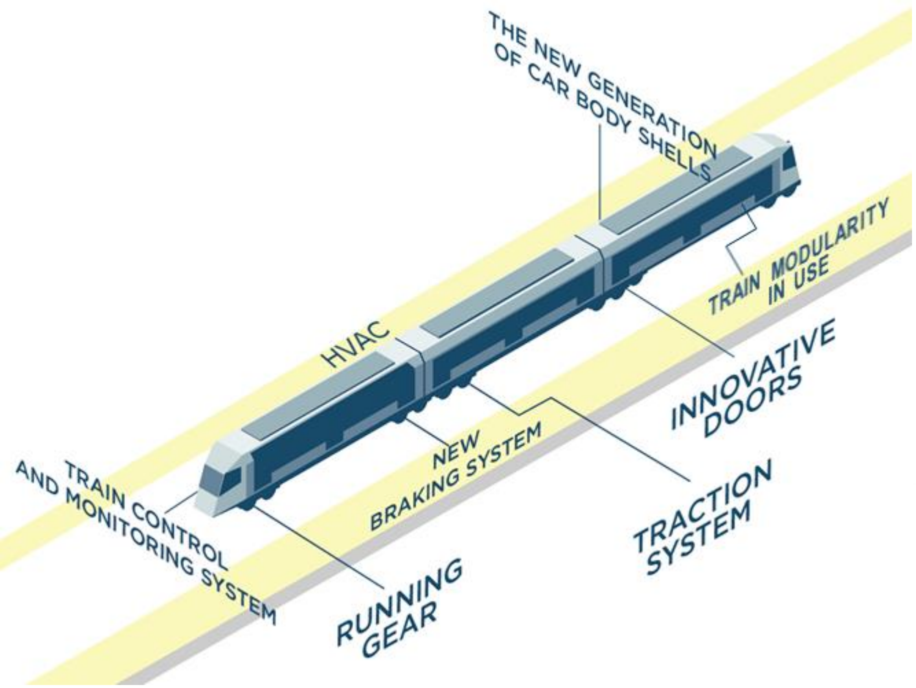
FINAL USER

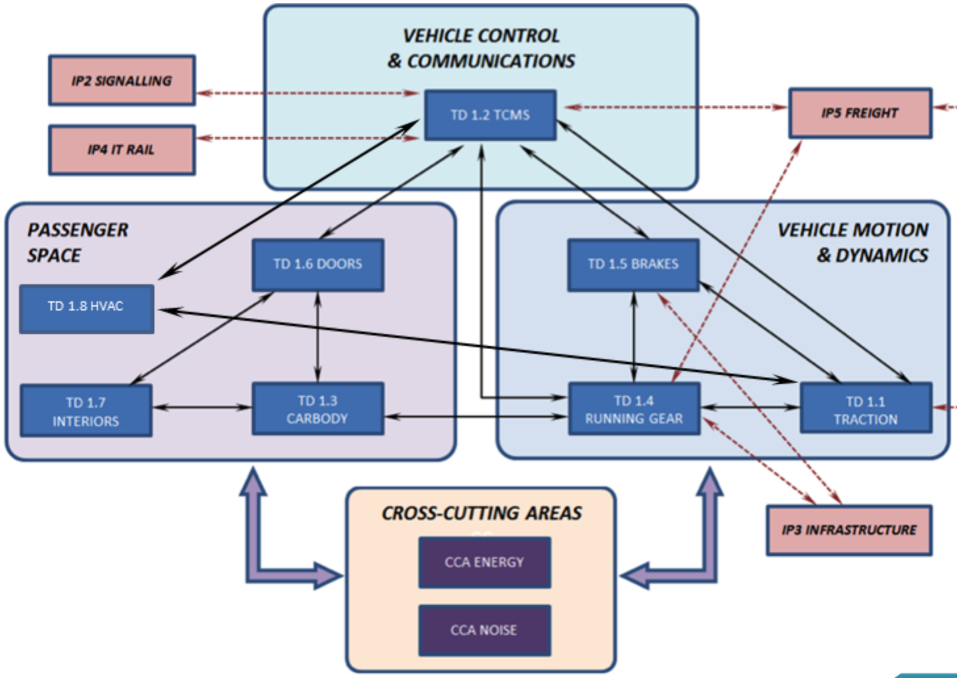
OPERATOR

INFRAMAN

SUPPLIERS

IP1: Cost-efficient and reliable trains, including high-capacity trains and high-speed trains





FOUNDING MEMBERS

- ALSTOM
- Ansaldo STS A Hitachi Group Company
- BOMBARDIER
- CAF
- NetworkRail
- SIEMENS
- THALES
- TRAFIKVERKET

ASSOCIATED MEMBERS

- AMADEUS
- AZD PRAHA
- DB
- DIGINEXT be visionary
- Faiveley Transport A Wabtec Company
- HaCon
- indra
- kapsch
- KNORR-BREMSE
- MERMEC AN ANGEL COMPANY
- SNCF
- Talgo

Virtual Vehicle Austria consortium+ (VVAC+)

- virtual vehicle
- WIENER LINIEN
- FCP
- TATRAVAGÓNKA POPRAD
- getzner engineering a quiet future
- ACT
- KIRCHDORFER CONCRETE SOLUTIONS
- Plasser & Theurer
- MCL
- voestalpine
- PJM
- AVL

European Rail Operating community Consortium (EUROC)

- ÖBB Immer in Bewegung
- bls
- CP COMBOIOS DE PORTUGAL
- PKP POLSKIE KOLEJE PAŃSTWOWE
- SBB CFF FFS
- ProRail
- Infraestruturas de Portugal
- TCDD
- Slovenske železnice

Swi'Tracken consortium

- RAILENIUM
- U.PORTO
- TATA STEEL
- TRONICO
- vossloh
- izt
- egis
- EURO TUNNEL

Smart DeMain (SDM) consortium

- Strukton Rail
- cemosa
- Fraunhofer IVI
- acciona
- DLR

AERFITEC

- AERnnova
- FIDAMC
- tecnalia

Competitive Freight Wagon Consortium (CFW)

- ConTraffic
- DLR
- DIE BAHNINDUSTRIE.
- ceit
- WBN

Smart Rail Control (SmartRaCon) consortium

- DLR
- RAILENIUM
- ceit
- NSL

Shift2Rail

@Shift2Rail_JU
#Horizon2020

Shift2Rail

Shift2Rail

FAIR STATIONS

Future Secure and Accessible Rail Stations

FAIR Stations Overview

PIVOT Mat4Rail RUN2Rail FAIR STATIONS

Horizon 2020 European Union Funding for Research & Innovation → SHIFT2RAIL

Innovation Programme 1	Innovation Programme 2	Innovation Programme 3	Innovation Programme 4	Innovation Programme 5
Efficient Technologies for High Capacity Trains	Traffic Management & Control Systems	Cost Efficient High Capacity Infrastructure	IT Solutions for a Seamless Railway	Technologies for European Freight





TD1.1	Traction
TD1.2	TCMS
TD1.3	Carbody shell
TD1.5	Running gear
TD1.5	Brakes
TD1.6	**Doors**
TD1.7	Train interiors

\+

TD3.1	Switches & Crossings
TD3.2	Next gen. Switches & Crossings
TD3.3	Optimised track systems
TD3.5	Next generation track
TD3.5	Bridges & tunnels
TD3.6	DRIMS
TD3.7	RIMMS
TD3.8	IAMS
TD3.9	Smart power supply
TD3.10	Smart metering
TD3.11	**Future stations**

FAIR STATIONS

Shift2Rail

Integration into S2R

TD1.6
Doors and entrance systems

Cost-efficient and reliable trains, including high-capacity trains and high-speed trains

IP1

FAIR STATIONS

Future Secure and Accessible Rail Stations

TD3.11
Future stations and accessibility

Innovative Solutions in Future Stations, Energy Metering and Power Supply

IP3

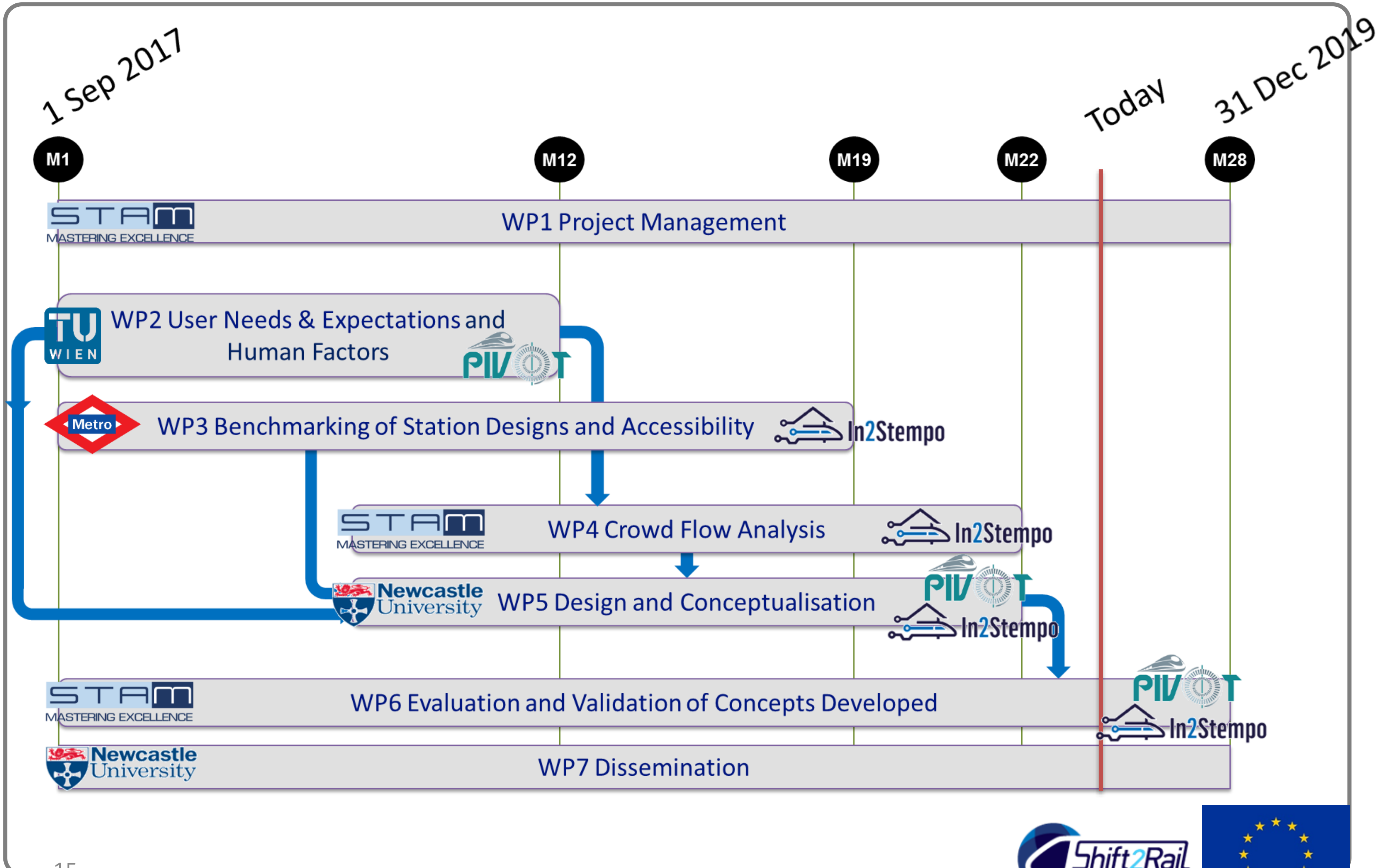
Consortium

Project Coordinator

Technical Coordinator

Partners

Project Structure



Objectives

1 Design an integrated station and train door access system

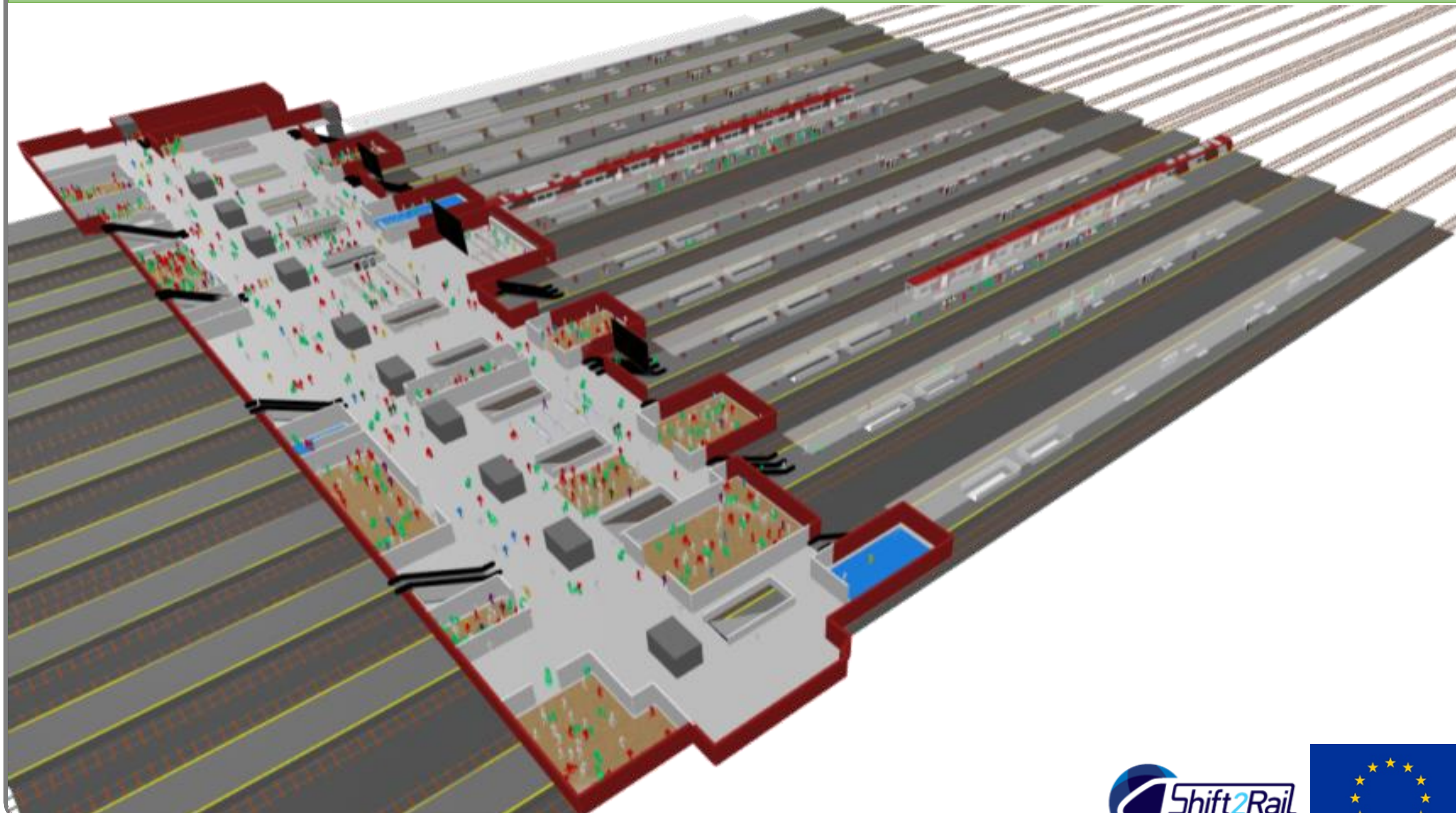
- For optimized & smooth passenger flow

2 Design stations with enhanced safety and security

- For customer satisfaction

Project Outputs

Validated passenger crowd analysis tool



Project Outputs

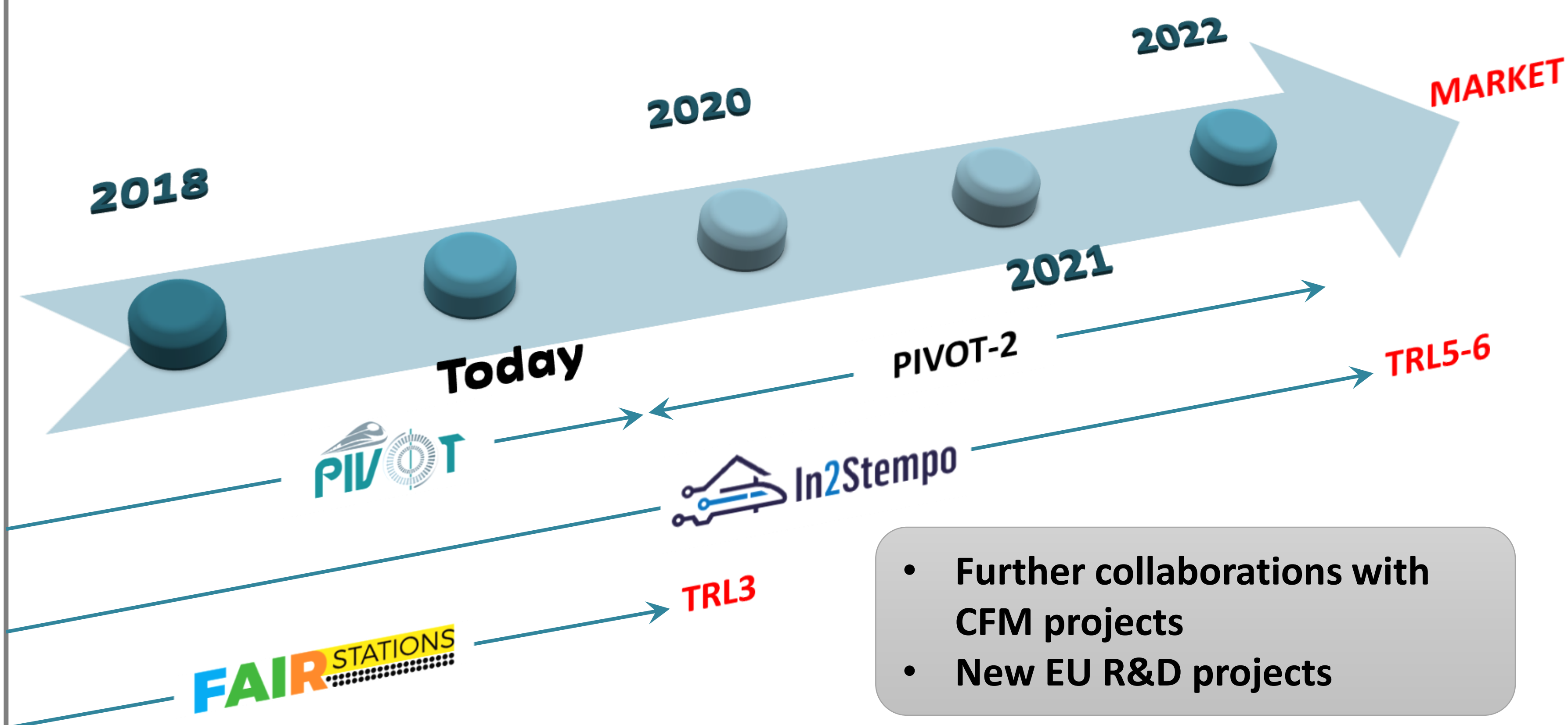
Universal design independent boarding system

Impacts

Improved…
Security
Safety
Customer satisfaction
Train dwell time
Crowd flow

Future Outlook

Innovative solutions for the PTI



- Further collaborations with CFM projects
- New EU R&D projects

Dissemination

Major Events:

- ❑ TRA 2018
- ❑ International Transport Forum Summit
- ❑ 15th Rail Transport Forum
- ❑ UTIP Global Public Transport Summit 2019

Dissemination material and public documents available at:

www.fairstations.eu

Innovative RUNning gear soluTiOns for new dependable, sustainable, intelligent and comfortable RAIL vehicles

PIVOT *Project Overview*

Horizon 2020
European Union Funding
for Research & Innovation

SHIFT²RAIL

Innovation Programme 1	Innovation Programme 2	Innovation Programme 3	Innovation Programme 4	Innovation Programme 5
Efficient Technologies for High Capacity Trains	Traffic Management & Control Systems	Cost Efficient High Capacity Infrastructure	IT Solutions for a Seamless Railway	Technologies for European Freight

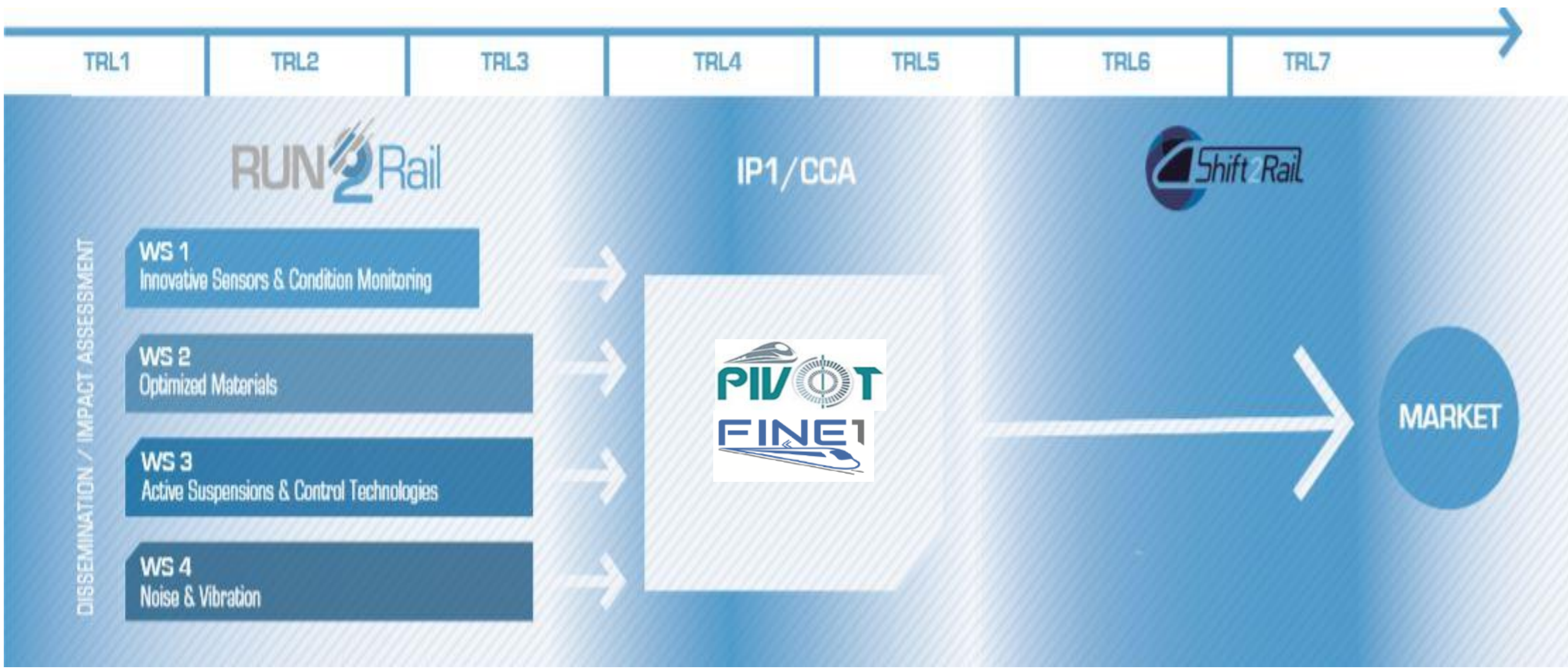



TD1.1	Traction
TD1.2	TCMS
TD1.3	Carbody shell
TD1.4	Running gear
TD1.5	Brakes
TD1.6	Doors
TD1.7	Train interiors

RUN2Rail

Integration into S2R

The challenge for Shift2Rail is to build a Running Gear Technology Demonstrator (TD1.4) that paves the way for the next generation of passenger rail vehicles → The aim of the RUN2Rail project is to identify and develop the key methods and tools that are required to allow the design and manufacture of this next generation of running gear



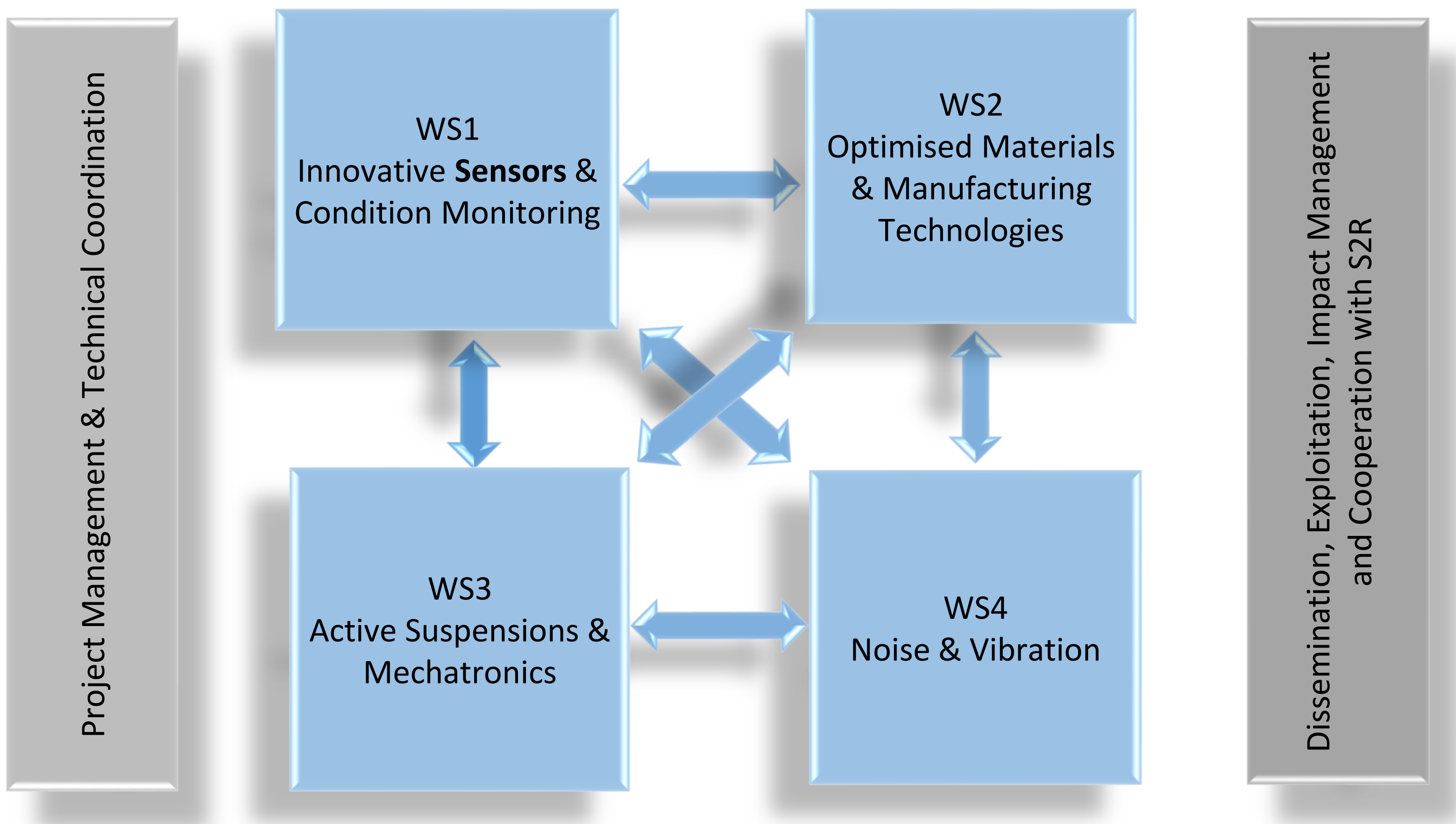
Consortium

Project Coordinator

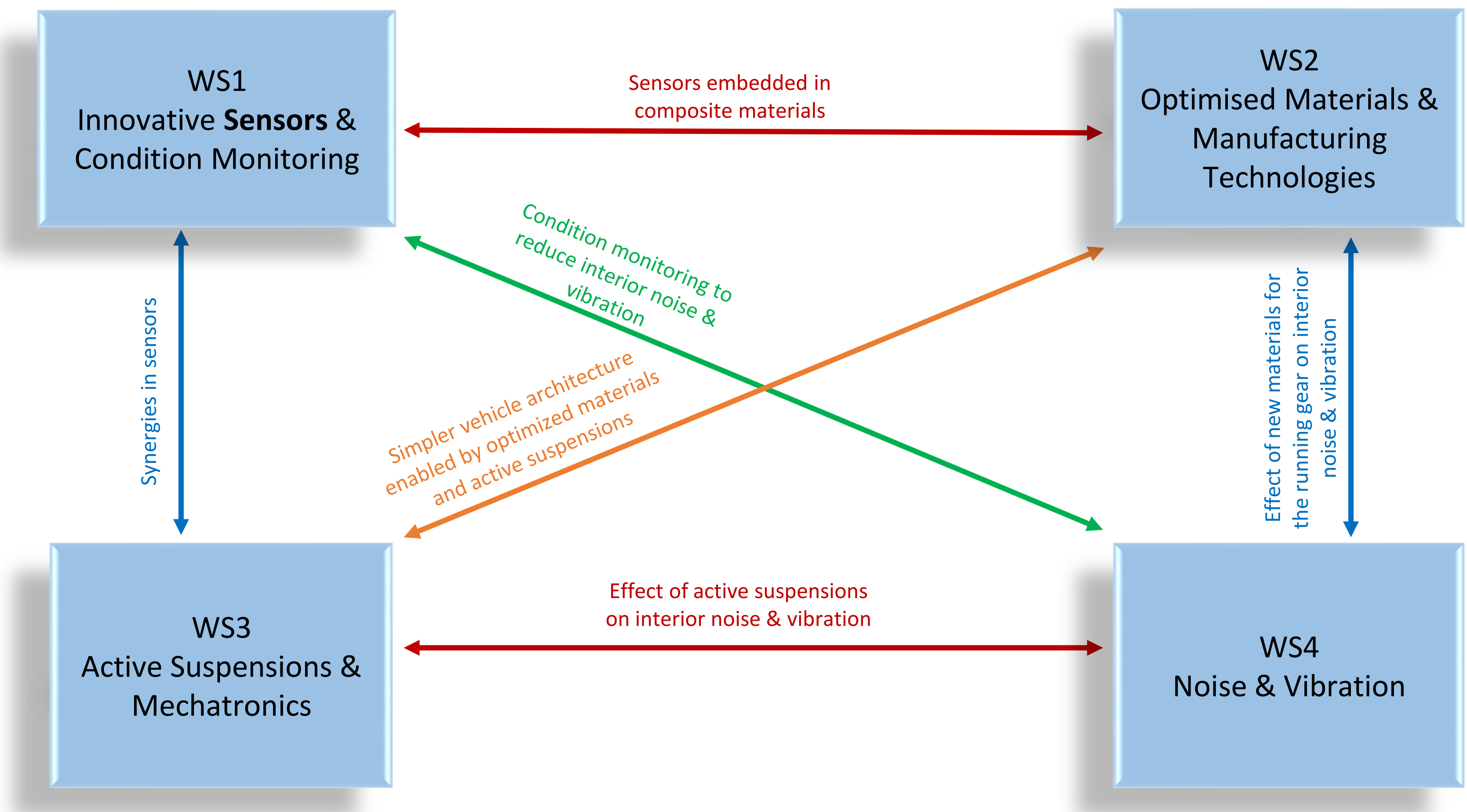
Technical Coordinator

Partners

Project Structure



Objectives



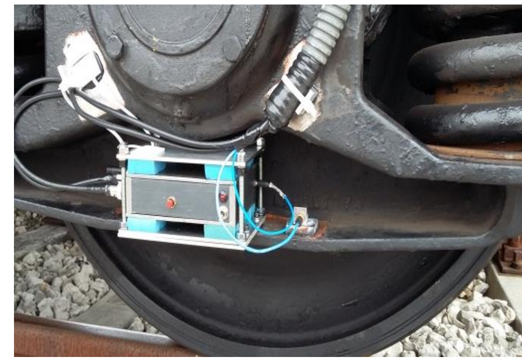
WS1
Innovative **Sensors** &
Condition Monitoring
Sensors embedded in
composite materials
WS2
Optimised Materials &
Manufacturing
Technologies
Condition monitoring to
reduce interior noise &
vibration
Synergies in sensors
Simpler vehicle architecture
enabled by optimized materials
and active suspensions
Effect of new materials for
the running gear on interior
noise & vibration
WS3
Active Suspensions &
Mechatronics
Effect of active suspensions
on interior noise & vibration
WS4
Noise & Vibration

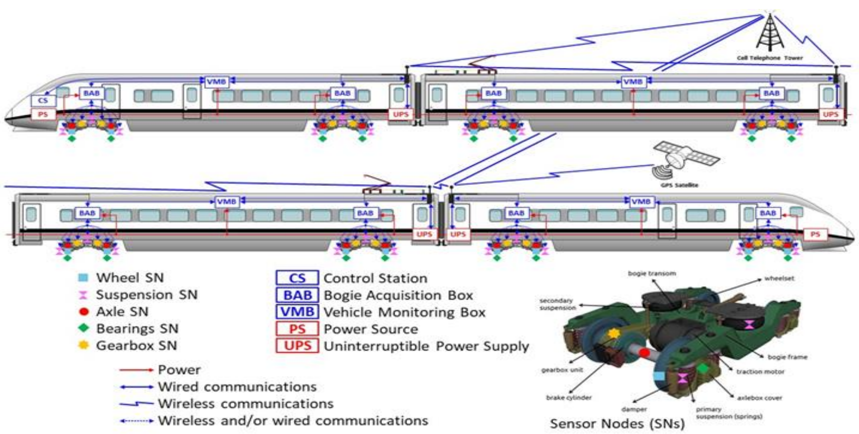
RUN2Rail WS1 highlights

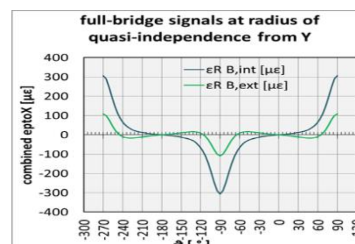
Scope: formulate technology concepts for condition monitoring systems considering three case studies: Smart wheelsets, Bearings and gearboxes, and Suspension components

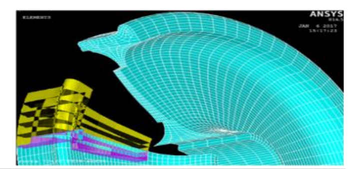
Structure:

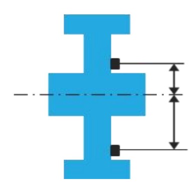
- Performance requirements and load cases;
- Vehicle concept design;
- Novel materials and manufacturing concept solutions.

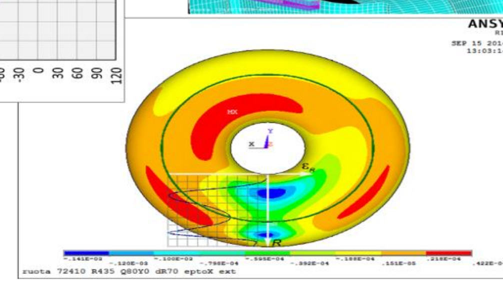












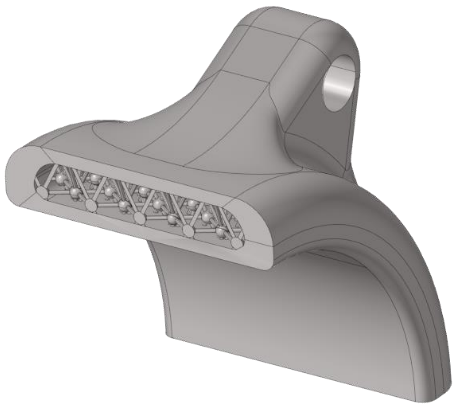
RUN2Rail WS2 highlights

Scope: Produce and evaluate concept designs for selected sub-systems in the running gear, to be manufactured using new lightweight materials and innovative manufacturing technologies. Assess key areas where standards or culture need to be changed to allow the adoption of novel materials.

Structure:

- Performance requirements and load cases;
- Vehicle concept design;
- Novel materials and manufacturing concept solutions.

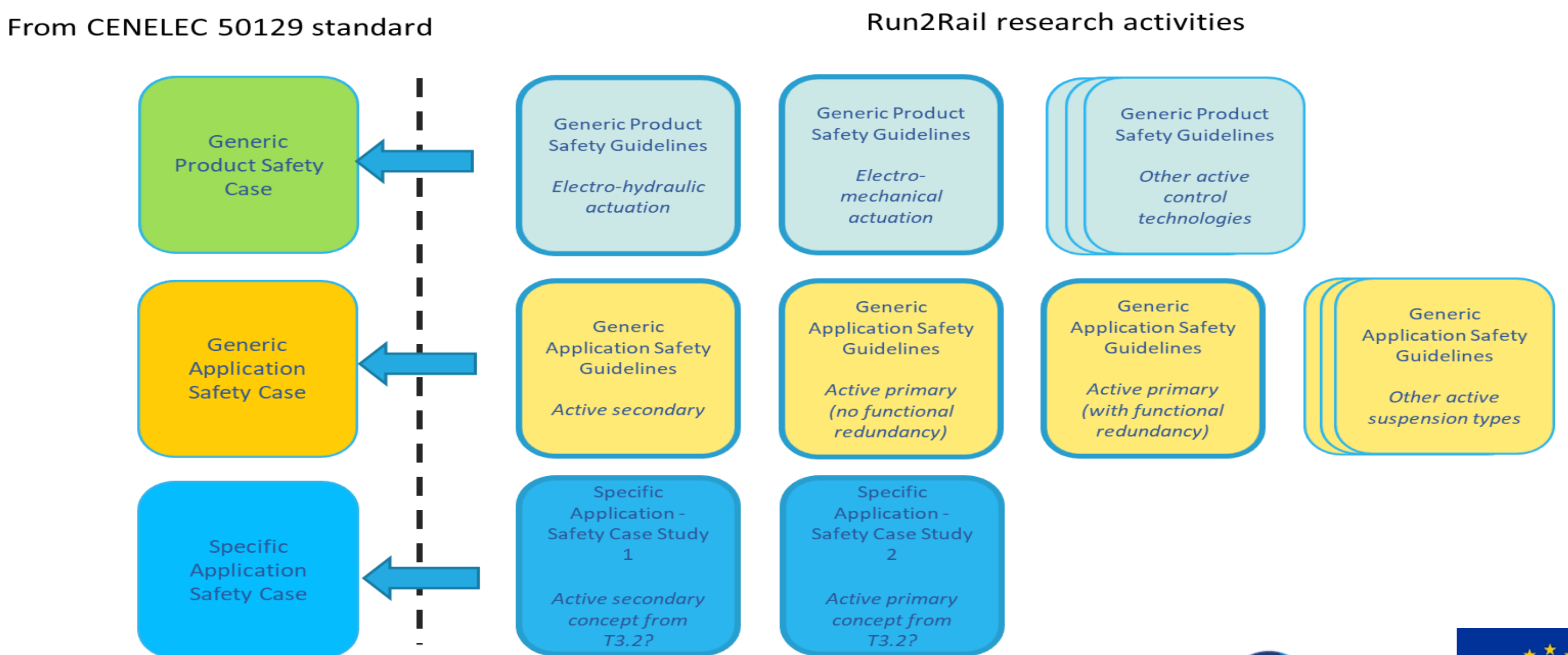
A quarter axlebox with an internal lattice structure has been manufactured



RUN2Rail WS3 highlights

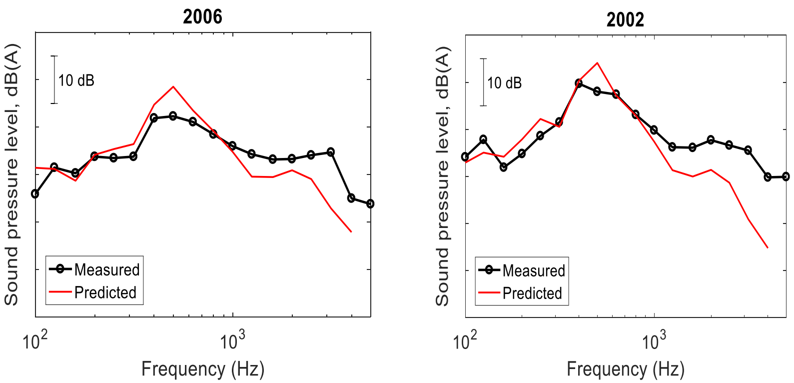
Scope: Research on active suspension in rail vehicles has been carried out for several decades. Very few studies, however, reached implementation in commercial products. Therefore the main objective of the work package is to detect the barriers and suggest measures to take them away.

AUTHORISATION STRATEGY - NEW STRATEGY FRAMEWORK PROPOSAL



RUN2Rail WS4 highlights

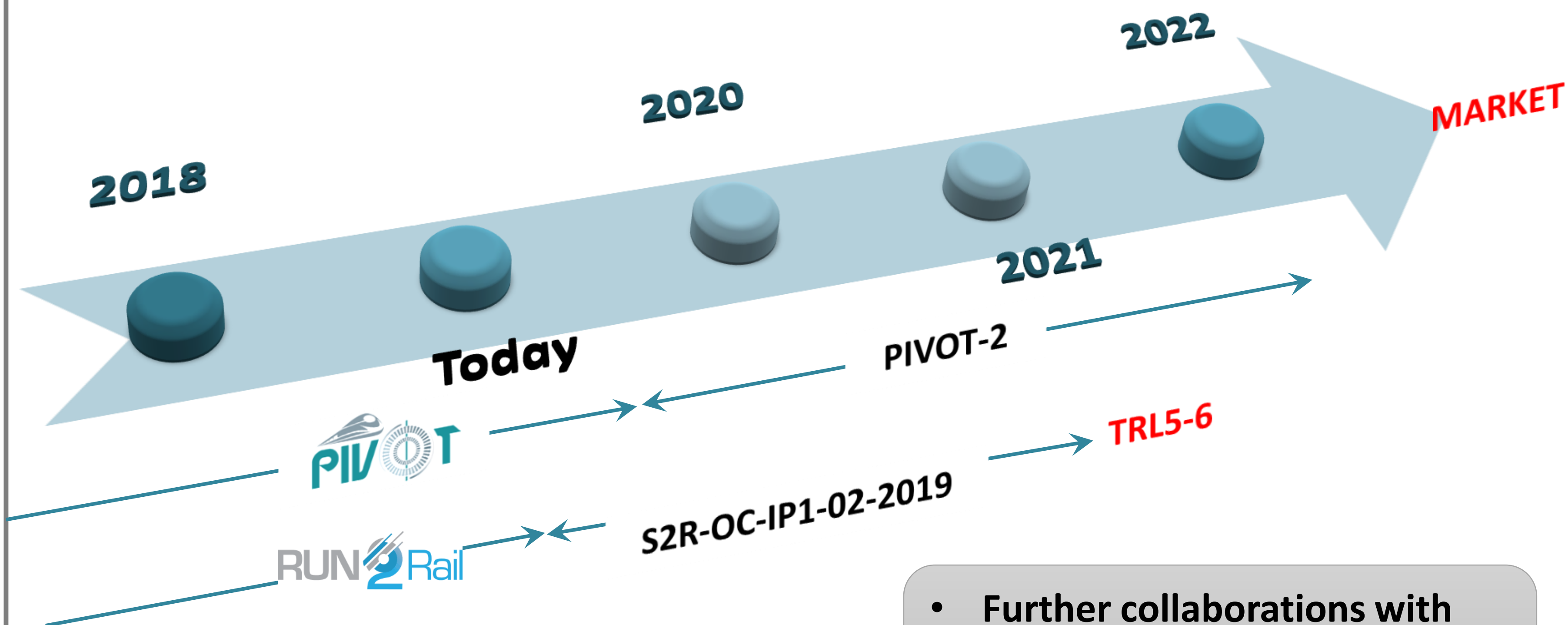
Scope: transmission of noise and vibration from the running gear into the carbody



Structure:

- Choice of case study vehicle
- Characterisation of suspension elements using laboratory measurements
- Develop methodology for predicting the transmission of noise and vibration ('virtual test method')
- Validation by means of physical tests (static and running tests)
- Assessment of noise reduction technologies

Future Outlook



- Further collaborations with CFM projects
- New EU R&D projects

More information about RUN2RAil

If you want to know more about the project please contact us

Marta Andreoni (UNIFE)
Project coordinator
Marta.andreoni@unife.org

or visit us at
http://www.run2rail.eu/

Designing the railway of the future: Fire resistant composite materials and smart modular design (Mat4Rail)

Mat4Rail *Project Overview*

Horizon 2020
European Union Funding
for Research & Innovation

Europe's railway industries require a **step change in technologies and design** for the next generation of **rail vehicles** to remain **globally competitive**.

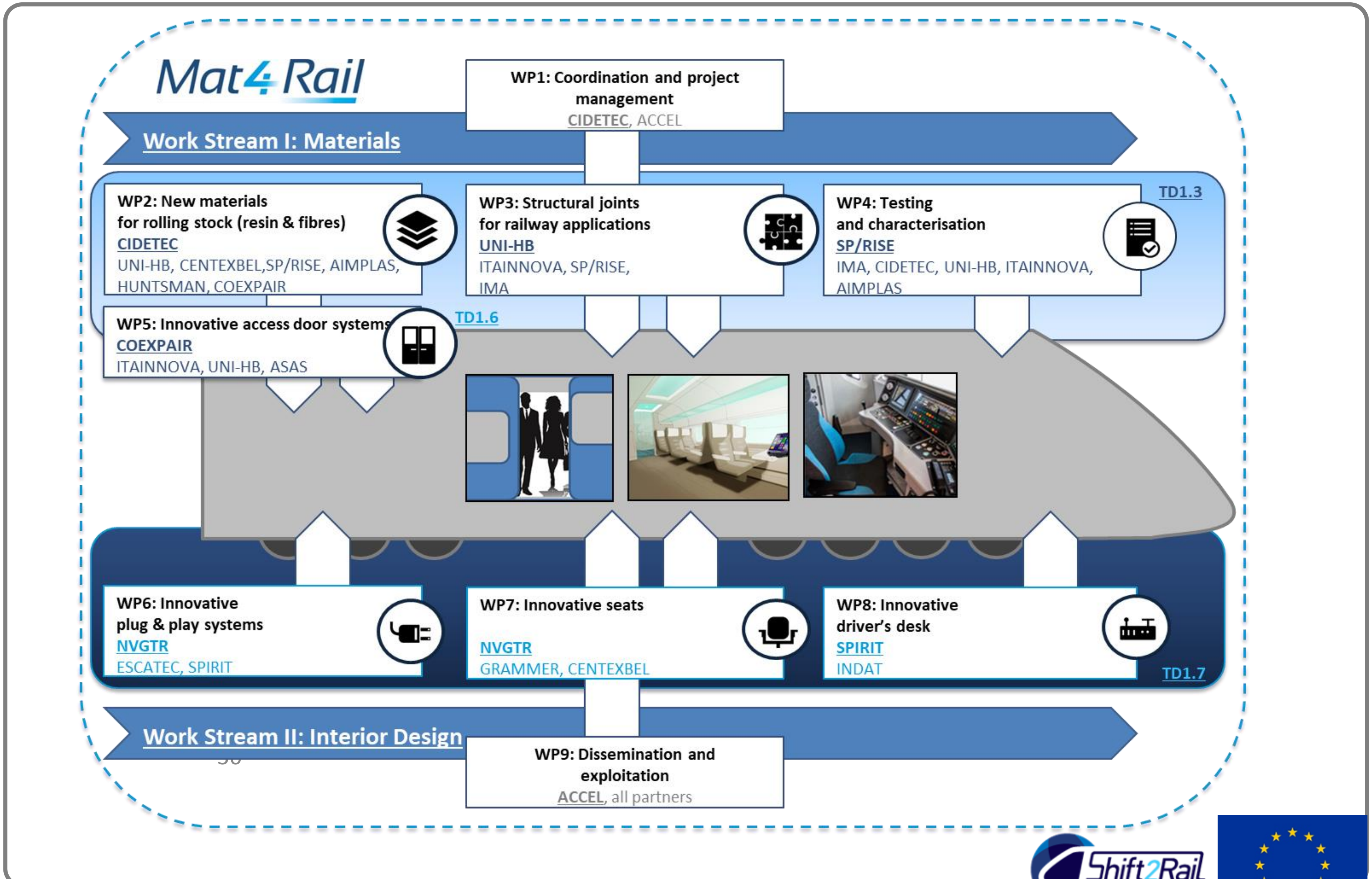
Innovation Programme 1	Innovation Programme 2	Innovation Programme 3	Innovation Programme 4	Innovation Programme 5
Efficient Technologies for High Capacity Trains	Traffic Management & Control Systems	Cost Efficient High Capacity Infrastructure	IT Solutions for a Seamless Railway	Technologies for European Freight

TD1.1	Traction
TD1.2	TCMS
TD1.3	Carbody shell
TD1.5	Running gear
TD1.5	Brakes
TD1.6	Doors
TD1.7	Train interiors

Mat4Rail
a Project of the S2R JU

- **Available structural composites do not meet Fire, Smoke & Toxicity requirement**s of the **railway** sector.
- **Innovative**, **energy- and cost efficient materials and design concepts** are needed.

Introduction Mat4Rail



Introduction Mat4Rail

PIVOT Mat4Rail RUN2Rail FAIR STATIONS

16 partners from 7 countries

- 7 SME

IMA DRESDEN, ESCATEC, NVGTR, coexpair, accelopment, INDAT INNOVATION, spirit design

- 5 Research Institutes

cidetec surface engineering, RISE, ITAINNOVA, AIMPLAS INSTITUTO TECNOLÓGICO DEL PLÁSTICO, CENTEXBEL

- 1 University

Universität Bremen

- 3 Industries

HUNTSMAN Enriching lives through innovation, GRAMMER, ASAŞ

Shift2Rail

Mat4Rail objectives;Materials Work stream

Reducing train weight by replacing metal parts with Fibre Reinforced Polymers (FRPs)

Develop FRPs (WP2 + testing in WP4) (TD1.3)

Develop structural joints for FRPs (WP3 + WP4) (TD 1.3)

Innovate access door system (WP5) (TD 1.6)

Main achievements of Mat4Rail WP2-4

✓ **6 new composites tested** for complete FST and mechanical characterization*.

	Resin type	Fibre type	Manufacturing process	T_g (ASTM D7028)	FVC (ASTM D3171)	Cured Ply Thickness (ASTM D3171)
Composite 1	Epoxy	Basalt	Prepreg+SQ-RTM	144	48,56%	0,270mm
Composite 2	Polybenzoxazine	Basalt	Infusion	164	52,34%	0,250mm
Composite 3	Hybrid chemistry	Carbon	DFCM**	287	48,85%	0,230mm
Composite 4	Polybenzoxazine	Glass	Infusion	163	51,48%	0,300mm
Composite 5	Hybrid chemistry	Basalt	DFCM**	304	56,18%	0,233mm
Composite 6	Hybrid chemistry	HP Carbon	DFCM**	301	59,07%	0,263mm

* All composites were manufactured with ~4 mm thickness.

** DFCM is Dynamic Fluid Compression Moulding. Could be also processed by infusion.

Main achievements of Mat4Rail WP2-4

➢ **Mechanical characterization** of materials have demonstrated their suitable performance for application in railway requirements

Test method	Parameter	Hazard levels requirements		
		HL1	HL2	HL3
ISO 5660-1	MAHRE (kW/m²)	-	90	60
ISO 5659-2	D_S max (-)	-	600	300
	CIT_G (-)	-	1,8	1,5
ISO 5658-2	CFE (kW/m²), min	20 (13*)	20 (13*)	20 (13*)

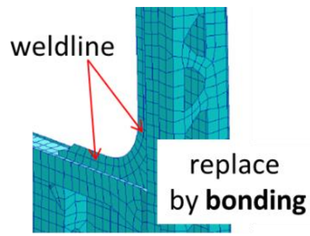
➢ **Complete accredited EN45545-2 (FST) classification tests conducted with the 6 composites.** Requirements for R7 (R8) and R17* railway **external applications** shown above.

➢ **Mat4Rail prepared 5 composites compliant with HL2.**

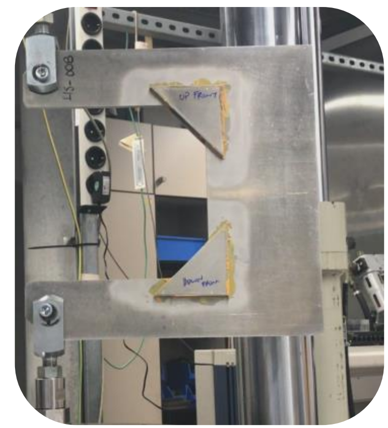
Property	Test method: Standard	Test method: Test specimen
Tensile strength	ISO 527-4	5 repetitions
Flexture strength	ISO 14125	5 repetitions
Interlaminar shear strength	ISO 14130	5 repetitions
Compression strength	ASTM D6641	5 repetitions
In plane shear strength	ISO 14129	5 repetitions
Bearing strength	ASTM D 5961 procedure A	6 repetitions
Open hole tensile strength	ASTM D 5766 procedure A	6 repetitions
Open hole compression strength	ASTM D 6484	6 repetitions
Interlaminar fracture toughness	EN 6033	10 repetitions
Fatigue strength	ISO 13003	36 specimen

WP3 - Development of structural joints for railway applications

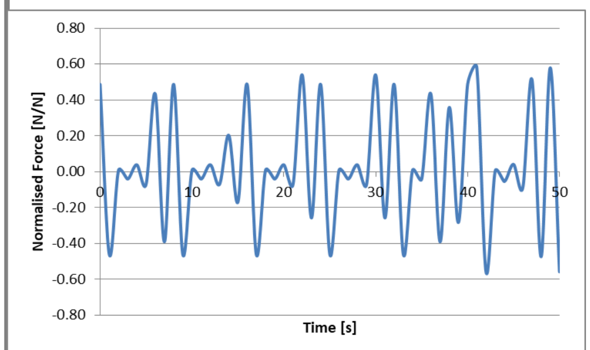
Methodology for static strength and fatigue assessment of joints



validation on demo case



load cases - DIN EN 12663



Testing of coupons

multiaxiality = hydrostatic/deviatoric stress

effects on strength:

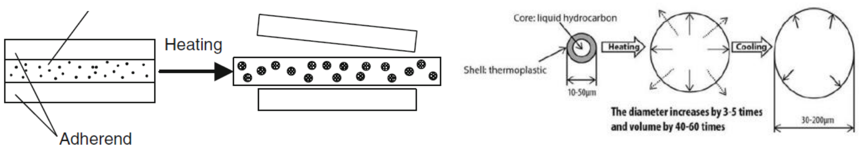
- temperature/moisture
- load ratio
- creep

➔ Homologation procedure for polymeric materials (fatigue, operational loads) validated for the example „structural adhesive“

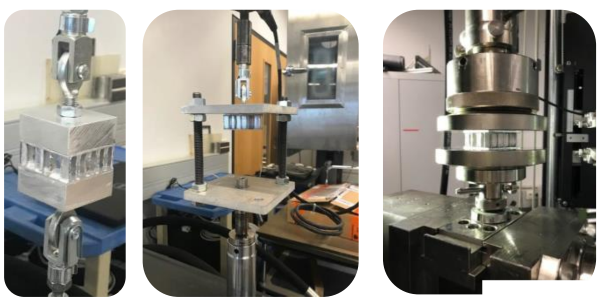
Joint concepts for refitting for dissimilar and/or polymeric materials

debonding on command

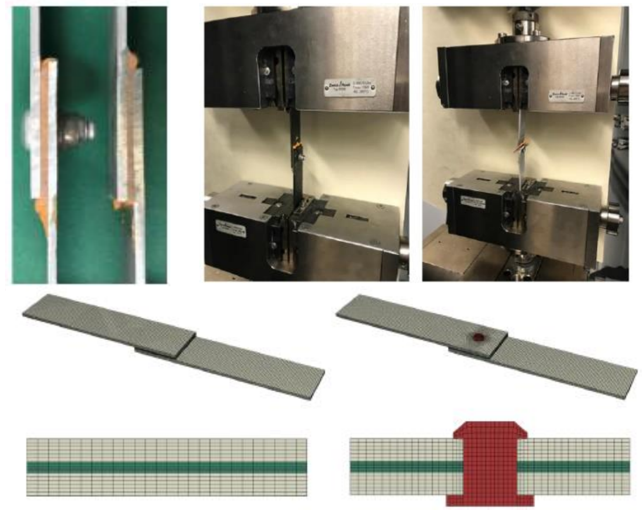
thermally expandable particles



sandwich structures/inserts



hybrid joints

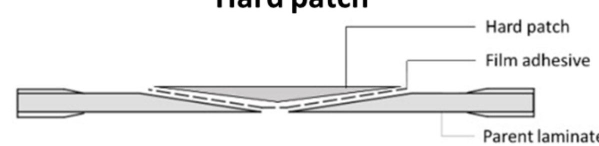


repair

Soft patch

Less complex and less expensive option

Hard patch



Approach preferred in aeronautics (higher level of quality control)

➔ Concepts for joining, refitting, repair

Images source: Handbook of Adhesion Technology, Springer,2011

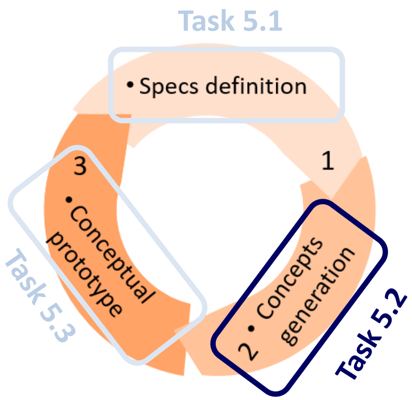
Innovate access door system (WP5)- TD 1.6;

disruptive” leaves

- Define **requirements and specifications for the door leaves** of access doors (Task 5.1)
- Identify, analyse and select door **concepts, materials and processes** (Task 5.2)
- Develop door concepts. **Study, benchmark and choose door leaves architecture** and **assembly solutions** for their manufacturing (Task 5.3)

Main achievementsof Mat4Rail WP5

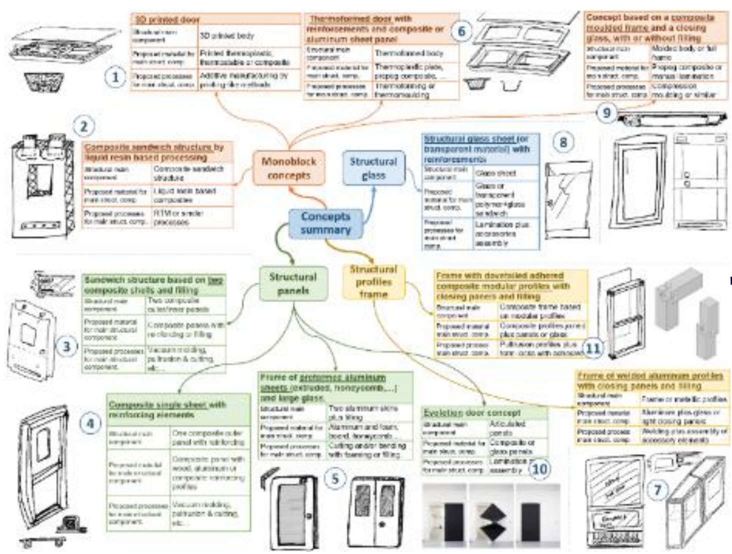
- “disruptive” leaves

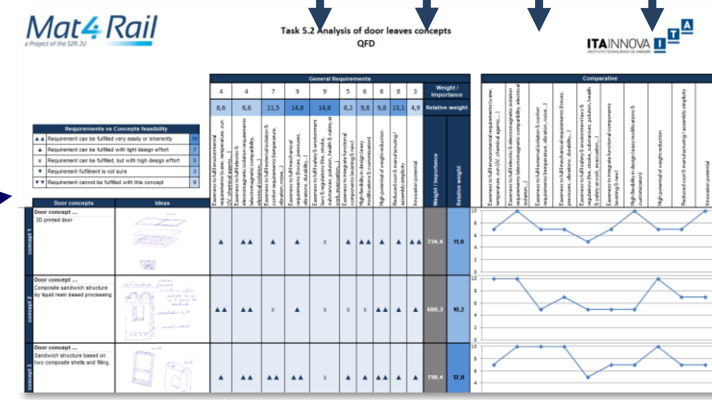


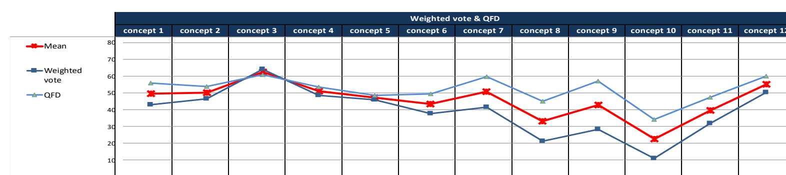
T5.2 Concepts generation

Concepts evaluation & selection

-Advantages vs Drawbacks
-Weighted vote
-QFD





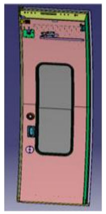


	concept 1	concept 2	concept 3	concept 4	concept 5	concept 6	concept 7	concept 8	concept 9	concept 10	concept 11	concept 12
Mean	49,39	50,09	62,39	51,06	47,13	43,49	50,55	33,09	42,67	22,65	39,60	55,11
	6	5	1	3	7	8	4	11	9	12	10	2

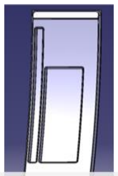
Main achievementsof Mat4Rail WP5

PIVOT Mat4Rail RUN2Rail FAIR STATIONS

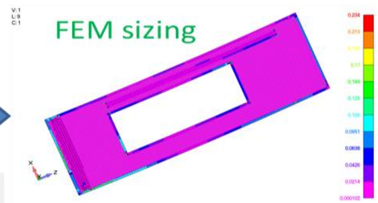
Concept 1: Composite materials



Current door



BFRP concept



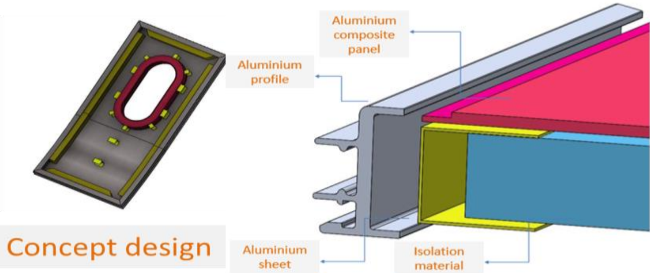
basalt/epoxy with foam core.

core machining

SQRTM injection

Out of outoclave closed mold process

Concept 2: Aluminium with innovative processes

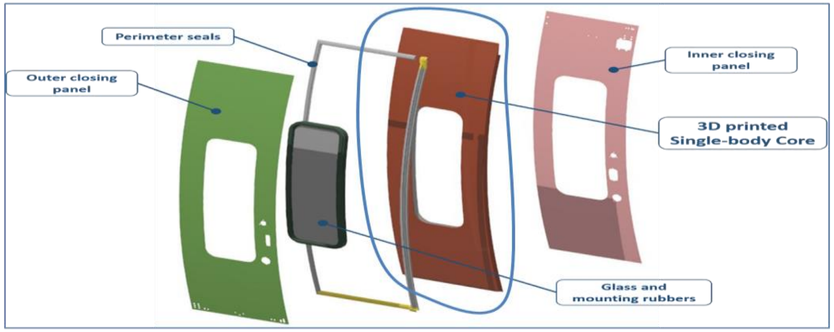


Concept design

•Improved in terms of weight, acoustic attenuation and thermal insulation

• Only adhesive used / No welding

Mock-up



Concept 3: Additive manufacturing

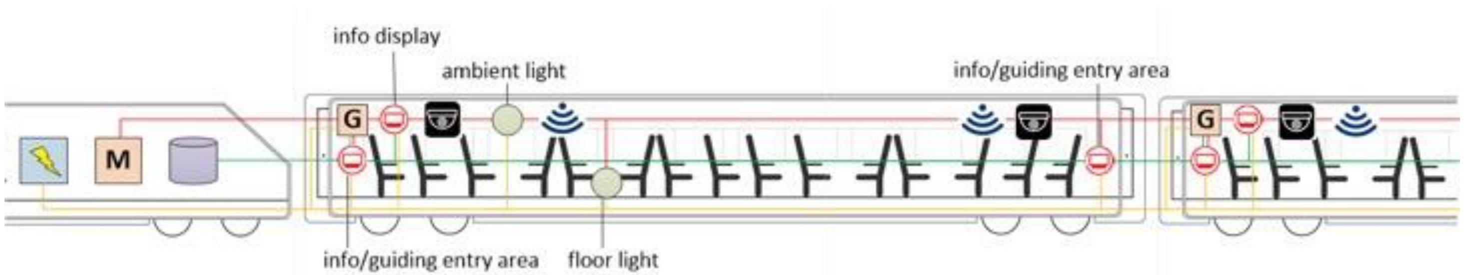
- **Single-body core** door leave concept with different **structural areas** defined depending on the **function**
- Concept based on **additive manufacturing** innovative processes configured with **different constructive internal structures within the same single part**

Shift2Rail

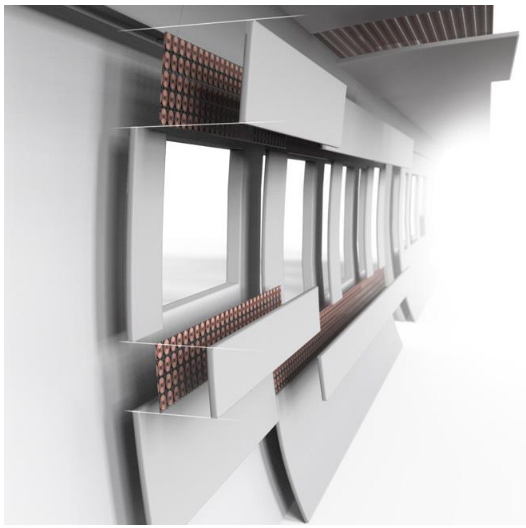
Mat4Rail objectives;
Interior Design Work stream

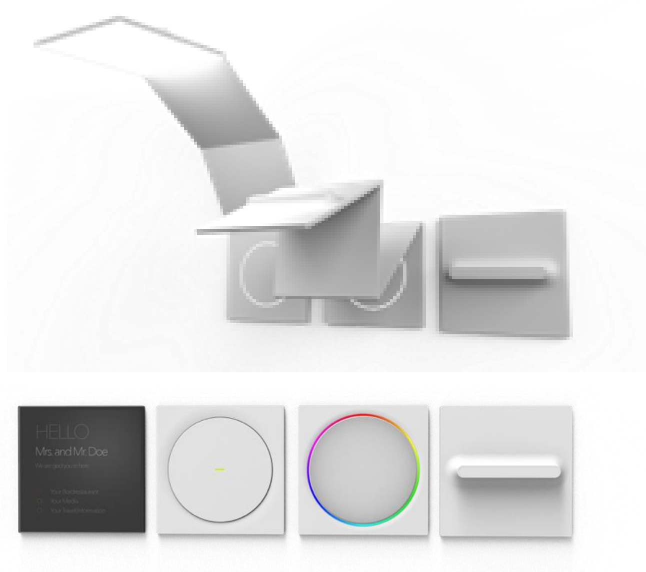
Innovative plug & play system (WP6)- TD 1.7

- Improve **train interiors layout and service** offering elements that add to passenger comfort being **easily modified** during their service life
- Develop **new modular and adaptable electric utilities** for the provision of services for passenger supported by design detailing that validates the key concept innovations with visualisations and UX mock ups.



Main achievements Mat4Rail WP6



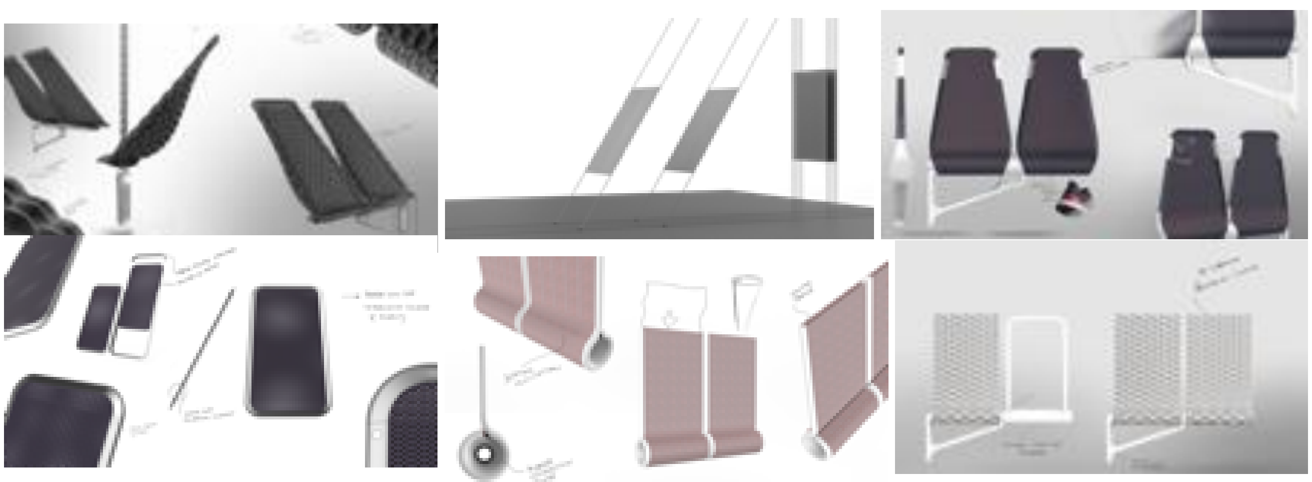


The final result of **Mat4Rail WP6 Plug & Play systems are first functional tile mock ups and energy prototype grid.** The system with the **functional tiles**, addresses all the needs with an **intelligent multi layered energy & communication grid** and its **flexible mounting structure.** For quick and easy refurbishment, Installation on side wall of the train. First tile wall concept solutions work with printed coil foil electro-magnetic solutions.

Main achievements Mat4Rail WP7

Innovative seats (WP7)- TD 1.7

- To develop a hyper flexible and intelligent **new ultra-lightweight seat system** that can be arranged and fitted in a **super dense and rapid way**.
- To design a new solution based on application innovation, **dynamic structure, plug & slide solutions and new flexible materials.**



Main achievements OC WP7

Final result: **first functional prototype.**

A new seat principle, a seating concept with the highest possible **flexibility** and **ultra-light weight**. A small frame structure is holding **an intelligent woven inlay structure**, that generates all the **ergonomic and comfort** need. The lightweight frame system is cantilever suspended or floor based fixed in single or double seat form.

Main achievements Mat4Rail WP7

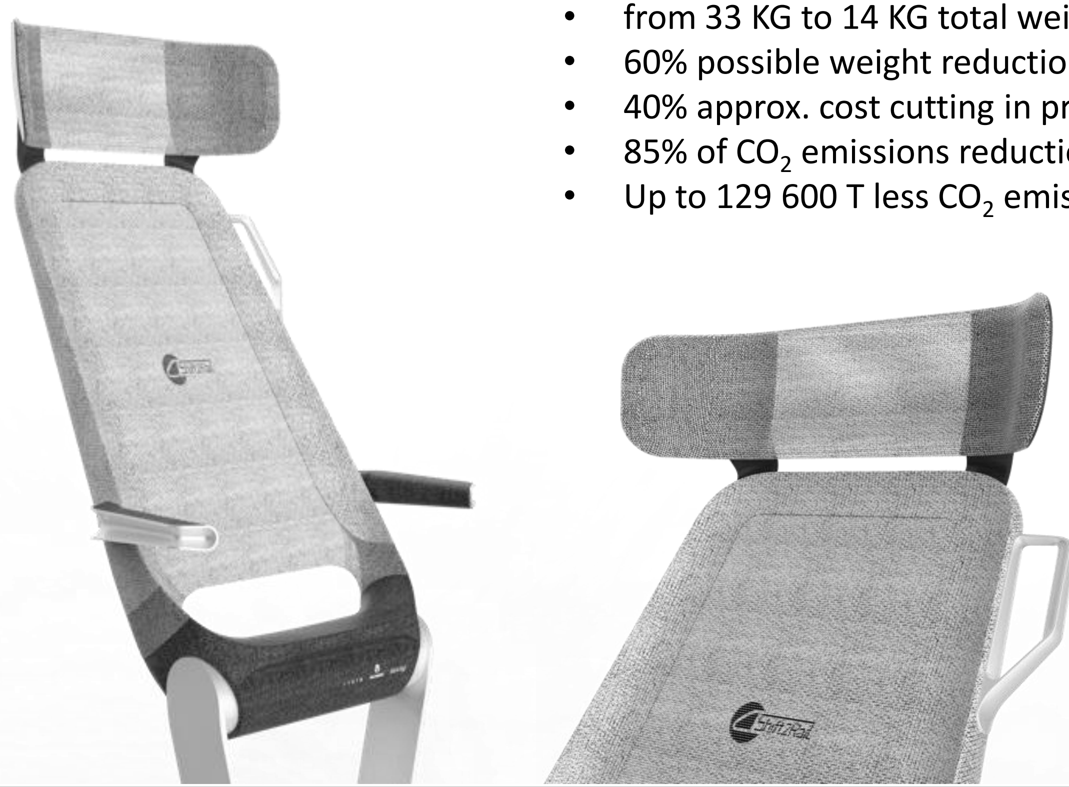
2T

APPROX. WEIGHT REDUCTION PER TRAIN

(MUNICH S-BAHN as Comparison Base - DB-Type Series 423 / 146 Seats)

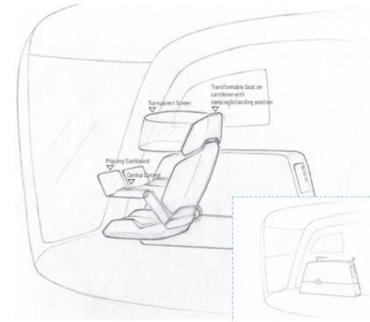
TANGIBLE, PRODUCIABLE VISION that has an impact on:

- reduction from upwards of 50 parts down to 7
- from 33 KG to 14 KG total weight (for one cantilevered seat)
- 60% possible weight reduction compared to industry standard
- 40% approx. cost cutting in production
- 85% of CO_2 emissions reduction during production
- Up to 129 600 T less CO_2 emissions per year, full average use



Mat4Rail objectives;

Interior Design Work stream



Innovative driver’s desk (WP8)- TD 1.7

- Identify **needs and opportunities**
- Develop **2D- and 3D-models** of the stand including modular built-up of the driver’s seat
- Develop a driver’s stand design that combines a **compact** driver’s space with **an easily evolutive built-up** and **modularity of the equipment** as well as the **possibility to integrate the desk on demand**.

Commuting train: *City shuttle SGP 80-73*

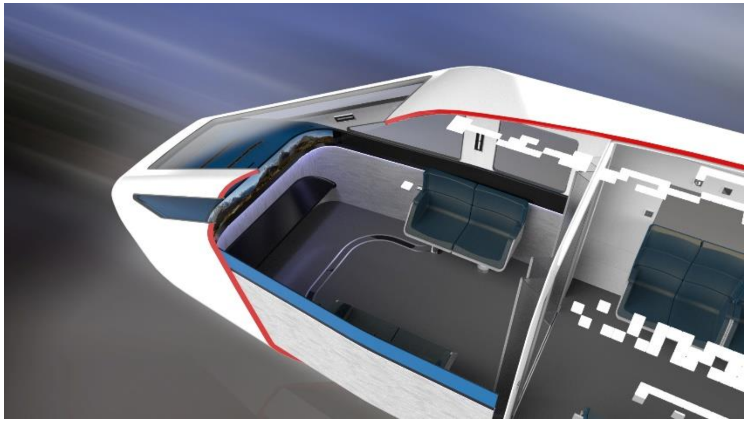
Shunter & track locomotive: SGP 1163

Track locomotive: Siemens 1116 Taurus

Results of WP8

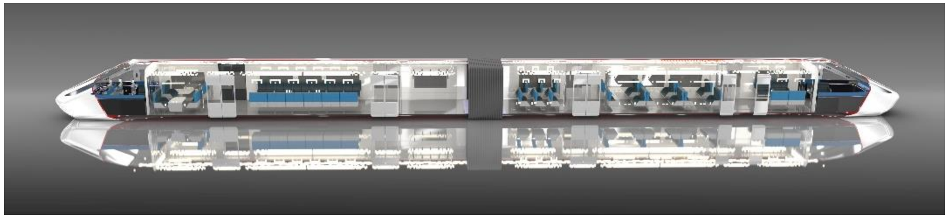
The resulting final virtual prototype contains:

- A very **compact** and **on-demand** drivers cabin which allows passenger- and driver mode
- A **robotic arm** which serves as a **modular mounting for the multifunctional HMI & control tablet**
- **A big screen with an augmented reality dashboard**
- A **simple** yet comfortable **seat layout** concept which allows **easy changing of modes** and seat models



WP8 Virtual Prototype in passenger mode

WP8 driver mode with trainer chair



Virtual Prototype for WP6 & WP8

Dissemination

Publications

(2019). Paving the way for a wider use of composites in railway industry. J. of Thermal Analysis and Calorimetry 1-12. doi: https://doi.org/10.1007/s10973-019-08286-6

Presentations

- March 2018, Fire protection of rolling stock FPRS 2018, Berlin, "Mat4Rail: Research on fire safe composite materials within the Shift2Rail programme"
- May 2018, Epoxy and Resins Technology Conference, Stockholm, "Towards a composite based carbody: Improving the FST properties of epoxy resins".
- June 2019, FPRM2019, Fire Retardant Polymeric Materials "Manufacturing of fiber reinforced polybenzoxazine with advanced fire, smoke and toxicity properties".
- July 2019, AB2019 Conference, 5th International Conference on Structural Adhesive Bonding, Porto, "Analysis of fracture toughness characterization for a structural high crash resistance adhesive".
- July 2019, MATCOMP 2019 XIII National Congress of Composite Materials, Galicia, Spain, "Study of the influence of flame-retardant additives on the mechanical properties of epoxy-fiberglass and basalt composites"
- September 2019, EUROMAT 2019, European Congress and Exhibition on Advanced Materials and Processes, "Composite materials for railways".

Videos

- Sept 2018, INNOTRANS, Shift2Rail quick win video presentation https://youtu.be/5vJ33idsfAs
- Mat4Rail video https://youtu.be/VprwkrvcR6A

Mat4Rail newsletter

Mat4Rail Newsletter 01 | June 2018

The project behind the trains of the future

What Mat4Rail is all about and who is involved

Mat4Rail Newsletter 02 | December 2018

The driver's desk of the future will be modular and flexible!

Mat4Rail proposes a user-centred concept development as an innovative solution

Mat4Rail Newsletter 03 | April 2019

Design in the Railway Industry

Subscribe to the Mat4Rail newsletter at our website:

mat4rail.eu

Or directly here:
http://eepurl.com/dvzoSf.

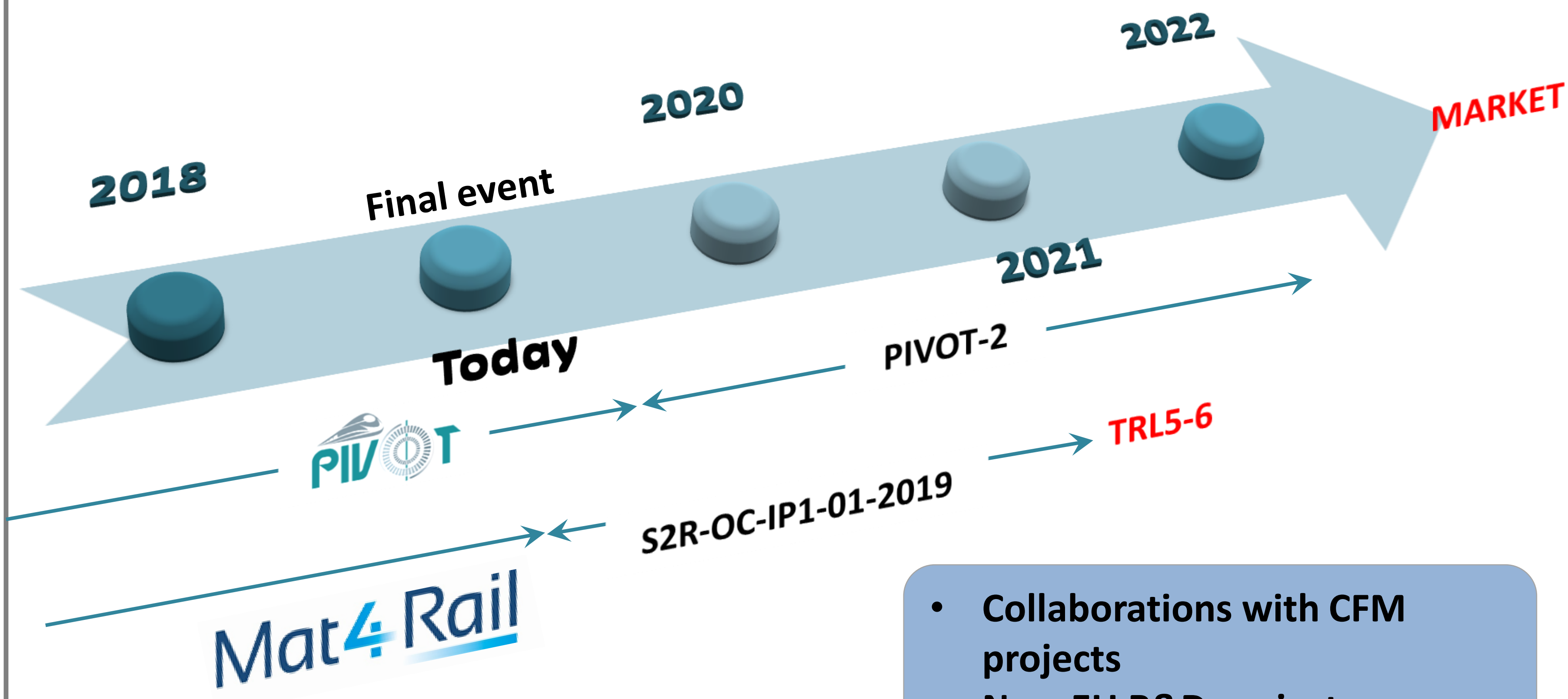
Final results in September newsletter

Sign-up now

3 Newsletters sent

- 27 June 2018
- 5 December 2018
- 30 April 2019

Future Outlook



- Collaborations with CFM projects
- New EU R&D projects

Mat4Rail main contact

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Mat4Rail Coordinator
Business Development Manager
Polymers & Composites Unit
Phone: +34 943 30 90 22/ +34 699 500 621
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cidetec

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20009 Donostia - San Sebastián
Spain

Motivation

PIVOT

PERFORMANCE IMPROVEMENT
FOR VEHICLES ON TRACK

PIVOT *Project Overview*

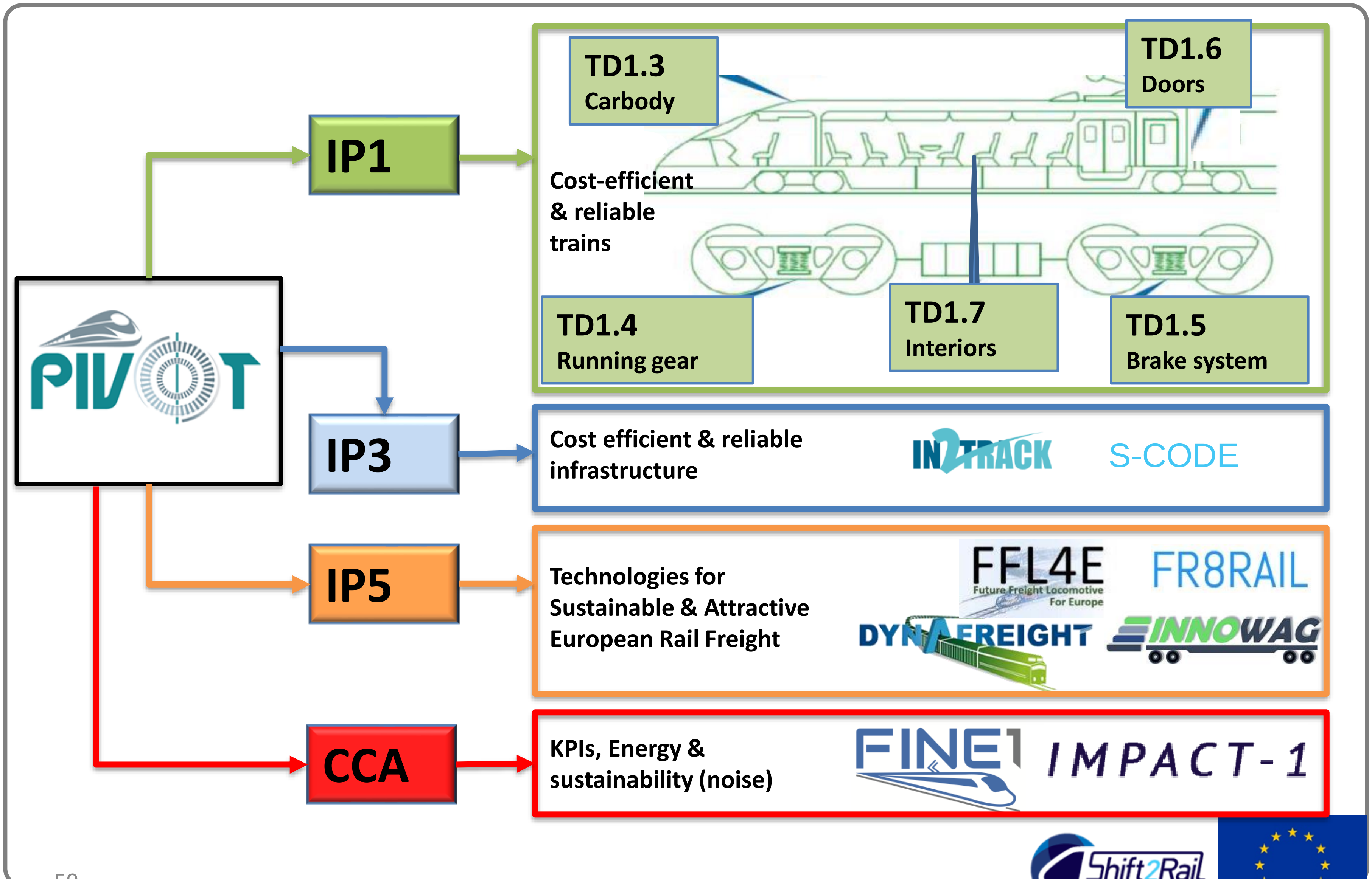
Horizon 2020
European Union Funding
for Research & Innovation

Innovation Programme 1	Innovation Programme 2	Innovation Programme 3	Innovation Programme 4	Innovation Programme 5
Efficient Technologies for High Capacity Trains	Traffic Management & Control Systems	Cost Efficient High Capacity Infrastructure	IT Solutions for a Seamless Railway	Technologies for European Freight

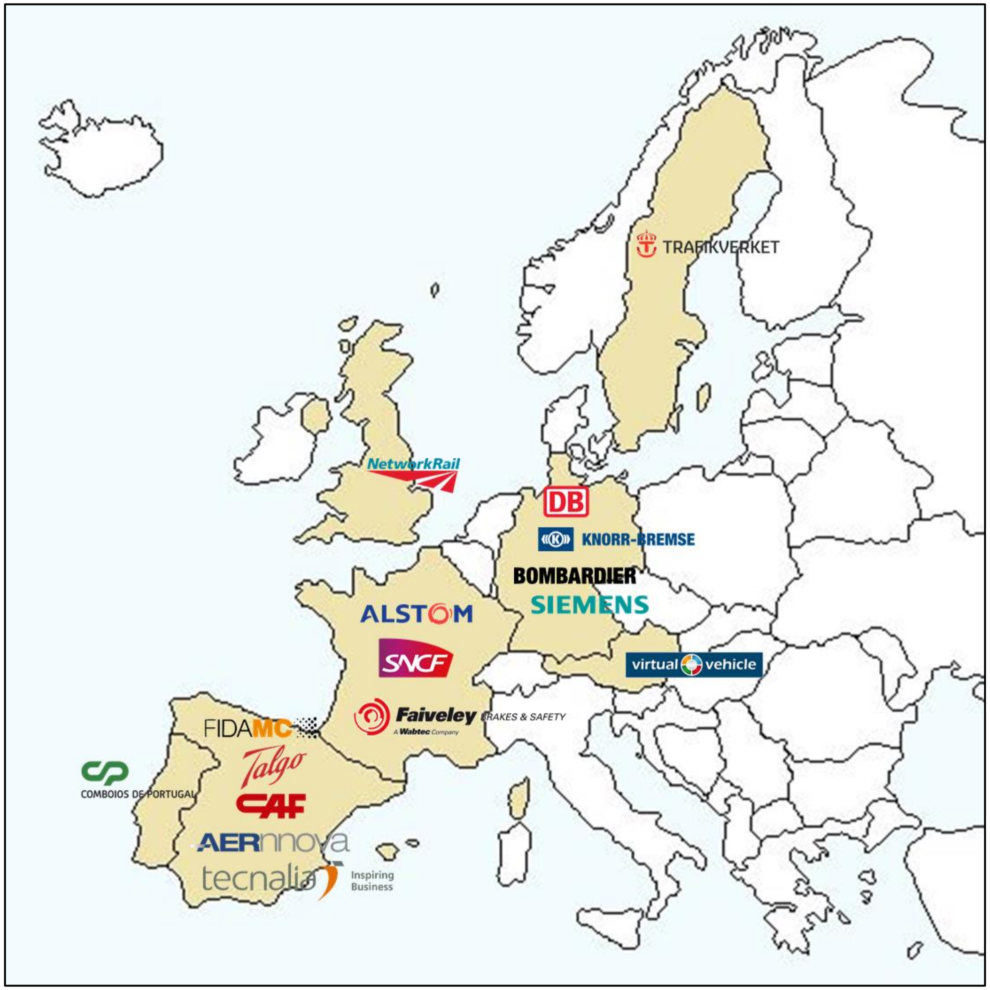



TD1.1	Traction
TD1.2	TCMS
TD1.3	Carbody shell
TD1.5	Running gear
TD1.5	Brakes
TD1.6	Doors
TD1.7	Train interiors

Integration into S2R



Project Partners and tech. WP Leaders



Project Coordinator –

BT – Paul Böttcher

WP1 – Talgo – Eduardo de la Guerra

WP2 – ANN – Carlos Eraso Alvarez

WP3 – CAF – Asier Alonso Pazos

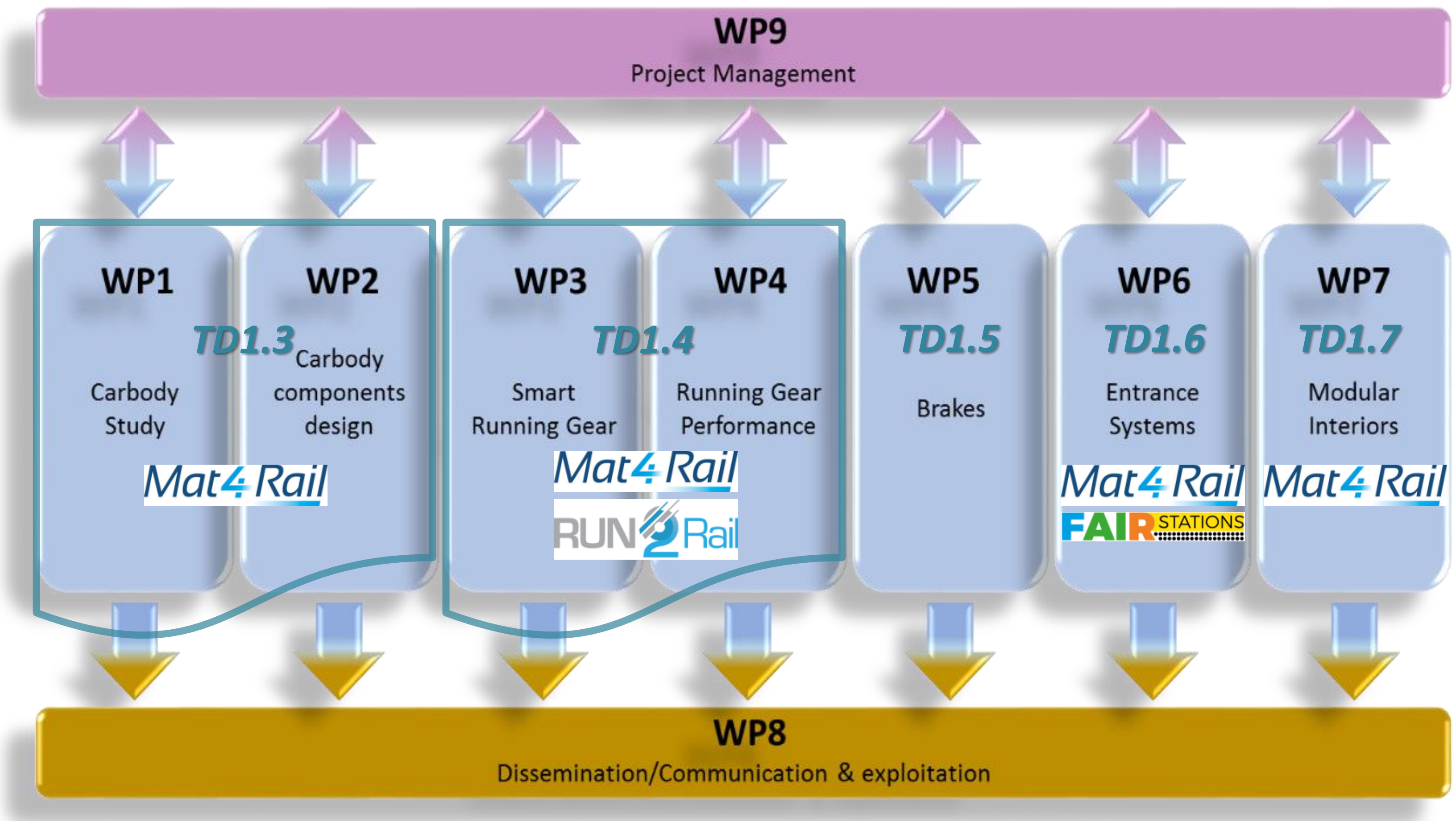
WP4 – Talgo – Eduardo de la Guerra

WP5 – KB – Jasmina Brackovic

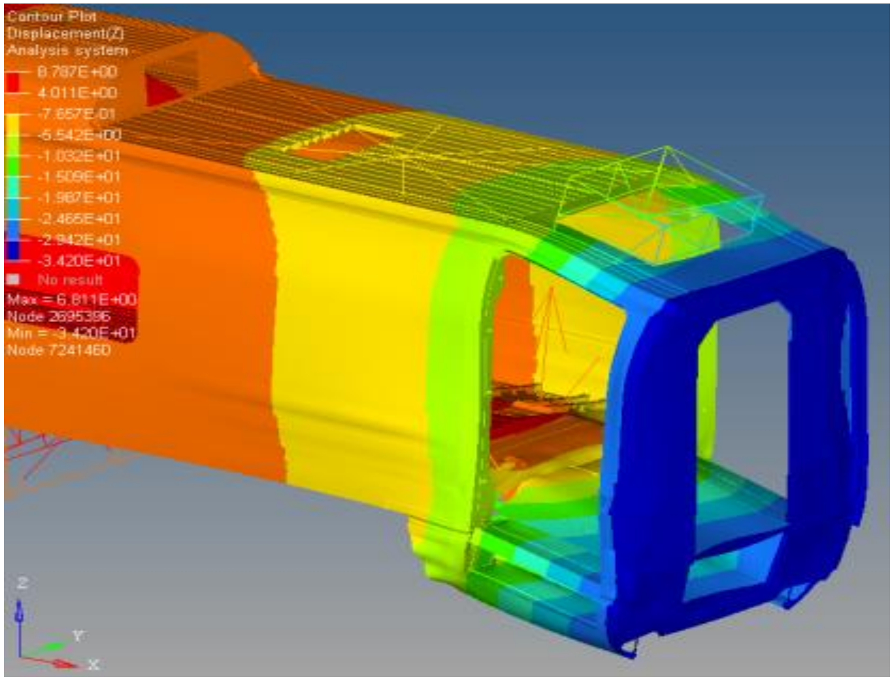
WP6 – FTT – Thierry Montanie

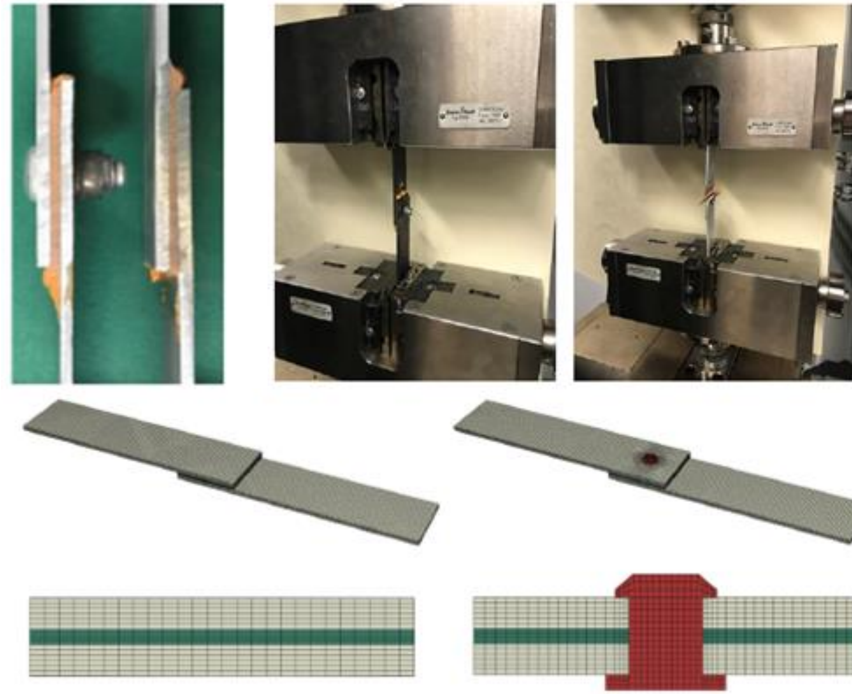
WP7 – SNCF-M – Robert Dumortier

Project Structure



PIVOT highlights TD1.3

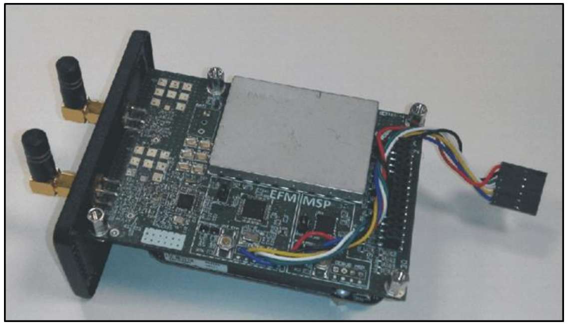


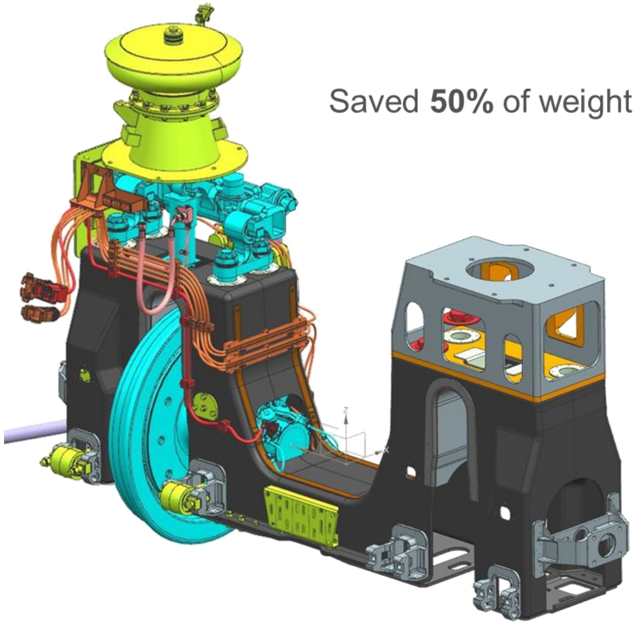


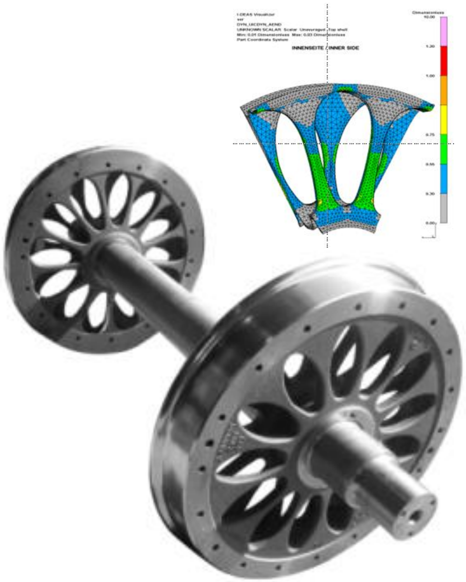
Composites in carbody

Joint concepts for polymeric and dissimilar materials

PIVOT highlights TD1.4





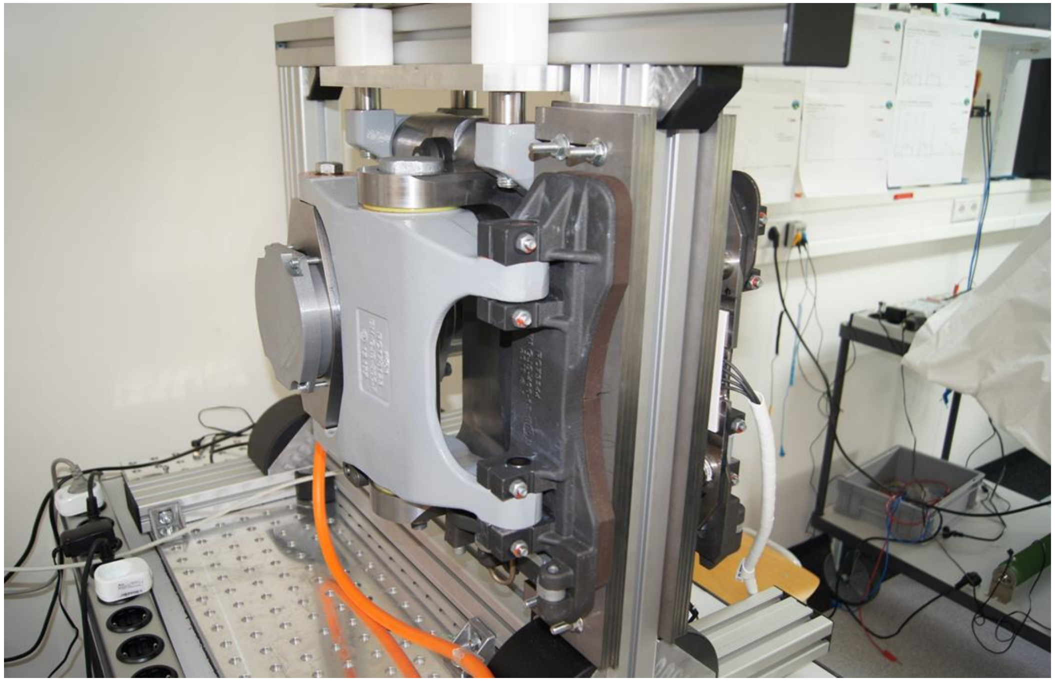


Running gear HMS for vehicles and track

Composites in structural components

ADI spoke wheel

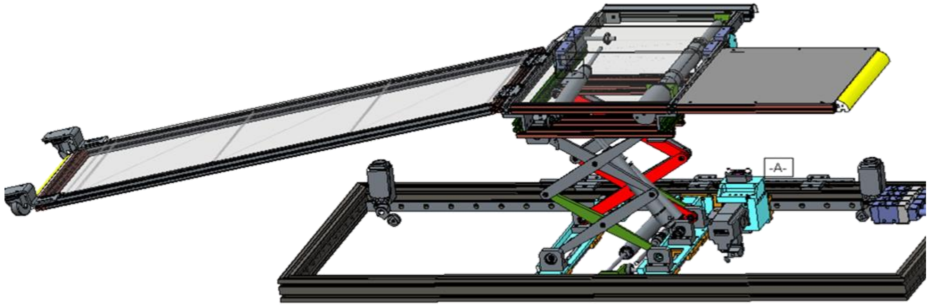
PIVOT highlights TD1.5

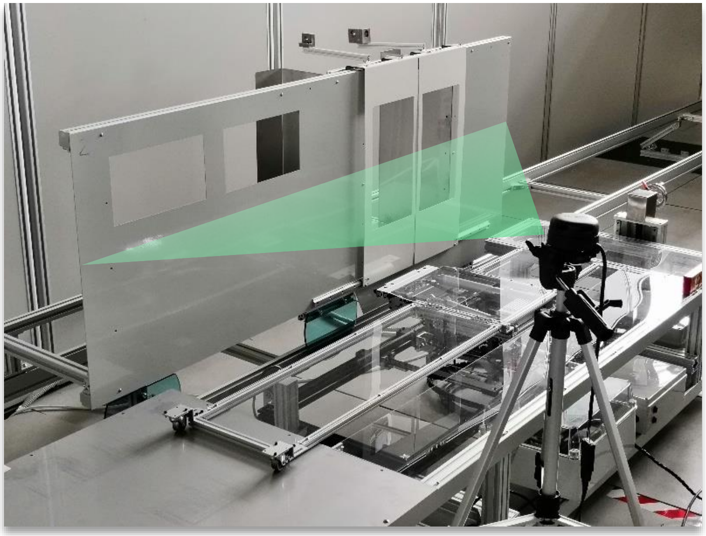


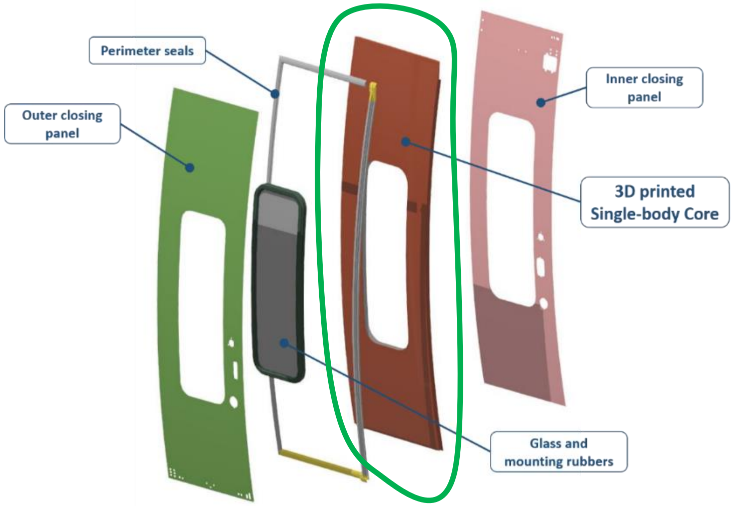
Electro-Mechanic Brake

Innovative Friction Pair

PIVOT highlights TD1.6



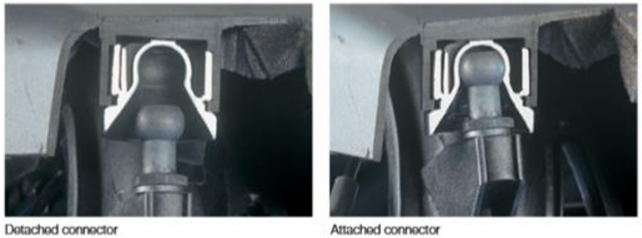




Entrance detection technologies

PTI platform solutions

“Disruptive” leaves



Opportunities of digitalization in cabin

Concepts modular interior

Dissemination

Major Events:

- ❑ InnoTrans 2018
- ❑ TRA 2018
- ❑ IWC 2019
- ❑ Composites in Rail
- ❑ CONFERENCE ON COMPOSITE
- ❑ ICCM22 TWENTY-SECOND INTERNATIONAL

Dissemination material and public documents available at:

https://projects.shift2rail.org/s2r_ip1_n.aspx?p=pivot

Long term objective

Agenda for today

Time	Topic of discussion	Speaker
08:00 – 09:00	*Registration and welcome*	
09:00 – 09:10	*Introduction by Shift2Rail*	S2R JU
09:10 – 09:50	*Project presentations; objectives, achievements and expectations on the joint final event*	P. Böttcher (BT) E. Jubete (CIDETEC) M. Andreoni (UNIFE) U. Battista (Stam)
09:50 – 10:40	*TD1.7 – Train modularity in use*	R. Dumortier (SNCF-M), C. Jurke (NVGTR) W. Fargel (SPIRIT)
10:40 – 10:55	*Video session*	W. Fargel (SPIRIT)
10:55 – 11:15	*Coffee break*	
11:15 – 12:05	*TD1.4 – Running gear*	E. de la Guerra (TAL), A. Alonso (CAF), S. Iwnicki (HUD), S. Stichel (KTH)

Agenda for today

Time	Topic of discussion	Speaker
12:05 – 12:55	*TD1.5 – New braking system*	J. Brackovic (KB) A. Boggione (Faiveley) S. Ferrara (Faiveley)
12:55 – 14:10	*Lunch / poster / demo session*	
14:10 – 15:00	*TD1.6 – Innovative doors*	T. Montanié (Faiveley) J. Arrabal (ANN) U. Battista (STAM) P. Severin (Coexpair) J. M. Bielsa (ITA)
15:00 – 15:50	*TD1.3 – The new generation of car body shells*	E. de la Guerra (Talgo) J. Arrabal (ANN) A. Rekondo (CIDETEC) M. Brede (Fraunhofer-IFAM, UNI-HB) P. Blomqvist (RISE)
15:50 – 16:00	*Wrap-up / end of the meeting*	

Enjoy the event!

17th September 2019
Paris

TD1.7 – Modularity In Use

Involved Projects: PIVOT, Mat4Rail

Technical Leaders: Robert DUMORTIER (SNCF Mobilités),
Christian Jurke (Navigator) and Wolfgang Fargel (Spirit Design)

PIVOT – OC final conference
17th September 2019
Paris


18
2953

Introduction to TD1.7

2018

Linear configurations

Design freeze

Task schedule

2022

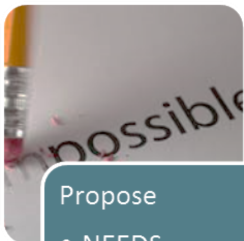
Configuration free

Free mind

Plug&Play

MORE ATTRACTIVE TO PASSENGERS
MORE FLEXIBLE TO OPERATORS

Introduction to TD1.7



Propose
- NEEDS
- PRIORITIES
- TECHNICAL WATCHES
- PRE-STUDIES
- TARGET COST

Develop
- FEASABILITY
- DRL/TRL SCALE
- PROOF OF CONCEPTS
- MOCK-UPS

Validate
- NEW MARKETS
- NEW OFFERS

PIVOT
2018-2019

PIVOT2
2019-2022

Reduce the time and cost to market :
IMAGINE / TEST / DEPLOY
ANYWHERE / ANYTIME

More attractive and more flexible :

- To reduce the cost of a refurbishment
- To reduce the time of layout change
- To set up a plug and play approach
- To offer the full freedom to change interiors
- To reduce cost operation
- To simplify the validation process

Introduction to TD1.7

PIVOT Mat4Rail RUN2Rail FAIR STATIONS

INTERIORS

CABIN

PIVOT

SNCF SIEMENS DB AERnnova

SNCF SIEMENS DB ALSTOM virtual vehicle

Mat4Rail

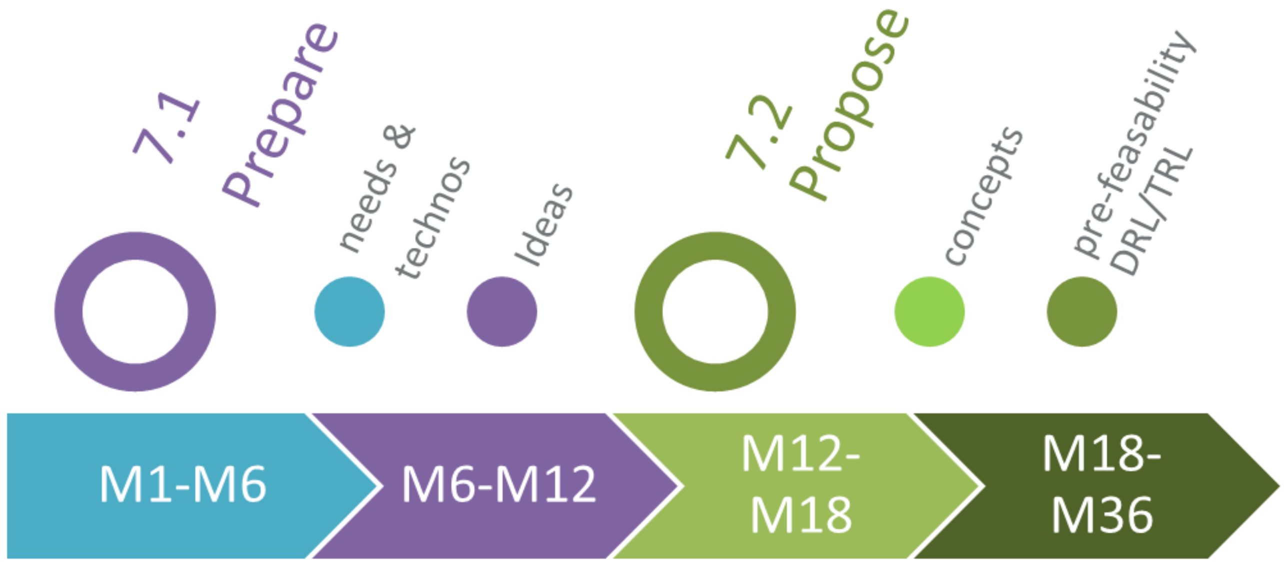
NVGTR PRODUCT INNOVATION I DESIGN STRATEGY

spirit design thinking the future

Shift2Rail

INTERIORS

Main achievements INTERIORS



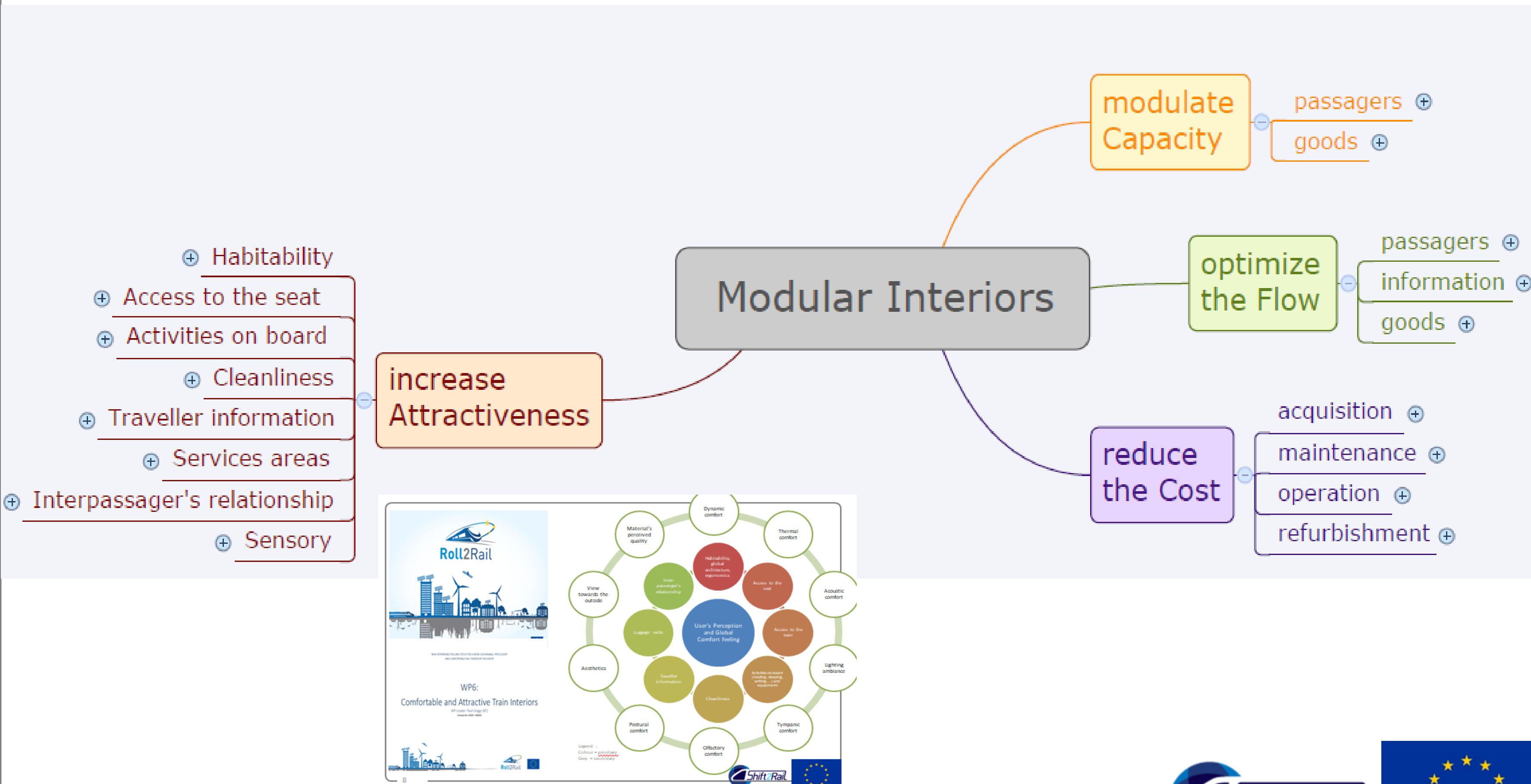
NVGTR
PRODUCT INNOVATION I DESIGN STRATEGY

ULTRA LIGHT SEAT – WP6

PLUG&PLAY SYSTEMS – WP7

Main achievements INTERIORS

NEEDS



Main achievements INTERIORS

NEEDS

MODULATE CAPACITY

- Layouts : add/delete seats and luggages racks
- Layout : configuration free
- Spaces : add/delete main services as toilet

OPTIMIZE THE FLOW

- modulate the information (visual / sound) or layout to guide passengers in real time
- add/delete equipements (handrail, ...) which could have an impac t about passengers flow

PRIORITIES

PIVOT

REDUCE THE COST

- Maintenance cost : quick replace
- Acquisition cost : design to cost
- Refurbishment cost : design to cost and quick replace
- Plug&Play also for electric equipment

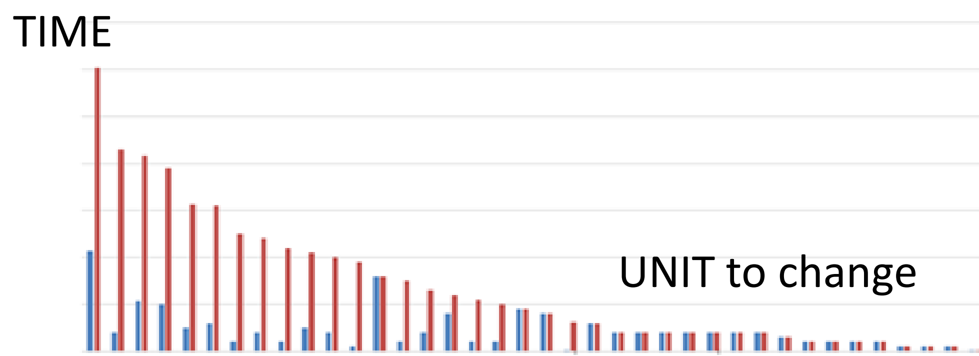
ATTRACTIVENESS

- Modulate activities on board
- Guarantee of cleanliness
- Modulate passenger information
- Modulate services aera
- Modulate interpassengers relationship
- Modulate the ambiance/comfort

Main achievements INTERIORS

COST

Analysis : Design cost study



Results : main opportunities

AXE 1

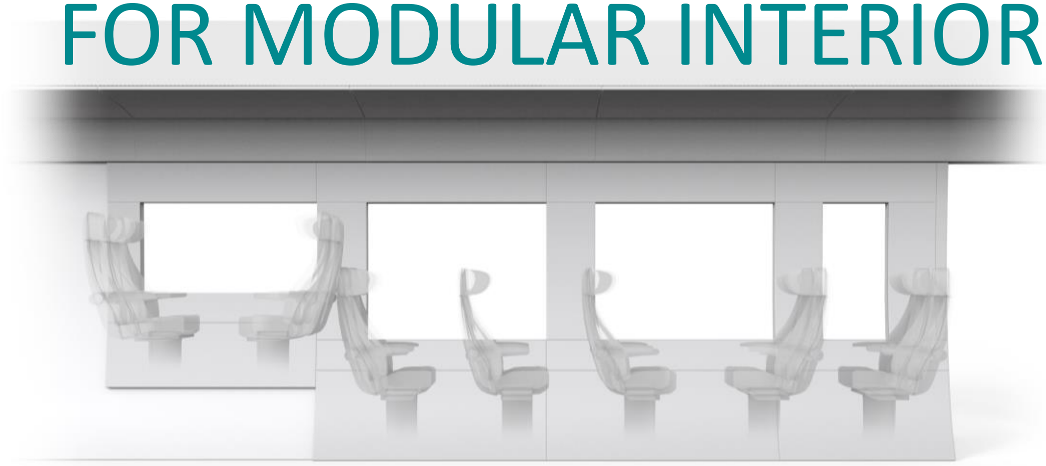
Modular layout

AXE 2

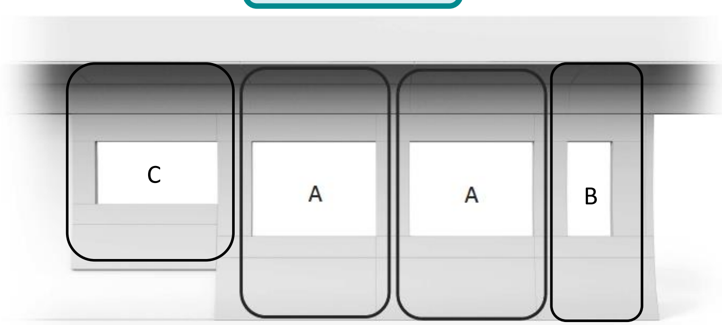
Modular Atmosphere

Main achievements INTERIORS

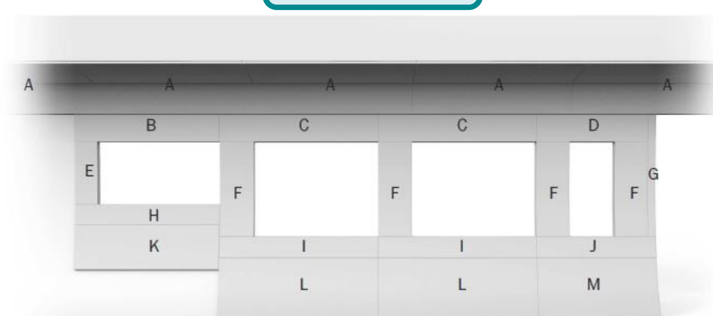
2 GREAT DESIGN MINDS FOR MODULAR INTERIORS



TYPE 1

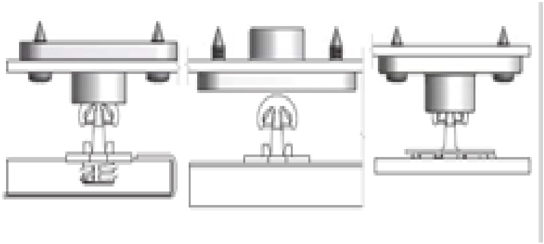


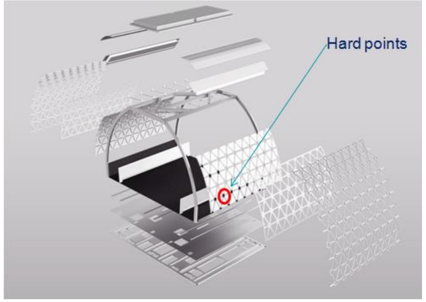
TYPE 2



TECHNOLOGIES

Study new advanced concepts interior joints





Detached connector

Attached connector

Main achievements INTERIORS

RESULTS

- modularity
- Improve requirements
- Easy assembly
- Easy maintenance
- Reduce cost

WP6- Plug&Play systems

WP7 – Ultralight Seats

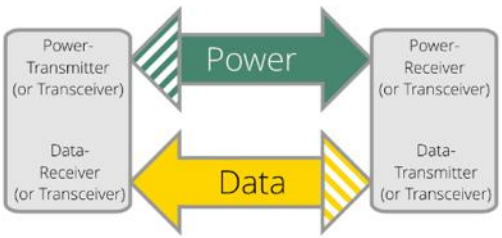
Main achievements OC Interiors

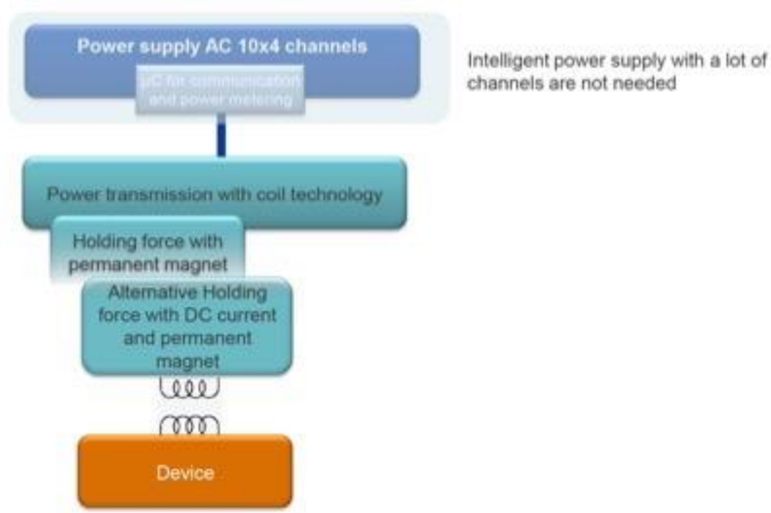
The final result of **Mat4Rail WP6 Plug & Play systems are: first functional tile mock ups and energy prototype grid.** It was developed based on the **following objectives** which were **derived from research, user analysis** and agile design concept development:

- Quick and easy refurbishment
- Installation on side wall of the train
- Many tracks possible -> can also be used for control bus
- Many different suppliers for lighting and crane systems
- Available with protection against contact
- Available with rollers or sliding contacts

The system with the functional tiles, addresses this needs with an intelligent multi layered energy & communication grid and its flexible mounting structure & coupling system. Derived from design iterations and concept progress, a "new possible standard" for functional tiles can be established. Future function tile size and the energy grid layout will be a proposed 75mm by 75mm.

Main achievements OC Interiors

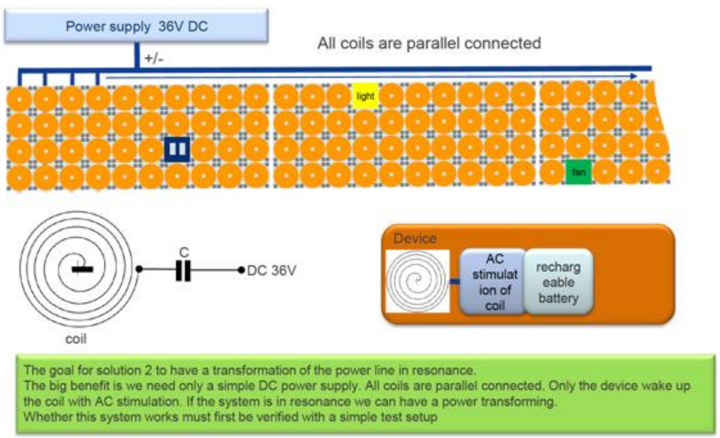


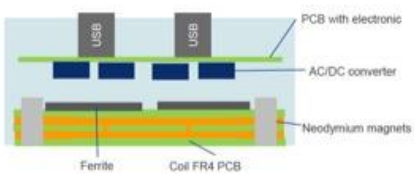


Cable and contactless energy and data transmission

With a customer-specific, contactless energy transmission systems, almost every use case requirement can be met. With specially adapted resonance transducers, the system succeeds in providing inductive power transmission with maximum possible efficiency while at the same time falling below the limit values prescribed for electromagnetic compatibility. Depending on the bridged distance and output power overall efficiencies of well over 90% are possible.

Main achievements OC Interiors



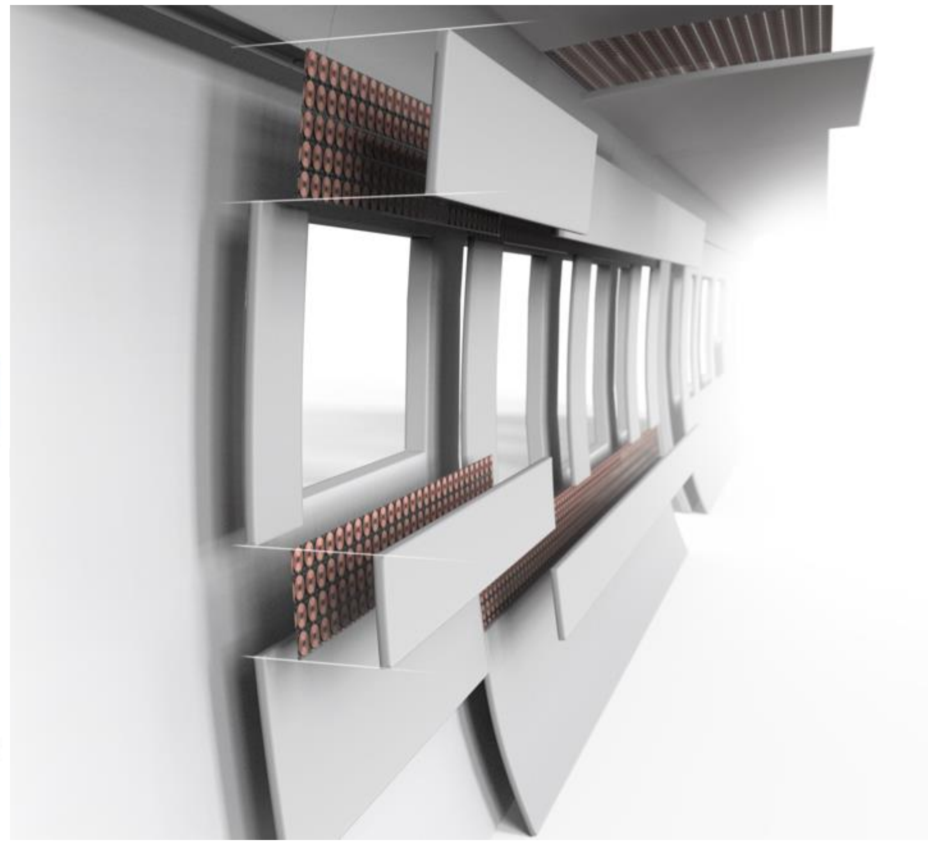


Electrical coil specification / proposal

- 20W Power Line per device
- 5V AC / 10mA - communication Line per coil
- search interval – all second for 10ms on communication line
- pitch for devices 75mm
- Dimension for devices 70 x 70mm

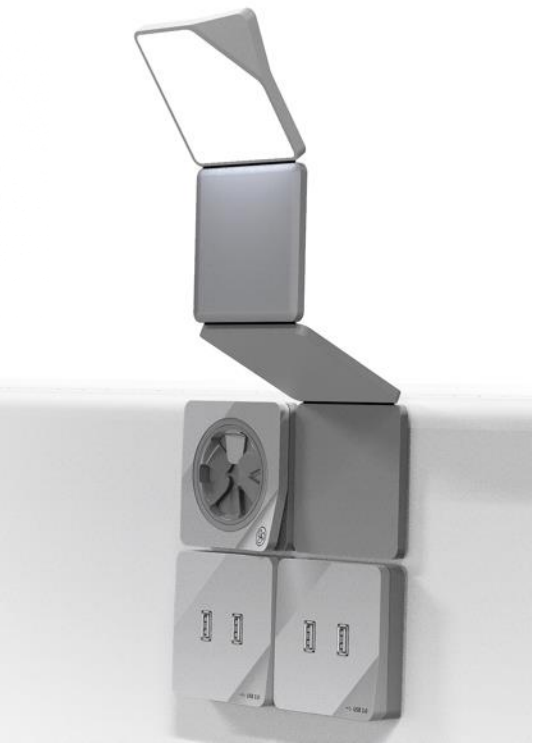
Device specification / proposal

- Holding force with permanent magnets, alternative solution a combination with coil and electro magnets.



WP6 Technical Layout and wall build principle of printed electronic coil foil in the new standard energy grid

Main achievements OC Interiors



WP6 First tile concept solutions

E-Ink display for seat numbering and sub permanent information (direction to bistro / personal information traveller / vessel number or similar)

- light switch
- light switch colour led dimmer
- light wall washer or aile illumination
- socket system (24V / USB / USB-C / induction)
- folding reading light

Main achievements OC Interiors

The final result of **Mat4Rail WP7 Ultralight seats system is a first functional prototype.**

The novelty of this work package is that of a new seat principle, a seating concept with the highest possible flexibility and ultra-light weight. The aim was to innovate and create a paradigm change in the way seats are being used, aiming for the best possible passenger comfort, simple build principles, low cost and outstanding user experience to address the upcoming transportation challenges. It was developed based on the **following objectives** which were **derived from research, user analysis** and agile design concept development and created in various iterations an trails to a new standard:

- ergonomics
- passenger security
- passenger flow
- active fitting
- product life cycle

The developed idea and the concept is that, of a small frame structure is holding an intelligent woven inlay structure, that generates all the ergonomic and comfort need. The lightweight frame system is cantilever suspended or floor based fixed in single or double seat form. For this new seat arrangement the following was also considered

Main achievements OC Interiors

Main achievements OC Interiors

The idea is a new seat principle and an alternative upholstery solution, making use of new technologies such as technical knitting or three-dimensional weaving to reduce upholsteries multidimensional negative impacts without decreasing passenger comfort. Applying this principle of circular economy to a train seat, it became clear that one has to cluster the seat elements regarding their longevity and materiality, enabling train operators to organize the resource cycles accordingly.

The **final result** is a **tangible**, producible **vision** that will have an impact up to:

- reduction from upwards of 50 parts down to 7
- from 33 KG to 14 KG total weight (for one cantilevered seat)
- 60% possible weight reduction compared to industry standard
- 40% approx. cost cutting in production
- 85% of CO_2 emissions reduction during production
- Up to 129 600 T less CO_2 emissions per year being in full average use

Main achievements OC Interiors

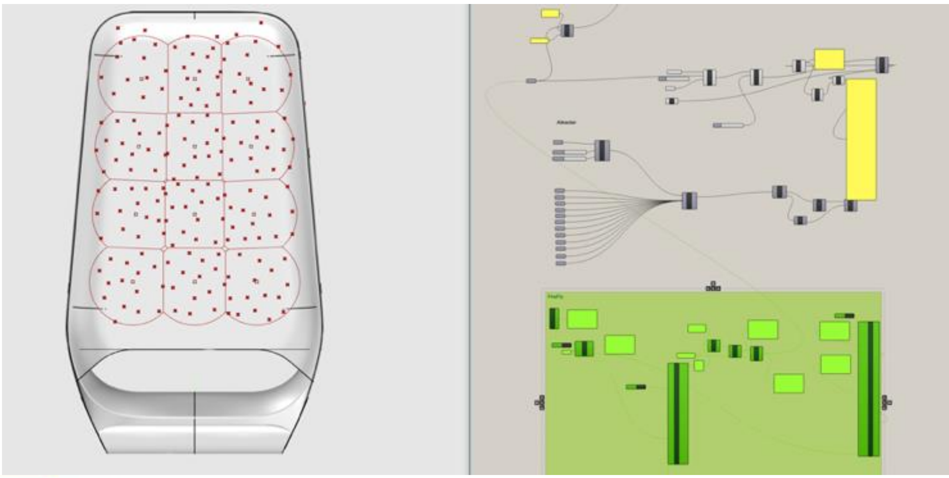
Main achievements OC Interiors

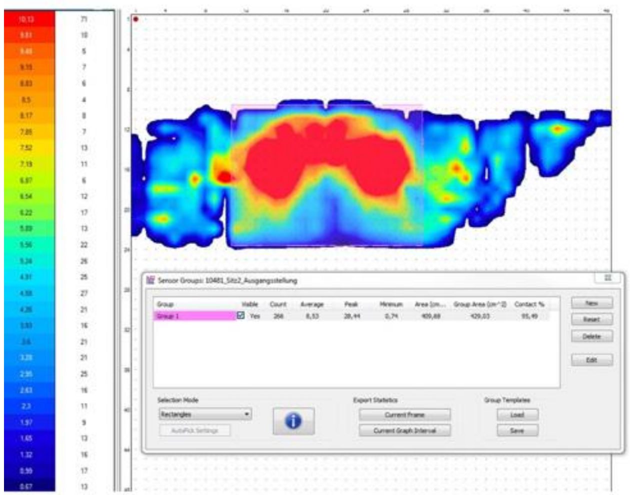
2T

APPROX. WEIGHT REDUCTION PER TRAIN

(MUNICH S-BAHN AS Comparison Base - DB-Type Series 423 / 146 Seats)

Main achievements OC Interiors





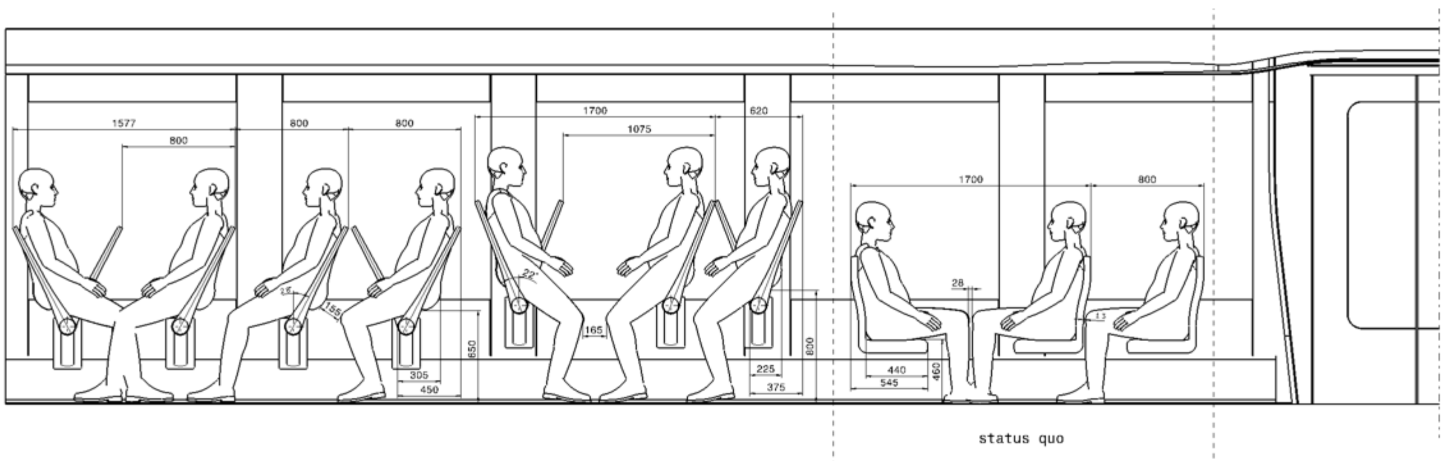
Exemplary pressure distribution of 3 Subjects

- The peak pressure, which should be concentrated underneath the ischial tuberosities, is spread over a wider area here
- The threshold for capillary occlusion (20 kPa) is exceeded
- Pressure gradient is too steep (perception of edge occurs)

ANALYSED and OPTIMIZED in induytry design prototype development process.

Pressure and seating touchpoints testing has been developed for optimizing the 3D knitting structure.
Engineering verification round had initial engineering approval (3D FEM analysis and testing); the final report confirming key technical settings for the chosen final design

Main achievements OC Interiors

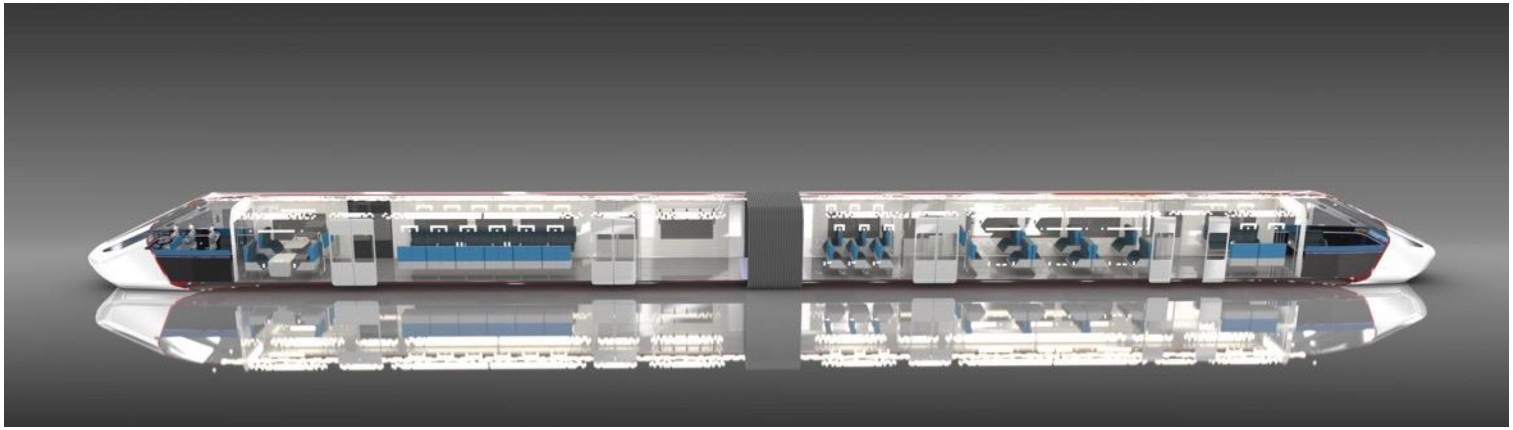


One outstanding innovation opportunity is the directional & flexibel seat pitch with a comfort distance from 750 mm between seat to seat, compared to 850 mm with a classic seating arrangement. A higher seating density and new arrangements can be achieved.

Main achievements OC Interiors

Main achievements OC WP8/WP6

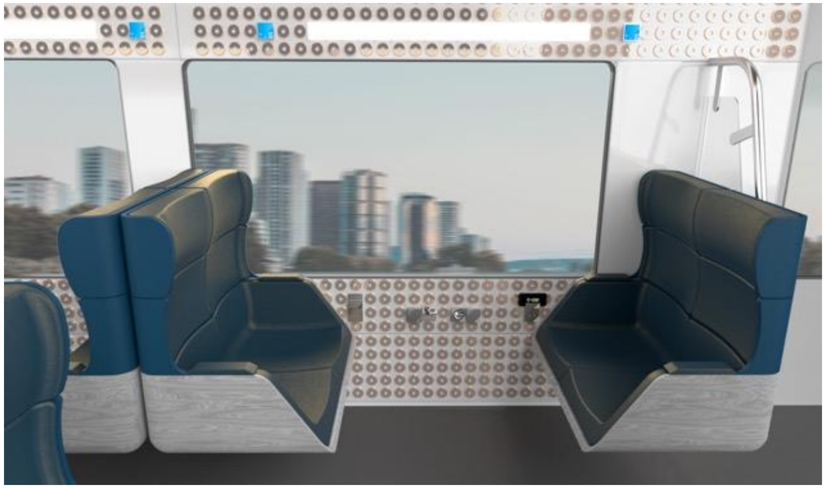
- One common **Virtual Prototype** for **WP6 Innovative plug & Play system** and **WP8 Innovative Driver's Desk**
- Two wagon **hybrid** of a **commuter train** and an **inter-regional train** with different interior design scenarios:
  - Seat group, facing each other with tables
  - Subway seat arrangement
  - Seat groups facing each other without tables
  - Area with no seats with ceiling mounted handrails
  - Two driver cabins for WP8 Innovative Driver's Cabin



WP8 Virtual prototype conceptualized and created iteratively by Spirit Design and INDAT

Main achievements OC WP8/WP6

WP6 Virtual prototype visualization four seats arrangement



WP6 Virtual prototype visualization of electromagnetic fixation coils

WP6 Virtual prototype visualization Subway

WP6 Virtual prototype visualization
Four seats with table

CABIN

Main achievements CABIN

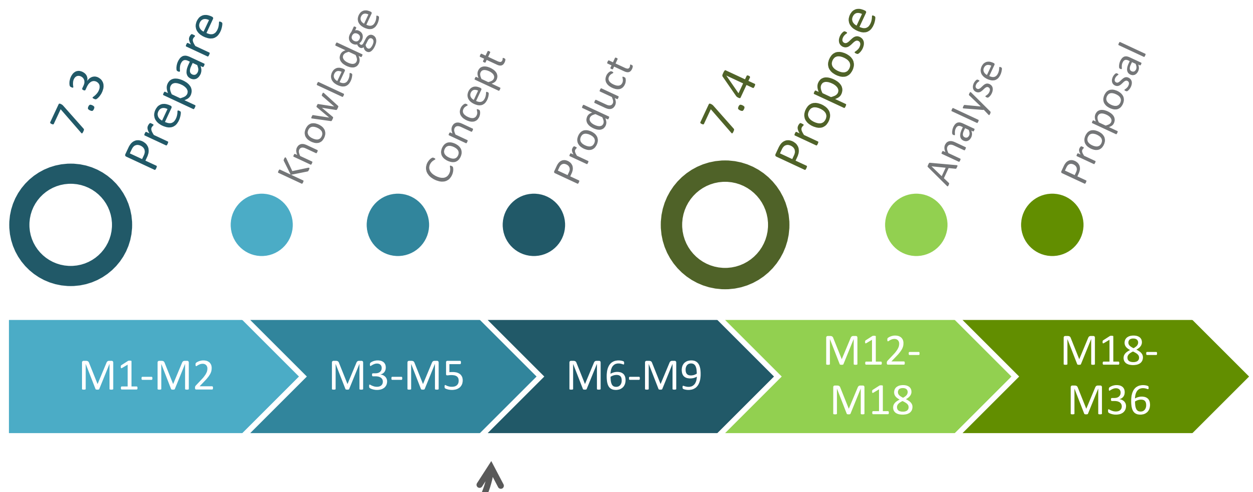

2018


1950

Main achievements CABIN

x2

Main achievements CABIN



spirit design
thinking the future

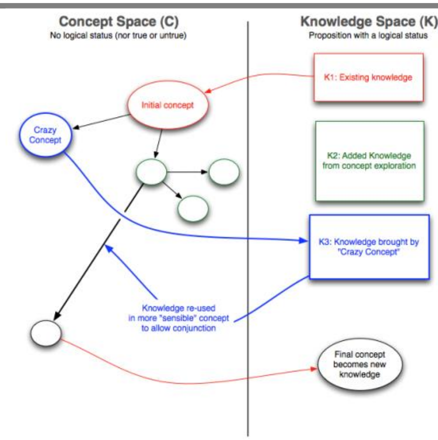
INNOVATIVE CABIN – WP8

Main achievements CABIN

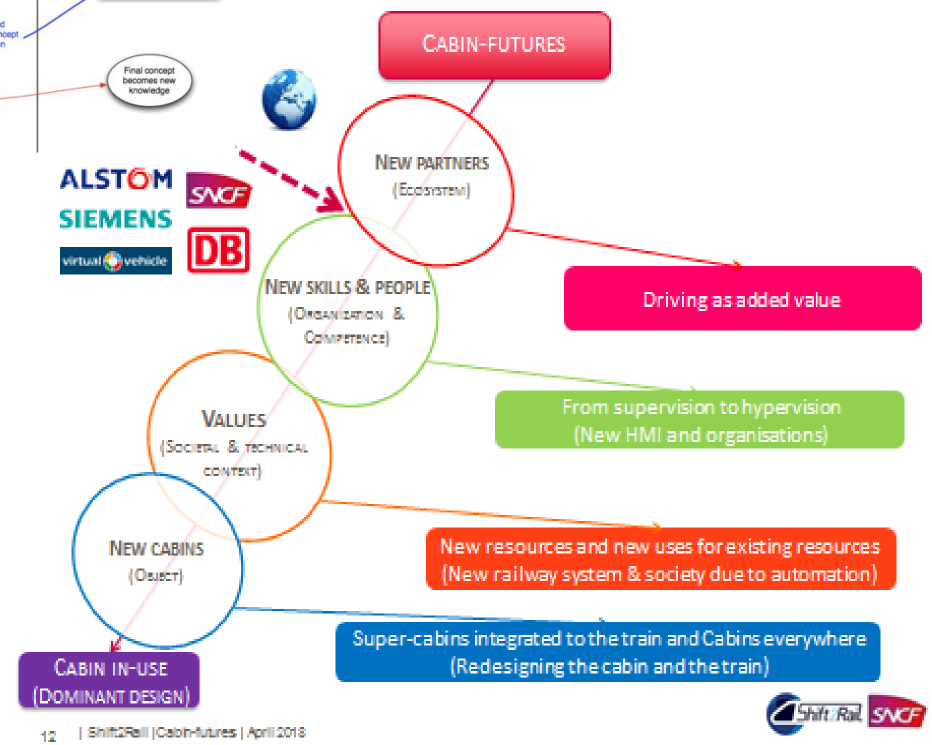
Théorie CK

Main achievements CABIN

THEORY CK

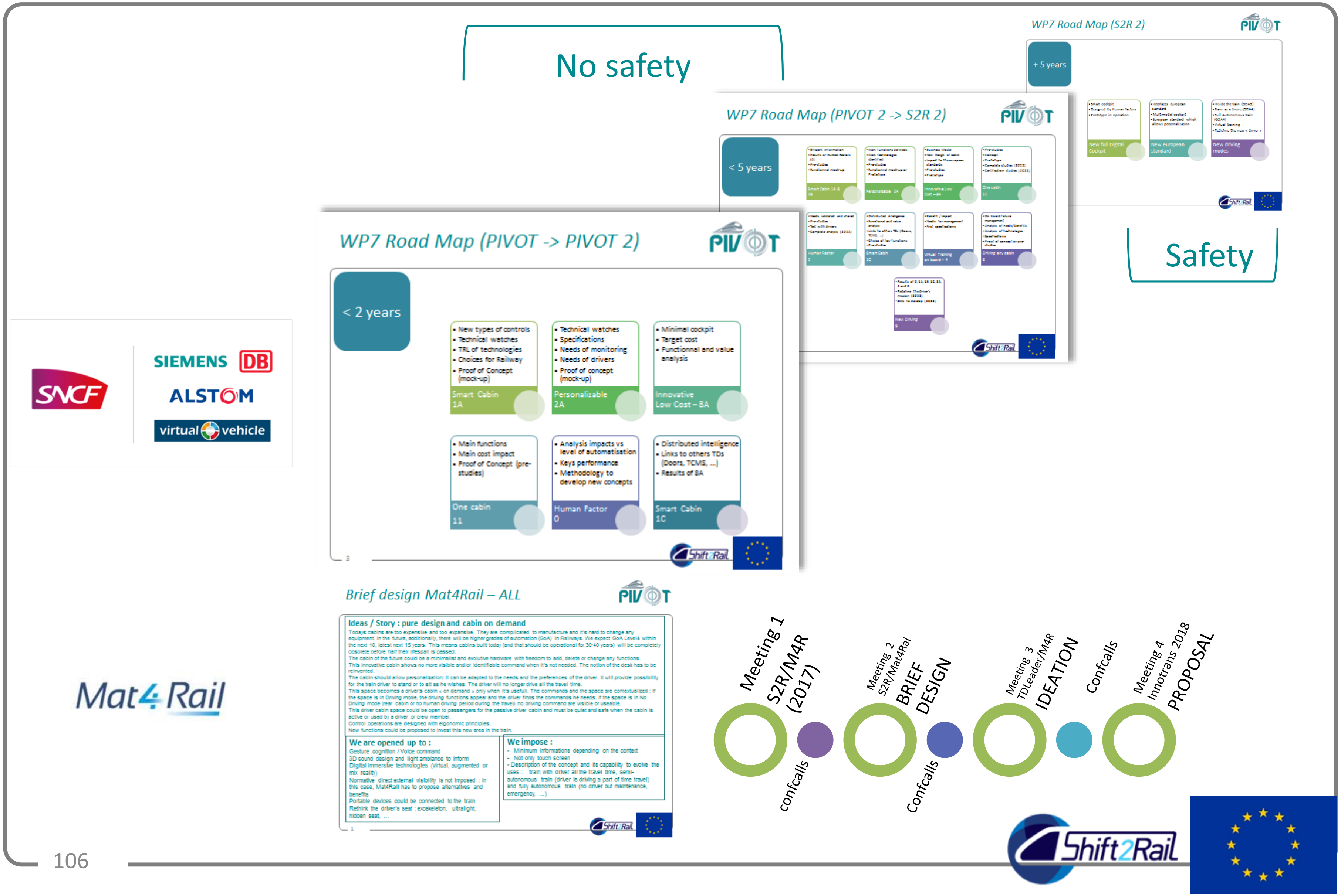


PRODUCT

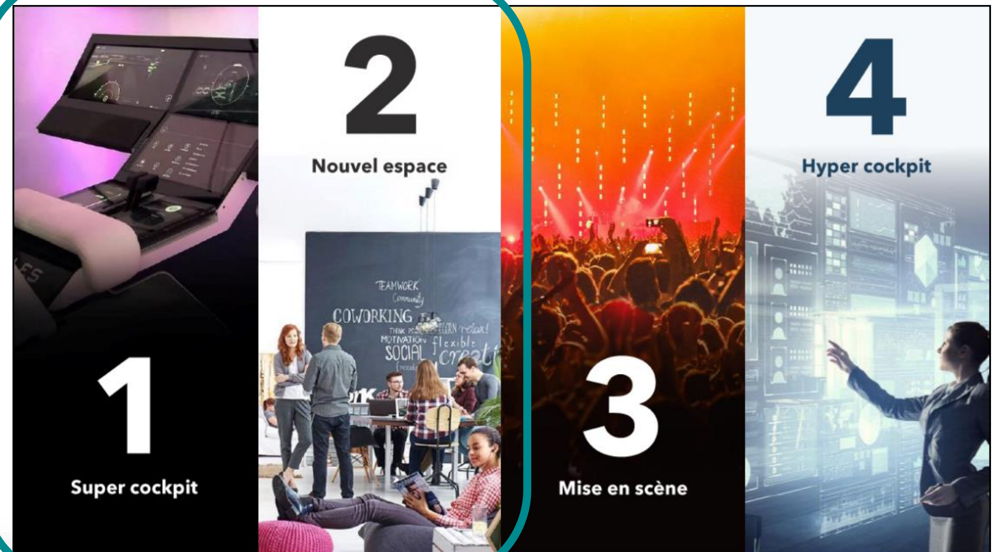


ROADMAP

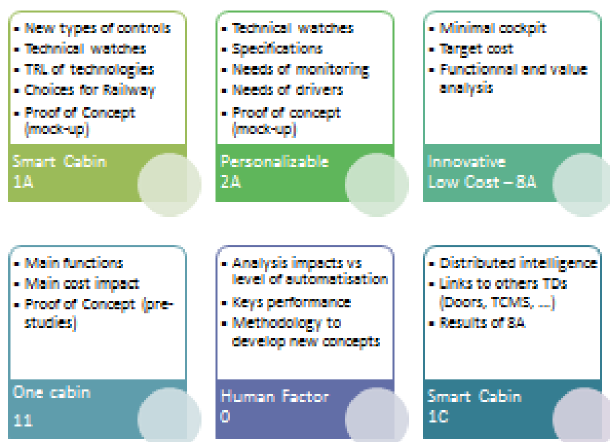
Main achievements CABIN



Main achievements CABIN



< 2 years



Minimal cockpit
New types of controls
Remote functions
New functions
=
Less weight & volume
Less cost
More flexibility

TECHNICAL WATCH


Thalès Avionics

27/05/2019 – Thalès, Bordeaux


Continental

04/04/2019 – SNCF, Le Mans

Main achievements CABIN

Opportunities of digitalization and redesign :

High

Medium

Low

Main achievements of OC

WP8 – Innovative driver's desk

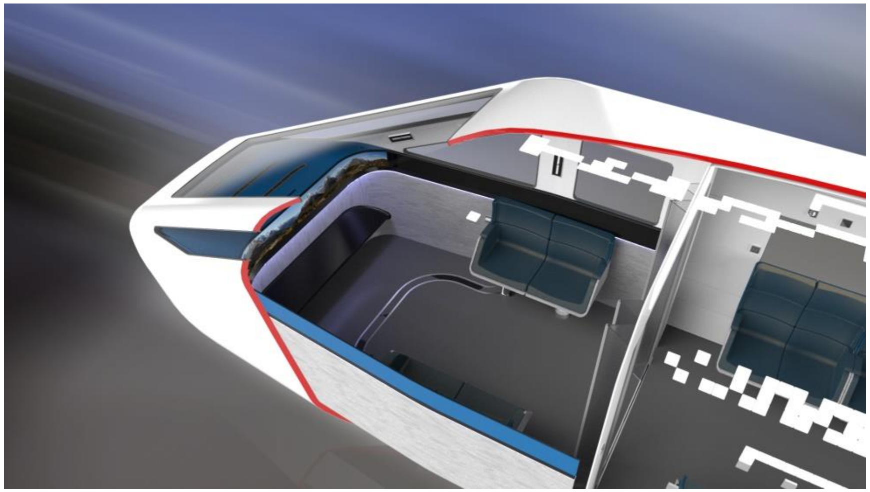
spirit design
thinking the future

Main achievements of OC

The final result of **Mat4Rail WP8 Innovative Driver's Desk** is the **virtual prototype 3D model.** It was developed based on the **following objectives** which were **derived from research** and iteratively **aligned with Shift2Rail partners**:

- Develop an **on-demand driver's cabin** that is ready for the upcoming stages of **ATO** (Grade of Automation level 2&3)
- **Reduce** current driver cabin & desk **layouts** to a **minimalistic but visionary** part of the train which is usable **for operators and passengers** alike
- Create a **very simple seat** with a **flexible layout concept** which can be used in **seated, standing driving position**, as well as for the passenger cabin
- **Neglect** and **go far beyond current standards** and **combine and minimize newest technologies** and visionary ideas to suit **future demands** regarding **human machine interfaces, design and comfort**
- Create a **modular environment** which is designed for the needs of **manufacturers, operators, drivers and passengers**

Main achievements of OC



WP8 Virtual prototype in passenger mode

Open glasdoor in passenger mode

A very compact and **on-demand drivers cabin** which allows **passenger- and driver mode** with a folding opaque **glas-door**

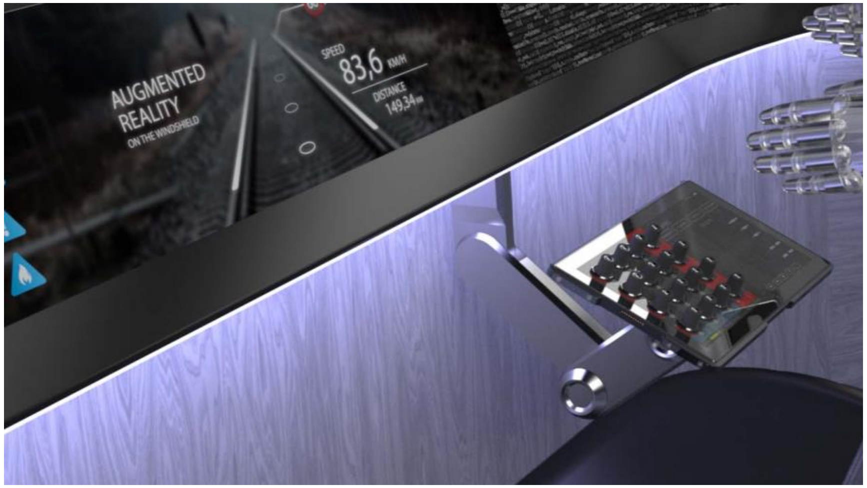
A simple yet **comfortable seat layout concept** which allows **easy changing of modes and seat models**

Main achievements of OC

A **big screen** with an **augmented reality dashboard with** integrated **vitality sensors** and a **head-up display**

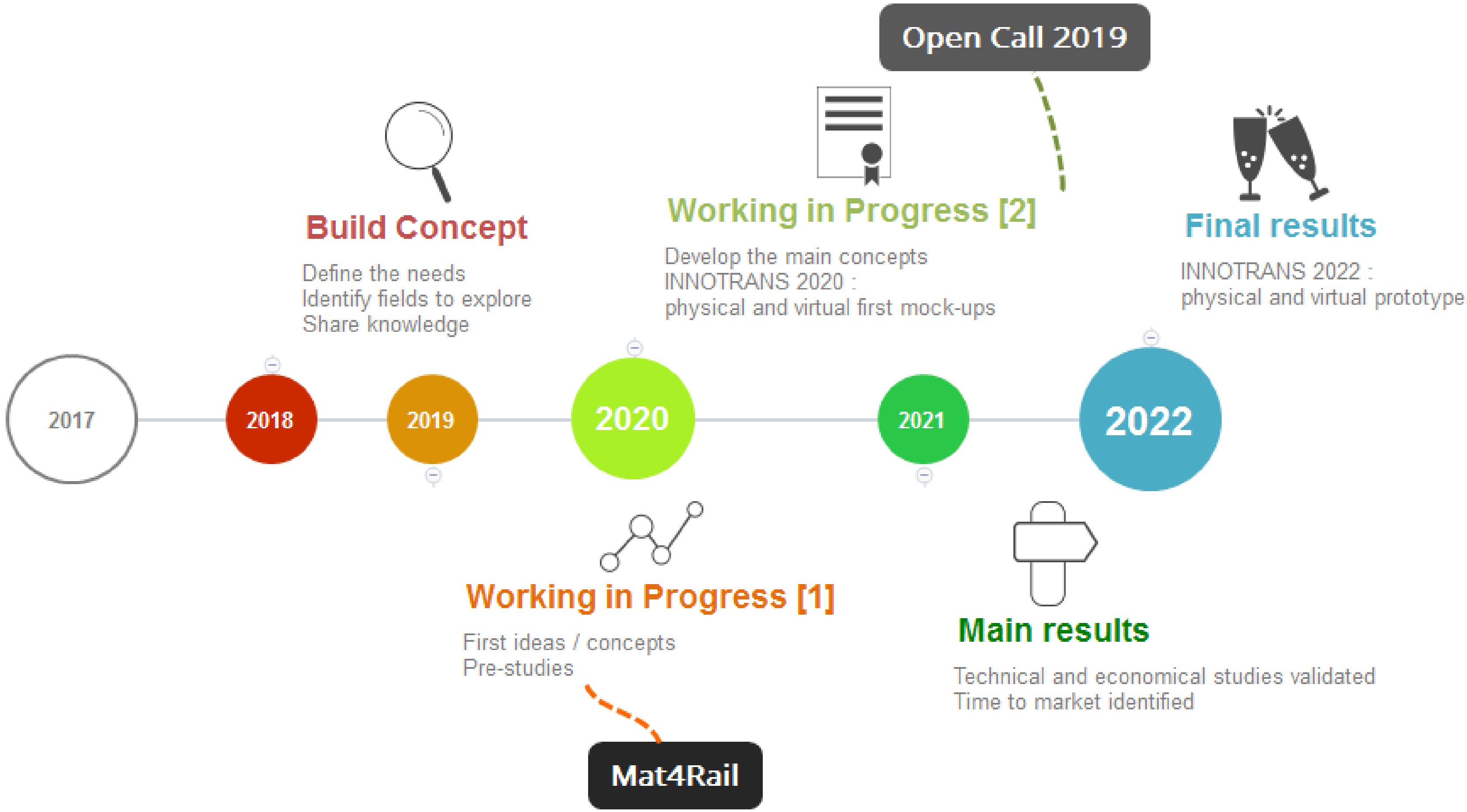
WP8 Virtual Prototype initiating driver mode

A **robotic arm** which serves as a mounting for the **multifunctional HMI & control tablet**



Robotic arm & HMI Tablet

Outlook


Open Call 2019
Build Concept
Define the needs
Identify fields to explore
Share knowledge
Working in Progress [2]
Develop the main concepts
INNOTRANS 2020 :
physical and virtual first mock-ups
Final results
INNOTRANS 2022 :
physical and virtual prototypes
2017
2018
2019
2020
2021
2022
Working in Progress [1]
First ideas / concepts
Pre-studies
Main results
Technical and economical studies validated
Time to market identified
Mat4Rail

Thank you for your kind attention

Agenda for today

Time	*Topic of discussion*	*Speaker*
08:00 – 09:00	**Registration and welcome**	
09:00 – 09:10	**Introduction by Shift2Rail**	**S2R JU**
09:10 – 09:50	**Project presentations; objectives, achievements and expectations on the joint final event**	**P. Böttcher (BT)** **E. Jubete (CIDETEC)** **M. Andreoni (UNIFE)** **U. Battista (Stam)**
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11:15 – 12:05	**TD1.4 – Running gear**	**E. de la Guerra (TAL),** **A. Alonso (CAF),** **S. Iwnicki (HUD),** **S. Stichel (KTH)**
12:05 – 12:55	**TD1.5 – New braking system**	**J. Brackovic (KB)** **A. Boggione (Faiveley)** **S. Ferrara (Faiveley)**
12:55 – 14:10	**Lunch / poster / demo session**	
14:10 – 15:00	**TD1.6 – Innovative doors**	**T. Montanié (Faiveley)** **J. Arrabal (ANN)** **U. Battista (STAM)** **P. Severin (Coexpair)** **J. M. Bielsa (ITA)**
15:00 – 15:50	**TD1.3 – The new generation of car body shells**	**E. de la Guerra (Talgo)** **J. Arrabal (ANN)** **A. Rekondo (CIDETEC)** **M. Brede (Fraunhofer-IFAM, UNI-HB)** **P. Blomqvist (RISE)**
15:50 – 16:00	**Wrap-up / end of the meeting**	

Project No. 777595

Mat4Rail

Designing the railway of the future: Fire resistant composite materials and smart modular design

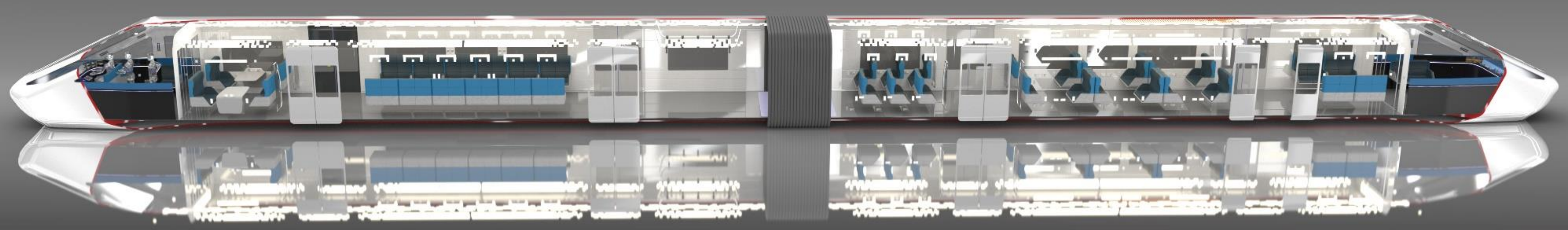
Virtual Prototype of

- WP6 Innovative Plug & Play systems
- WP8 innovative Driver’s Desk

This project has received funding from the Shift2Rail Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 777595.

Virtual Prototype of WP6 & WP8

Let's start the tour!



Virtual Prototype of WP6 & WP8

Entering the passenger cabin

Virtual Prototype of WP6 & WP8

Going down the aisle

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a Project of the S2R JU

spirit design INDAT INNOVATION NVGTR

Project aim Work Package 6

The goal of WP6 Plug & Play Systems was to **design & develop** a **hyper flexible and intelligent new "plug & play" system** as well as **single solutions** for train operators, who wish to be able to **reconfigure the interior layout** of a train as well as the **service offerings & elements** that **add to passenger comfort**.

To do this more easily and **just in time** to react to **dynamic needs** and in **response to changes in interior trends**, we aim for suiting solutions.

The Plug & Play System has been deployed **addressing all those needs, offering single tile solutions** applied within a **last dye coil magnetic grid**.

Virtual Prototype of WP6

Four seats with all elements

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Virtual Prototype of WP6

Last dye coil magnetic grid

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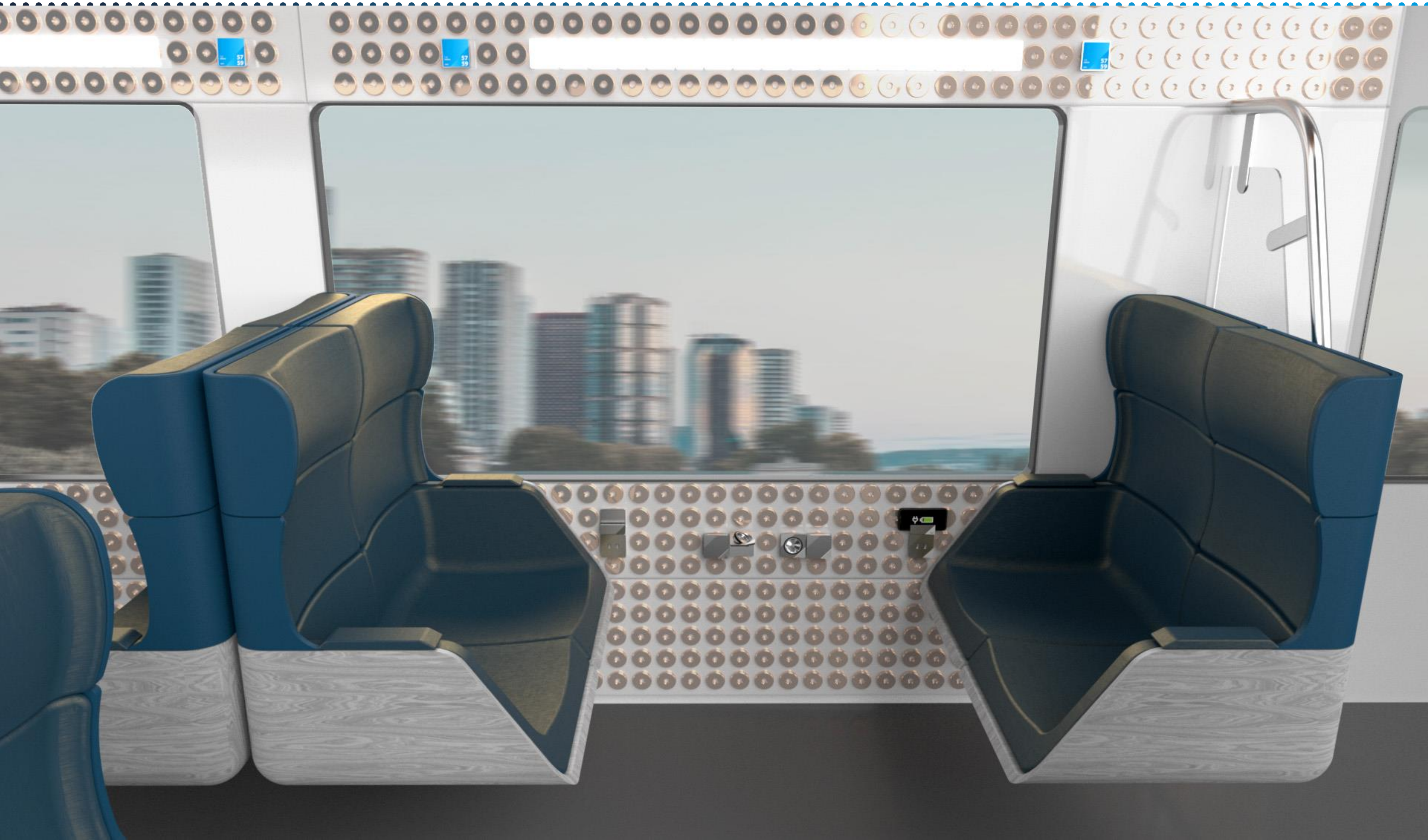

Virtual Prototype of WP6

Detail presentation of elements

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Info/Reservation OLED Screen

- configuration in time
- direct connect with own IP
- simple design
- easy to exchange
- low energy consumption
- can be connected to form screens

Virtual Prototype of WP6

Detail presentation of elements

Virtual Prototype of WP6

Detail presentation of elements

Giro Fan Cooler

- individual cooling fan
- simple & sturdy design
- easy to exchange
- low energy consumption

Virtual Prototype of WP6

Detail presentation of elements

Giro Fan Cooler

- individual cooling fan
- simple & sturdy design
- easy to exchange
- low energy consumption

Virtual Prototype of WP6

Detail presentation of elements

Mini Power Outlets

- universal usb 3 chargers
- multi device solution
- easy installation
- sturdy design

Virtual Prototype of WP6

Detail presentation of elements

Mat4Rail
a Project of the S2R JU

spirit design INDAT INNOVATION NVGTR

Mini Power Outlets

- universal usb 3 chargers
- multi device solution
- easy installation
- sturdy design

Virtual Prototype of WP6

Detail presentation of elements

Mat4Rail
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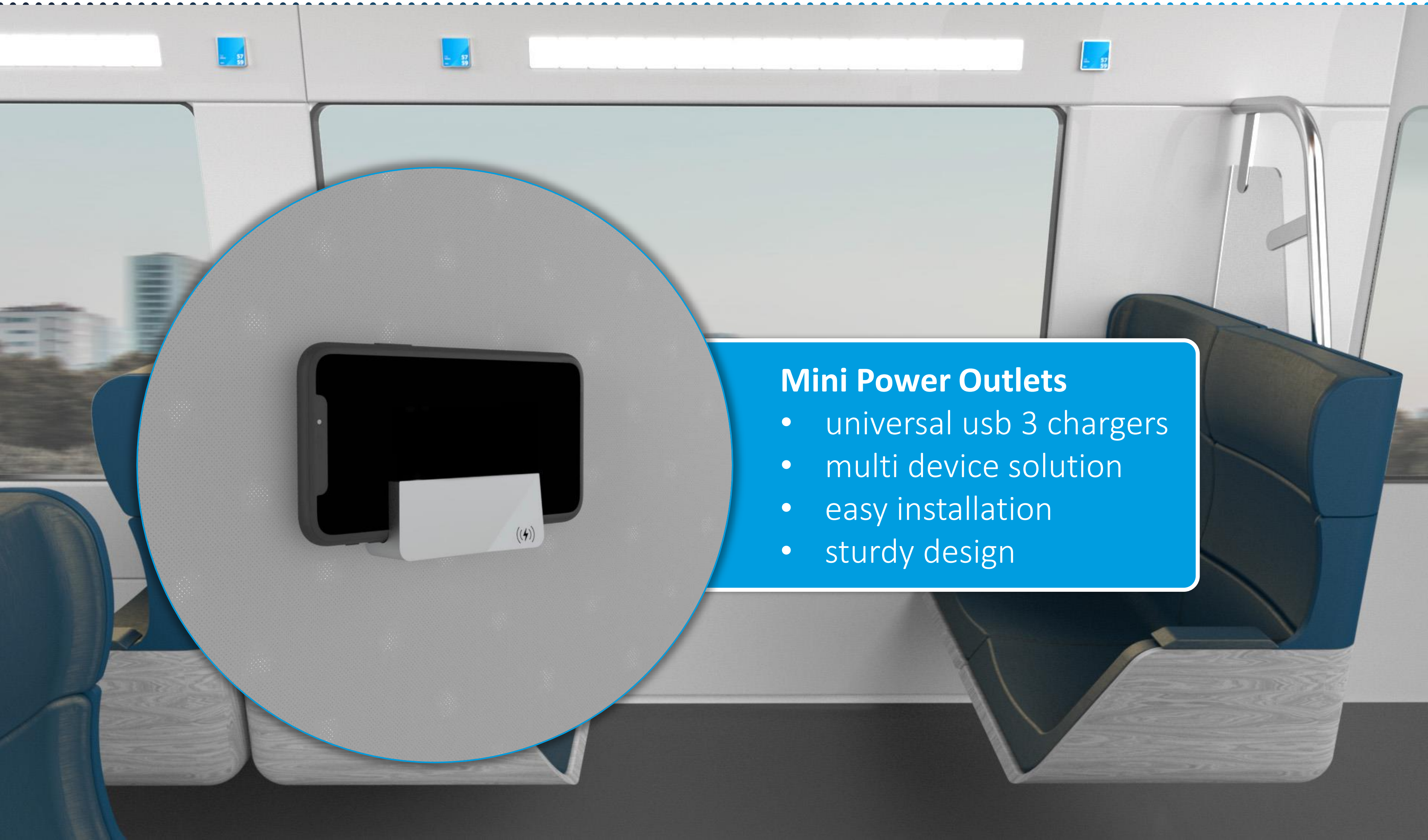

Virtual Prototype of WP6

Detail presentation of elements

Mini Power Outlets

- universal usb 3 chargers
- multi device solution
- easy installation
- sturdy design

Virtual Prototype of WP6

Four seats with table

Ambeo reading light

- mini ambient wall washer
- flexible reading light
- easy to use
- easy installation
- touch sensitive surface switch

Virtual Prototype of WP6

Four seats with table

Mat4Rail
a Project of the S2R JU

spirit design INDAT INNOVATION NVGTR

Ambeo reading light

- mini ambient wall washer
- flexible reading light
- easy to use
- easy installation
- touch sensitive surface switch

Virtual Prototype of WP6

Flexible arrangements of elements

Virtual Prototype of WP8

Project aim Work Package 8

The overall aim of **WP8 Innovative Driver's Desk** was to develop a **driver's stand design** that combines a **compact driver's space** with an **easily evolutive built-up seat** and **modularity of the equipment** as well as the possibility to integrate the **desk on demand**.

Virtual Prototype of WP8

Let‘s enter the driver’s cabin

Virtual Prototype of WP8

Let‘s enter the driver’s cabin

Mat4Rail
a Project of the S2R JU

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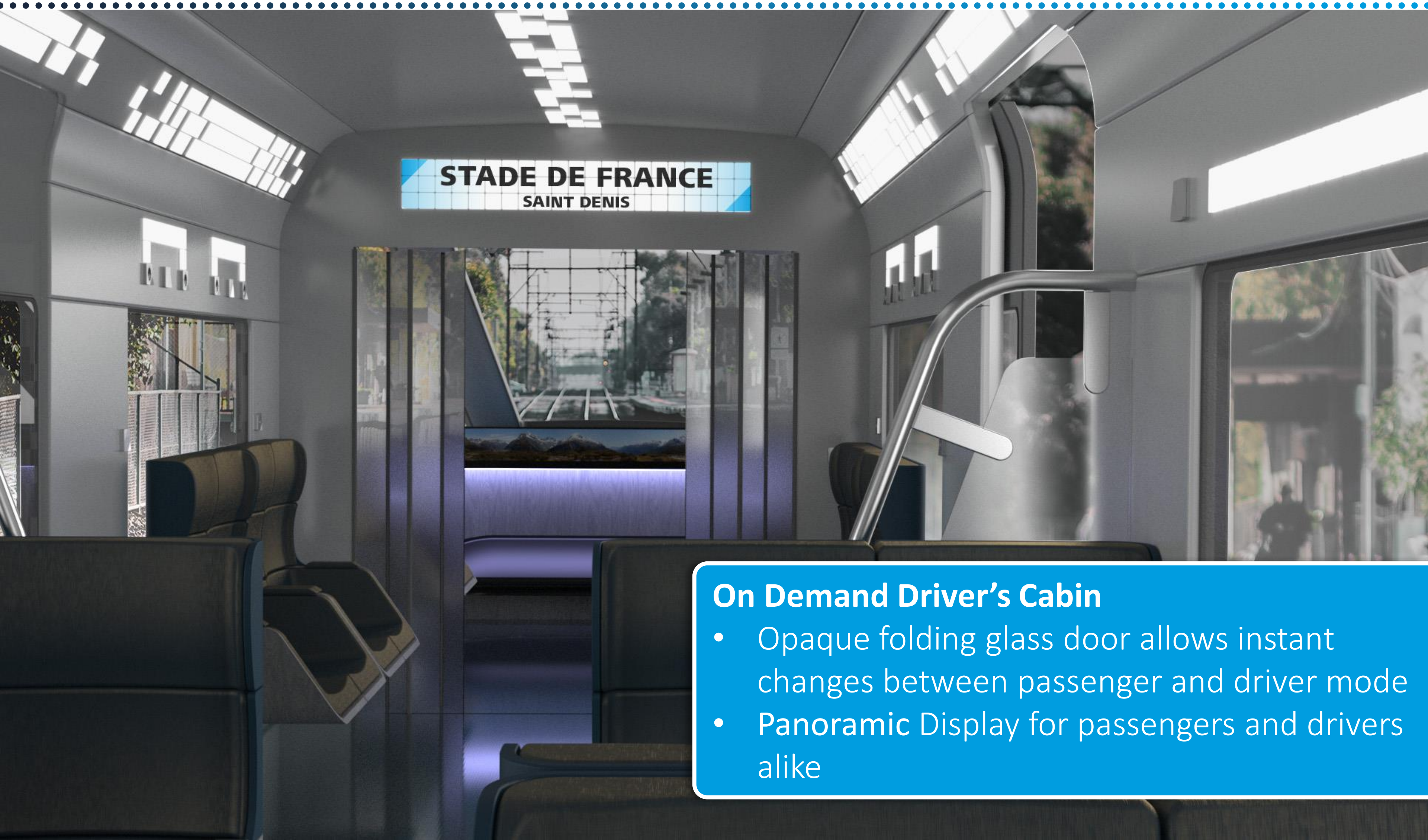


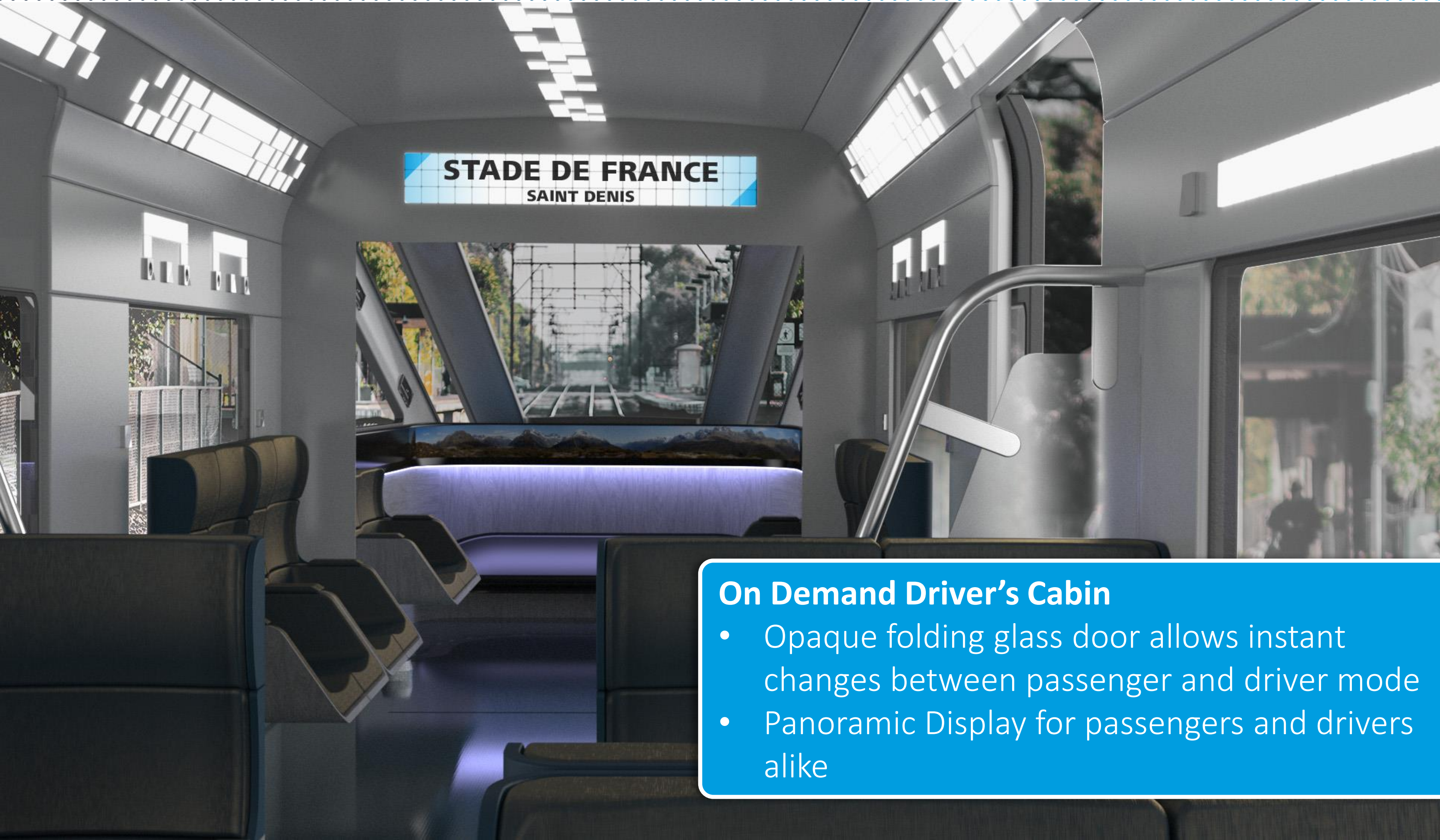
On Demand Driver’s Cabin

- Opaque folding glass door allows instant changes between passenger and driver mode
- **Panoramic** Display for passengers and drivers alike

Virtual Prototype of WP8

Let's enter the driver's cabin

Mat4Rail
a Project of the S2R JU
spirit design INDAT INNOVATION NVGTR



On Demand Driver's Cabin

- Opaque folding glass door allows instant changes between passenger and driver mode
- Panoramic Display for passengers and drivers alike

Virtual Prototype of WP8

Extended cabin open for passengers

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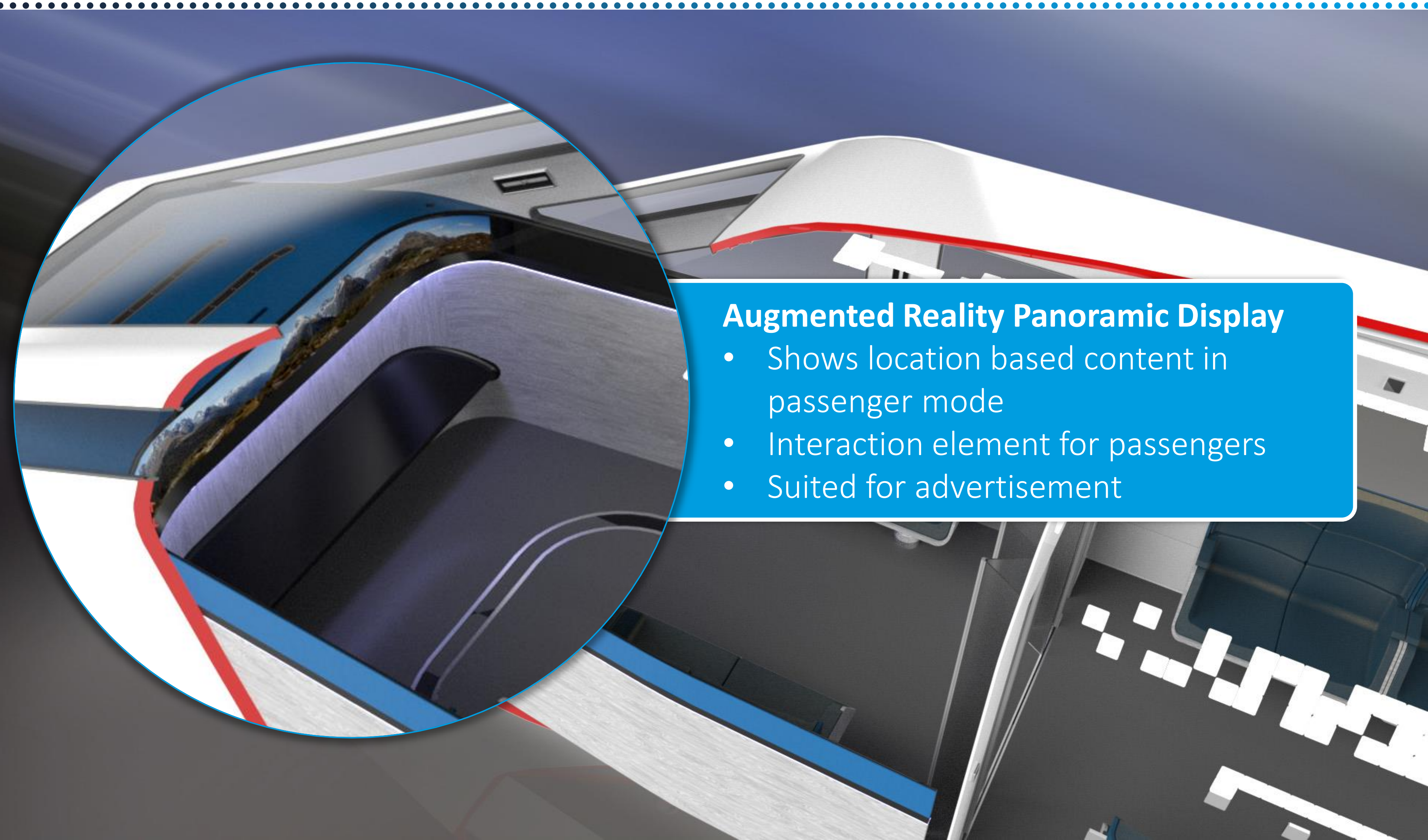
spirit design
INDAT INNOVATION
NVGTR



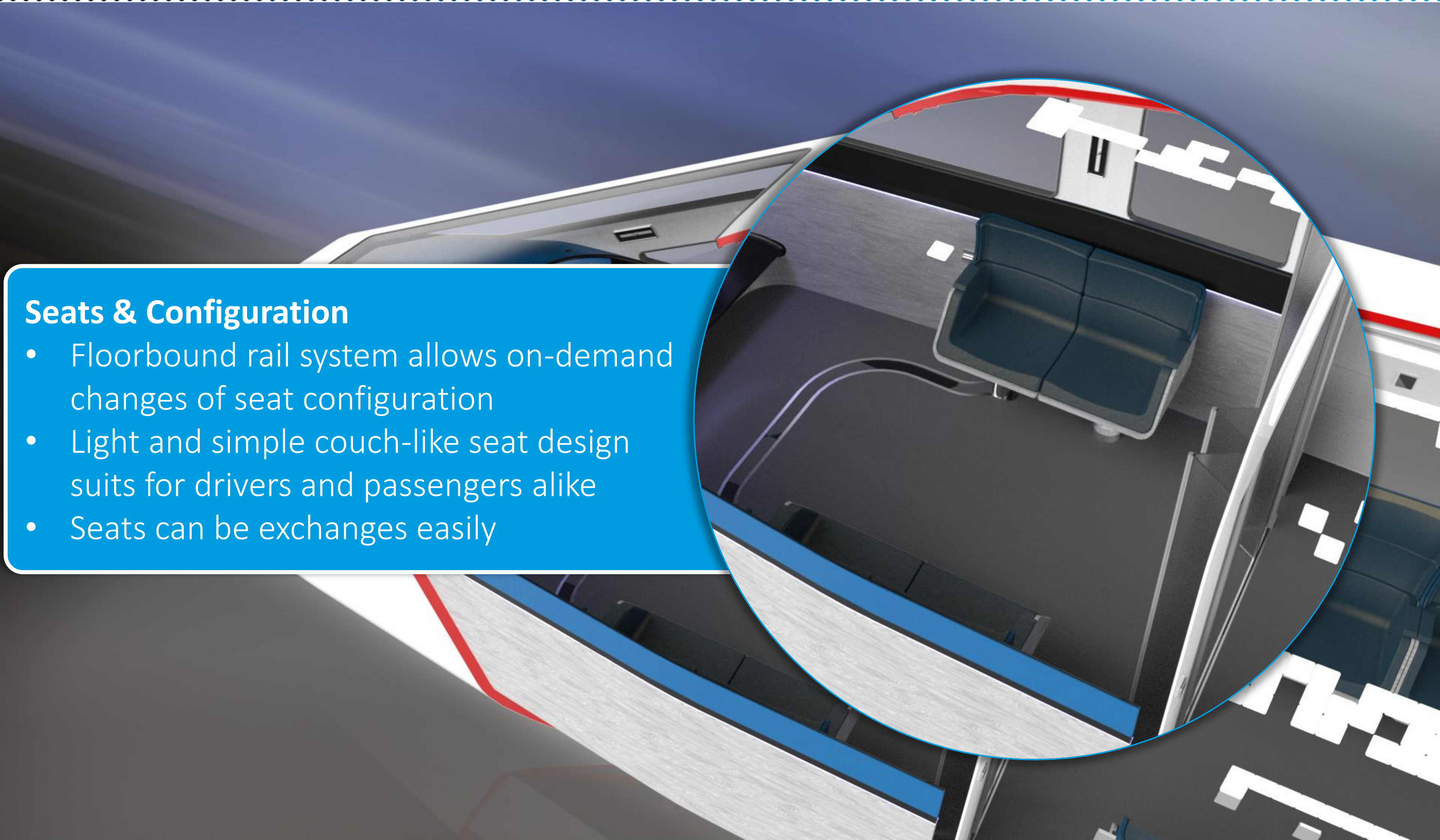
Augmented Reality Panoramic Display

- Shows location based content in passenger mode
- Interaction element for passengers
- Suited for advertisement

Virtual Prototype of WP8

Extended cabin open for passengers

Mat4Rail
a Project of the S2R JU
spirit design
INDAT INNOVATION
NVGTR



Seats & Configuration

- Floorbound rail system allows on-demand changes of seat configuration
- Light and simple couch-like seat design suits for drivers and passengers alike
- Seats can be exchanges easily

Virtual Prototype of WP8

On-demand ‘driver mode‘

Mat4Rail
a Project of the S2R JU

spirit design INDAT INNOVATION NVGTR

Initiating ‘Driver mode’

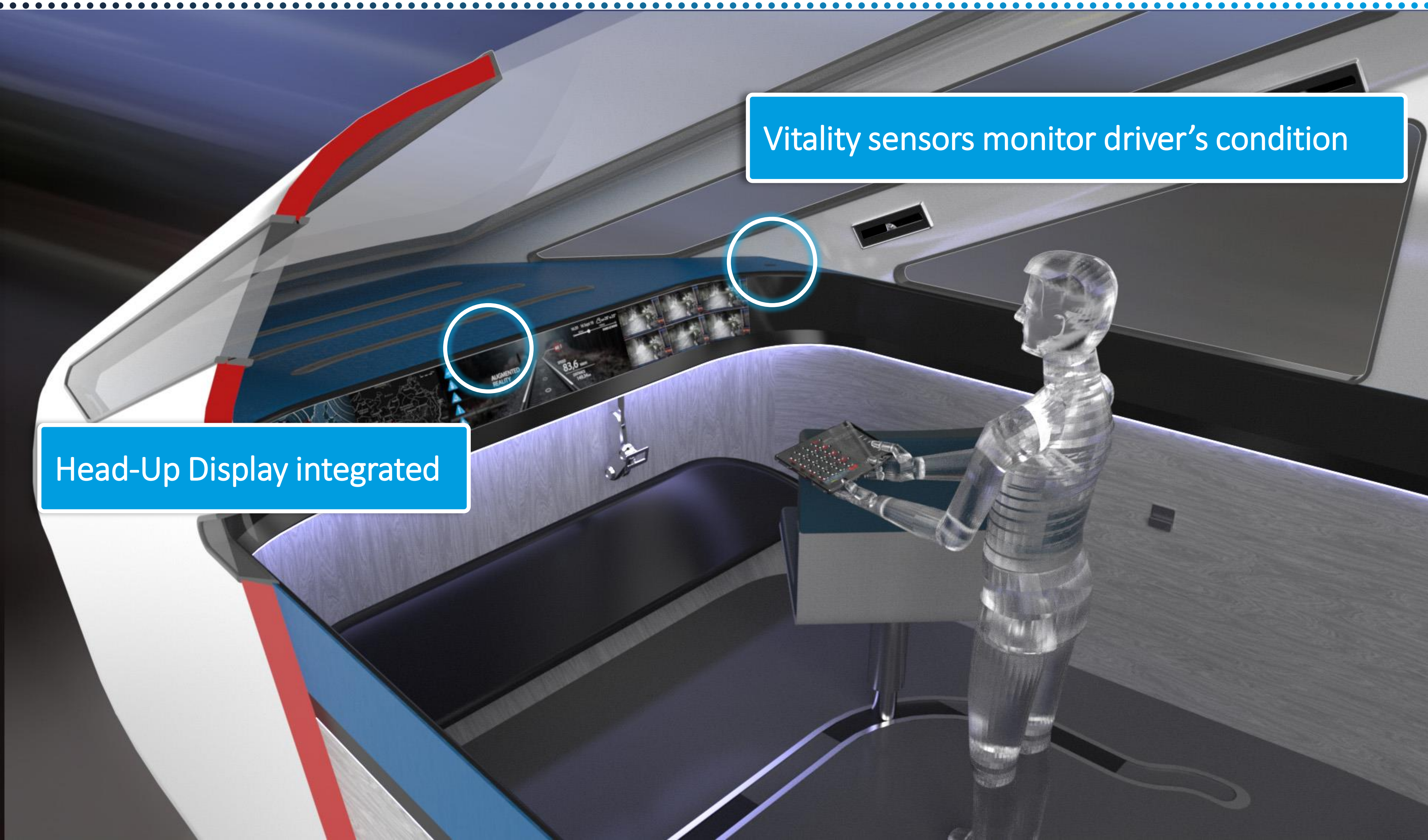
- Conductor enters the cabin
- Driver seat moves automatically towards the dashboard
- Robotic arm approaches automatically the HMI tablet
- Display changes to drivers’ dashboard

Virtual Prototype of WP8

On-demand ‘driver mode‘

Mat4Rail
a Project of the S2R JU

spirit design INDAT INNOVATION NVGTR



Virtual Prototype of WP8

On-demand ‘driver mode‘

Robotic Arm & Multifunctional Tablet

- Robotic Arm is hinged under the dashboard along a guide rail
- It extends towards the location of the tablet and is adjustable
- Tablet can be exchanged and upgraded

‘Driver mode’ engaged

- Conductor takes place on chair and controls the train via the multifunctional tablet
- Augmented Reality display shows all necessary dashboard information

Virtual Prototype of WP8

Trainer set up with 2nd chair

Mat4Rail
a Project of the S2R JU

spirit design INDAT INNOVATION NVGTR

‘Trainer mode’ engaged

- Second passenger chair can automatically positioned through floorbound rail system
- Gives a trainer the spot to teach

Virtual Prototype of WP8

Back to passenger mode

'Passenger mode' engaged

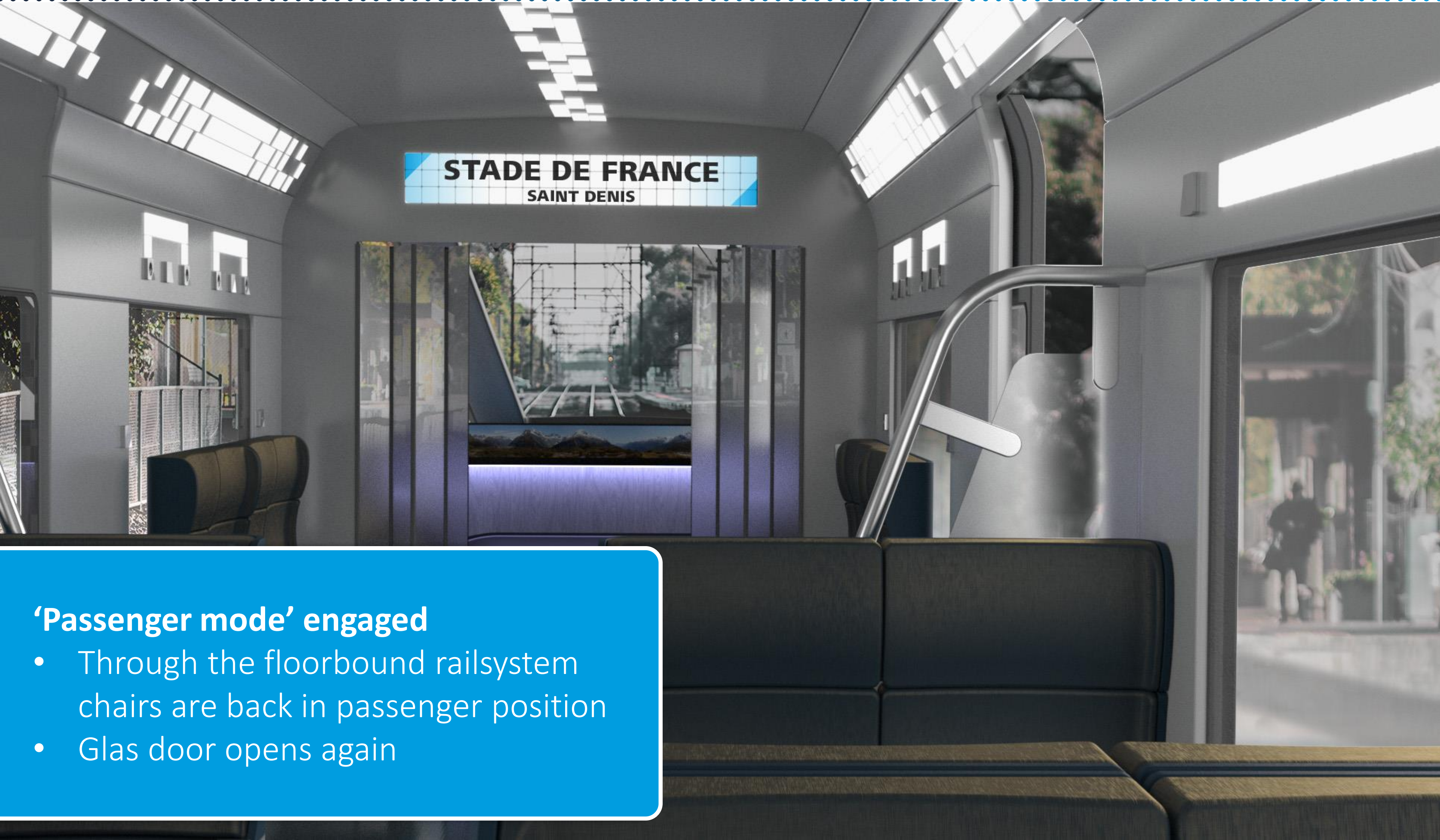
- Through the floorbound railsystem chairs are back in passenger position
- Glas door opens again

Virtual Prototype of WP8

Back to passenger mode

Mat4Rail
a Project of the S2R JU

spirit design INDAT INNOVATION NVGTR



‘Passenger mode’ engaged

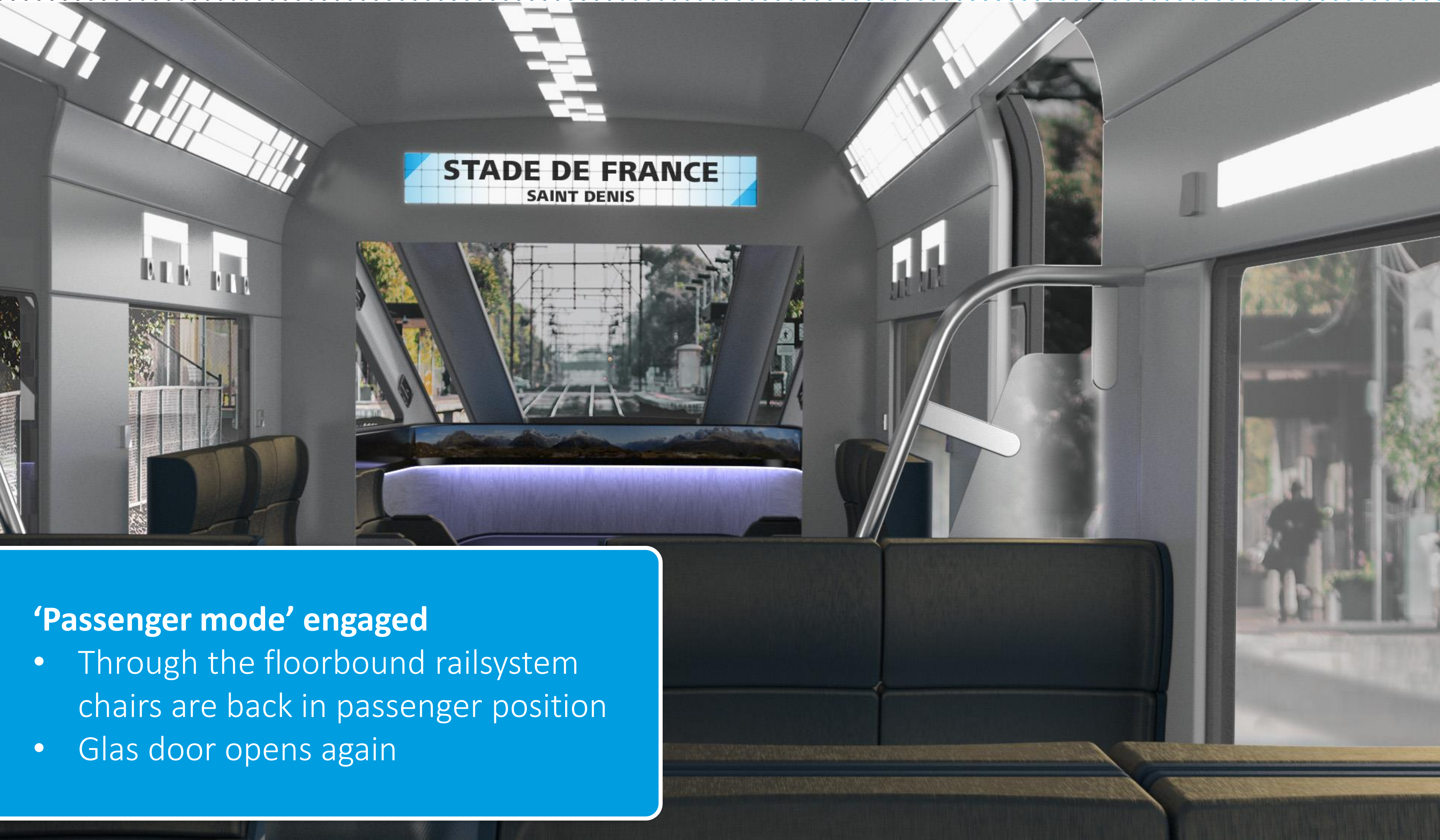
- Through the floorbound railsystem chairs are back in passenger position
- Glas door opens again

Virtual Prototype of WP8

See you soon!

Mat4Rail
a Project of the S2R JU

spirit design INDAT INNOVATION NVGTR



'Passenger mode' engaged

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- Glas door opens again

Thank you!

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12:55 – 14:10	**Lunch / poster / demo session**	
14:10 – 15:00	**TD1.6 – Innovative doors**	**T. Montanié (Faiveley)** **J. Arrabal (ANN)** **U. Battista (STAM)** **P. Severin (Coexpair)** **J. M. Bielsa (ITA)**
15:00 – 15:50	**TD1.3 – The new generation of car body shells**	**E. de la Guerra (Talgo)** **J. Arrabal (ANN)** **A. Rekondo (CIDETEC)** **M. Brede (Fraunhofer-IFAM, UNI-HB)** **P. Blomqvist (RISE)**
15:50 – 16:00	**Wrap-up / end of the meeting**	

Agenda for today

Time	*Topic of discussion*	*Speaker*
08:00 – 09:00	**Registration and welcome**	
09:00 – 09:10	**Introduction by Shift2Rail**	**S2R JU**
09:10 – 09:50	**Project presentations; objectives, achievements and expectations on the joint final event**	**P. Böttcher (BT) E. Jubete (CIDETEC) M. Andreoni (UNIFE) U. Battista (Stam)**
09:50 – 10:40	**TD1.7 – Train modularity in use**	**R. Dumortier (SNCF-M), C. Jurke (NVGTR) W. Fargel (SPIRIT)**
10:40 – 10:55	**Video session**	**W. Fargel (SPIRIT)**
10:55 – 11:15	**Coffee break**	
11:15 – 12:05	**TD1.4 – Running gear**	**E. de la Guerra (TAL), A. Alonso (CAF), S. Iwnicki (HUD), S. Stichel (KTH)**
12:05 – 12:55	**TD1.5 – New braking system**	**J. Brackovic (KB) A. Boggione (Faiveley) S. Ferrara (Faiveley)**
12:55 – 14:10	**Lunch / poster / demo session**	
14:10 – 15:00	**TD1.6 – Innovative doors**	**T. Montanié (Faiveley) J. Arrabal (ANN) U. Battista (STAM) P. Severin (Coexpair) J. M. Bielsa (ITA)**
15:00 – 15:50	**TD1.3 – The new generation of car body shells**	**E. de la Guerra (Talgo) J. Arrabal (ANN) A. Rekondo (CIDETEC) M. Brede (Fraunhofer-IFAM, UNI-HB) P. Blomqvist (RISE)**
15:50 – 16:00	**Wrap-up / end of the meeting**	

TD1.4 –Running Gear

Involved Projects: PIVOT, Run2Rail

Technical Leaders: Eduardo de la Guerra (TALGO),
Asier Alonso(CAF)
Sebastian Stichel (KTH)
Simon Iwnicki (HUD)

PIVOT – MAT4RAIL – RUN2RAIL – FAIRSTATION final conference
17th September 2019
Paris

Introduction to TD1.4

WP3 Smart Running Gear

- HMS for SCM
- Active Steering Systems
- Active Suspension Systems

WP4 Running Gear Performance

- Technical specifications
- New Materials
- Noise and Vibration
- Virtual Homologation

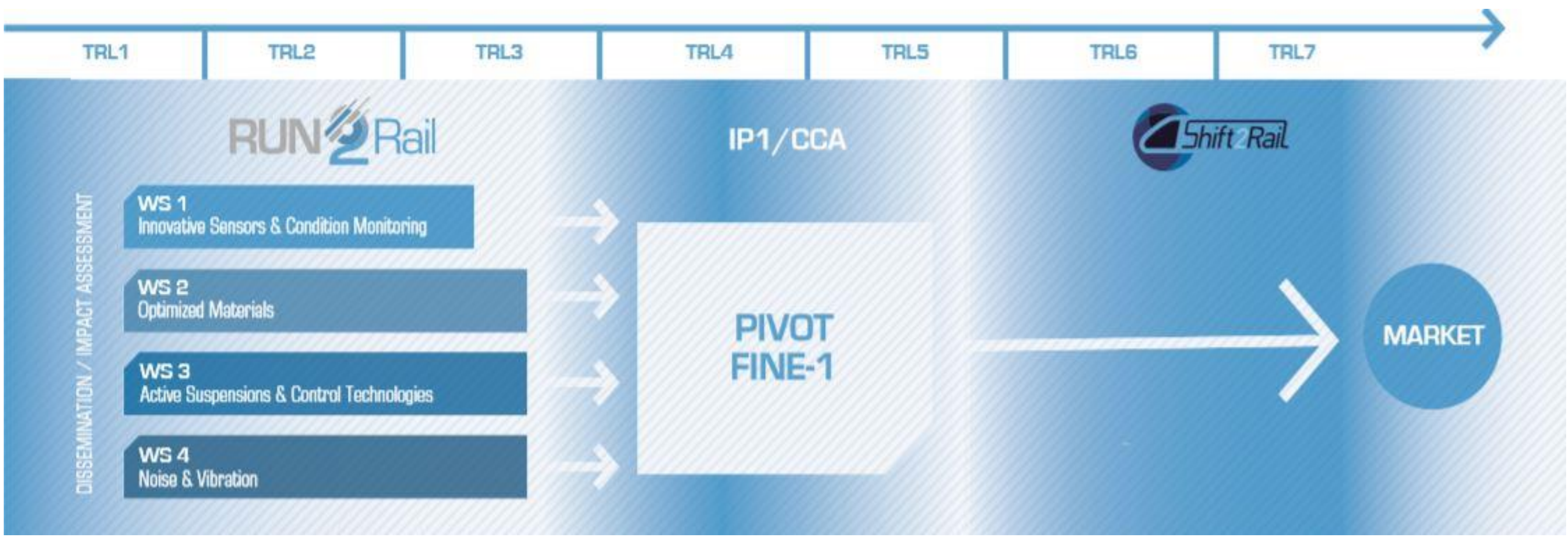
TD1.4 Objectives

- Infrastructure damage and wheel wear
- Reliability and Availability
- Maintenance cost
- Noise emission
- Dynamic characteristics
- Energy usage
- Safety

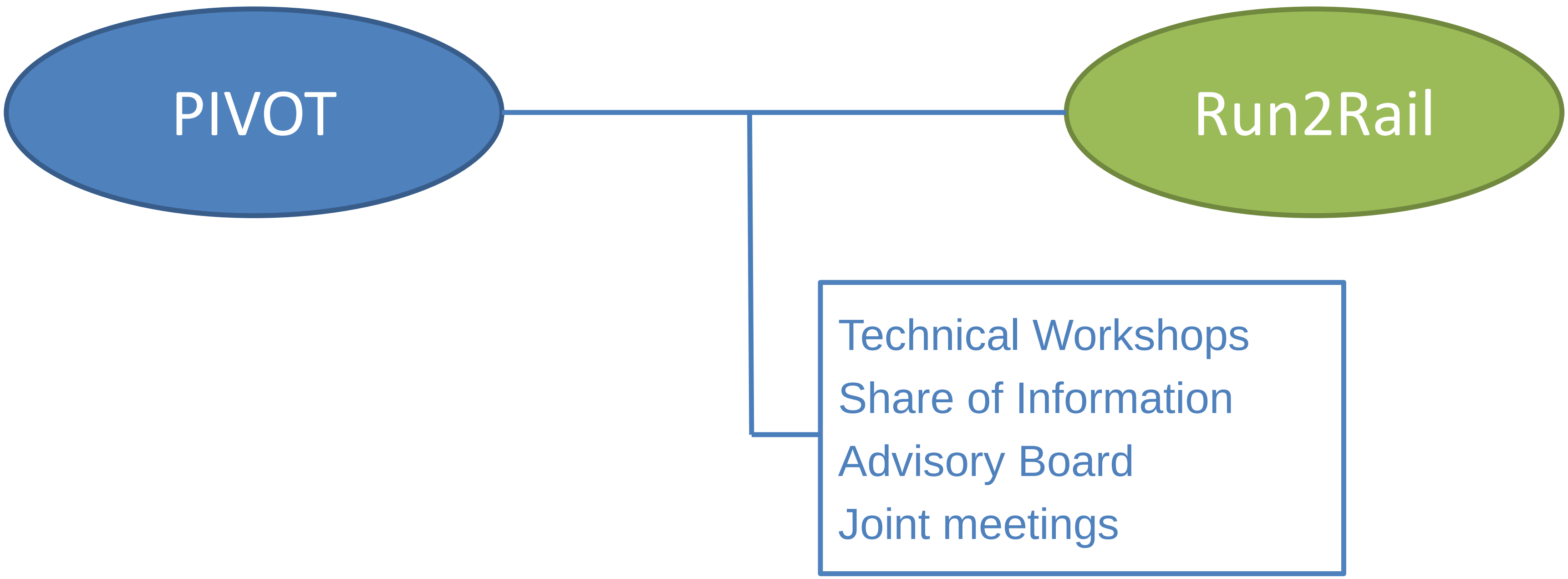
Introduction to TD1.4

- Mapping of S2R objectives with Run2Rail

The challenge for Shift2Rail is to build a Running Gear Technology Demonstrator (TD1.4) that paves the way for the next generation of passenger rail vehicles → The aim of the RUN2Rail project is to identify and develop the key methods and tools that are required to allow the design and manufacture of this next generation of running gear



Introduction to TD1.4



WP3 Smart Running Gear

Current situation

Many ideas for innovative solution are proposed in scientific/technical community

- Active steering systems
- Active suspension systems
- Hold-off systems

However…

- Standardization/homologation issues
- Reliability
- LCC

General objective

"Boost the introduction of smart innovative solution in running gear systems in order to improve their dynamic behavior and reduce their overall cycle cost "

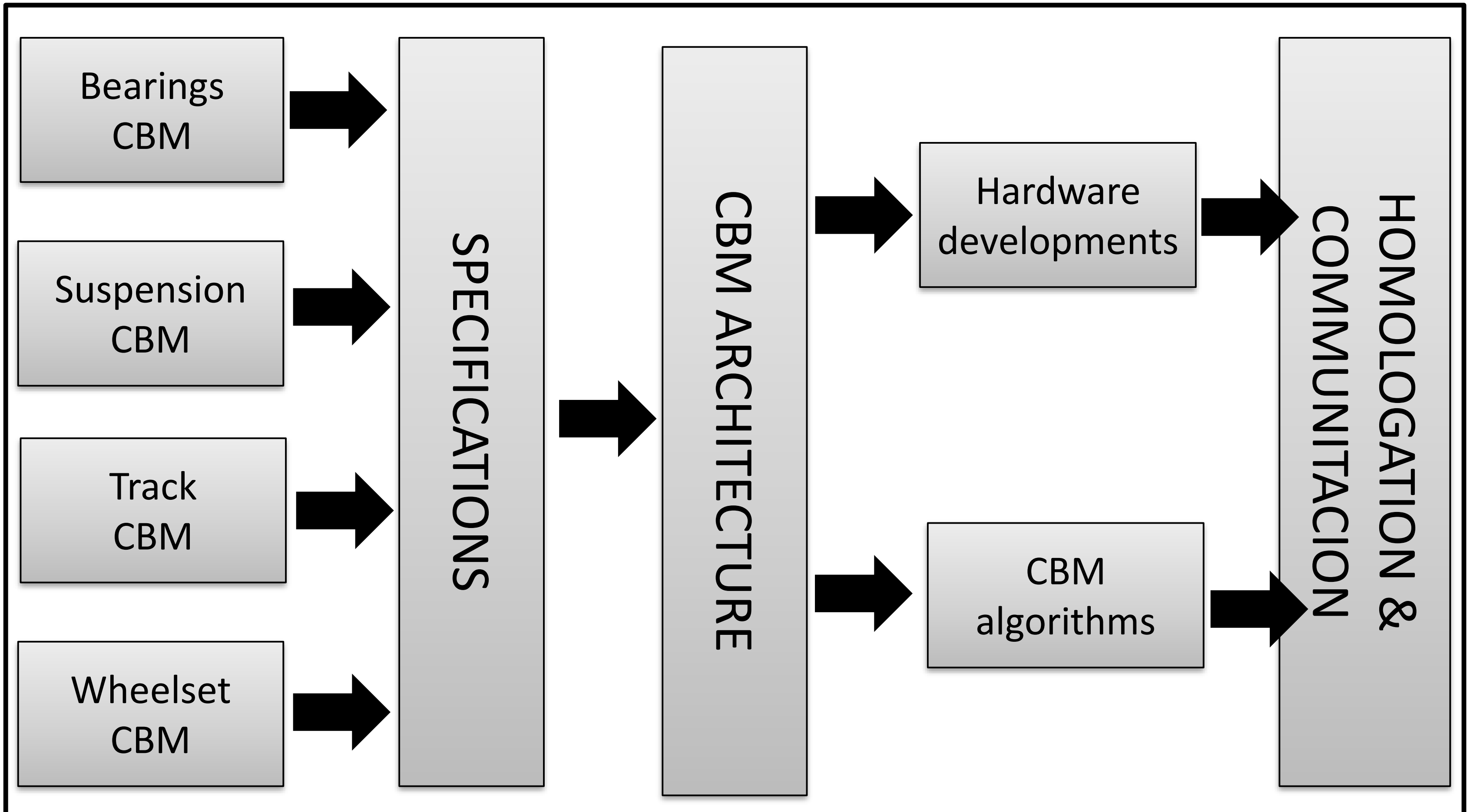
WP3 Smart Running Gear

Structure

SMART RUNNING GEAR		
HMS for CBM	Active Steering Systems	Active Suspension Systems
• Specifications • Architecture definition • Hardware development • Algorithms • Homologation • Data usage	•State of the art •Hardware and software requirements •Feasibility studies of different solutions •Preliminary design •Testing on component level •Field tests	•State of the art •Hardware and software requirements •Feasibility studies of different solutions •Preliminary design •Testing on component level

WP3.1 HMS for CBM

Work Flow



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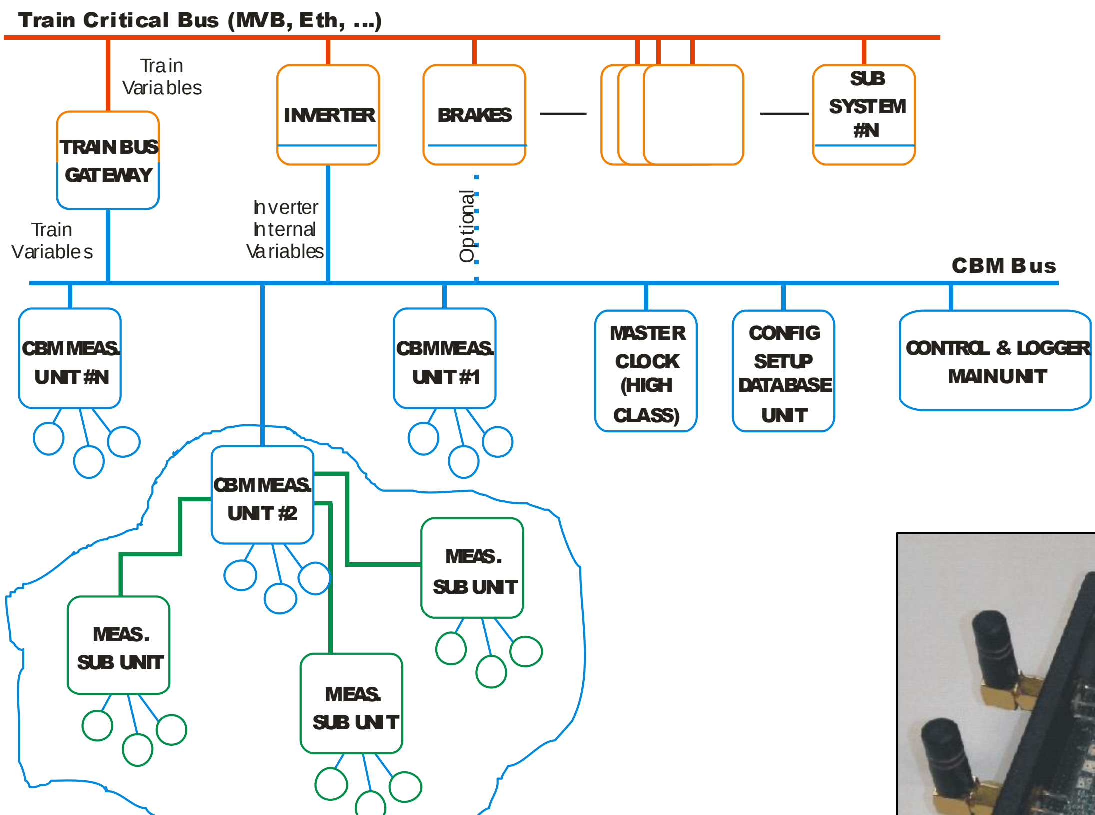
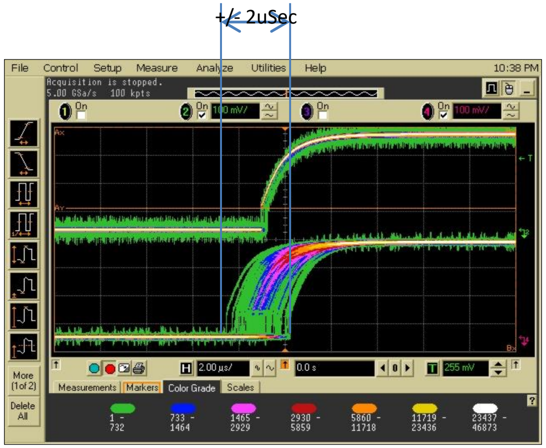
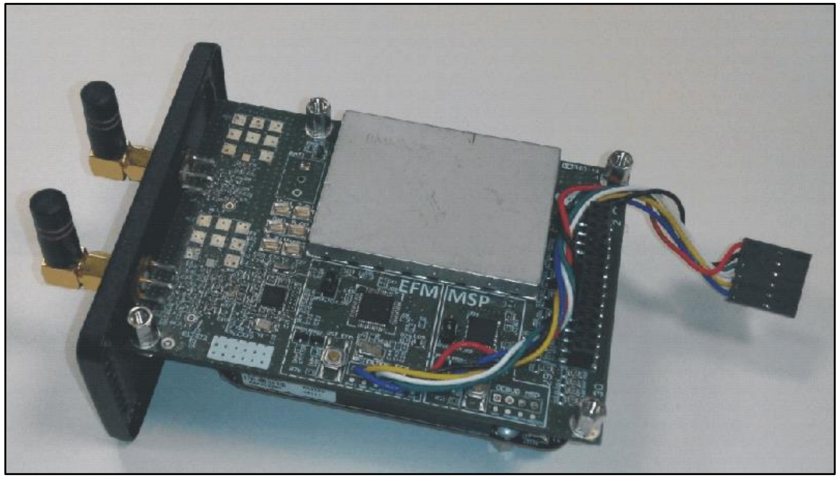
WP3.1 HMS for CBM





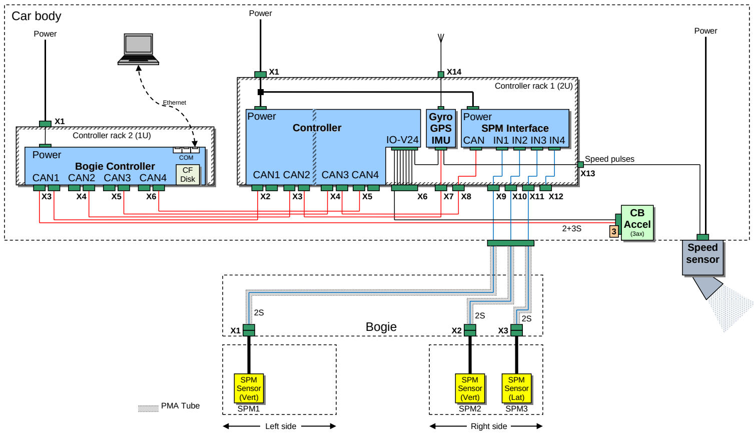


Synchronization (different levels)
Power supply
Wired /wireless nodes
...

WP3.1 HMS for CBM

TRACK CBM

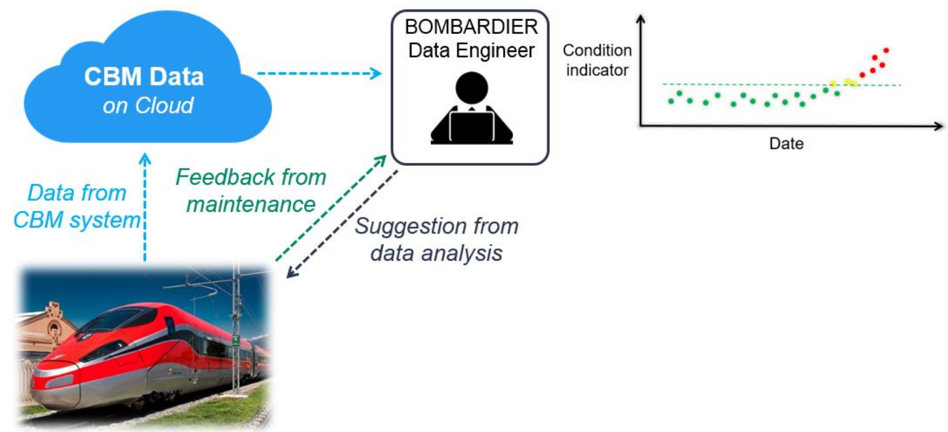
1. Definition of system architecture + hardware



2. Pilot application on tram

BEARING CBM

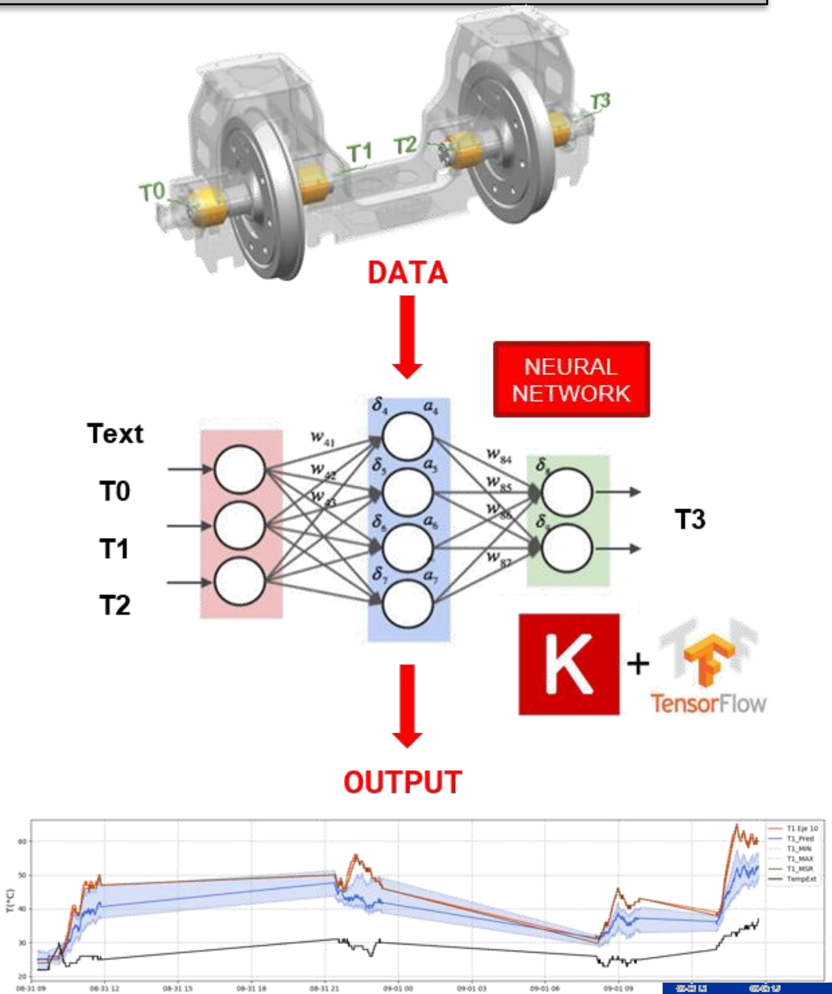
- **Axle bearing fault detection and severity level classification using axle box SPM sensor data**
- **Maintenance feedback is used for validation and calibration**
- **In case an axle bearing is confirmed as faulty, its temperature data is analysed to see if the bearing fault is indicated**



WP3.1 HMS for CBM

BEARING CBM

- **Software Development** for Evaluation of Bearing´s health through temperatures.
- Detection of anomalies in bearing temperatures through comparison with temperatures predicted by **Machine Learning algorithm**.
- Anomalies could be also identified by comparison with other magnitudes, such the reference temperature of **similar bearings**.
- Other useful information is included in the analysis, as for example the temperature of **redundancy sensor** or main calculated **parameters**.

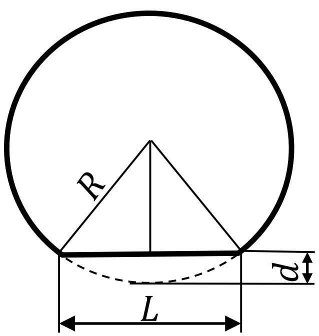


WP3 Smart Running Gear

Wheelset CBM (SIE)

Current limits for out-of-round wheels:

→ Limit the wheel geometry
→ Checking is very time consuming
→ Not checked continuously



Out of round…

…permissible
…not permissible

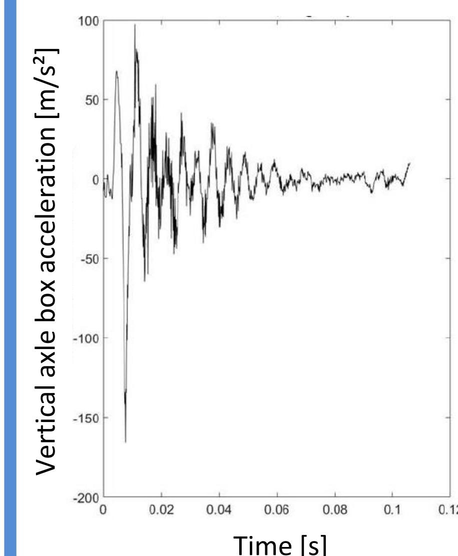
Table 7 — Limit lengths of wheel tread defects

M (t)		$M \leq 18$			$18 < M \leq 22.5$				$22.5 < M$		
V (km/h)		$V \leq 160$	$160 < V \leq 200$	$200 < V$	$V \leq 120$	$120 < V \leq 160$	$160 < V \leq 200$	$200 < V$	$V \leq 100$	$100 < V \leq 120$	$120 < V$
D (mm)	$1\,000 < d$	80	60	40	80	60	50	35	X	X	X
	$840 < d \leq 1\,000$	60	50	30	60	50	35	25	60	50	30
	$630 < d \leq 840$	40	30	25	40	30	25	20	40	X	X
	$550 < d \leq 630$	35	25	X	X	X	X	X	X	X	X
	$d < 550$	30	X	X	X	X	X	X	X	X	X

M: axle load in tonnes (t).
d: actual wheel diameter
X: reserved (no application known)

New approach:

→ Investigation of dynamic effects
→ Assessing the effect (axle box accelerations) and not the cause (geometric properties of the unroundness)
→ Fast and continuous evaluation possible



Out of round…

…permissible
…not permissible

WP3.1 HMS for CBM

Homologation

What must be validated?

- Good application of standards concerning hardware requirements
- Trustworthiness of the data provided by CBM

What must be homologated?

- Use of CBM does not have to reduce Safety
- Application of CSM (EU Regulation n°402/2013)

Train Track communication

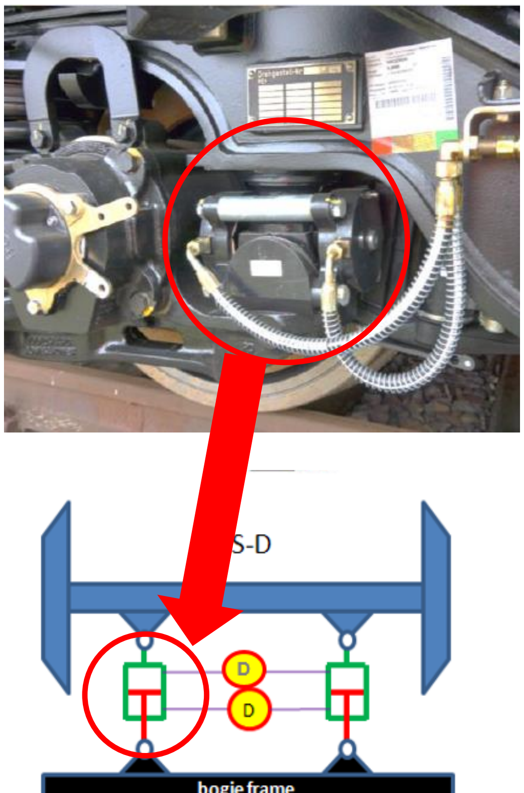
Data that are not currently collected that can be beneficial for different problems (i.e. improve Track acess charges)

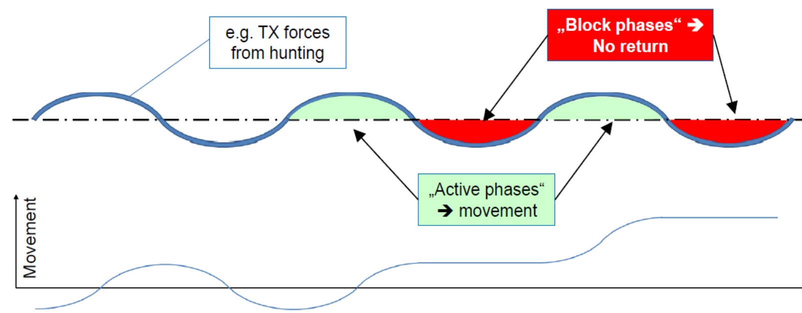
What can be done with the current data?

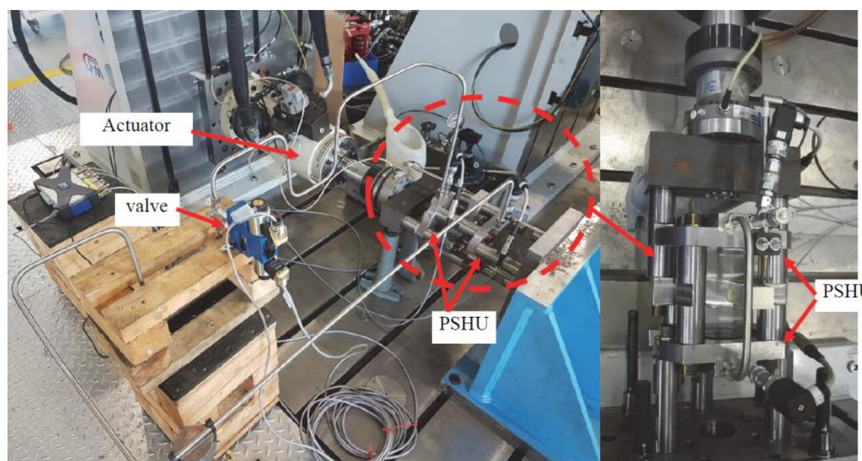
WP3.2 Active steering systems

Development and testing of semi-active wheelset steering

1. Integration of FLEXX Curve element in primary suspension
- with hydraulic piping between left and right side of the wheelset
- with 2 controllable valves (D) in the hydraulic pipes



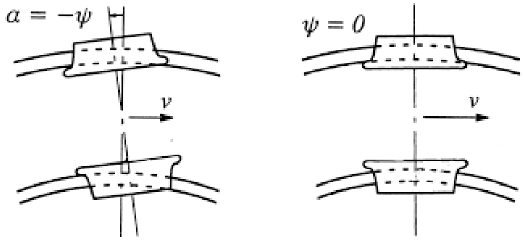




3. Laboratory tests

WP3.2 Active steering systems

Active Steering System for Independent Rotating Wheels



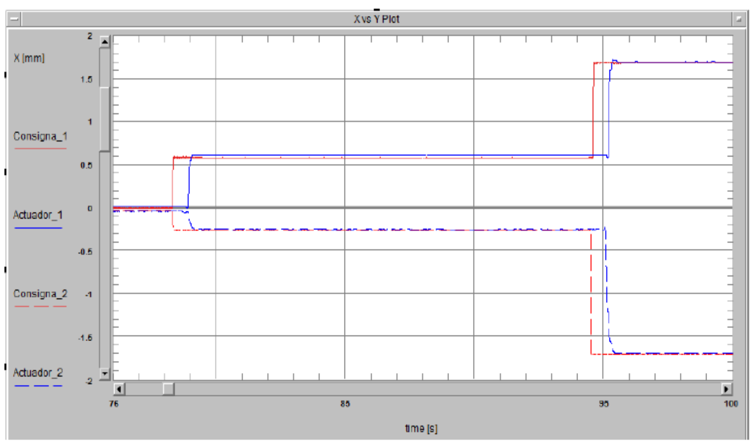
Both static and dynamic test (330km/h)

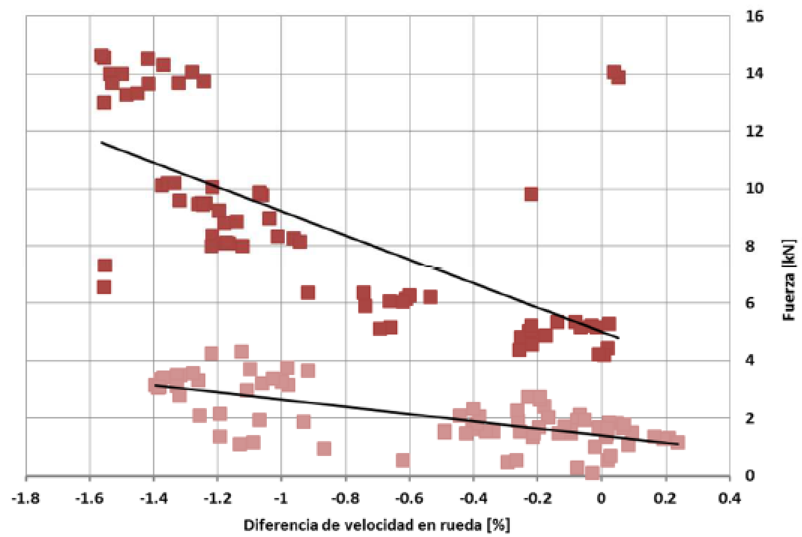
WP3.2 Active steering systems

Active Steering System for Independent Rotating Wheels

Main achivements:

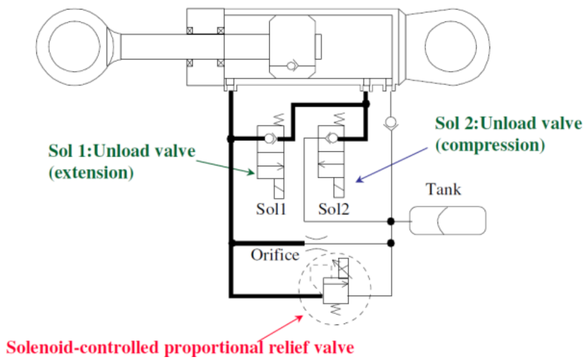
- The system is able to reduce the wheel speed difference, acting with the slope provided and in the established time.
- Reductions in the speed difference between wheels of the same stand, lead to reductions in lateral wheel force while driving straight

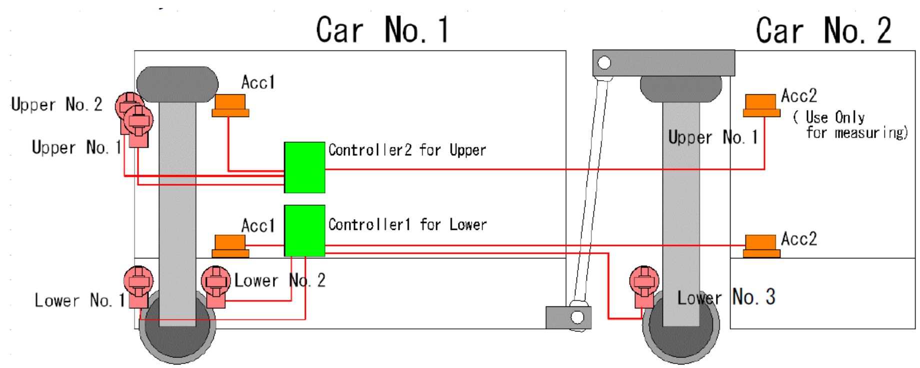


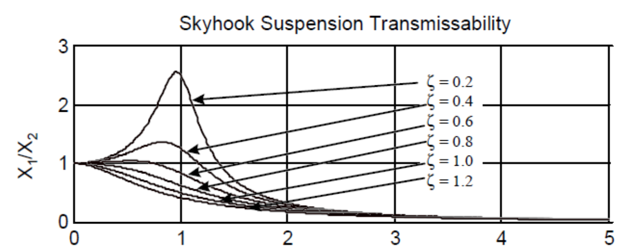


WP3.3 Active suspension systems

Active Suspension System for Independent Rotating Wheels





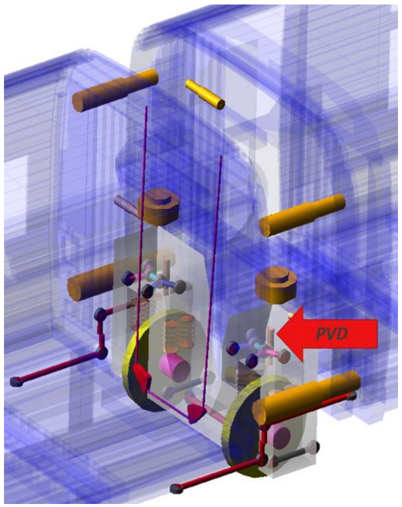


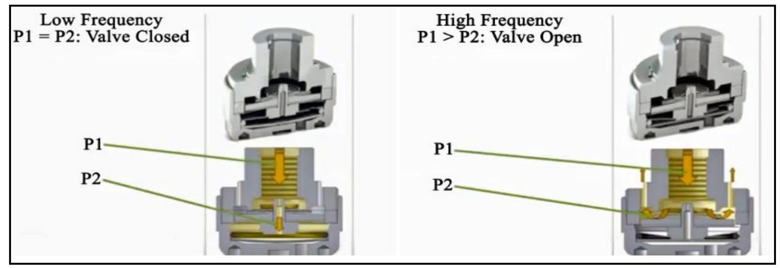
Objective

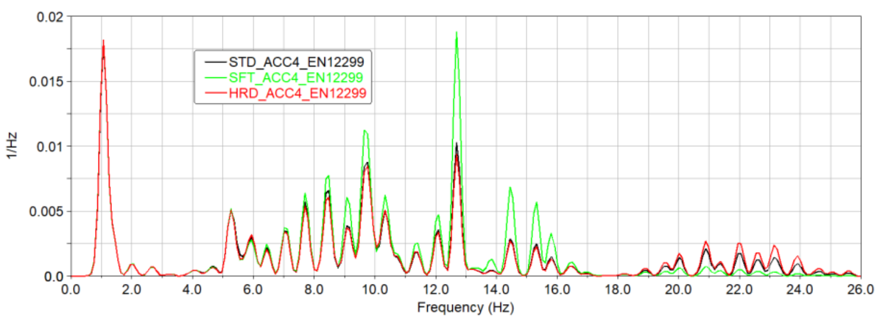
Increase Passenger Comfort Level by means of an Active Suspension

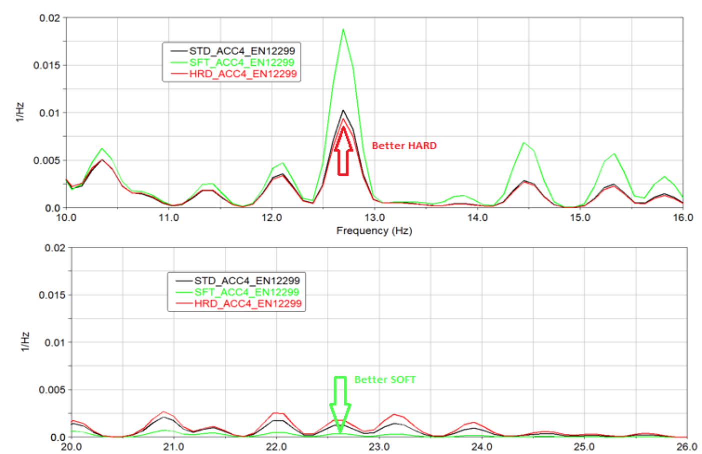
WP3.3 Active suspension systems

Active Suspension System for Independent Rotating Wheels



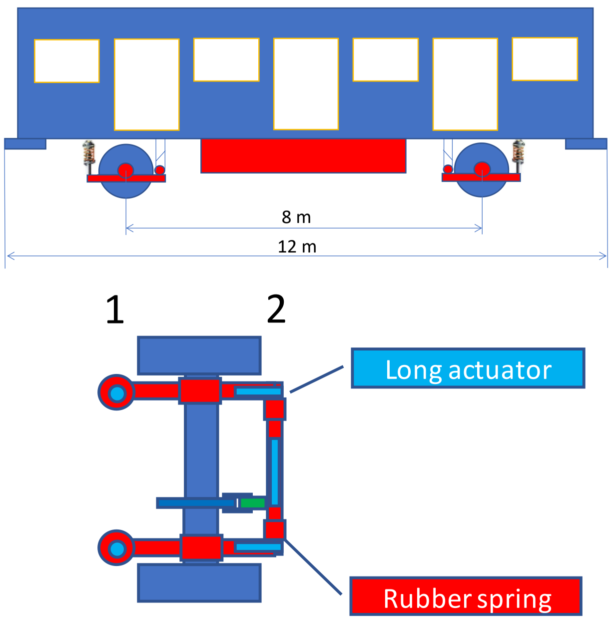




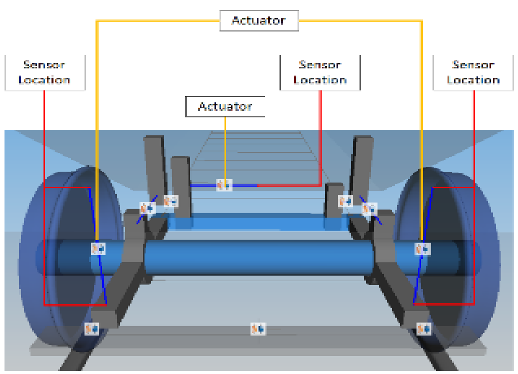


WP3.3 Active suspension systems

Active System



The innovative vehicle is designed for the same payload as the reference vehicle. Significant reduction of vehicle weight due to low weight running gear.



Long wheel base is known to cause high wheel and rail wear. Active wheelset steering proposed. 71% reduction in calculated wear compared to reference vehicle.

Single stage suspension is known to cause poor vibrational ride comfort. Active dynamic suspension proposed. Simulation shows results that is classified as good ride comfort.

PIVOT WP4 - Objective

Main goal of WP4

Define methodologies to improve performance of Running Gear

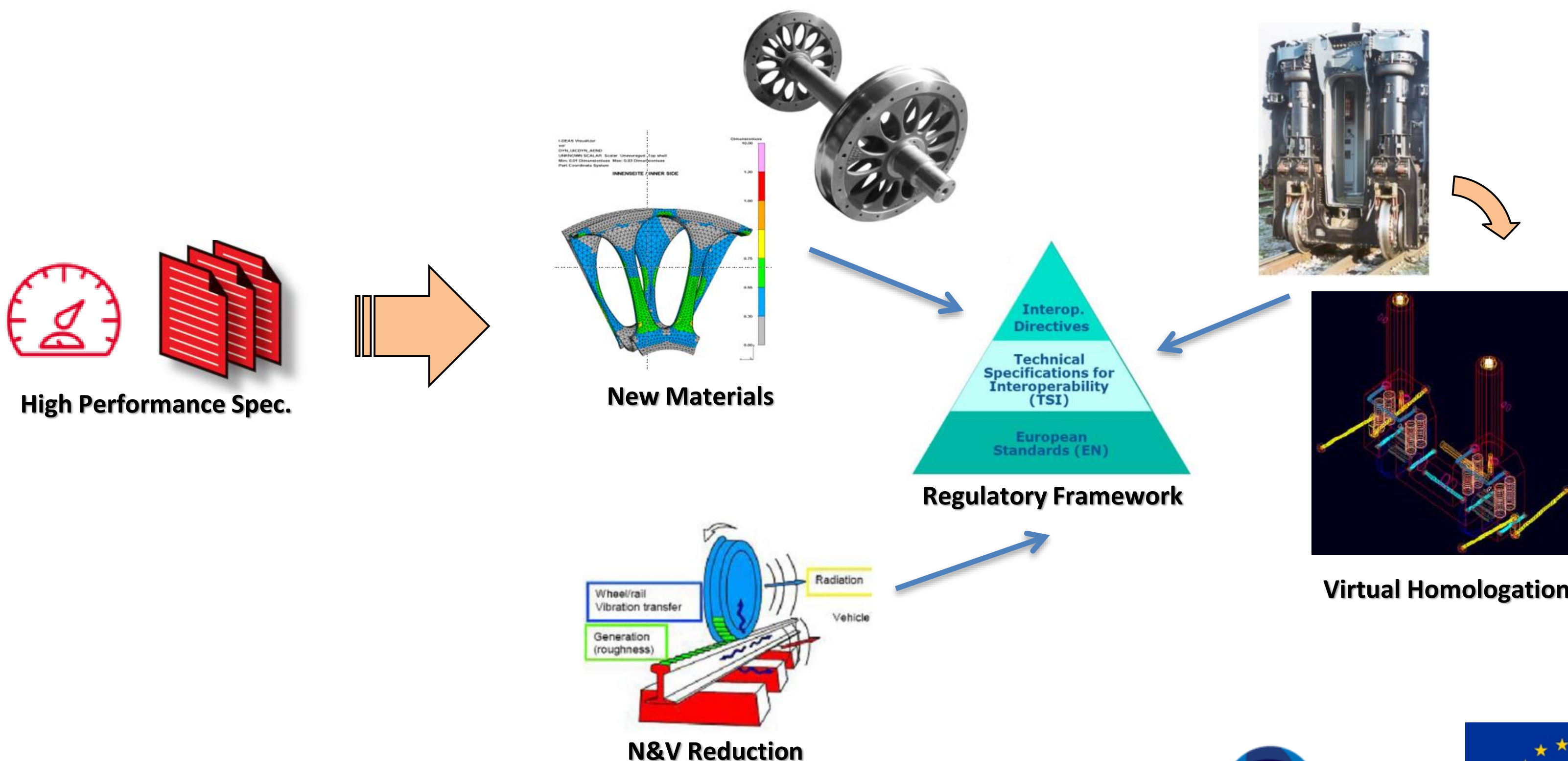
- ↓ Weight
- ↓ Wheel/Rail Forces
- ↓ Wear
- ↓ Energy Cost
- ↓ N&V Emission
- ↓ Homologation Costs

↓ LCC

↑ Reliability and Capacity

PIVOT WP4

- A Technical Specification for High Performance Running Gear.
- Study on the use of New Materials for Running Gear components.
- Noise and Vibration reduction to improve passenger comfort.
- Promote Running Gear certification by Virtual Homologation.
- Analysis of current regulatory framework affected by introduced technologies.

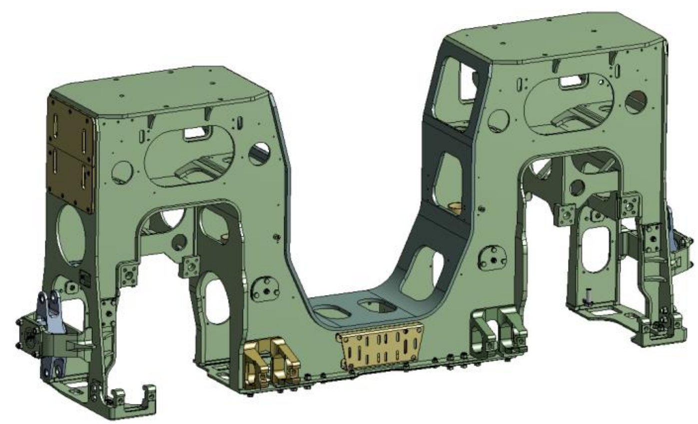


WP4: New Materials for Running Gear Frames

IRW Running Gear Frame for High Speed

Objective

Save up to 50% of the frame for HST Talgo AVRIL with inclusion of CFRP and High Strenght alloys taking into account specific requirements of fire resistance and ballast Impact.



Existing Welded Frame → Lighweight multi-material frame

IRW Running Gear Frame for High Speed

- New raw materials and processes imply modification in the current cost structure ↑↑
- The prices of raw material can diminish if automotive industry push on the supply chain or the demand in railway industry of high performance material increases dramatically .
- Specialized process which require skill workers and machinery

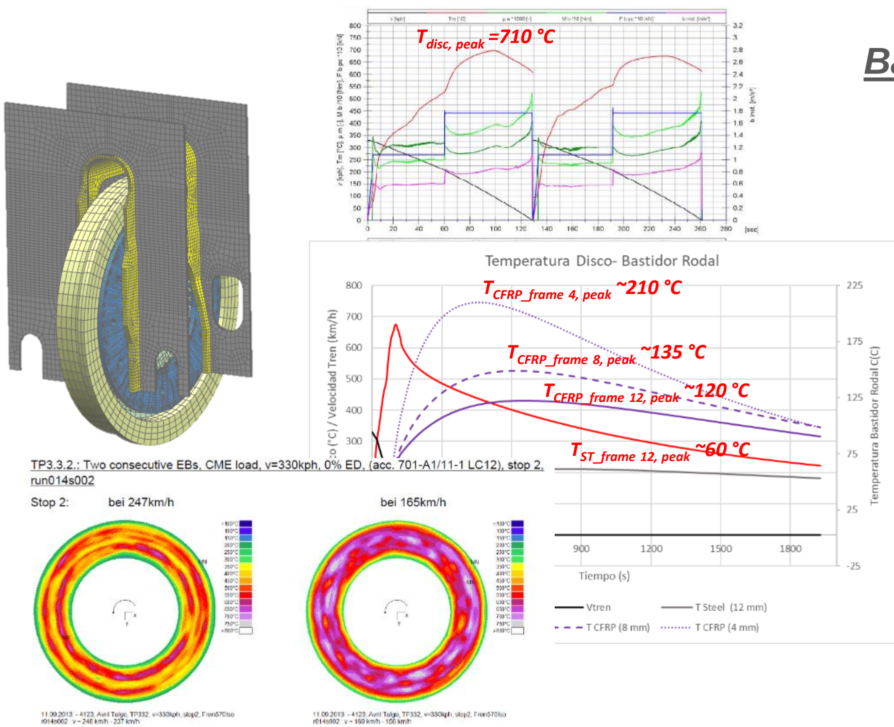
- The investment should justify trough cost reduction in other fields:
  - Energy consumption
  - Infrastructure canon
  - No. of passengers
  - others

Description	Design life One Train Savings (€/kg)
Energy	5-8
Canon	6-12
Passengers	50-100

IRW Running Gear Frame for High Speed

Brake Disc Areas Thermal Evaluation Numerical Thermal Simulation S355 Steel vs CFRP Design. Analysis Scenarios:

- Scenario 1: 330 → 0 km/h + 30 min stop (12mm Steel)
- Scenario 2: 330 → 0 km/h + 30 min stop (12mm CFRP)
- Scenario 3: 330 → 0 km/h + 30 min stop (8mm CFRP)
- Scenario 4: 330 → 0 km/h + 30 min stop (4mm CFRP)



Ballast high speed impact

- *Minimum protection level Requirement (with or without shields protection)*
- *According with NF F 07-101: 2002 (by Test)*
- *Defined by exposure Areas*:
  - *"A" – Direct frontal: level protection ≥ K9 (210 J).*
  - *"B" – Direct tangential: level protection ≥ K5 (60 J).*
  - *"C" – Tool drop: level protection ≥ K4 (35 J).*
  - *"D" – Others: level protection ≥ K1 (12 J).*
- *Test as specimen level*

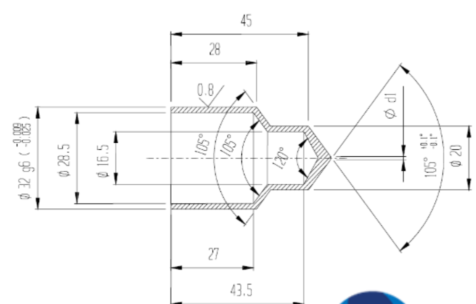
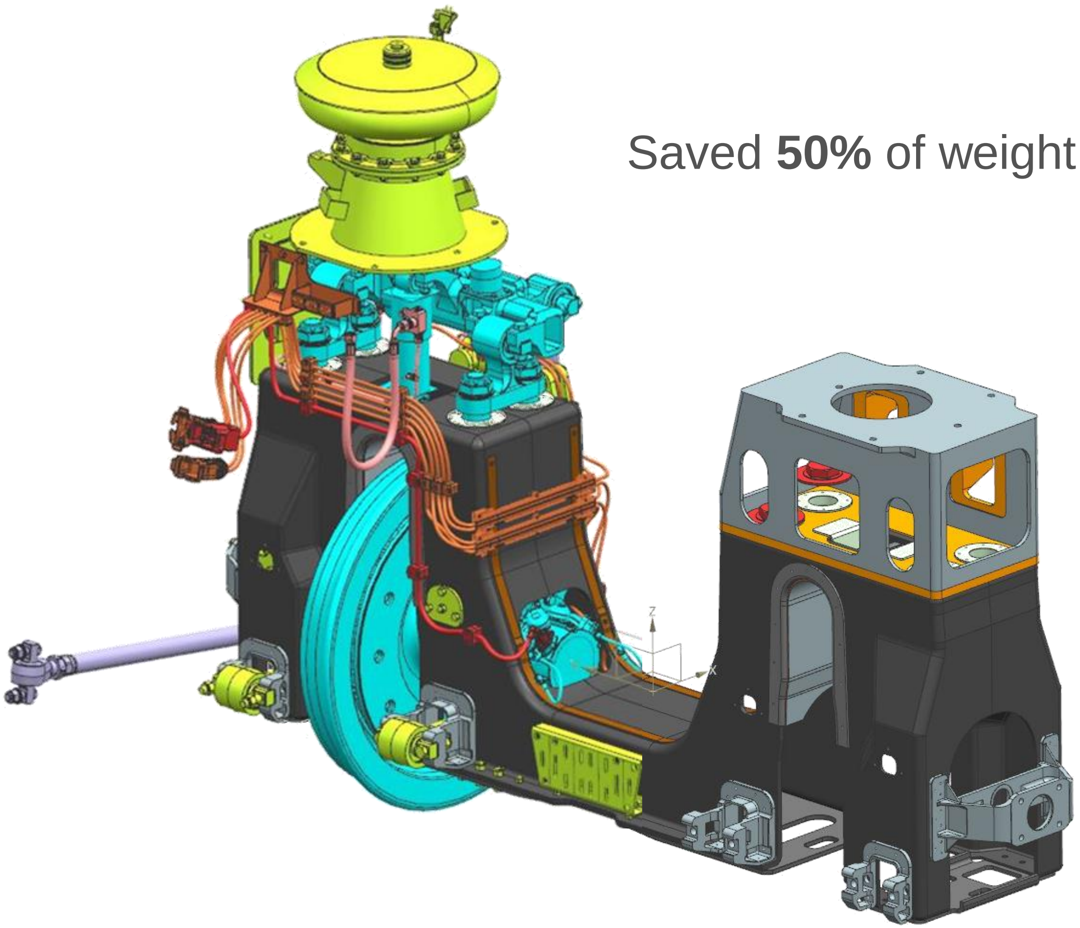
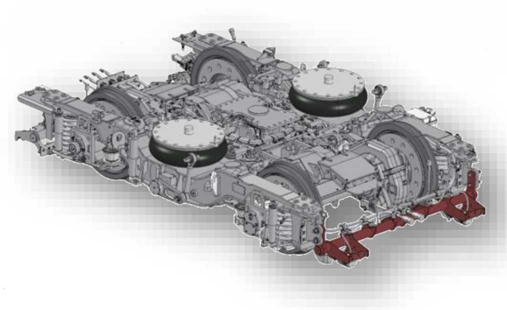


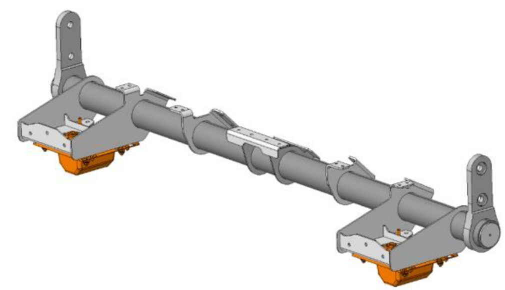
Figure 2 — Projectile



Saved **50%** of weight

Composite Antenna Beam





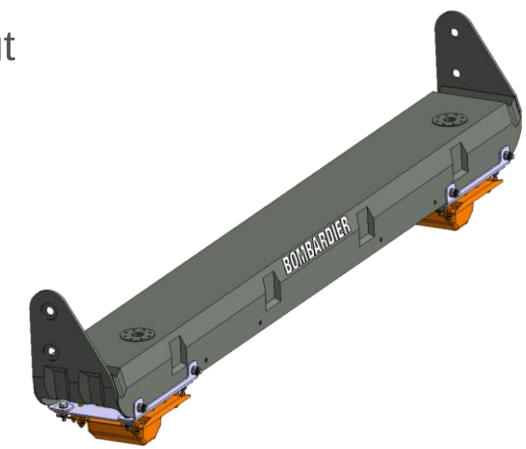
Existing Antenna Beam on Steel (~60kg)

Objective

To replace the respective conventional welded construction out of structural steel of the “BOMBARDIER* OMNEO* trains”.

Main achivements and Next steps

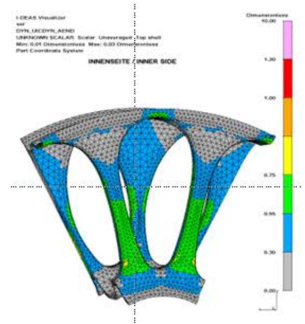
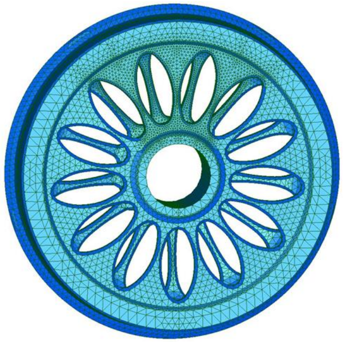
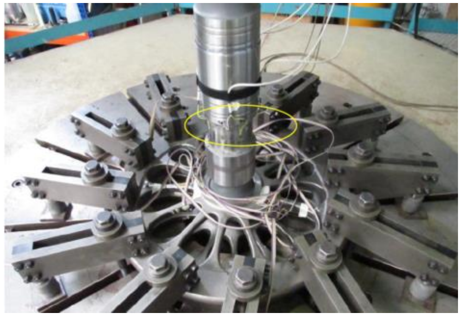
- Prototype manufactured and presented in Innotrans 2018
- Validation of the Composite Antenna Beam for use in normal railway service on test rig and by test runs.



New Antenna Beam on CFRP (~13kg)

PIVOT WP4: New Materials for Wheels

New Material and Wheel Design

Objective

Development of a new wheel with reduced:

- Wheel wear
- Tendency for polygonisation
- Weight
- Noise emission


Main achivements and Next steps

- Prototype manufactured, bench tested and presented in Innotrans 2018
- To validate in on-track tests at Metro Nuremberg for >1 year to gather long term information about wear.

PIVOT WP4. Materials

- Setting the state of the art on new materials. Standardization activities
  - CEN Survey Group
  - New Work Item Proposal for TC256
  - Process Standard for the Introduction of New materials

New Work Item Proposal	
C57/2019 – SC2/WG54 – Adoption of NWI for New materials	
TC 256 – Railway Applications	
Secretariat: DIN	Proposal documented in N xx
Date of circulation: 2019-07-04	Closing date for voting:

Railway Applications: Process standard for the introduction of new materials.

PIVOT WP4. Materials

Dissemination

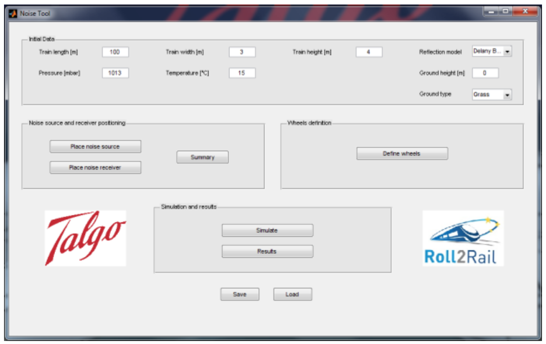
TRA2020 (sent).

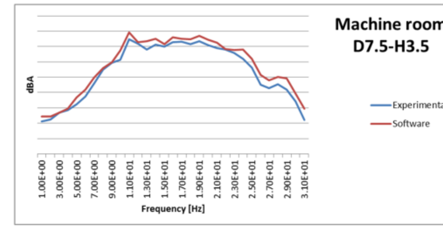
- Lightweight Running Gear frame for High-Speed application

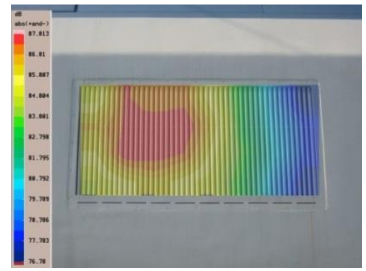
Composites in Rail

- Challenges for composites in primary structures and running gear frames- putting them to test on track.

Noise Tool





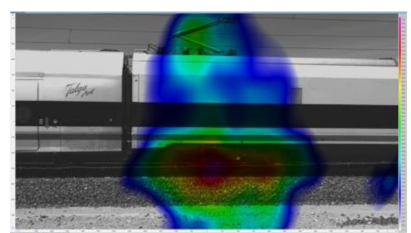


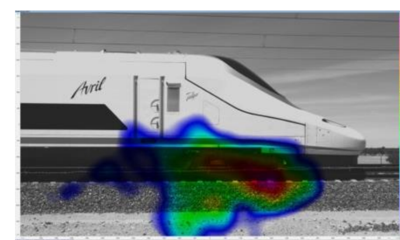
Objective

Develop a Noise Prediction Tool for exterior noise prediction in order to establish a standardized framework for any rolling stock manufacturer.

Main achivements and Next steps

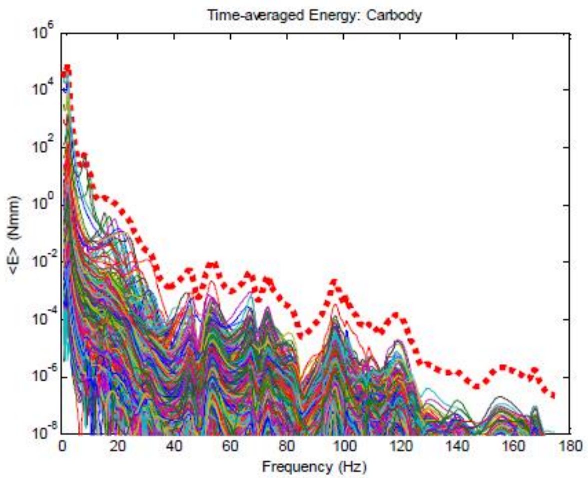
- Noise tool validated in Static Test
- Analyse measured data from field tests and correlate with calculated values.

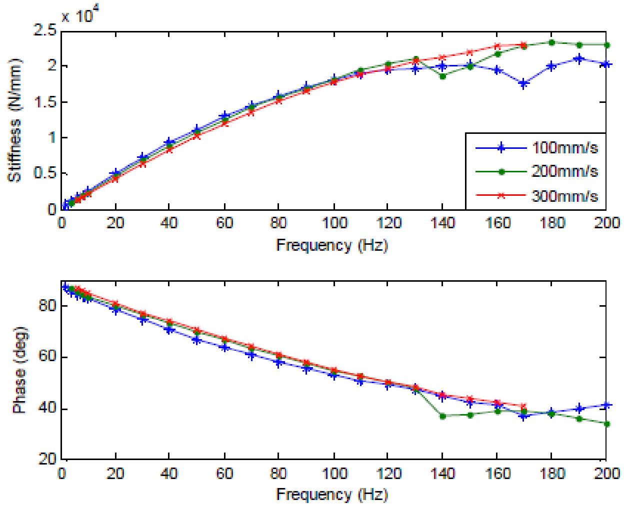




Vibroacoustic Characterization of Suspension elements

- Increase the knowledge about medium-high frequency behavior of suspension elements and its influence on vibration/noise transmission paths



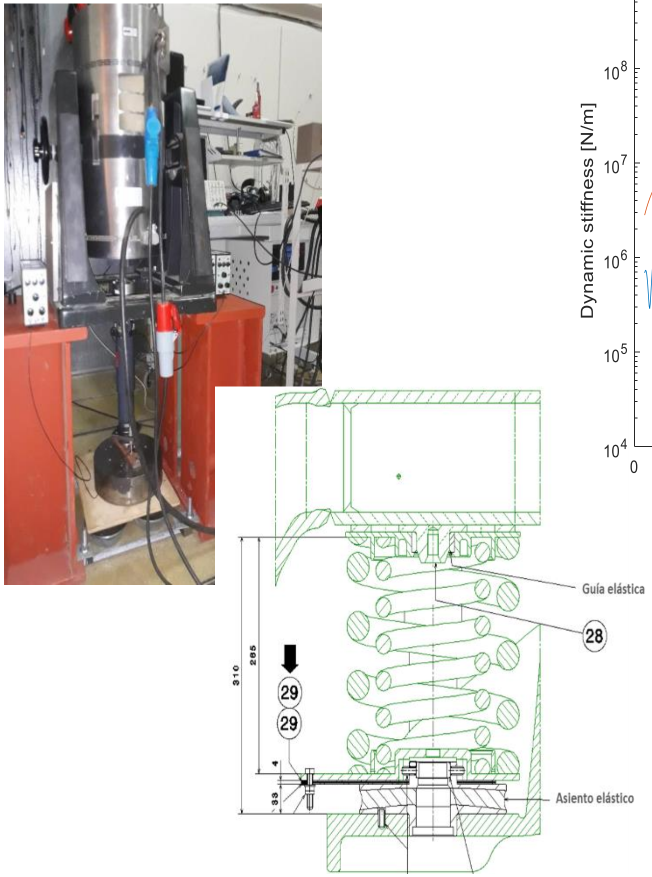


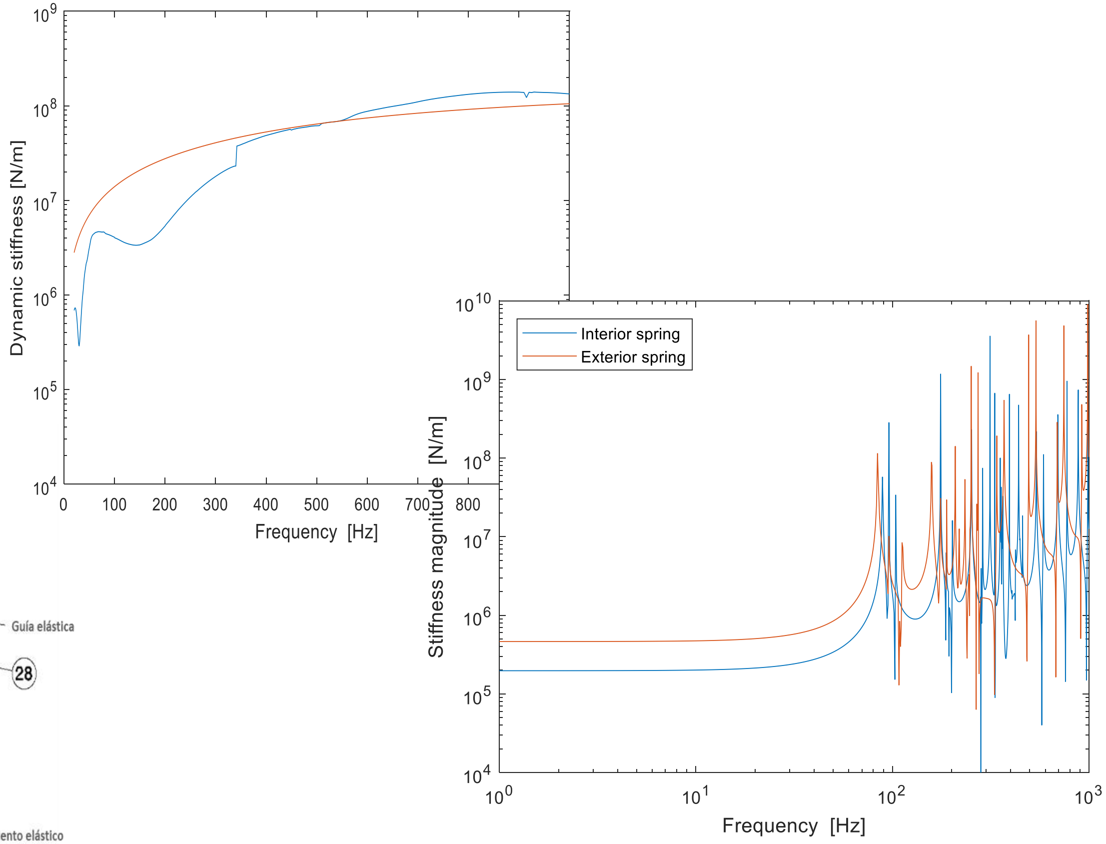
Main achivements and Next steps

- Test requirements defined
- Analyse the influence of the different suspension elements on the global behaviour

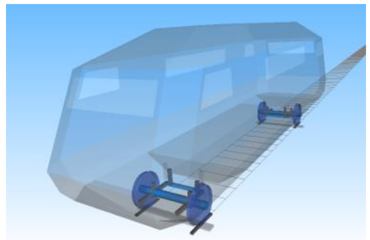
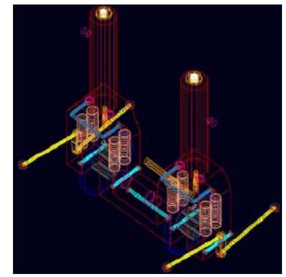
Vibroacoustic Characterization of Suspension elements

- Testing and simulation of railway component





Virtual Homologation Techniques


Objective

Define a new virtual certification method for running gears in order to reduce on-track tests in favor of increasing simulations and bench tests.

Next steps

- State of the Art
- Definition of Methodology
- Model Validation Strategy

RUN2RAIL – THE CONSORTIUM

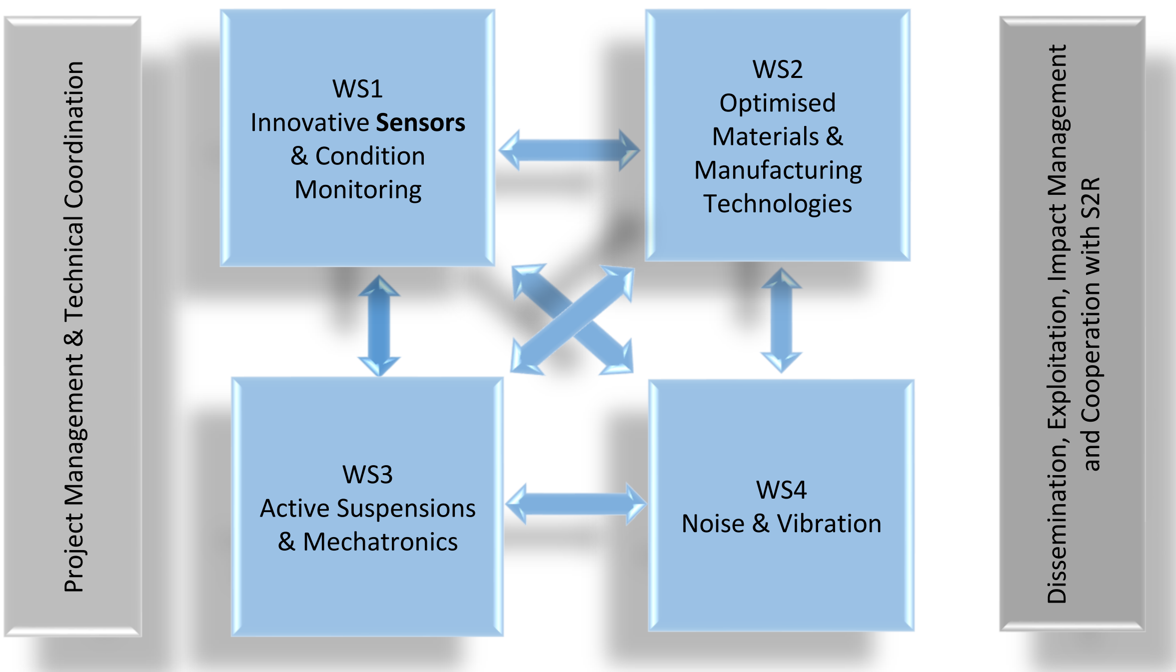
PROJECT COORDINATOR

TECHNICAL LEADER

BENEFICIARIES

RUN2RAIL – PROJECT STRUCTURE

- Four thematic workstreams
- One cross-cutting Work Stream ‘Impact Management Support and Assessment’
- Special consideration of aspects related with the authorisation of vehicles with innovative components



Scope: formulate technology concepts for condition monitoring systems considering three case studies:

- Smart wheelsets
- Bearings and gearboxes
- Suspension components

Structure:

- System requirements and architectures
- Hardware for condition monitoring
- Data processing, fault detection methods

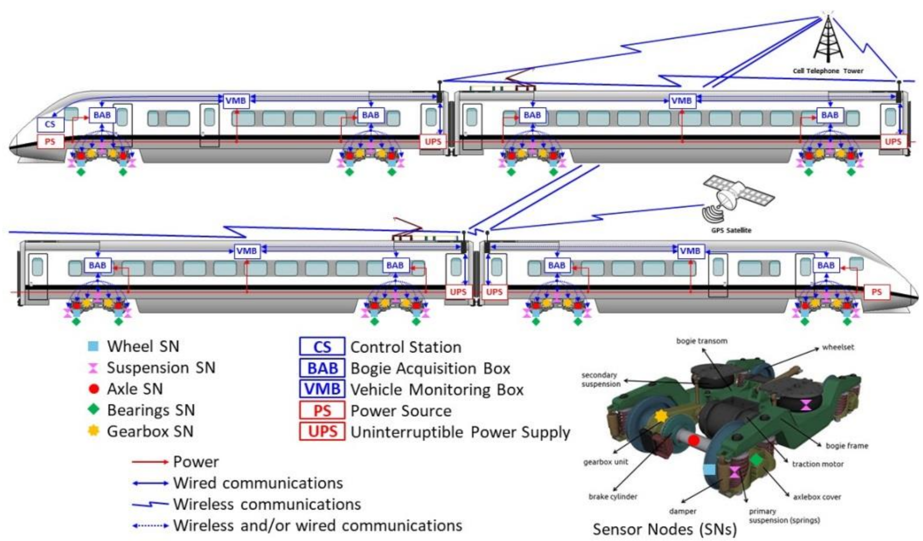
WS1 – SYSTEM REQUIREMENTS AND ARCHITECTURES

Objective:

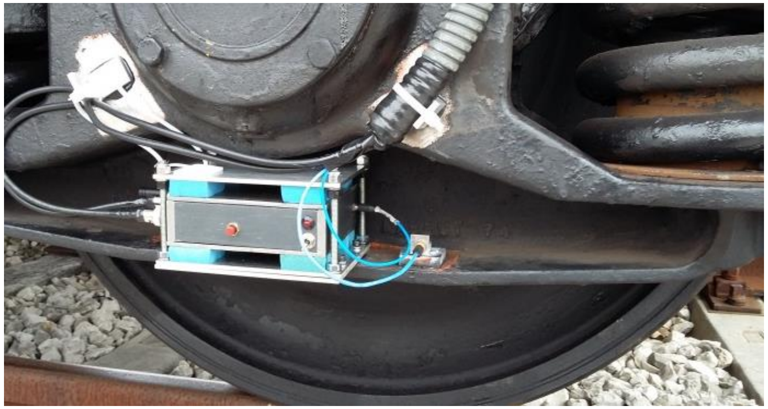
to define a concept for the system architecture of the condition monitoring system and a set of performance/functional requirements

Results achieved:

- State-of-Art analysis also covering other industry sectors
- Design of a modular, flexible system architecture for the on-board CM system
- Definition of a set of requirements including in terms of number and position of the sensor nodes, transducer performance, data acquisition, processing and storage, power supply

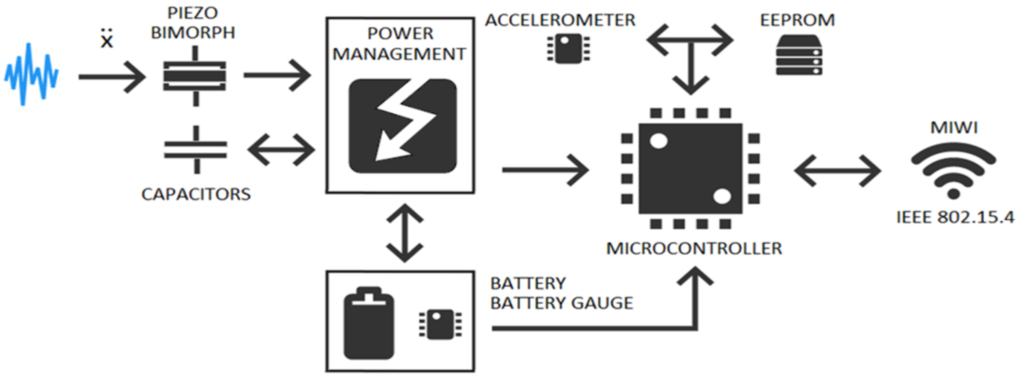


Objective:
to identify suitable hardware components for the different components of the CM system. Perform preliminary RAMS analysis to assess the use of components in the railway environment



Results achieved:

- Review of existing condition monitoring components
- Use of embedded, self-powered sensors to monitor wheelset axles
- Assessment of optimal system configurations
- Specification of selected configurations

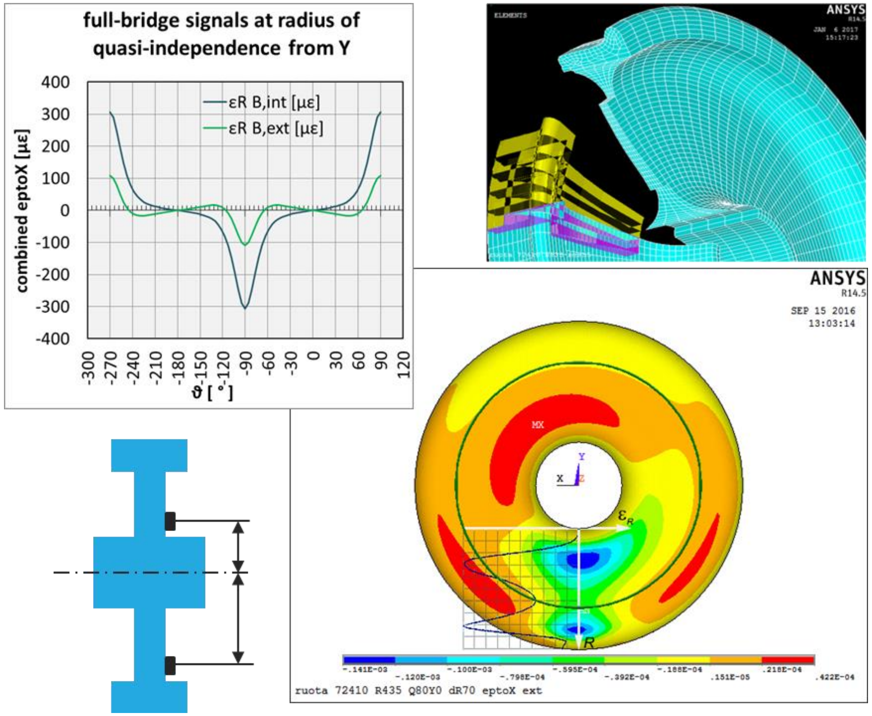


Objective:

to develop data processing techniques suitable to extract information on the condition of the running gear, to be used for predictive maintenance purposes

Results achieved :

- Feasibility of a low-cost strain-gauge-based measuring system for monitoring wheel/rail contact forces;
- Low-cost & robust detection of faults in the powertrain by measuring the instantaneous angular velocity;
- Monitoring of suspension components based on bogie-mounted acceleration sensors

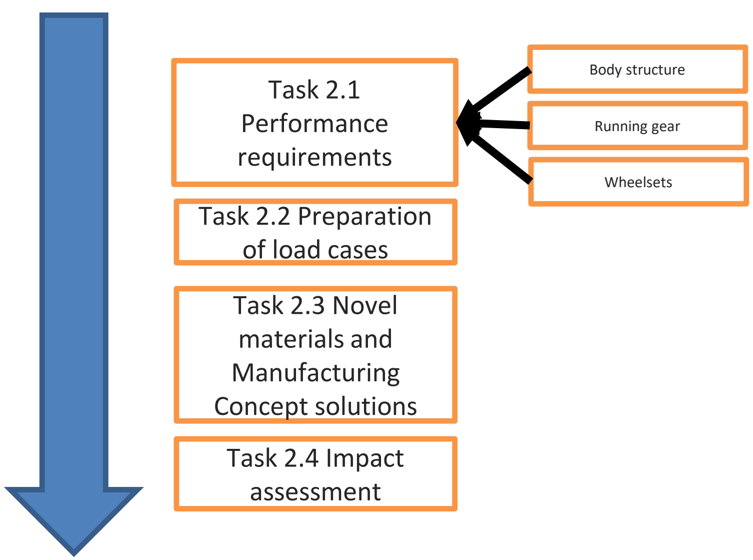


WS2 – OPTIMISED MATERIALS AND MANUFACT. TECH.

Scope: Produce and evaluate concept designs for selected sub-systems in the running gear, to be manufactured using new lightweight materials and innovative manufacturing technologies. Assess key areas where standards or culture need to be changed to allow the adoption of novel materials.

Structure:

- Performance requirements and load cases
- Vehicle concept design
- Novel materials and manufacturing concept solutions



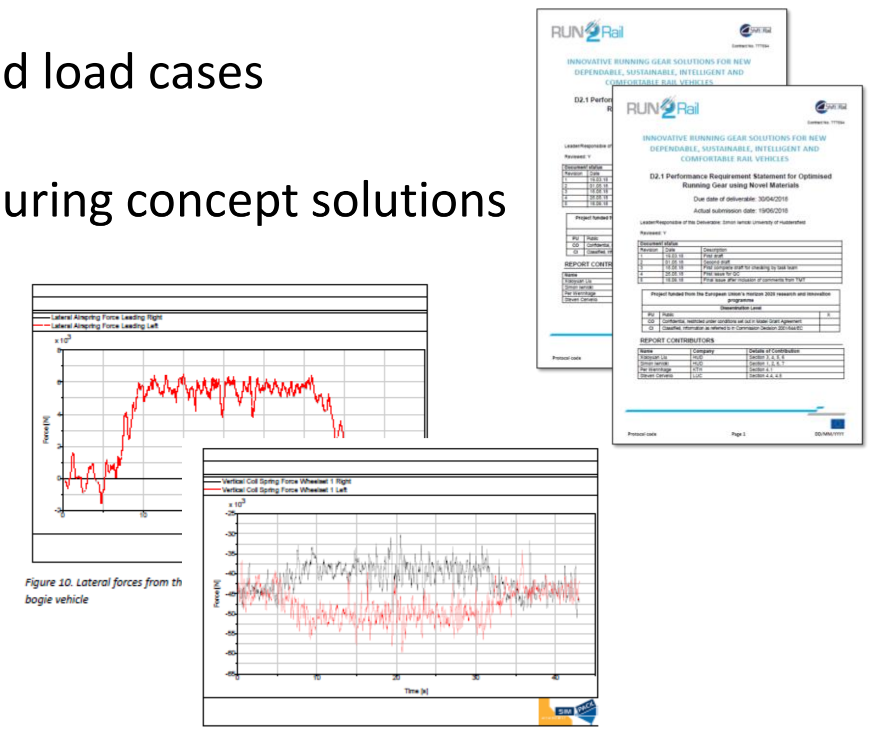
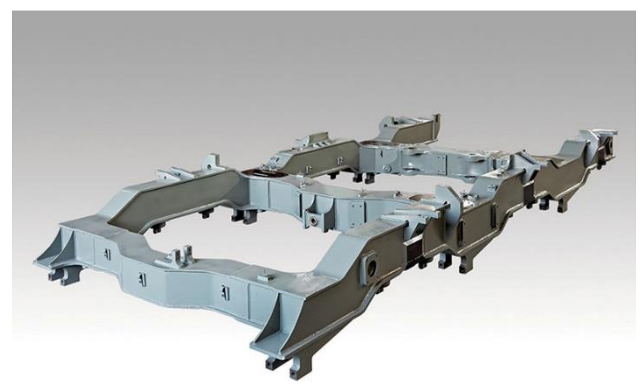


Figure 10. Lateral forces from th bogie vehicle

Figure 8. Vertical forces on the bogie frame from the primary coil springs of the leading axle of bogie vehicle

WS2 – OPTIMISED MATERIALS AND MANUFACT. TECH.

Methods considered



Additive Manufacturing

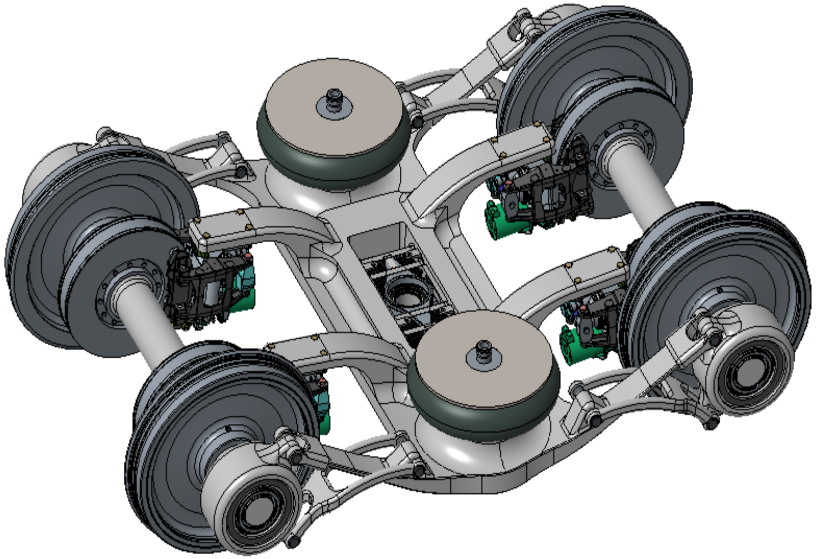
- Selective Laser Melting
- Review of powder metallurgy
  - Alloy
  - Powder morphology
- Potential components include:
  - Axle box
  - Component mounting links

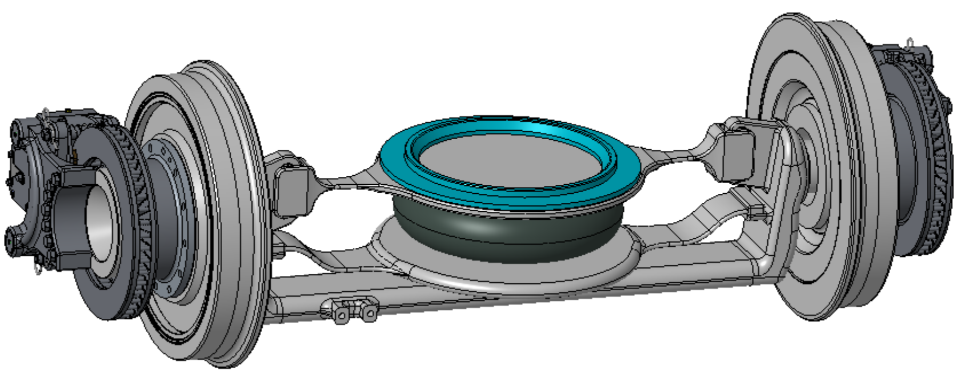
Carbon fibre

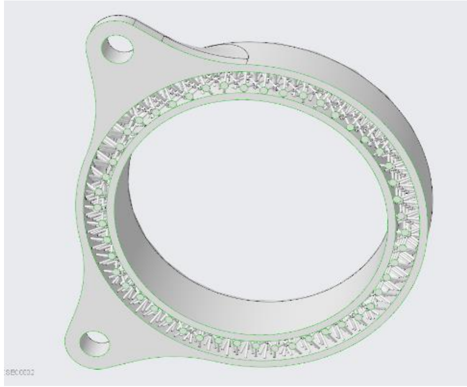
- Robotic layup of long fibres
- Potential components include:
  - Bogie side frame
  - Portal frame

WS2 – OPTIMISED MATERIALS AND MANUFACT. TECH.

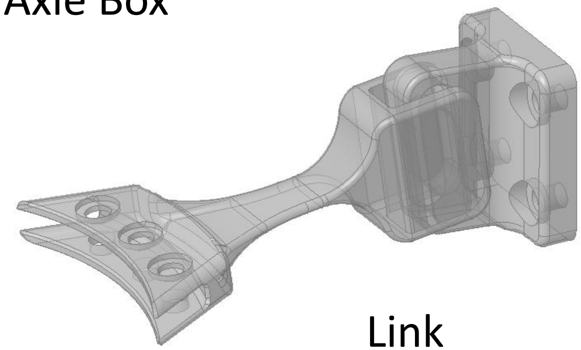
Components considered







Axle Box

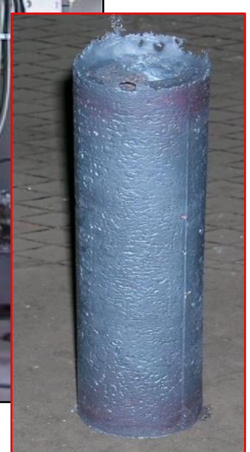


Link

WS2 – OPTIMISED MATERIALS AND MANUFACT. TECH.

PIVOT Mat4Rail RUN2Rail FAIR STATIONS

VACUUM INDUCTION MELTING



VACUUM INDUCTION GAS ATOMISATION

Shift2Rail

WS2 – OPTIMISED MATERIALS AND MANUFACT. TECH.

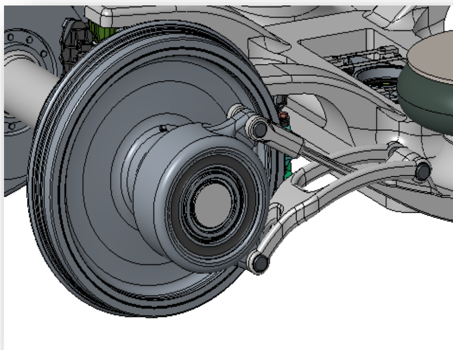
Samples manufactured and tested

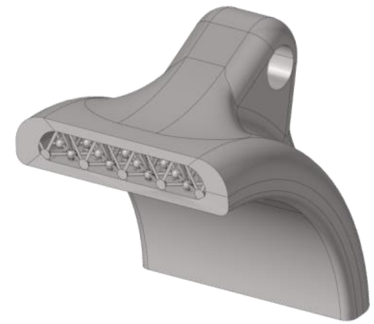
(a)

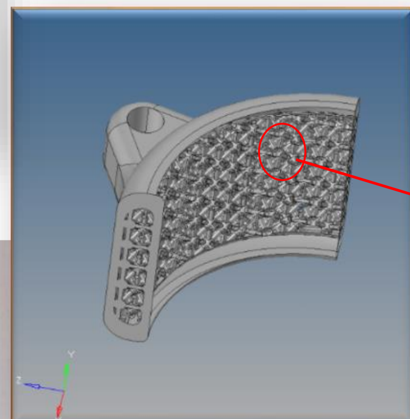
(b)

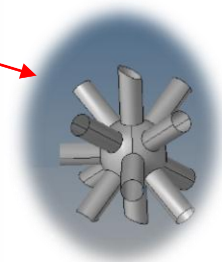
WS2 – OPTIMISED MATERIALS AND MANUFACT. TECH.

A quarter axlebox with an internal lattice structure has been manufactured

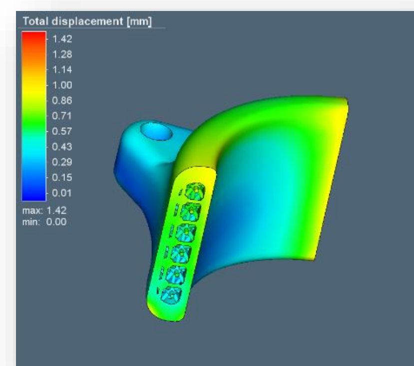








FE analysis carried out



The main objective is to remove barriers to the introduction of active suspension systems in railway vehicles

Scope:

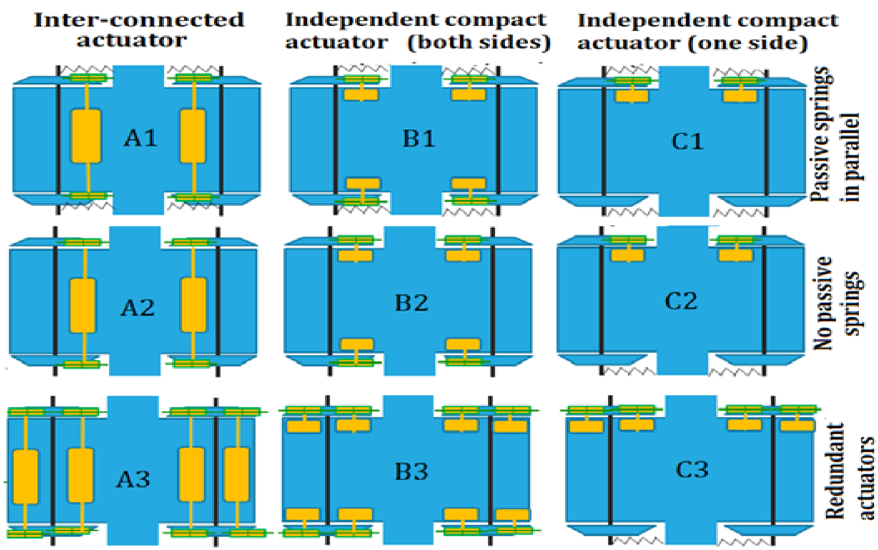
- Investigate the **suitability of existing actuator technology** for mechatronic suspensions in railway vehicles
- **Easier authorisation procedure**
  - Analysis of fault tolerant actuation systems
  - Authorisation strategies for active suspension: templates and examples of safety cases for the authorisation strategy.
- Concept of a metro vehicle with **innovative single axle running gear** and mechatronic suspensions

Scope:

- State-of-Art analysis of existing actuation systems
- Expert assessment of the suitability of different types of actuator technology for active / semi-active suspensions
- Outcome in the form of a "Technical Validation Matrix"

				Actuator technology							
Type				Full active					Semi-active		
				1	2	3	4	5	6	7	8
Description				hydraulic central power pack	hydraulic compact actuator	electro-mechanical	pneumatic use of existing supply	electro-magnetic	hydraulic	magneto rheological	electro rheological
Level of maturity of technology			slow acting	5	5	5	5	2			
			fast acting	5	5	4	2	4	5	5	1
Active suspension application	vehicle with 2 suspension stages	Secondary	lateral (centering)	3,33	4,17	3,50	4,00	2,17	2,00	1,67	1,17
			lateral (dynamic)	3,33	4,33	3,00	2,17	4,00	4,50	3,00	1,83
			vertical (levelling)	3,17	4,00	3,33	4,83	2,17	2,00	1,67	1,17
			vertical (dynamic)	3,17	4,00	2,83	2,00	3,50	4,50	3,50	2,17
			yaw (stability)	3,33	3,83	3,17	1,33	2,33	3,17	2,33	1,67
			yaw (steering)	3,00	3,67	4,00	2,00	2,33	2,00	2,00	1,50
		Primary	lateral (dynamic)	1,33	1,50	1,17	1,00	1,17	1,83	1,17	1,00
			vertical (dynamic)	1,83	2,17	2,00	1,83	2,00	3,17	2,33	1,33
			yaw (stability)	2,50	3,00	3,50	1,50	1,83	2,00	1,00	1,00
			yaw (steering)	3,00	3,83	4,83	2,33	1,67	1,00	0,83	0,83
	Innovative vehicle with one suspension stage		lateral (centring)	2,50	3,17	2,50	3,33	2,00	1,83	1,50	1,00
			lateral (dynamic)	2,83	3,33	2,50	1,83	3,67	3,83	2,83	1,83
			vertical (levelling)	2,67	3,50	2,50	3,83	2,17	2,00	1,67	1,17
			vertical (dynamic)	2,83	3,50	2,33	2,33	3,33	4,17	3,50	2,33
			yaw stability	3,00	3,33	3,33	1,50	1,67	2,50	1,67	1,33
			yaw (steering)	3,17	3,67	4,67	2,00	1,83	1,00	0,83	0,83

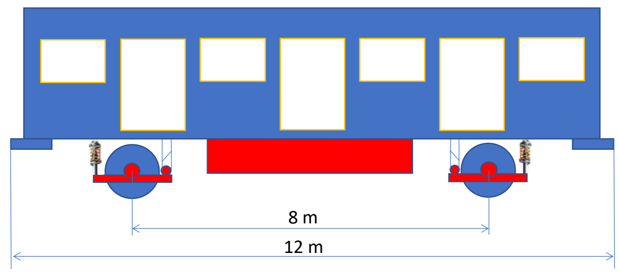
- Analysis of control strategies and actuator technologies for active steering of the bogie through curves
- Assessment of benefits via MBS simulation
- Analysis of different suspension configurations and comparison of RPN for different fault cases, to optimise fault tolerance

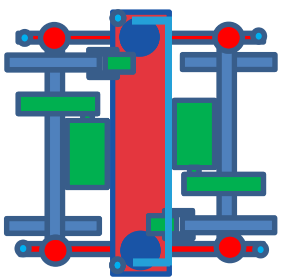


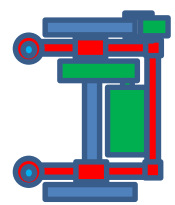
	Max force		Zero force		Harmonic excitation	
Schemes	Config 1	Config 2	Config 1	Config 2	Config 1	Config 2
A1	12	4	4	4	6	3
B1	8	4	3	3	4	4
C1	9	3	3	3	6	3
A2	16	8	8	4	9	6
B2	32	8	6	3	20	12
C2	9	6	9	3	18	6
A3	4	4	5	5	4	4
B3	4	4	4	4	8	4
C3	4	4	3	3	4	4

Two-axle vehicles with active suspension

The innovative vehicle is designed for a payload of 1 000 kg/m, which is the same as the reference vehicle. Significant reduction of tare weight is expected.







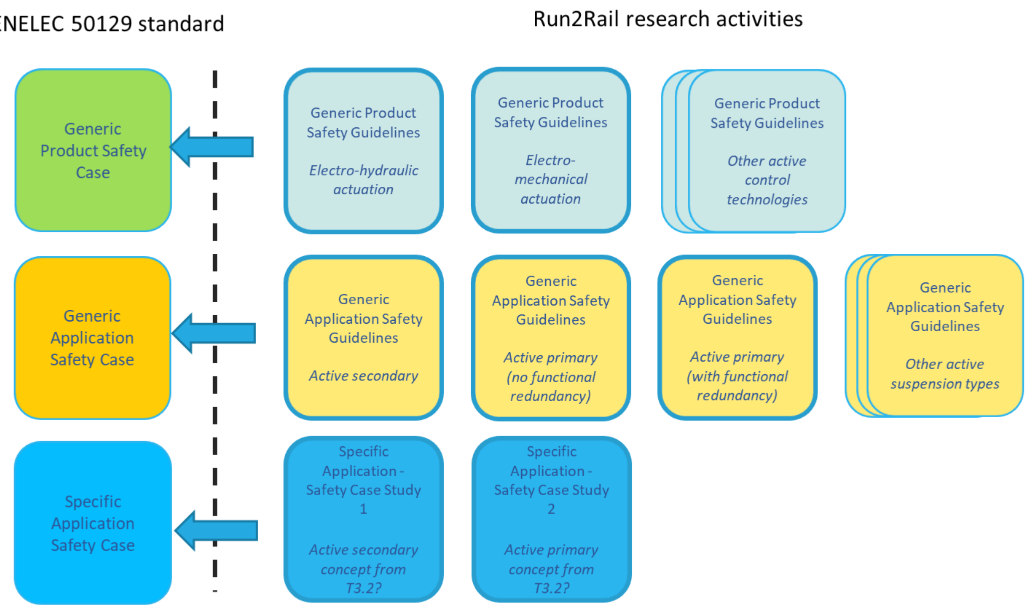
In total 400 kg/m weight savings

The axle boxes moved to inside the wheels	=> Shorter and lighter axle More compact and lighter frame
One suspension step eliminated	=> Less weight
No need for air suspension	=> Air free train???
Anti roll bar part of frame	=> Less weight

The weight savings on the running gear will lead to other weight savings (100 kg/m)

WS3 – AUTHORISATION STRATEGY

NEW STRATEGY FRAMEWORK PROPOSAL



Run2Rail T3.3: Authorisation Strategy

This is a draft document for discussion.

This document contains colour-coded text. The system of colour-coding is:

Orange text: This is guidance material for people completing this safety case template. Orange text describes the purpose of each section of the report. It is intended that orange text should be deleted by the safety case author.

Italic green text: This provides information on the content that should be provided in each section, sometimes simple examples are provide to clarify the nature of the content that is required. It is intended that italic green text is replaced by the correct content by the safety case author.

Black text: This is boilerplate text that will be needed in the final safety case. It is intended that black text be kept *as-is* in the safety case document.

Red text: This is discussion text intended for the T3.3 project team during review of this document. Red text will not be included in the released version of this document.

Template for Generic Product Safety Case Guidelines

This document is one of three templates that has been prepared to allow for safety cases to be developed for active suspension systems for rail vehicle.

The three templates are for a:

- *Generic Product Safety Case (GPSC) – this document;*
- *Generic Application Safety Case (GASC); and*
- *Specific Application Safety Case (SASC).*

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Template for Specific Application Safety Case Guidelines

This document is one of three templates that has been prepared to allow for safety cases to be developed for active suspension systems for rail vehicle.

The three templates are for a:

- *Generic Product Safety Case (GPSC);*
- *Specific Application Safety Case (GASC); and*
- *Specific Application Safety Case (SASC) – this document.*

Run2Rail T3.3: Authorisation Strategy

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Template for Generic Application Safety Case Guidelines

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The three templates are for a:

- *Generic Product Safety Case (GPSC);*
- *Generic Application Safety Case (GASC) – this document; and*
- *Specific Application Safety Case (SASC).*

WS4 – NOISE AND VIBRATION

Scope: transmission of noise and vibration from the running gear into the carbody

Structure:
- Choice of case study vehicle
- Characterisation of suspension elements using laboratory measurements
- Develop methodology for predicting the transmission of noise and vibration (‘virtual test method’)
- Validation by means of physical tests (static and running tests)
- Assessment of noise reduction technologies

Objective:

Measure dynamic stiffness of key components from suspension

Results achieved:

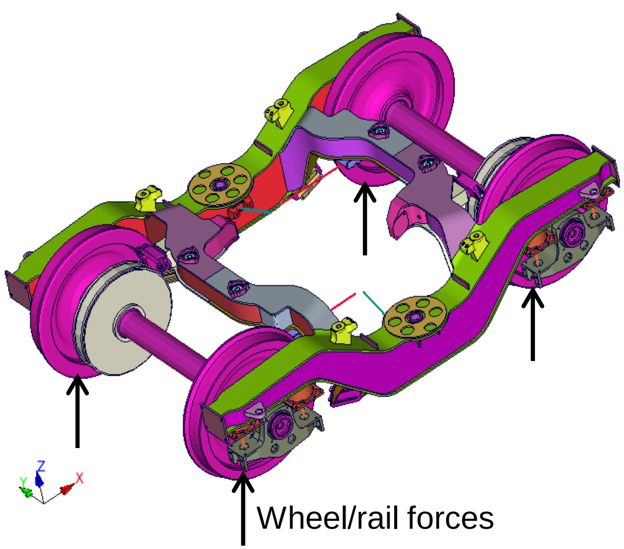
- Vertical and lateral dynamic stiffness of primary suspension spring measured under different preloads (50~600 Hz)
- Dynamic stiffness of lateral damper and traction rod bushings from secondary suspension

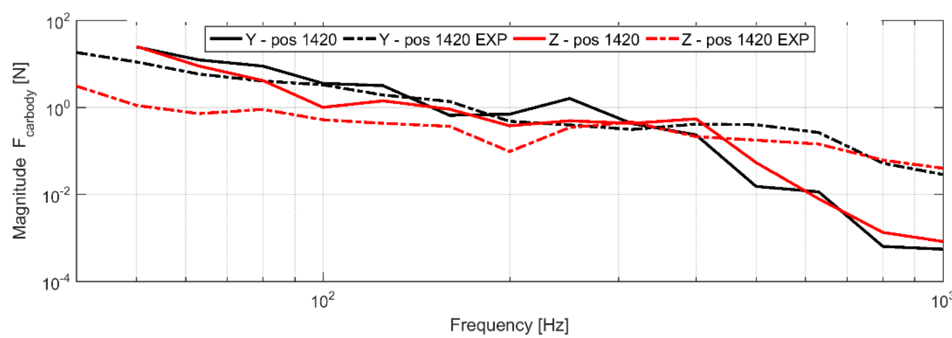
Objective:

To develop a methodology for predicting the structure-borne noise and vibration transmission from the running gear to the carbody.

Results achieved:

- Models of structure-borne transmission based on detailed finite element model of the bogie
- Good agreement with experimental assessment up to 400 Hz

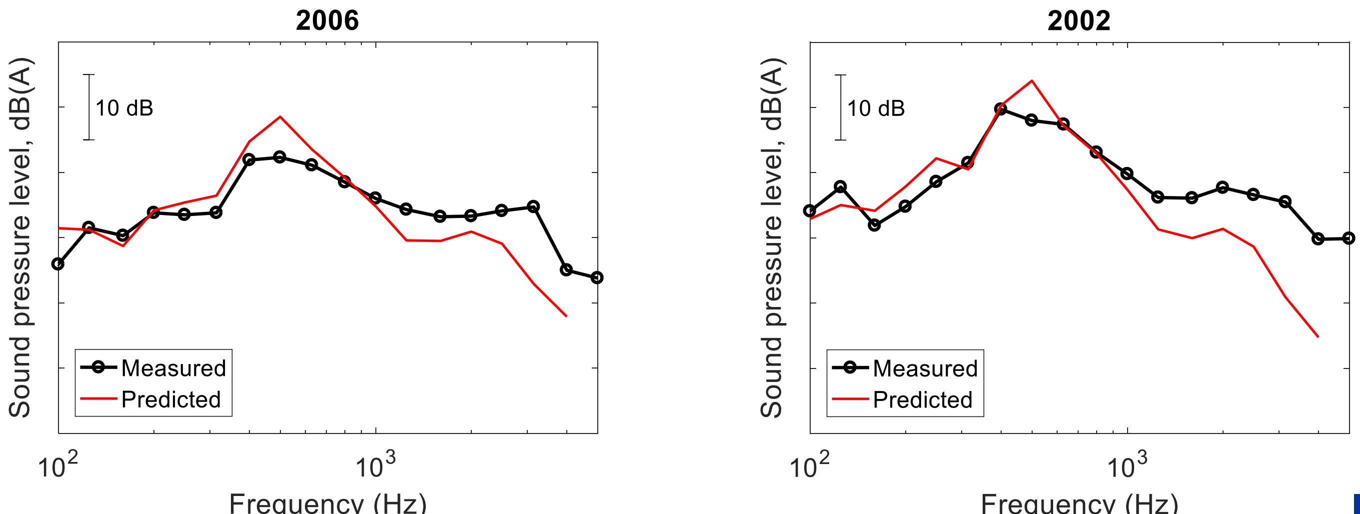




Blocked forces due to lateral damper: — model; –· –· measured; black lateral, red vertical

Objective:
To develop a methodology for predicting the airborne noise transmission from the running gear to the carbody.

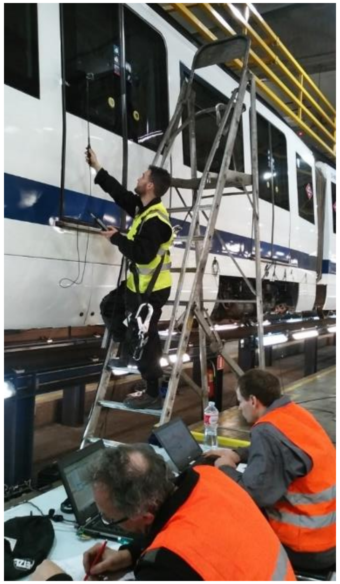
Results achieved:
- Rolling noise model (TWINS) including discretely supported track
- Models for sound transmission beneath vehicle and around the side walls validated with measurements
- Overall noise inside vehicle predicted within 3 dBA



WS4 – VALIDATION TESTS

Objective:
to validate and determine the reliability of the prediction approach using extensive field measurements

Results achieved:
- Extensive validation measurements in Madrid including static and running measurements
- Comparison with models giving good agreement for both structure-borne and airborne transmission



Objective:

to use the new virtual test method to study the effects of various changes to the running gear on the noise transmission

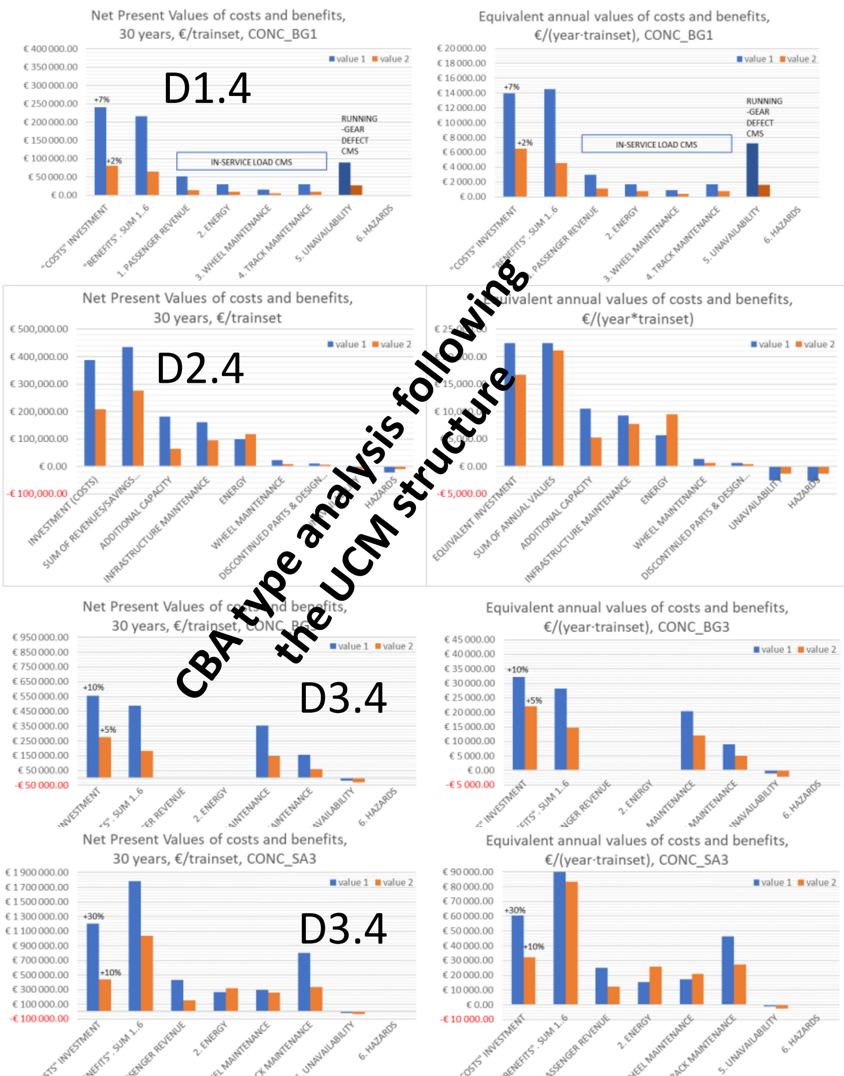
Results achieved:

- Sensitivity analysis using the model demonstrates the benefits of optimising the bushing stiffnesses
- Simplified assessment shows that using carbon fibre for the bogie frame could potentially lead to an increase in structure-borne noise by 10 dBA compared with steel. The methodology should be applied to specific designs
- Simplified assessment shows that introducing active control in the suspension system would not lead to excessive structure-borne noise transmission at higher frequencies
- Feasibility study of the use of magneto-sensitive rubber in suspension elements has shown that they are limited to 25 Hz

Scope:

- To identify the impacts targeted by RUN2Rail, linking them with Shift2Rail objectives and the other relevant required higher-level impacts, forming internal consensus on them, and subsequently sharing them with the relevant Target Groups.
- To provide a representation and assessment of impacts of the project, with particular care for those related to Shift2Rail and to R&S, with the utmost care devoted to the accuracy of the assessment so as to provide credible and convincing information to decision-makers.

ECONOMIC, ENVIRONMENTAL, SOCIAL IMPACTS



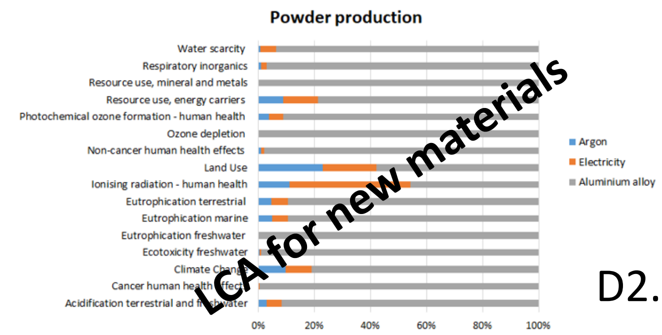
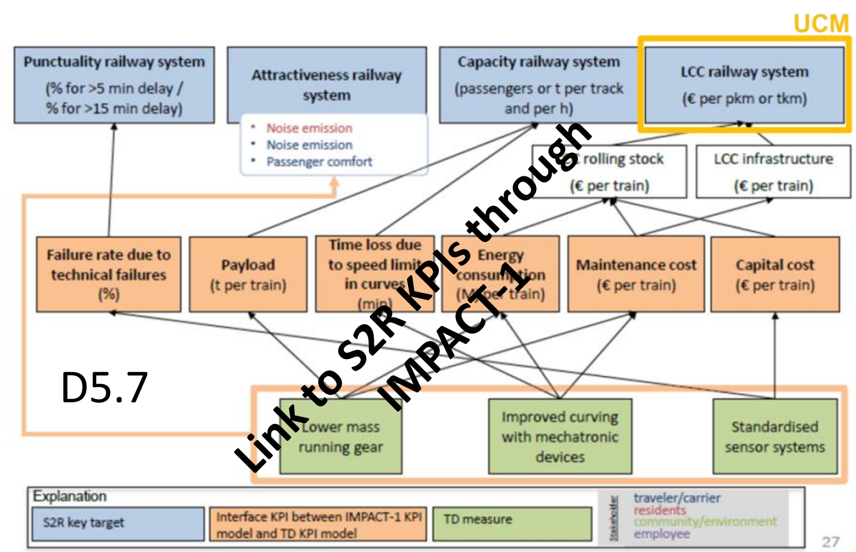


Figure 26: Environmental impacts distribution of the powder production process



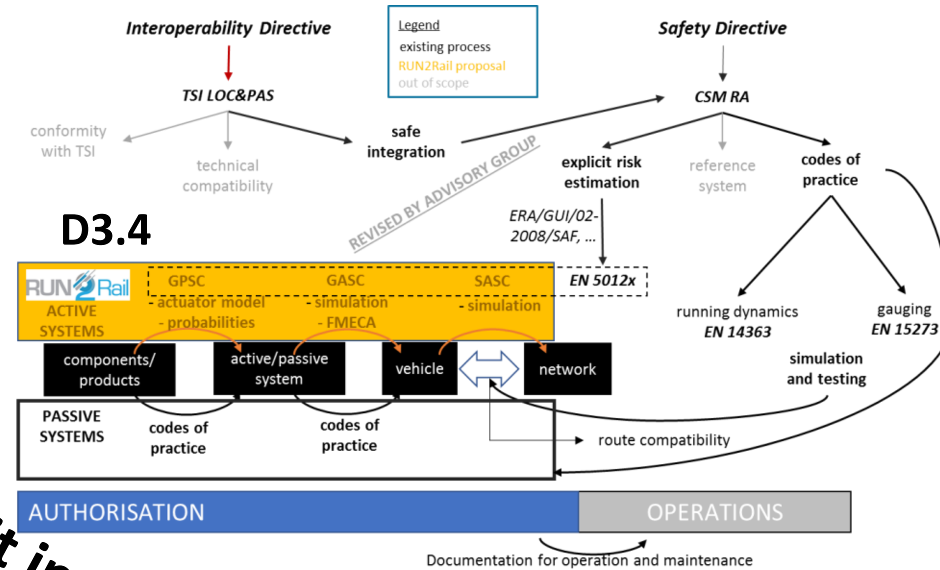
R&S impacts

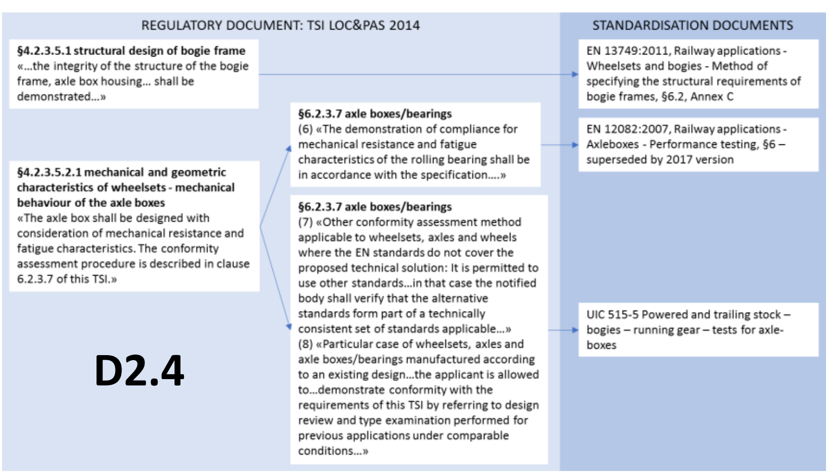
How RUN2Rail results fit into the R&S framework

Table 36. List of key EN 15380-4 functions related to RUN2Rail WP1 outputs.

First level	*Second level*	*Third level*
H provide train communication, monitoring and control	HB keep the train staff informed	HBE provide maintenance information
		HBE provide diagnostic information
	HG provide diagnostics	
	HH assist troubleshooting	
J support and guide the train on the track	JB guide the train	JBJ monitor gearbox status
		JBK provide a suspension diagnostic
	Inverse functions	
U display information	UA display diagrams	UAB display information for monitoring
		UAC display information for diagnostics
		UAD display information for maintenance
W provide diagnostics	WE provide maintenance (used for a function to provide the list of information for maintenance staff related to the function)	
X communicate with the train bus		
Y communicate with the consist bus		
Z communicate with the ground level		

D1.4





D2.4

RUN2Rail

Shift2Rail

Contract No. 777564

INNOVATIVE RUNNING GEAR SOLUTIONS FOR NEW DEPENDABLE, SUSTAINABLE, INTELLIGENT AND COMFORTABLE RAIL VEHICLES

Task 5.3 – Impact management support and assessment including Target Group interactions

Deliverable D5.7 Assessment results and impacts, including direct R&S impacts

Due date of deliverable: 31/08/2019

Actual submission date: dd/mm/yyyy

D5.7

Summary of expected results for AWP2017

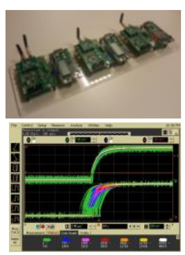
October 2017

Conceptual design

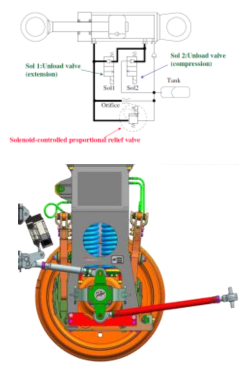
Authorization Strategy

Lab Tests

December 2019



CBM for HMS



Active Systems

Novel materials

N&V reduction

Up to TRL 3 - 4

Summary of expected results for **AWP2019**

October 2019

PIVOT-2

Manufacture

Bench Tests

On-track Tests

End of Shift2Rail 2022

Up to TRL 6 - 7

Demonstrators validated in relevant operational Enviroment

Thank you for your kind attention

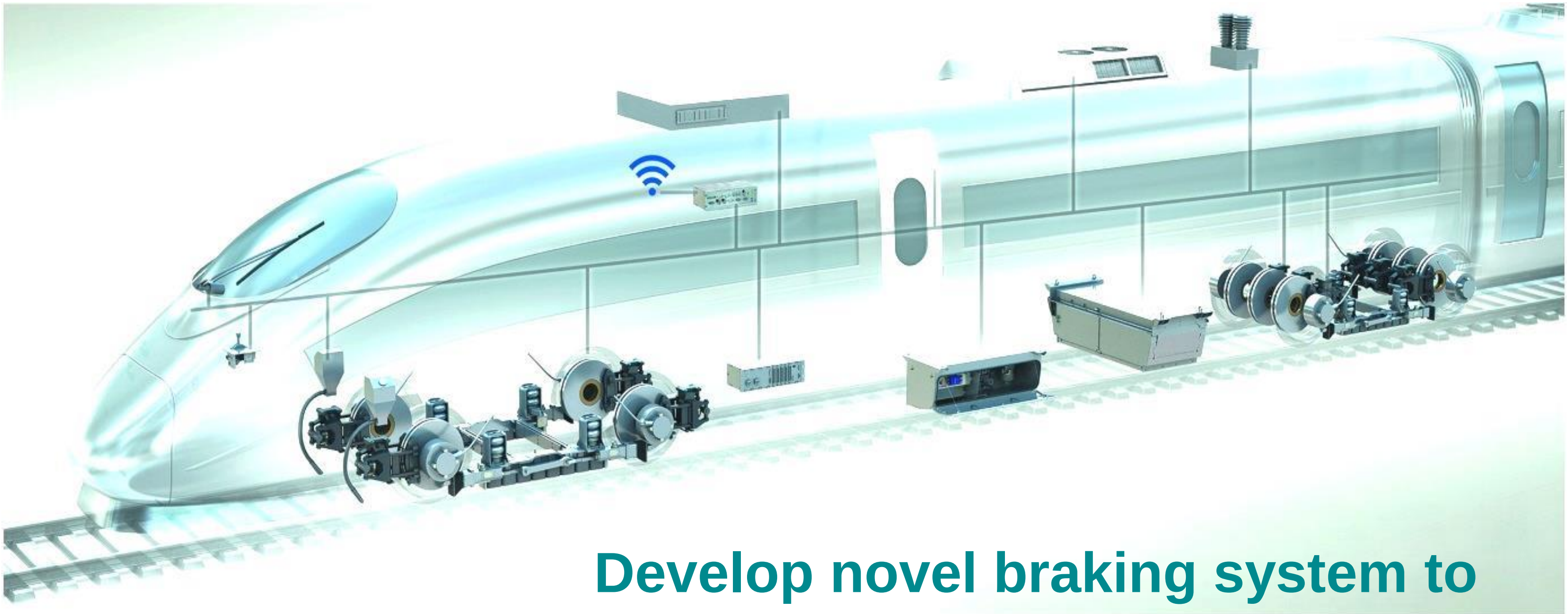
TD1.5 – Braking Systems

Involved Projects: PIVOT

Technical Leaders:
Ambra Boggione (Faiveley Transport)
Jasmina Brackovic (Knorr-Bremse)
Stefania Ferrara (Faiveley Transport)

PIVOT – OC Final Conference
17th September 2019
Paris

Objectives

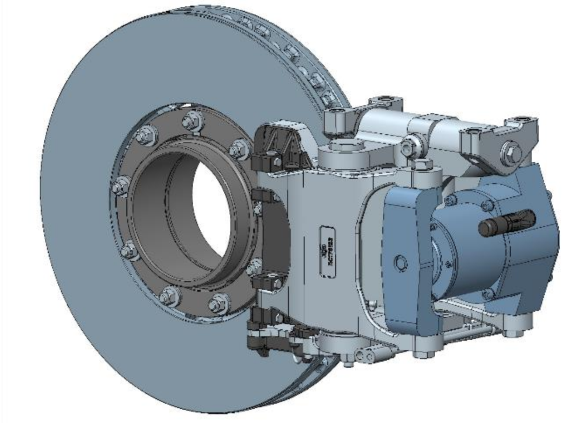


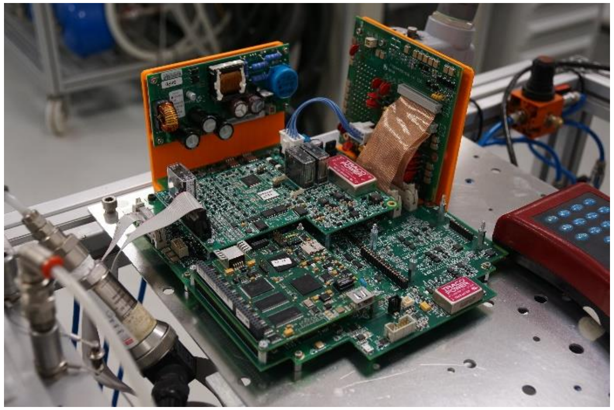
Develop novel braking system to

- improve performance, reliability and punctuality
- increase line capacity
- reduce LCC

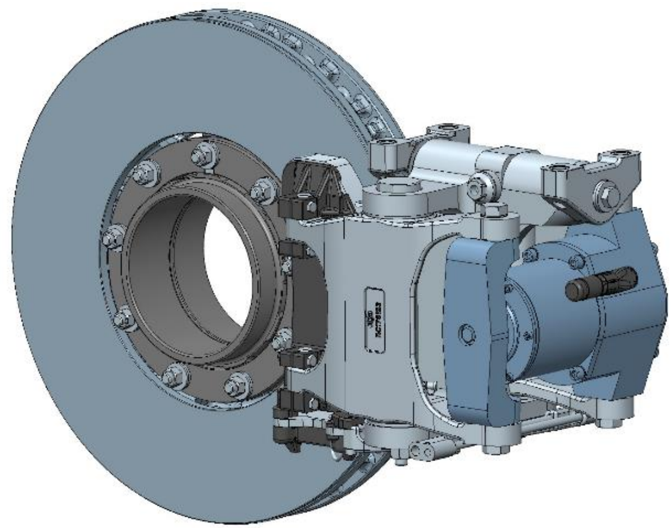
Focus areas

- Electro-mechanic brake
- Virtual validation and certification
- High SIL electronics
- Innovative friction pairings





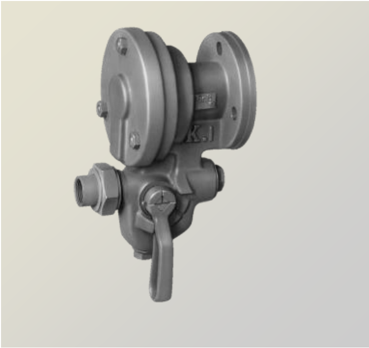
ELECTRO - MECHANIC BRAKE

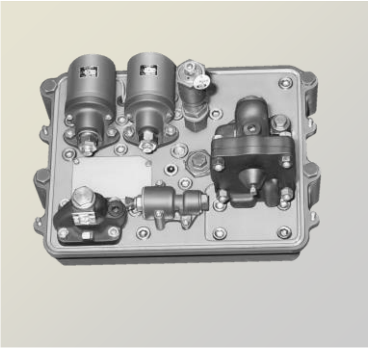


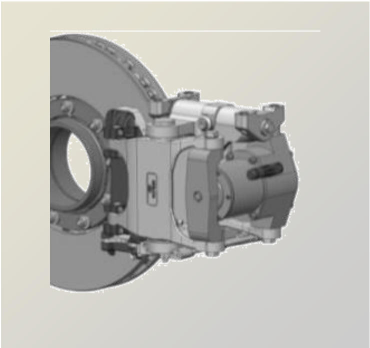
Electro-Mechanic Brake

DEVELOPMENT OF BRAKING SYSTEMS

TOMORROW







Pneumatic Brake Systems

Electro-**Pneumatic** Brake System

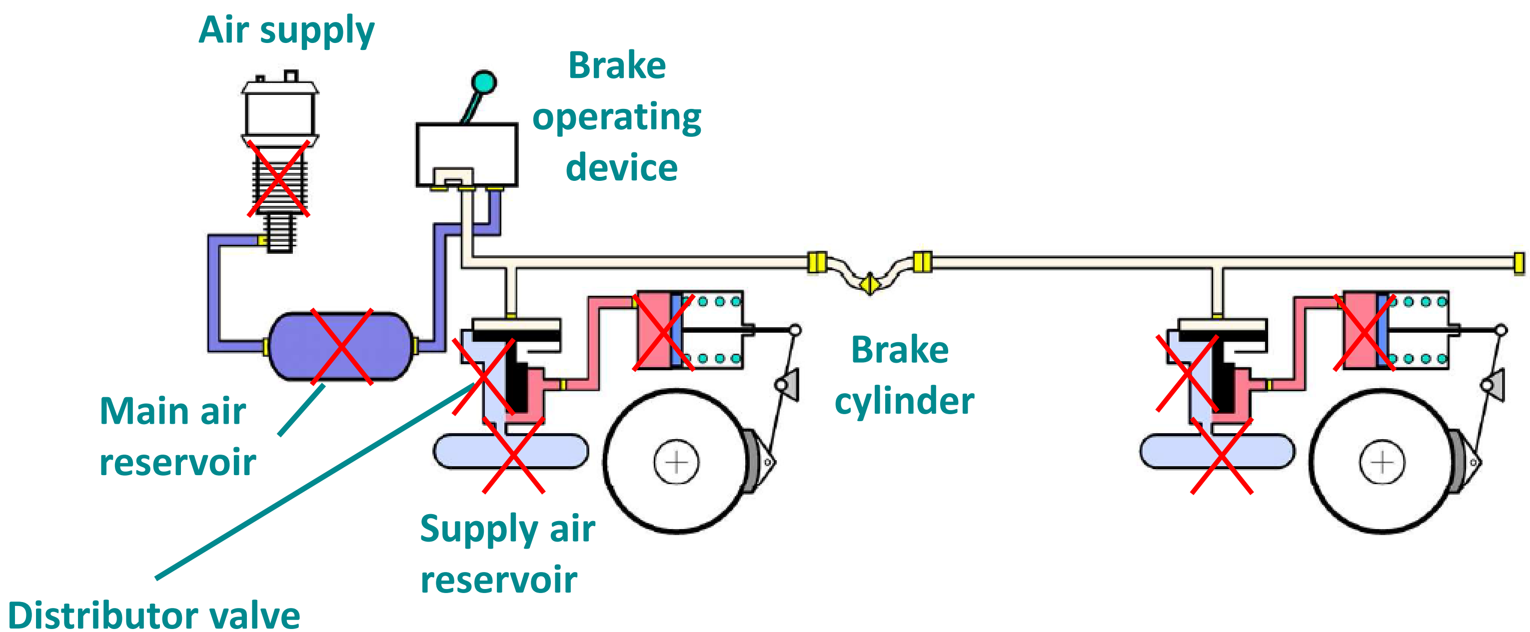
Electronically Controlled **Pneumatic** Brake System

Electro-Mechanic Brake System

Advantages

- Effective transfer of braking signal
- No need for air-supply
- Better diagnostic
- Fewer components → reduction in weight, energy consumption and LCCs

Status-Quo



Source: Knorr-Bremse

Vision

DEMONSTRATOR

Brake initiation (driver)

EM Brake actuator

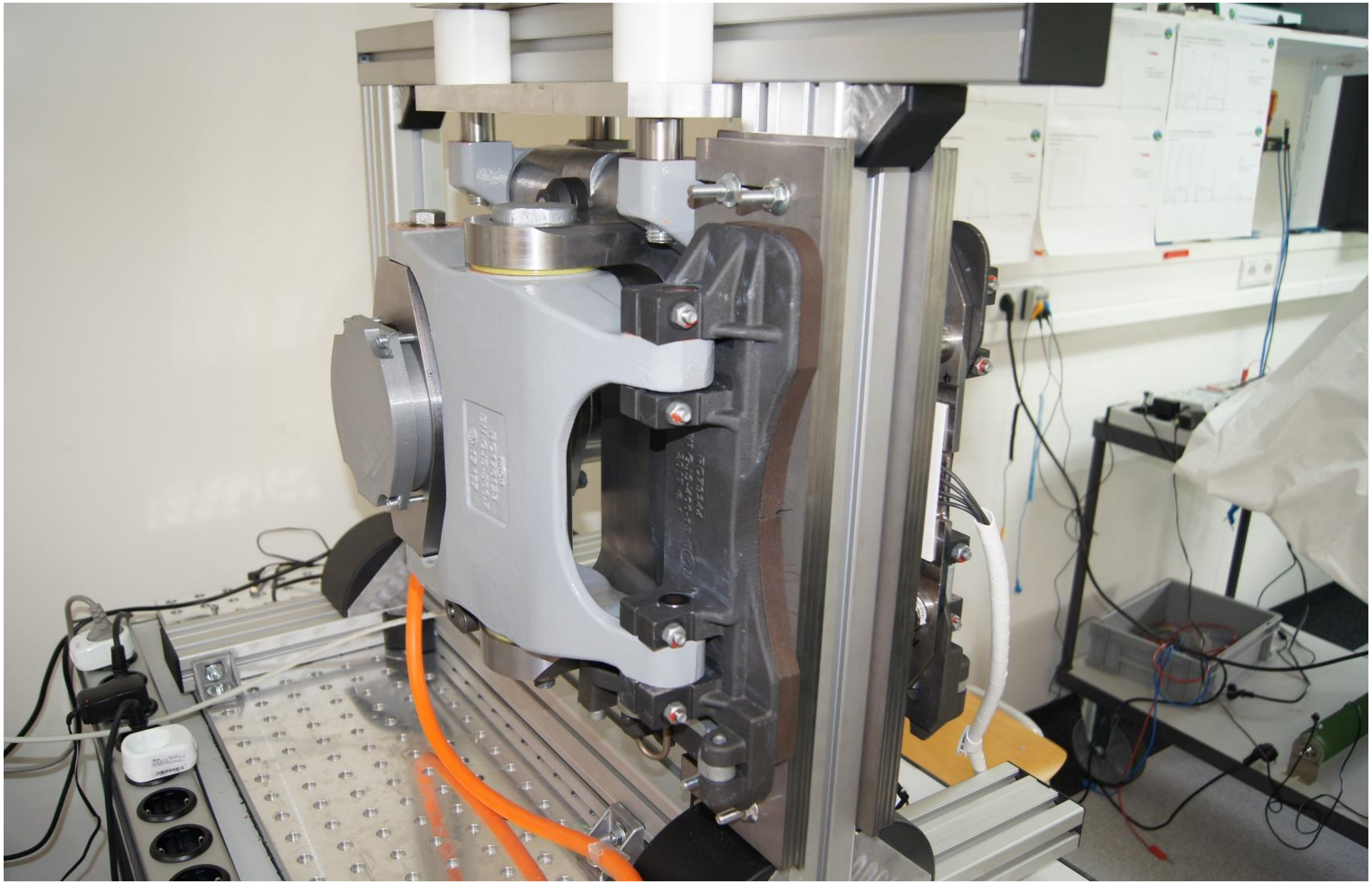
Mechanics to generate brake force

Approach

- Functional and Performance Requirements
  - ➢ provide main brake functions

    (emergency, service, parking and holding brake)
  - ➢ automatic brake test
  - ➢ system diagnosis and status
  - ➢ "zero-speed" output
  - ➢ no restriction on train coupling
  - ➢ …

Results



Challenges

- Cybersecurity
- Electromagnetic compatibility
- Validation, certification and authorization
- Safety evaluation

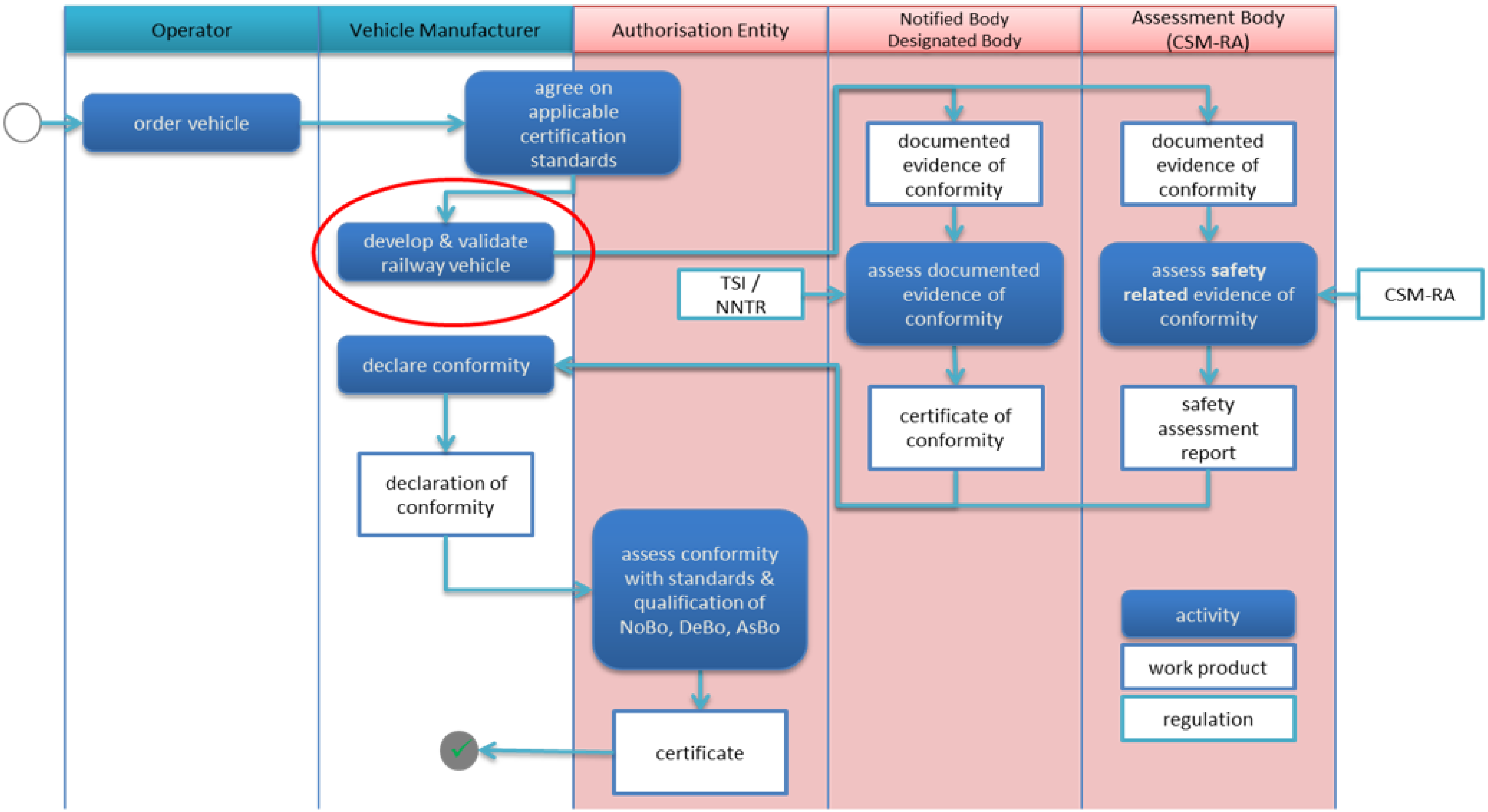
VIRTUAL VALIDATION AND CERTIFICATION

Motivation and Objective

- Current procedure is time-consuming and cost-intensive:
  - ➢ Numerous EU and national procedures
  - ➢ Ambiguous roles and responsibilities
  - ➢ Non-transparent requirements

Reduce the cost and duration by using simulation!

Process



Operator
Vehicle Manufacturer
Authorisation Entity
Notified Body
Designated Body
Assessment Body
(CSM-RA)
order vehicle
agree on applicable certification standards
develop & validate railway vehicle
declare conformity
declaration of conformity
TSI / NNTR
documented evidence of conformity
assess documented evidence of conformity
certificate of conformity
documented evidence of conformity
assess safety related evidence of conformity
CSM-RA
safety assessment report
assess conformity with standards & qualification of NoBo, DeBo, AsBo
certificate
activity
work product
regulation

Status Quo

- A number of on-train brake tests required:
  - ➢ Normal & low adhesion conditions
  - ➢ Different braking modes
  - ➢ Diverse initial speeds
  - ➢ Diverse loading condition
  - ➢ …

Results

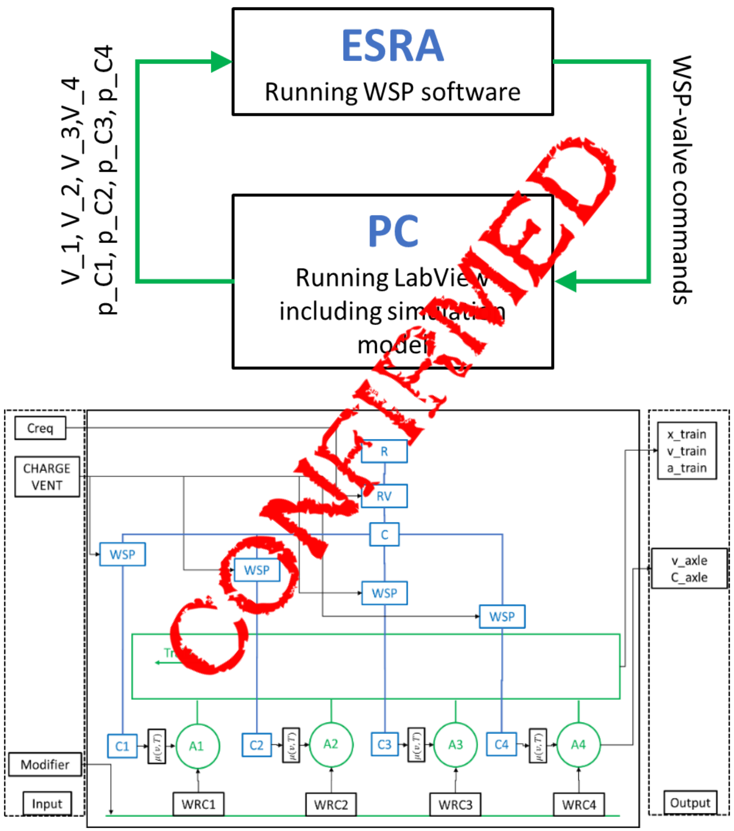
Replacement of on-train tests by virtual methods is technically feasible!

Virtual Validation and Certification of Braking System

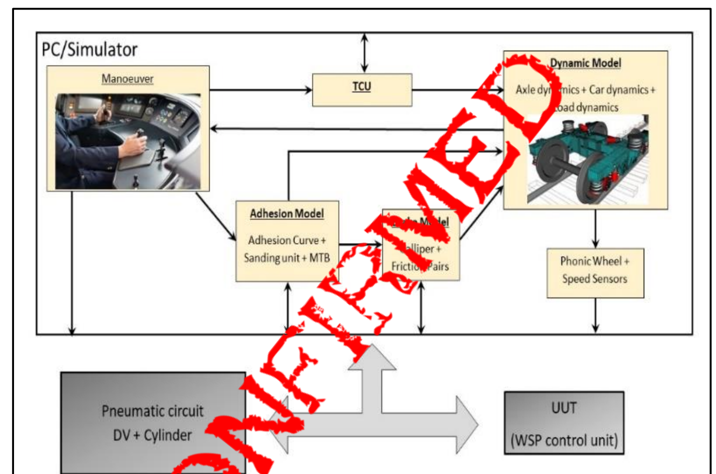
VIRTUAL TOOLS	VIRTUAL TOOLS VALIDATION PROCESS	VEHICLE VALIDATION PROCESS
• Test facilities • Brake system simulation • Vehicle simulation • Vehicle environment simulation • Simulation infrastructure	• Calibration & validation • Basic adaptation • Accreditation	• Virtual testing • Homologation • Commissioning

Proof of Concept

Knorr-Bremse model



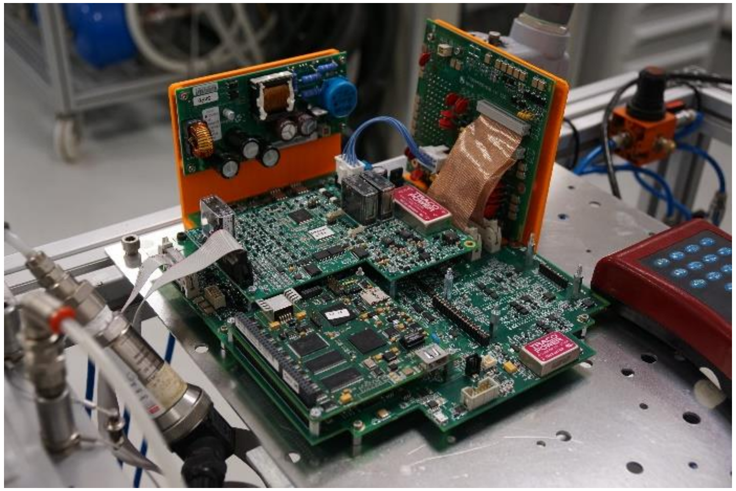
Faiveley model



Challenges

- Development of reliable models
- Prerequisite: acceptance of simulation results
- Adaptation of legal requirements and standards

HIGH SIL ELECTRONICS



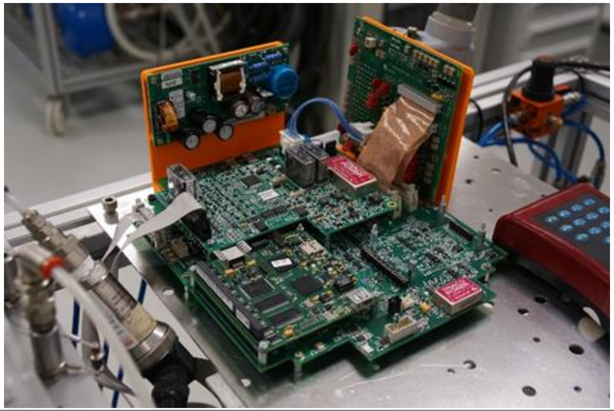
HSIL in TD 1.5 Brakes

CONNECTA → **WP5 High Safety Level Electronic Solutions for Brake Control** →

- **System brake architechture**
- **System requirements**
- **Assessment report**
- **Sub system detailed requirements**
- **Final assessment report**

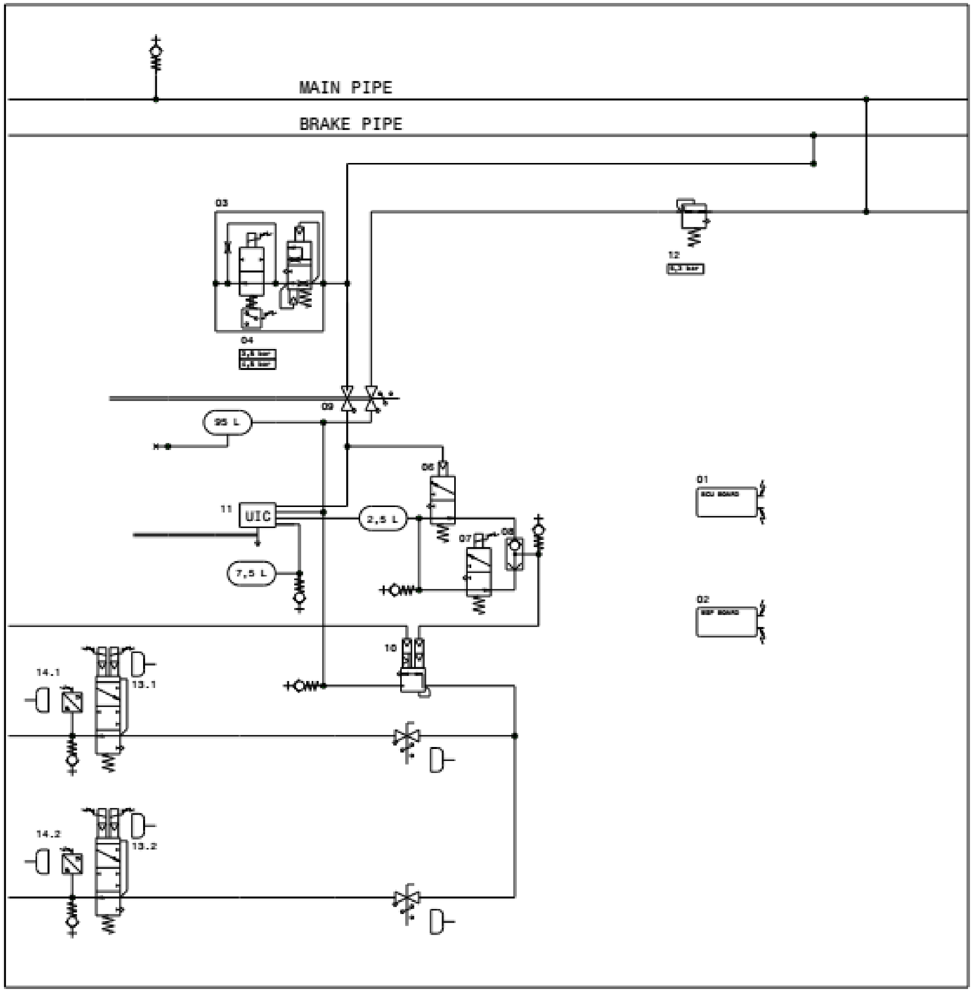
→ **TRL 3 /4**

PIVOT → **WP5 Development of future brake system solution** → **System Brakes Architecture, higher SIL allocation on electronics** → **TRL 4/5**



Lessons from CONNECTA

From the LCC analysis, the EDV device allows to reduce the use of pneumatic components, increasing safety thanks to the SIL4 architecture



We expected about :

Preventive Maintenance

28% Reduction Off.

Corrective Maintenance

27% Reduction Off.

Main achievements in PIVOT

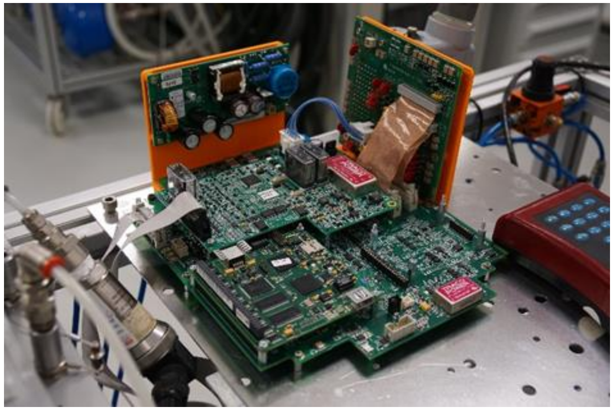
Methodology

The conceptual organization of the technical activities is provided through a **V-cycle** tailoring the generic representation provided by the EN 50126. The work has done starting from CONNECTA analysis, with the aim to achieve **TRL 5**

→ **EDV SW development and availability**

→ **Proto development availability**

→ **Test bench for lab validation**



Most significant achievements

1) optimise onboard systems by reducing the number of sophisticated pneumatic components and improving the overall LCC → **Maintenance reduction -25%**

2) Improving the reliability of the braking function (Emergency), implemented by a safe electro-pneumatic unit, functional to guarantee a precise and repetitive train stopping distance → **Stopping distance reduction in lab -10/15%**

Main achievements in PIVOT

video

What's next in PIVOT 2

PIVOT 2 → WP9, WP10, WP11 →

- HSIL-electronic Solutions Brake System Simulator
- HSIL-electronic Solutions Brake System Demonstrator Implementation
- Train Brake System Demonstrator integration for HSIL

→ TRL 7

Expected outcome

→ Confirmation of PIVOT results of system test bench

→ Confirmation of laboratory test on field

→ Emergency stopping distance between **10 and 15% less compared to the traditional brake system**

What’s new in PIVOT 2

The main aim is to achieve TRL 7, thanks with the close collaboration with EUSKOTREN

→ 2020: Higher SIL-electronic Solutions Brake System Simulator

A train simulator of a brake system with pneumatronic equipment based on High SIL electronic prototype (EDV) is fore seen. A dedicated **test bench will simulate the train behavior** for the train braking function. A particular focus will be done for distributed braking strategy. The goal is to check and verify the performance of the innovative brake system HSIL4 compared with the existing braking system

→ 2021: Higher SIL-electronic Solutions Brake System Demonstrator Implementation

The scope is to **test on field a new generation of HSIL brake system**. **A prototype will be installed directly in a service train**. Static and installation tests are foreseen.

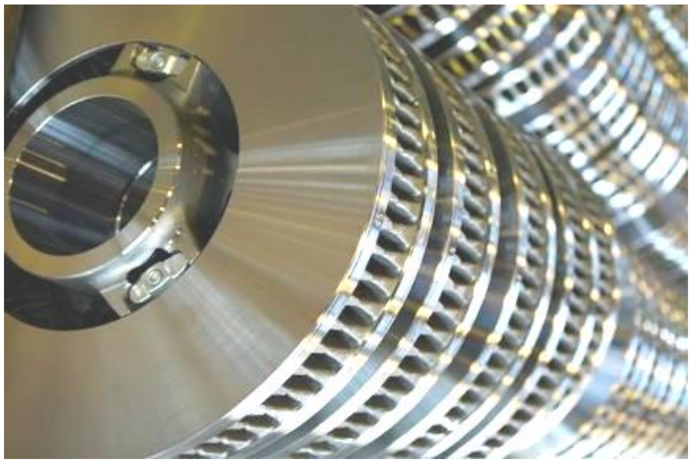
→ 2022 :Train Brake System Demonstrator integration for HSIL

A dynamic system integration in a field demonstrator is foreseen. The already validated prototype on lab, will be tested in a real situation**. Dynamic tests on service train (tram) is foreseen**.

INNOVATIVE FRICTION PAIRINGS

Innovative Friction Pair

Current situation



Task objectives

Development and testing of a new friction pair solution able to achieve the following goals:

- Reducing weight
- Reducing Life Cycle Costs (LCC)
- Improving braking performance

Innovative concept MODULAR DESIGN

1st Component of the friction pair: **THE BRAKE DISC**

- Cast Axle Mounted Disc
- Modular design
- Materials with duty adapted properties and good availability

Innovative concept MODULAR DESIGN

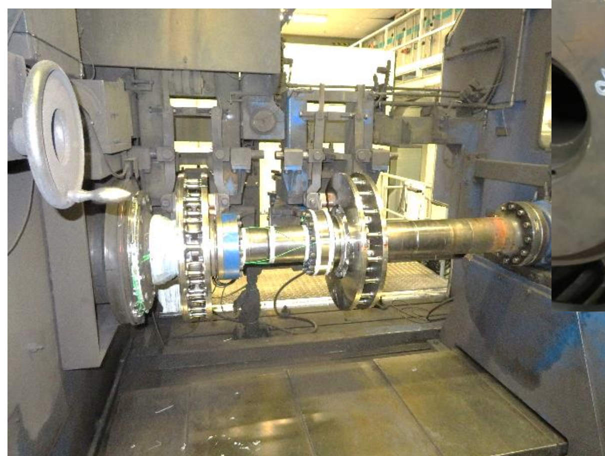
2nd Component of the friction pair: **THE BRAKE PAD**

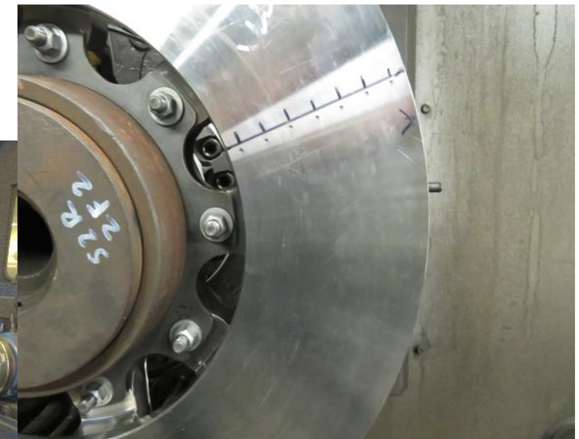
- Rigid pad
- Modular design
- Organic materials or mixed, sintered and organic

Development Approach

Innovative concept ❯❯❯ MODULAR DESIGN

DYNAMOMETER TESTS



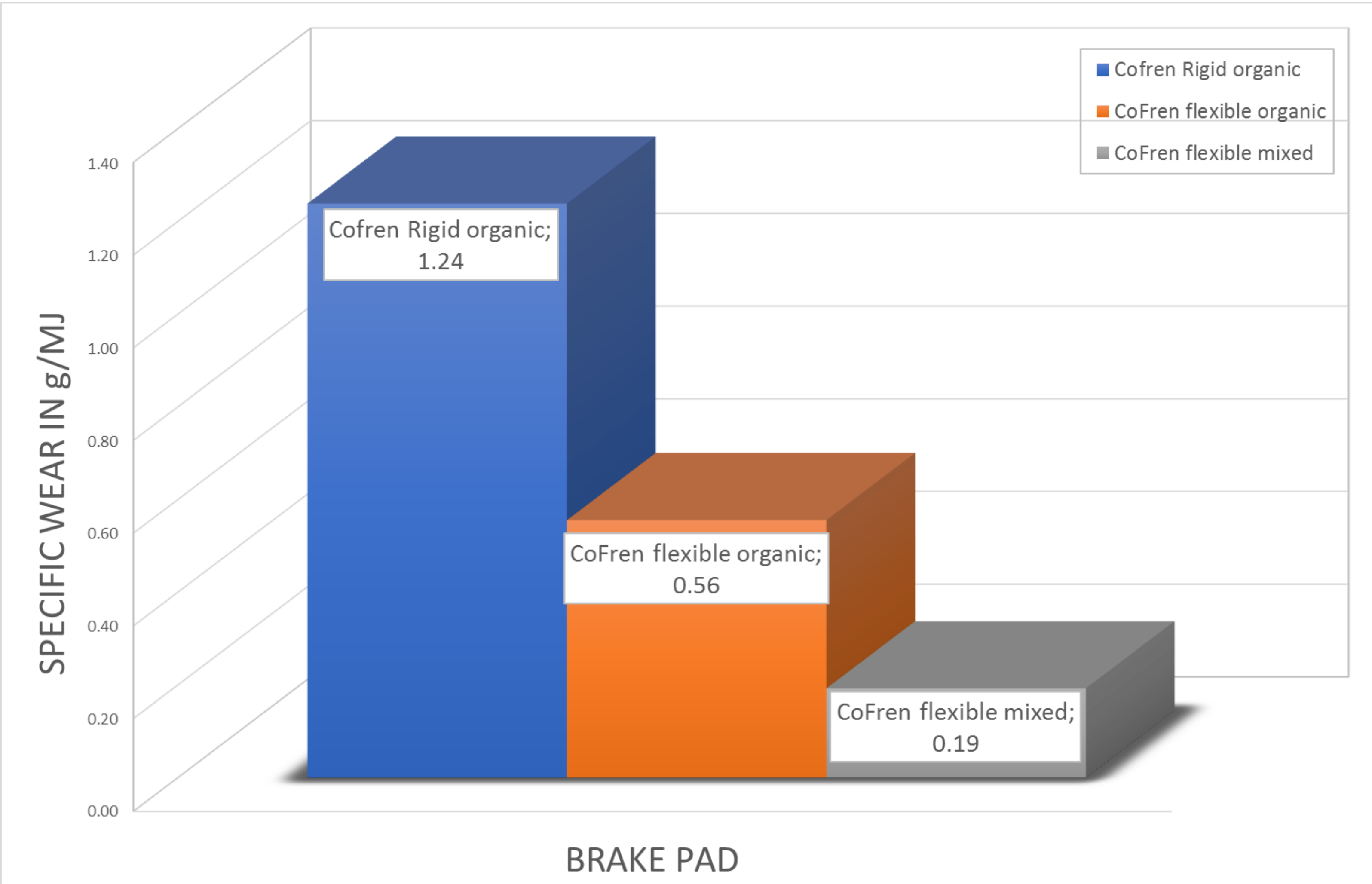


- UIC 541-3 tests T1
    - speed = 200 km/h
    - mass = 7.7 t
    - energy = 11.8 MJ
- 2 route profiles
    - Bern - Brig
    - Aachen - Bielefeld
- Comparison with commercial friction pairs under same testing conditions

Main achievements

Task objectives		Task achievements
• Reducing weight	→	✓ Weight reduction of approx. 16%
• Reducing Life Cycle Costs (LCC)	→	✓ Pad specific wear reduction of approx. 55% with organic flexible pads and approx. 84% with mixed flexible pads
• Improving braking performance	→	• Test at dynamometer in progress

Main achievements



What’s new in PIVOT 2

PIVOT 2 → TARGETS

Development of a new concept for an eco-friendly, innovative friction pair solution which should significantly **reduce the brake dust emissions as well as the brake noise**

→ 2020: High level analysis of different brake disc and brake pad concepts
A high level analysis regarding different brake disc and pad concepts showing the potentiality for the reduction of brake dust, noise and energy consumption will be carried out. It will consider different pad/disc designs, innovative materials and/or eventually the use of specific tools/devices.

→ 2021: Release of a product and test specification for the new friction pair
Starting from previous results, a product specification will be released under consideration of the friction pair requirements. A test specification for tests on dynamometer will be also delivered.

→ 2022: Prototype manufacturing, testing at dynamometer and on field
According to previous task outcome, a friction pair prototype will be realised. Afterwards, it will be tested at dynamometer under different test conditions and on field.

Video

video

Thank you for your kind attention

Agenda for today

Time	Topic of discussion	Speaker
08:00 – 09:00	**Registration and welcome**	
09:00 – 09:10	**Introduction by Shift2Rail**	**S2R JU**
09:10 – 09:50	**Project presentations; objectives, achievements and expectations on the joint final event**	**P. Böttcher (BT) E. Jubete (CIDETEC) M. Andreoni (UNIFE) U. Battista (Stam)**
09:50 – 10:40	**TD1.7 – Train modularity in use**	**R. Dumortier (SNCF-M), C. Jurke (NVGTR) W. Fargel (SPIRIT)**
10:40 – 10:55	**Video session**	**W. Fargel (SPIRIT)**
10:55 – 11:15	**Coffee break**	
11:15 – 12:05	**TD1.4 – Running gear**	**E. de la Guerra (TAL), A. Alonso (CAF), S. Iwnicki (HUD), S. Stichel (KTH)**
12:05 – 12:55	**TD1.5 – New braking system**	**J. Brackovic (KB) A. Boggione (Faiveley) S. Ferrara (Faiveley)**
12:55 – 14:10	**Lunch / poster / demo session**	
14:10 – 15:00	**TD1.6 – Innovative doors**	**T. Montanié (Faiveley) J. Arrabal (ANN) U. Battista (STAM) P. Severin (Coexpair) J. M. Bielsa (ITA)**
15:00 – 15:50	**TD1.3 – The new generation of car body shells**	**E. de la Guerra (Talgo) J. Arrabal (ANN) A. Rekondo (CIDETEC) M. Brede (Fraunhofer-IFAM, UNI-HB) P. Blomqvist (RISE)**
15:50 – 16:00	**Wrap-up / end of the meeting**	

TD1.6 – TD Entrance System

Involved Projects: PIVOT, MAT4RAIL, FairStations

Technical Leaders: Thierry Montanié (Faiveley)

Pierre Severin (Coexpair)

Umberto Battista (STAM)

PIVOT – MAT4RAIL – RUN2RAIL – FAIRSTATION final conference

17th September 2019

Paris

Introduction to TD1.6

IC1
Automated Train Operation
Autonomous access
Smo

Su

IC6
Service Operation time to second

IC4
More value for Data
Area
ce => s
ed door

IC9
Intelligent trains
with passenger

IC10
Stations and Smart Cities mobility
ed
w and
dwell time

Provide easy, autonomous and safe access to the train to all passengers including persons with reduced mobility

while adding more functionalities to the door and access systems

BB1.6.1 PRM access, safety and door entry surveillance solutions

Services for ALL passengers
IC2 Mobility as service
More comfort

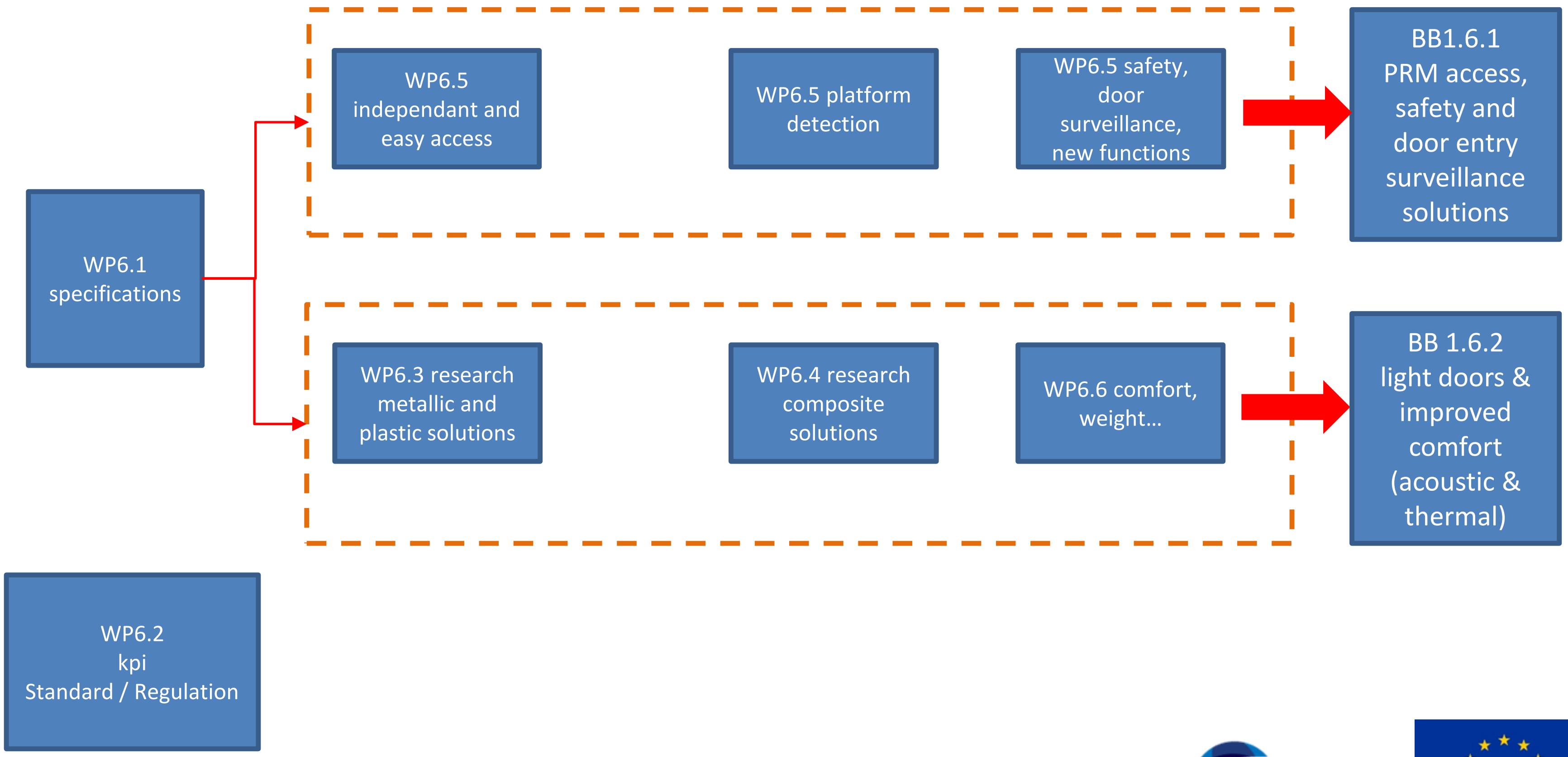
Optimized solutions
IC7 Low cost railway
Lighter materials

BB1.6.2 light doors & improved comfort (acoustic & thermal)

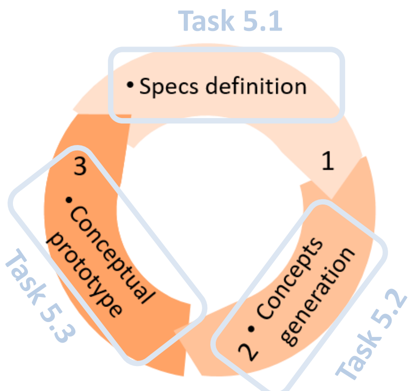
and while reducing the weight and the cost, improving the comfort features (noise, thermal, etc.)

IC5
Optimum energy use

PIVOT IN TD1.6



MAT4RAIL - WP5 Access door systems – new concepts



- Main deliverable

  Development of an innovative doors leaves design looking for improvements in terms of weight, acoustic attenuation and thermal insulation

- Approach

  i. Introduction of **new materials** and/or multi-material solutions, and also in terms of **processes** (i.e. manufacturing and joining/assembling techniques)

  ii. Use of different **design and analysis tools** to ensure the analysis of the widest range of concepts

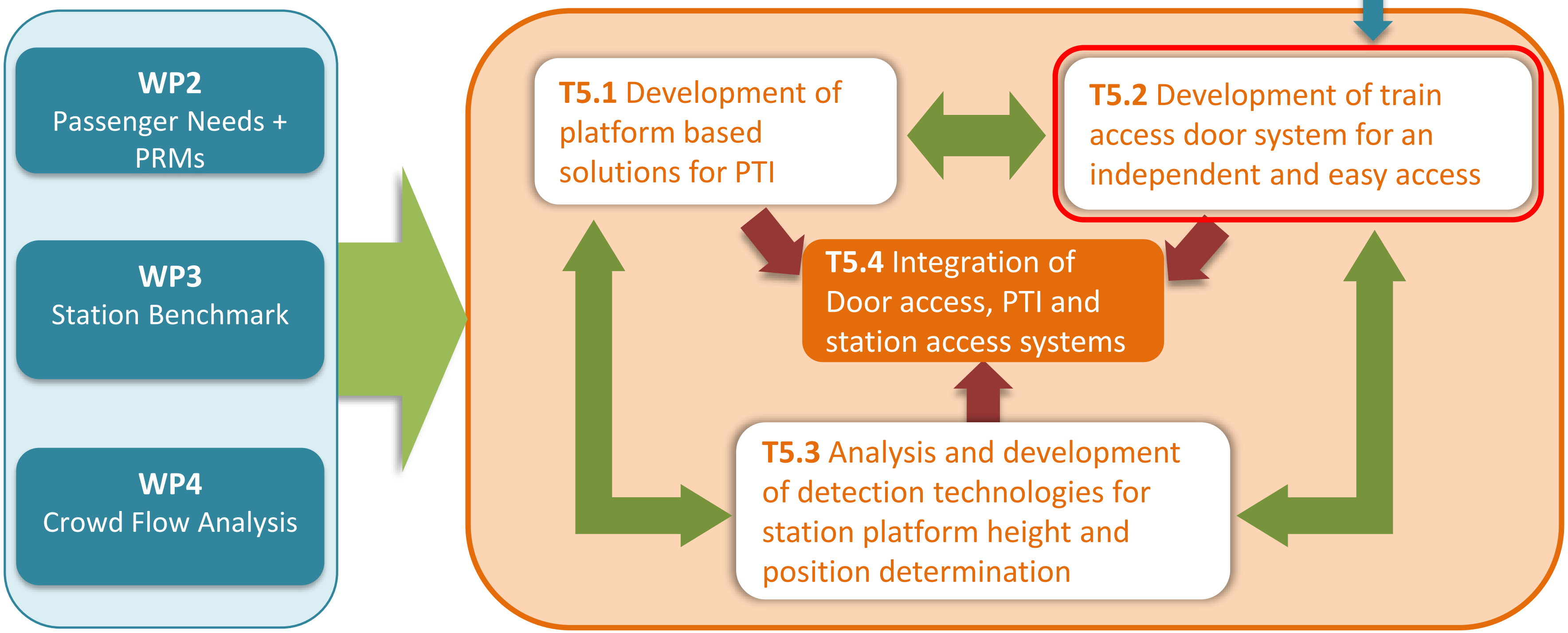
  iii. Application of standardized analysis methods integrated in a procedure for **low cost manufactured oriented railway parts**

- Results: good behavior of concepts from sizing and manufacturing

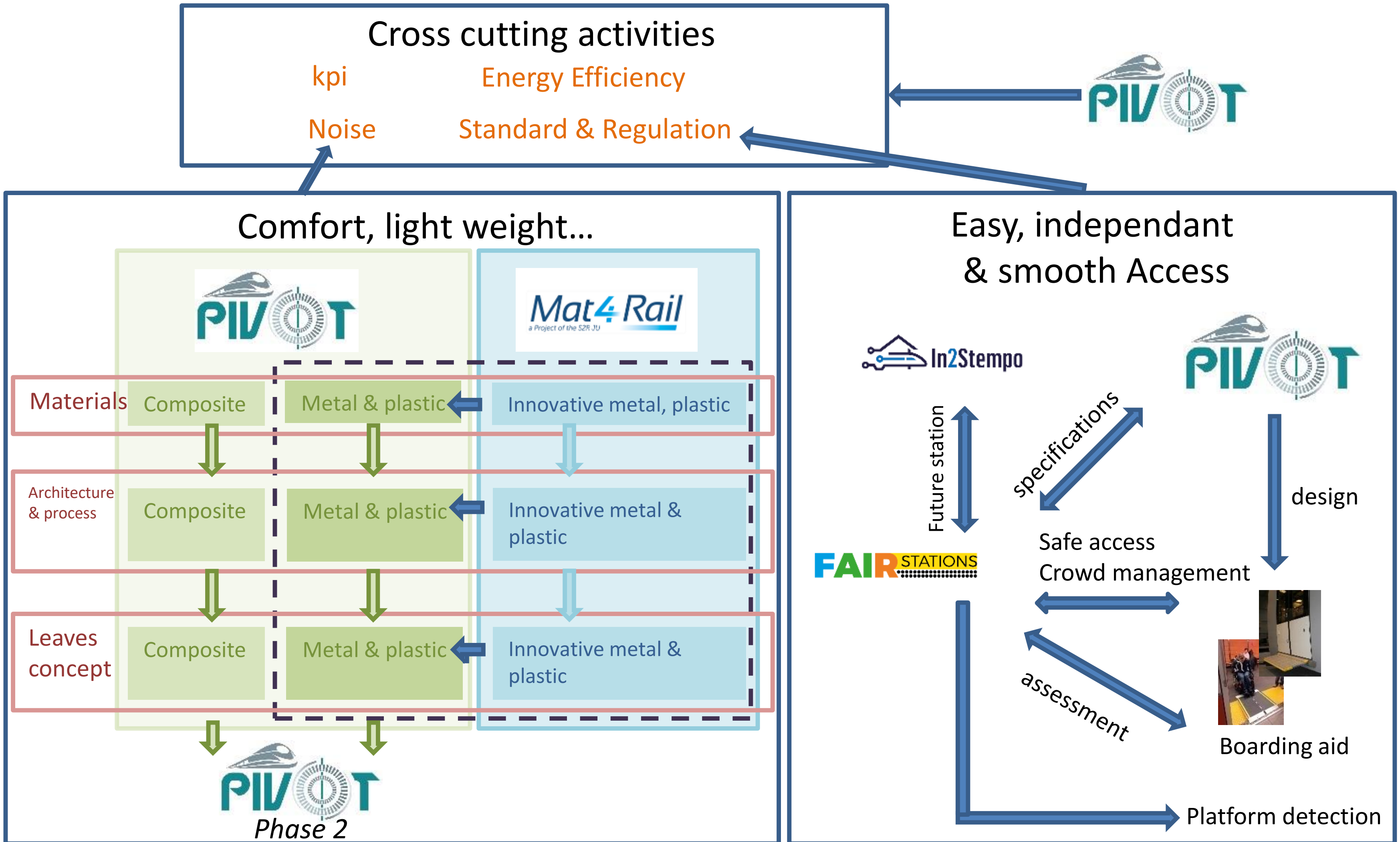
- Conclusion: successful achievement of conceptual designs in term of innovative material & advanced manufacturing processes

FAIRStations in TD1.6

WP5 Design and Conceptualisation



Collaborations in TD1.6



Main achievements

• #1 Comfort and weight	
• Composite leaves	PIVOT
• Metallic leaves	PIVOT
• Ecodesign	PIVOT
• “Disruptive” Leaves	MAT4RAIL
• #2 Accessibility	
• On board solutions	PIVOT
• Off board solutions	FAIRSTATIONS
• #3 Door functions	PIVOT
• #4 Integrated solutions	PIVOT

#1.1 Composite Leaves

#1.1.1 Definition of Composite Leaves – preliminary requirements

According to document **PIVOT-WP6.4-T-FTT-018-02 "**Specification of composite leaves mainly for Regional market", a composite door should fulfill:

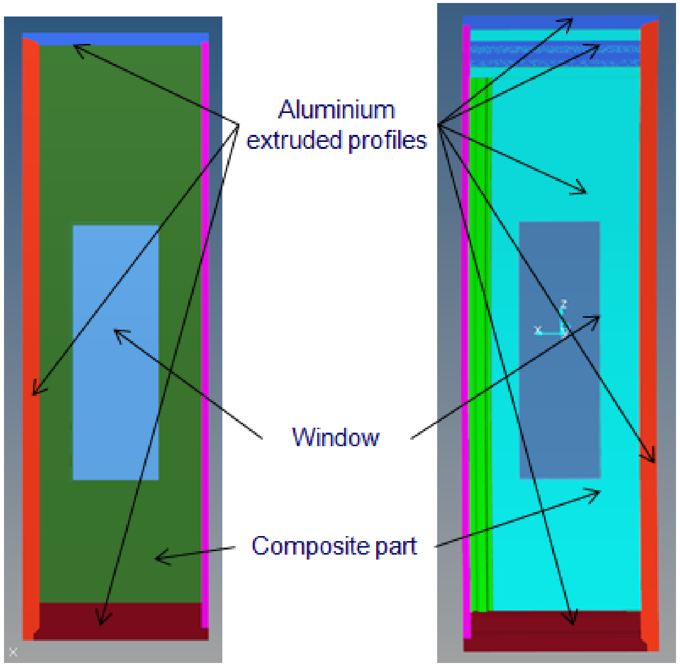
- Environmental conditions
  - [EN 50125-1 (2014) Environmental conditions for equipment]
- Mechanical characteristics
  - Load [EN 14752 (2015) Railway applications -Body side entrance systems for rolling stock]
  - Fatigue Loads
  - Obstacle during closing
  - Impact on the leaf at the end of the closing sequence
- Acoustic attenuation
- …..

#1.1 Composite Leaves

#1.1.2 Composite preliminary design solutions

Composite sandwich base with aluminium extruded profiles.

- Extruded profiles: aluminium.
- Composite part - materials:
  - Core: PET foam.
  - Semipreg Biaxial E-Glass epoxy resin FST
  - Semipreg Biaxial Carbon epoxy resin FST
- Window

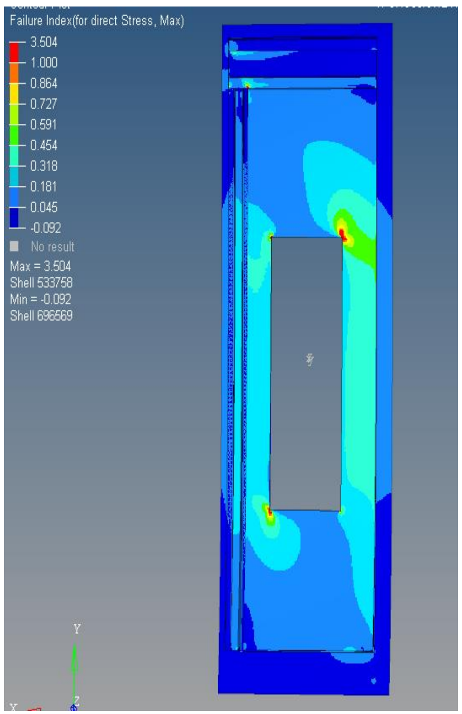


#1.1 Composite Leaves

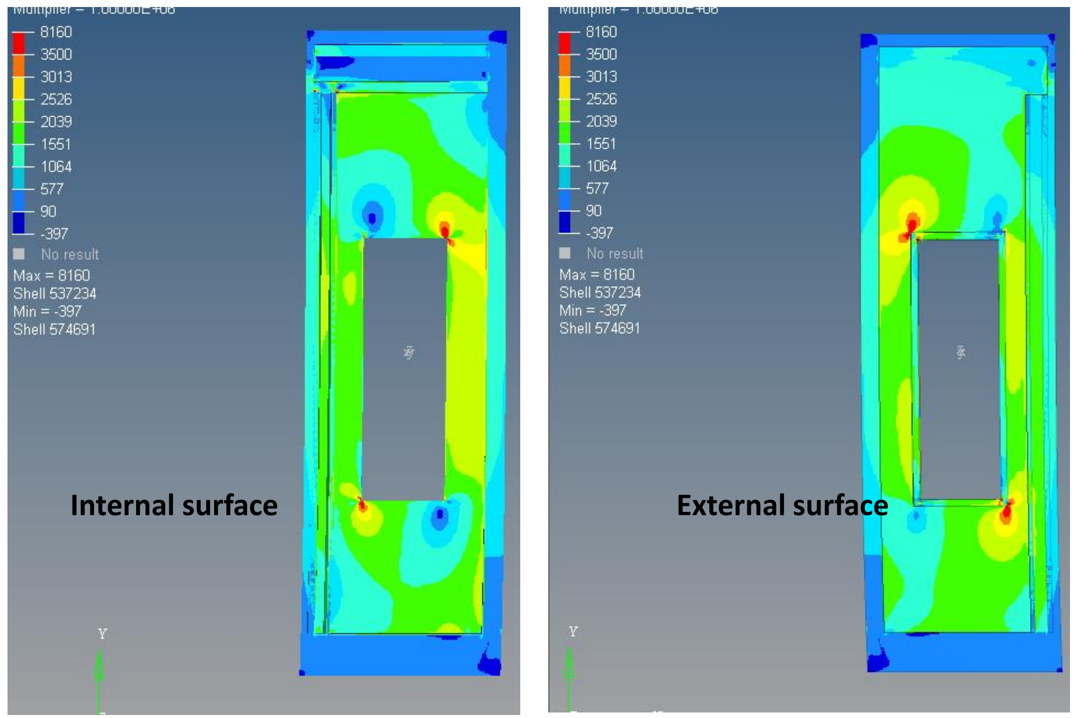
#1.1.3 Composite engineering results

Engineering studies done with FEM Model with NASTRAN and HYPERMESH

Tsai-Wu



Micro-strains- tension

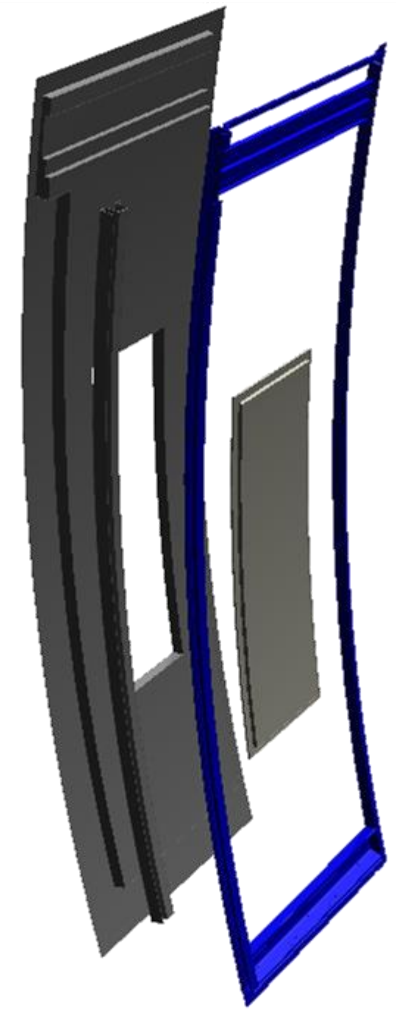


#1.1 Composite Leaves

#1.1.4 Achievement and composite leaves

In PIVOT, the preliminary design has been finished with encouraging results.

- Deflection inside the allowable parameters
- Micro strains in tension/compression below assumed allowable ones for composite materials
- Weight around 19 kg (below target)
- Pending acoustic and thermal studies in final model

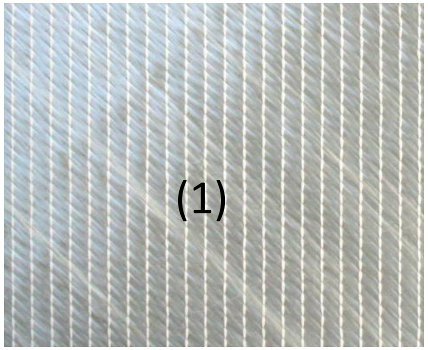


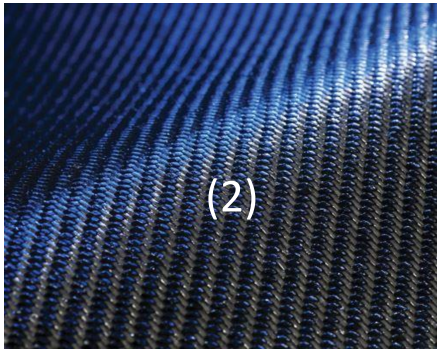
#1.1.5 Composite materials used (fibers, core…)

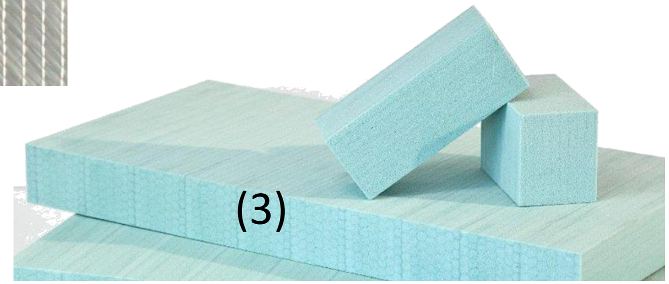
(1) Semipreg Biaxial E-Glass epoxy resin FST

(2) Semipreg Biaxial Carbon epoxy resin FST

(3) PET Recyclable structural Foam FST 80 Kg/m3







The mechanical, acoustic and thermal properties of the materials have been tested and characterized.

#1.1.6 Composite manufacturing process used

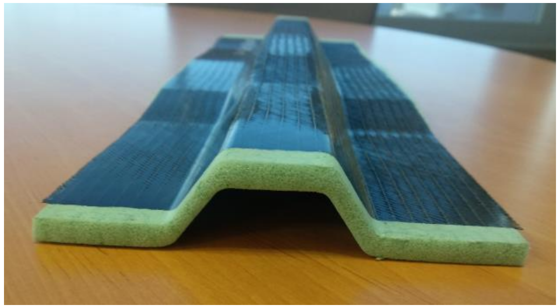
(1,2,3) Press Molding – Sandwich composite – One Shot

Hand Layup Out of Autoclave – Profiles Door

Optional – Pultrusion – Profiles Door

1 - Press Molding Process

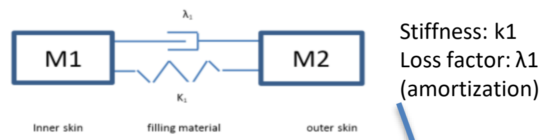
2 - Test Trial Press Molding

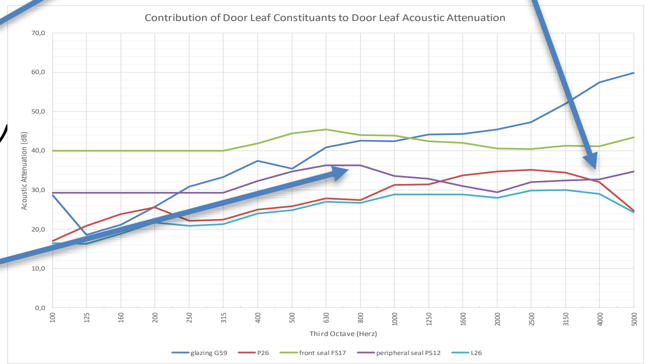


3 - Press Molding Machine

#1.2 Metallic Leaves

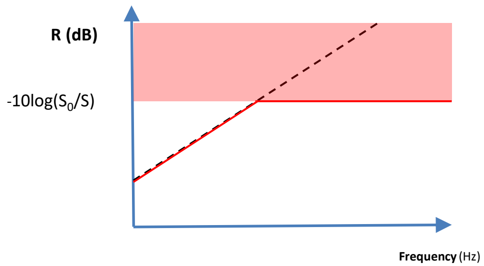
#1.2.1 Current Status





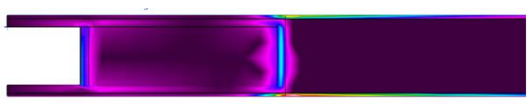
Acoustic

- *The weakest parts are:*
  - *the sandwich due to the breathing frequency*
  - *the peripheral seals*
  - *the total surface (S) of holes that limits acoustic attenuation*
    (S_0: surface of the panel)



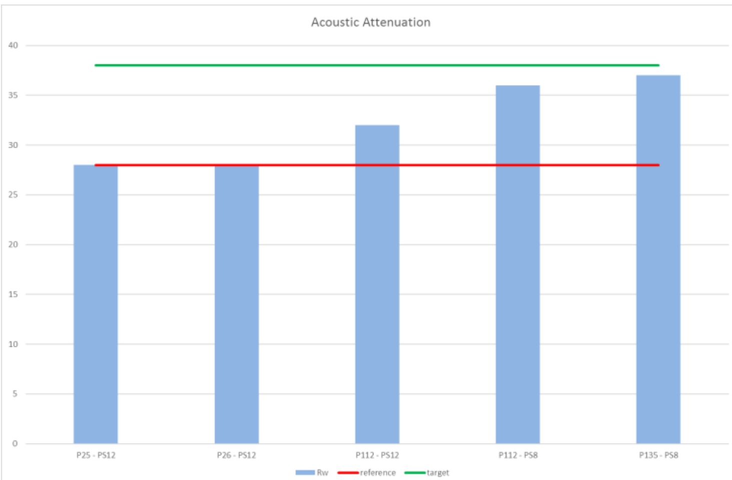
Thermal

- *The most important parameters are the thermal bridges created by aluminium profiles*

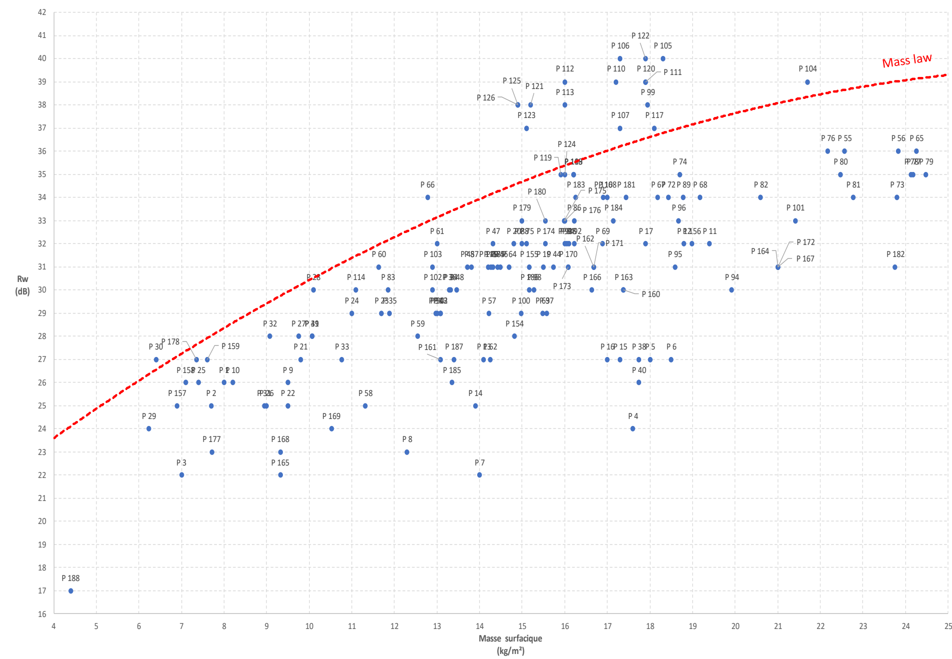


#1.2 Metallic Leaves

#1.2.2 Acoustic Attenuation

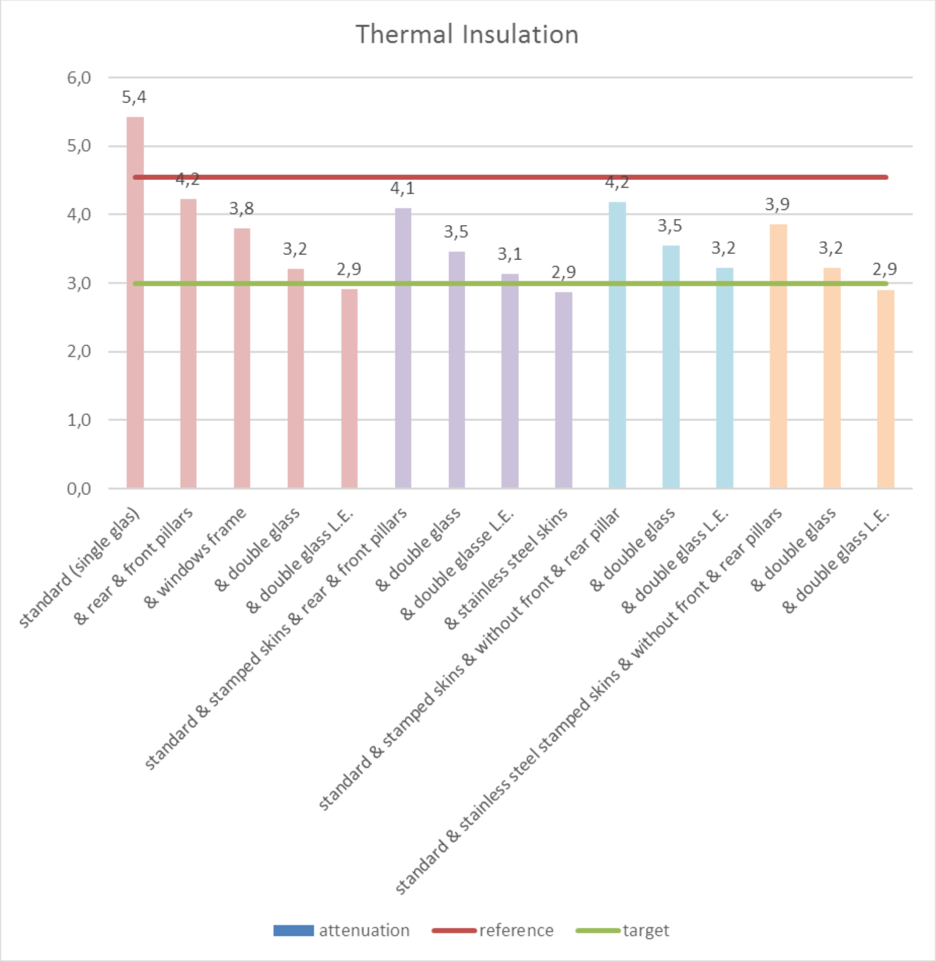


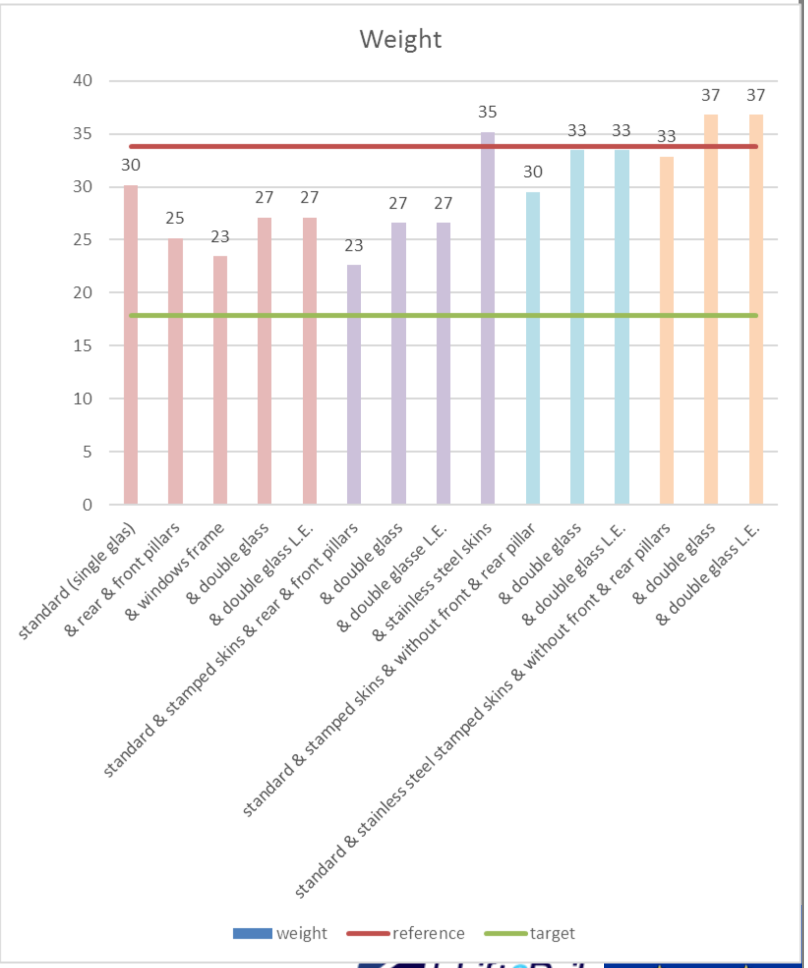
Measurement on 1m² panels



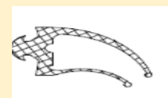
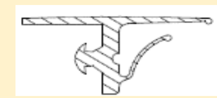
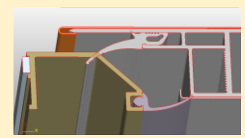
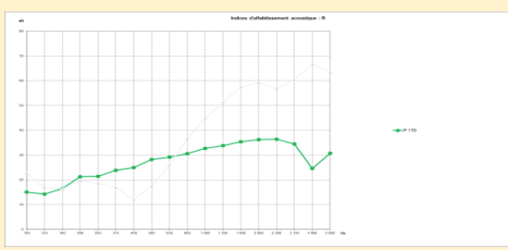
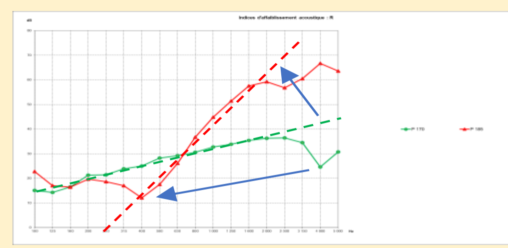
#1.2 Metallic Leaves

#1.2.3 Thermal Transmission



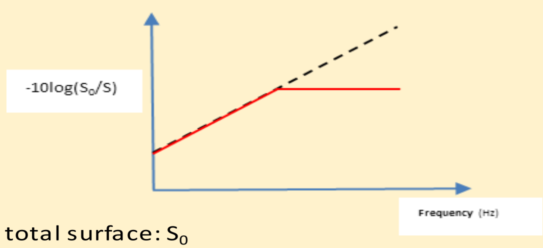
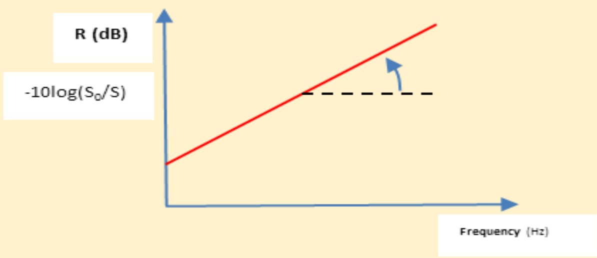


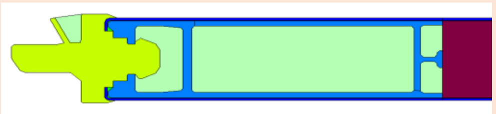
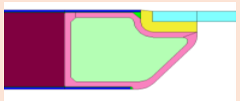
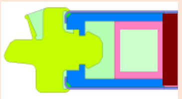
#1.2.4 Action Plan (1/2)

Acoustic	Actual	Action plan
Seals	1 lip / 1 seal 	2 lips  
		2 seals 
		increase of seal / seal-land contact pressure
Panels	rigid foam stiffness K1 & loss factor $\lambda 1$ 	acoustic foam with new panel architecture K1 ↘ & $\lambda 1$ ↗ 

#1.2 Metallic Leaves

#1.2.4 Action Plan (2/2)

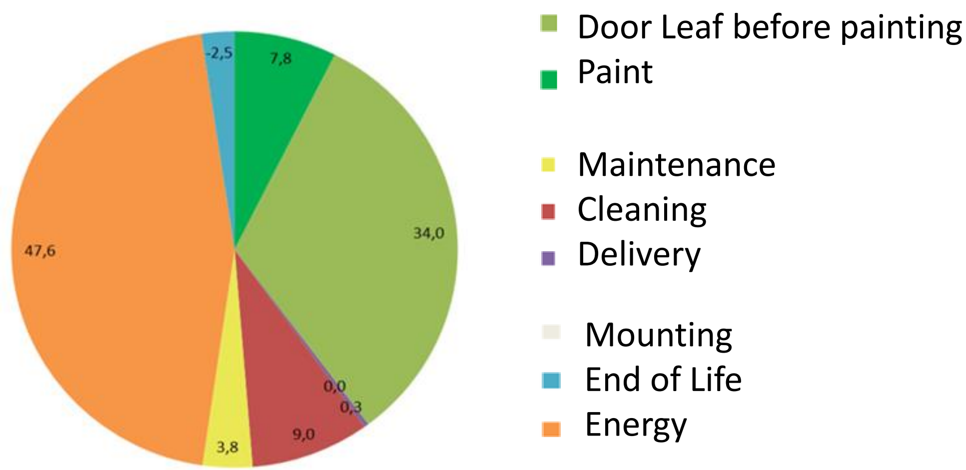
Acoustic	Actual	Action plan
Tightness	Holes Surface: S	remove holes: S ↘
	 total surface: S_0	

Thermal	Actual	Action Plan
Thermal bridge	aluminium frame 	composite / plastic profile  
		2 semi-half aluminium profile separated by a plastic profile 

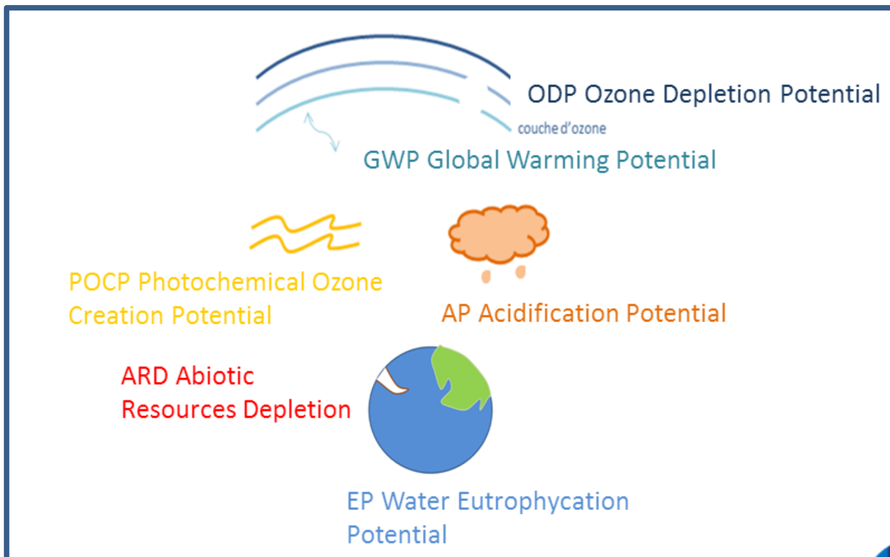
#1.3 Ecodesign

#1.3.1 Targets

Life cycle assessment and application of ecodesign approach to stainless steel door leaves using EIME software



Life cycle assessment of door leaf

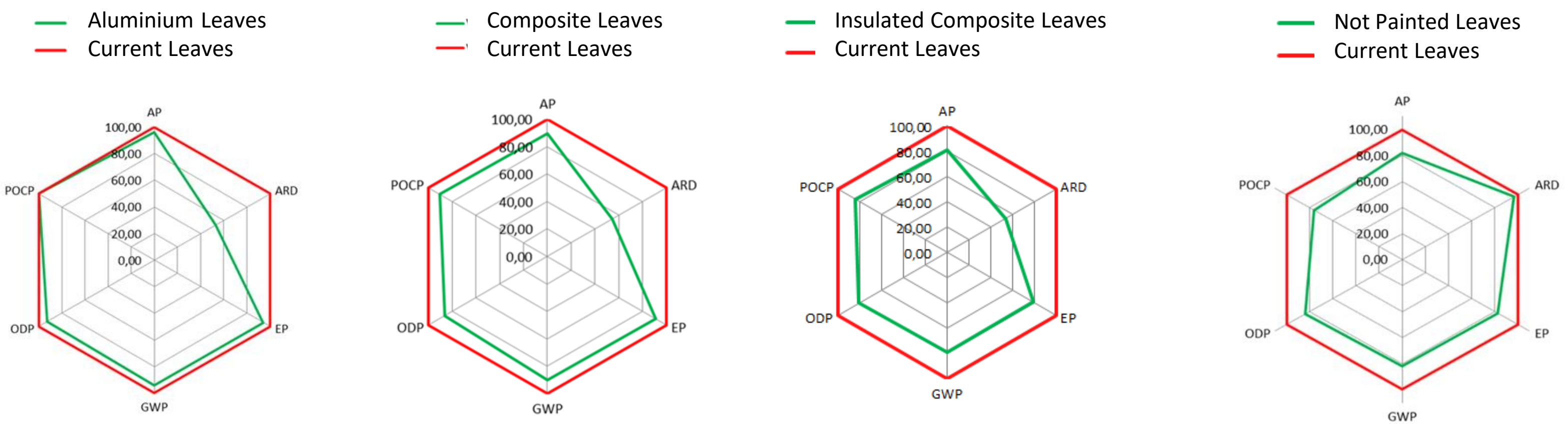


Environmental criteria

#1.3 Ecodesign

#1.3.2 Results & perspectives

Weight decrease, thermal insulation and paint removal improve significantly environmental impact



Impact of different leaf desings on environment

Similar Model could be used for the other parts of the trains

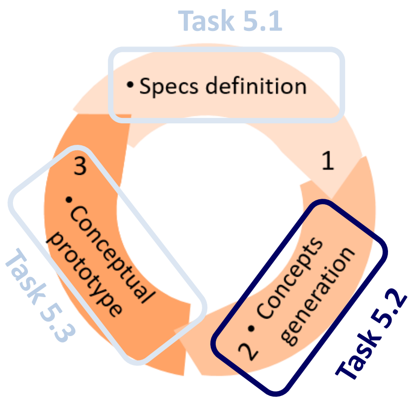
On-going watch on bio-based materials and characterisation of organic fibers: flax (linen) fibers, nettles fibers…

Introduction of detailed design information in PIVOT2

#1.4 “disruptive” leaves

- #1.4.1 Concepts evaluation & selection

Completed

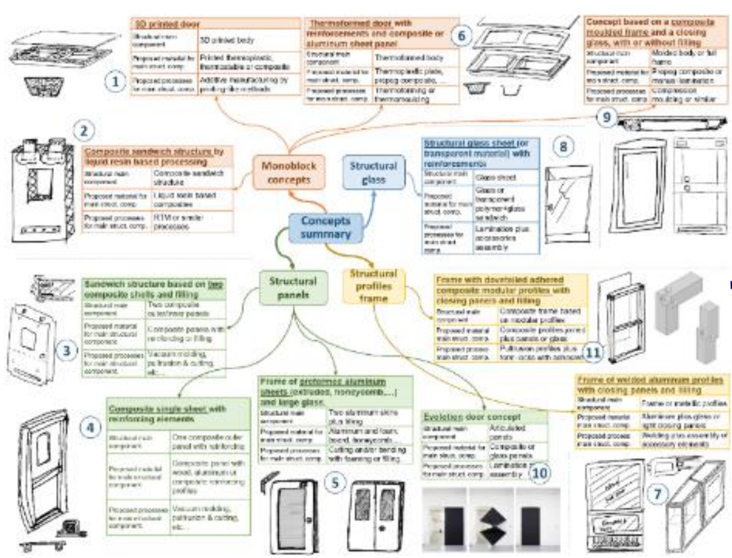


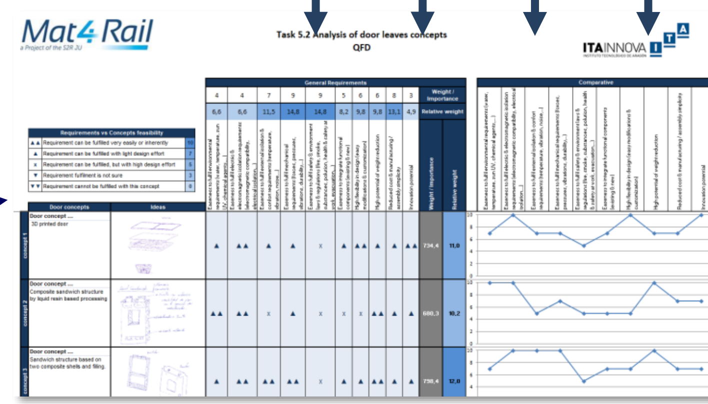
T5.2 Concepts generation

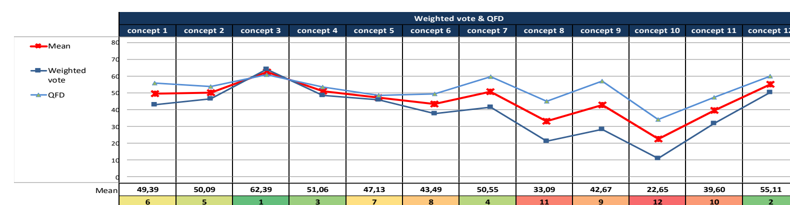
Concepts evaluation & selection

-Advantages vs Drawbacks
-Weighted vote
-QFD

ASAŞ
coexpair
ITAINNOVA
Universität Bremen



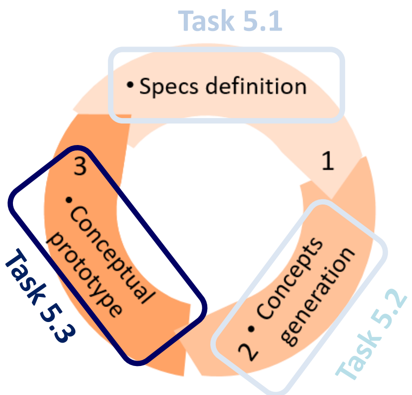




#1.4 “disruptive” leaves

- #1.4.2 Conceptual prototype

completed



T5.3 Conceptual prototype

Concepts 3, 4 and 2 are related to ideas in **composite materials** with different processes or assembly techniques.

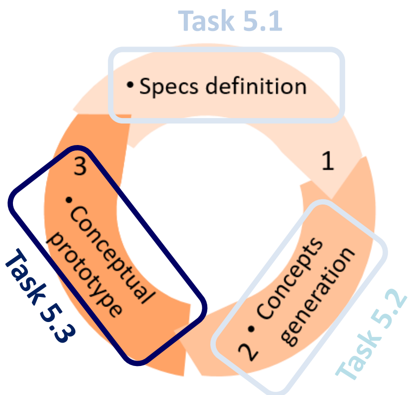
Concepts 12 and 7 are related to ideas where the main structural component is proposed in **aluminium with innovative processes**. Concept 7, in fact, is similar to a conventional current design with some improvements.

Concept 1 is related to **innovative processes, like additive manufacturing**, where processes show, in general, a high potential but are usually still in development where specific materials are required.

#1.4 “disruptive” leaves

- #1.4.2.1 First Concept

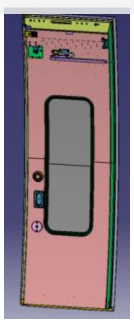
T5.3 Conceptual prototype

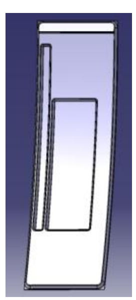


- Proposal of a **conceptual design** taking advantage of the potential integration of multiple functionalities in a single part
- Material: basalt fiber & epoxy resin with foam core

Concept based on the manufacturing of an **economical single composite part with integrated functions.** Aim: lighten leaf at same manufacturing cost to reduce train energy consumption. Conclusion: good mechanical behavior with promising cost. Manufacturing tests on-going

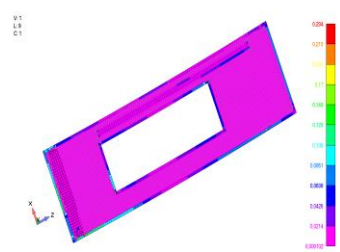
Current door





BFRP concept

FEM sizing

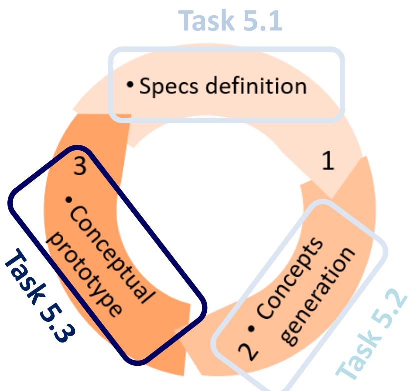


core machining

SQRTM injection

Main achievements

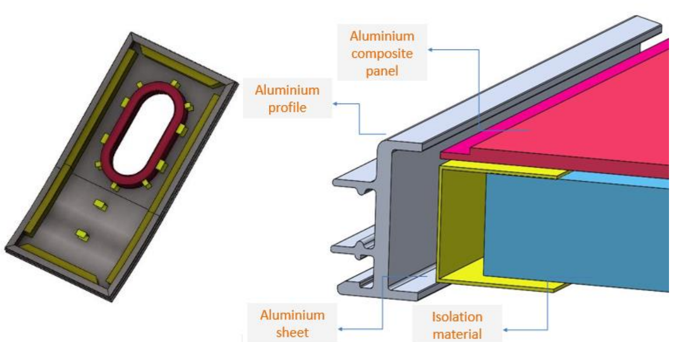
- #2.3 “disruptive” leaves



T5.3 Conceptual prototype

- Proposal of a **conceptual aluminium design** taking advantage of the potential use of adhesive only with new aluminium folding process **=> spare weight and spare manufacturing time**

Concept based on **hybrid material solution**: aluminium sheet / profile / aluminium composite panel. Aim: improved leaf in term of weight, acoustic attenuation & thermal insulation. Conclusion: advanced design achieved & good manufacturing tests results



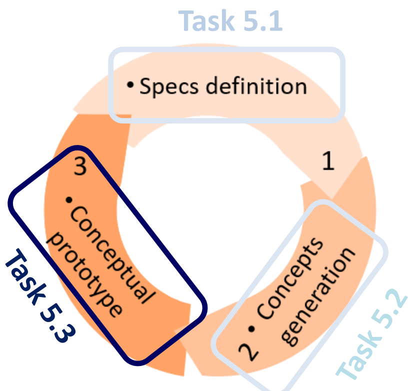
Concept design

Materials

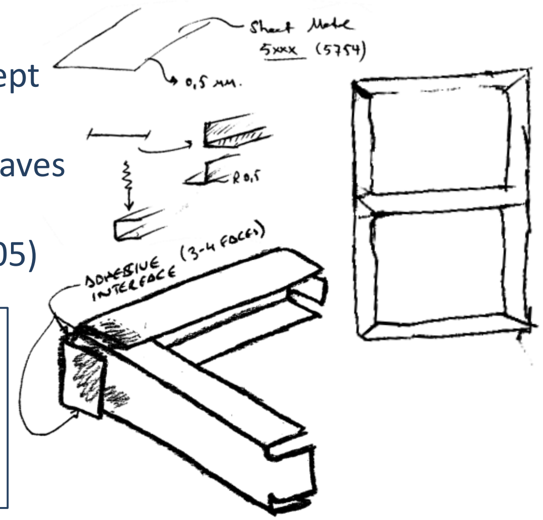
Mock-up

#1.4 “disruptive” leaves

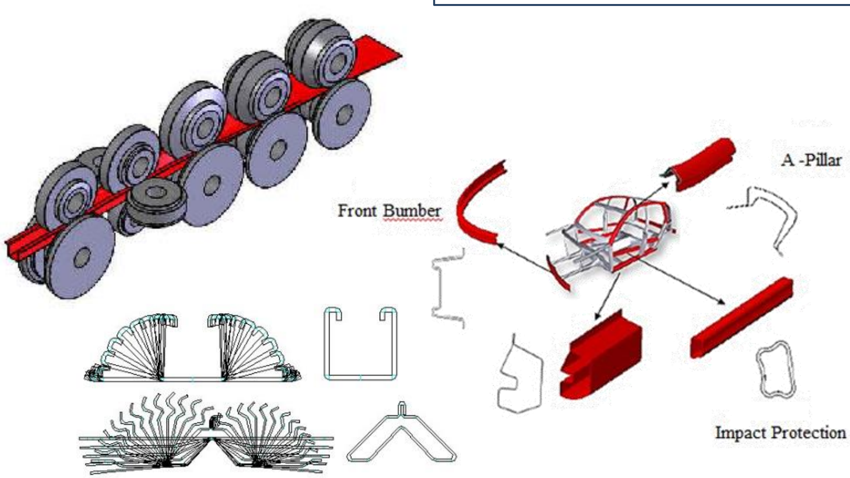
- #1.4.2.3 Second Concept 2/2 **T5.3 Conceptual prototype**



ASAS finished activities
QFD and brainstorming about the new concept
4 new 3D designs
Review of available info about PIVOT door leaves
Selection of the concept
Material specification and select (EN AW 3105)



In the selected concept the door frame can be manufactured by simply bending just one aluminium sheet, to get the required shapes and profiles, which are joined by adhesive.

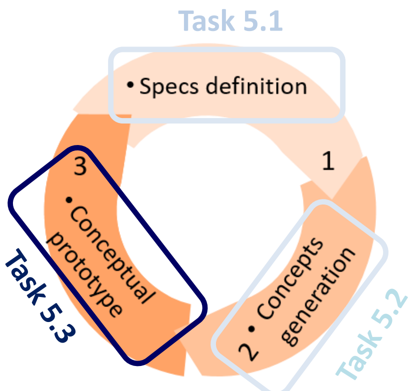


Boeing 737-800 body section detail

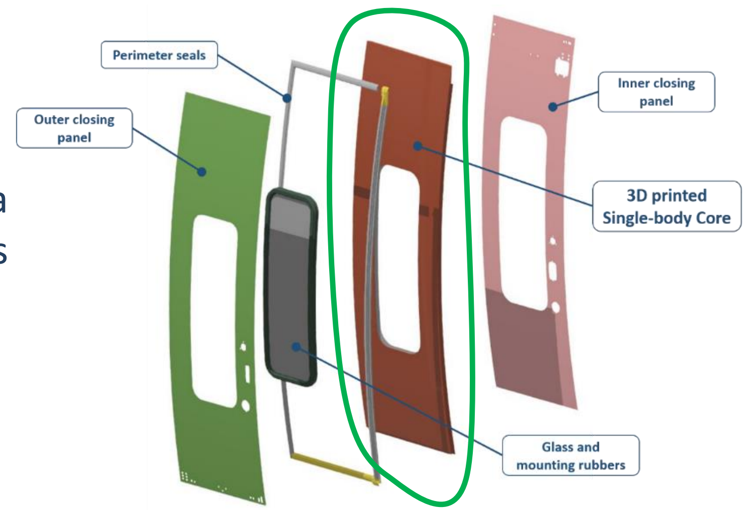
#1.4 “disruptive” leaves

- #1.4.2.4 Third Concept

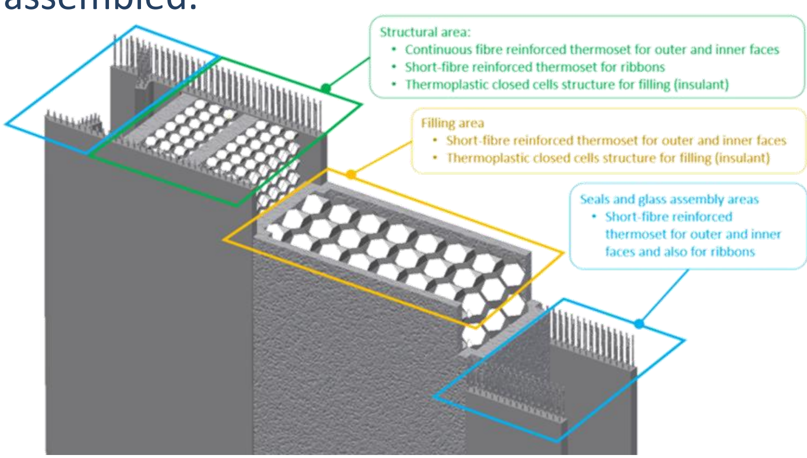
T5.3 Conceptual prototype



- Proposal of a **conceptual design** taking advantage of the potential flexibility of additive manufacturing.



Conceptual design is based on the manufacturing of a **single-body core** where other functional components are assembled.



#2 Accessibility

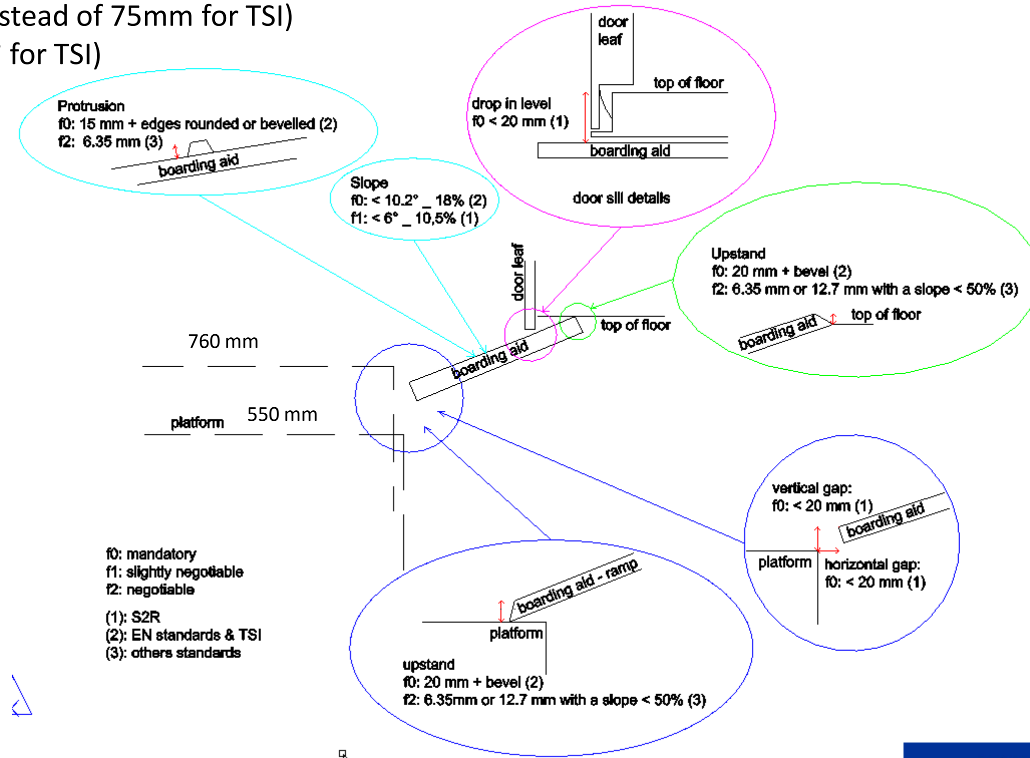
#2 Accessibility

#2.1 Train solutions ➔ PIVOT

#2.2 Platform solutions ➔ FAIRStations

#2.1.1 On board adaptive boarding aid

- Main target is to evolve to a “step” which allows a wheelchair user to be use the door in an **autonomous and spontaneous** way (No need of third party and minimizing the impact on non PRM flow)
  - Max **20mm vertical gap** (instead of 50mm for TSI)
  - Max **20mm horizontal gap** (instead of 75mm for TSI)
  - Max **6° slope** (instead of 10,4° for TSI)
- Suitable for both TSI platform heights

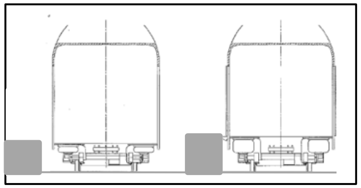


Taking into account the benchmark of standards and regulations (EN, STI, ADA) and also publications CH, RISSB, CRC…

#2.1 Train solutions

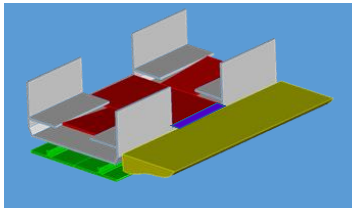
#2.1.2 Benchmark of solutions

Different solutions could meet the need of adaptative boarding aid :

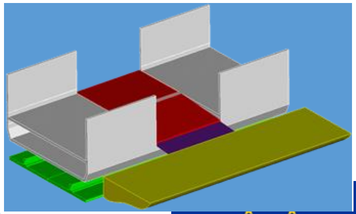


- ***train suspensions with adaptive height*** *: difficult to absorb such 300mm amplitude – out of the scope of TD1.6*

- ***2 door levels per coach*** *: one high level and one low level.*
  But it does not cover intermediate levels and platform tolerances.



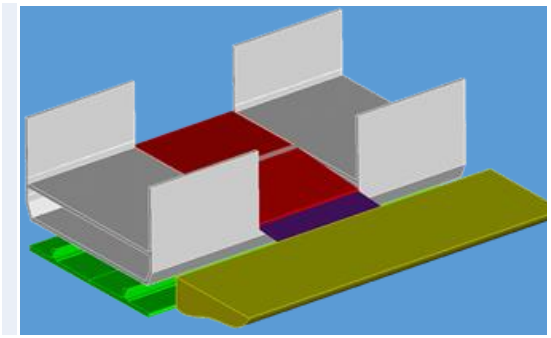
- **Vertically moving vestibule equipped with sliding gap filler and inside longitudinal ramp**: no smart solution for the connection between the boarding aid and the door leaves, very high constraint on motor design to move the ramp and the vestibule and on vehicle integration



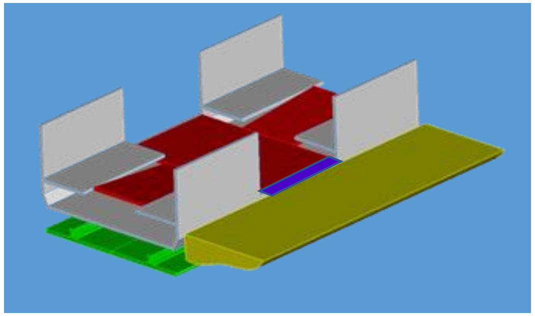
- **Inside lateral ramp equipped with sliding gap filler**: considered as technically viable. It gives nevertheless a big constraint for interior space design and the slope reaches 6° (10%), even more in case of tilt.

#2.1 Train solutions

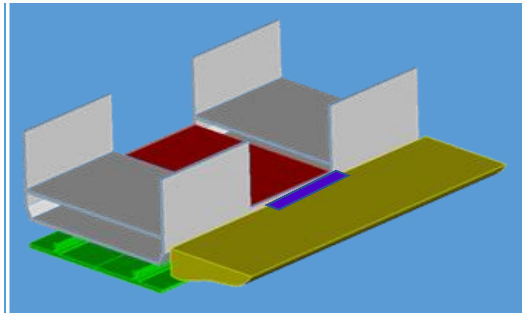
#2.1.3 Benchmark of the solutions



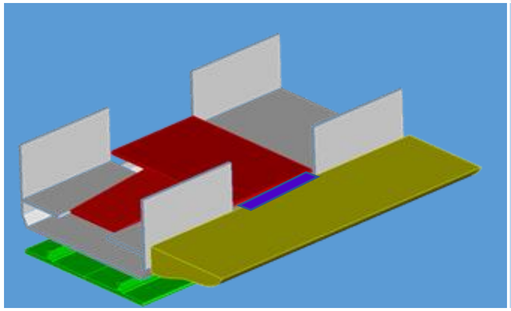
Lateral ramp
inside and outside the train
(extension of the internal ramp
with a sliding gap filler)



2 longitudinal ramps
inside the train
with **vertically moving vestibule**
and sliding gap filler



Vertically moving vestibule
and sliding gap filler

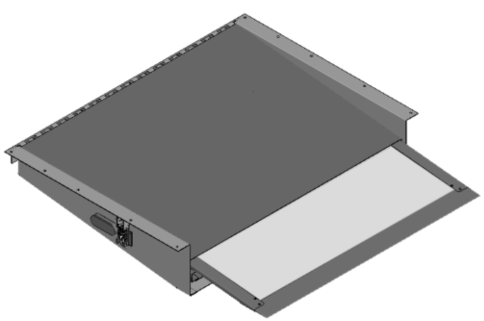


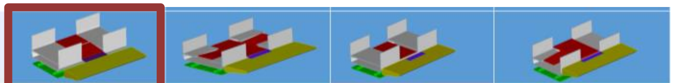
1 longitudinal ramp
with **vertically moving vestibule**
and sliding gap filler

#2.1.4 Assessment of the solutions

Lateral ramp extended with sliding step:
Ok for 1 platform height (100 mm amplitude) in all cant conditions
Ok for 2 TSI platforms heights with tolerances (300 mm amplitude) <u>only under flat conditions</u> (see next slide)

➔ it could be considered as first step toward accessibility solution





1	Wheelchair flow	Fluid if we consider sufficient space availab around the vestibule (if there is no toilet besides the door)	Fluid	Vertical gap is 150mm until the door closes	Fluid going one side only (250mm vertical gap on the other side)
2	Interior space constraints	The corridor needs a central lane of 2,1m wide to allow the wheelchair manoeuvring. The toilets can be put besides the door only on extremity coaches.	Even if it can be at any position (central or not) the ramps should be minimum 1,2 m wide and 2,5m long (3,58°)	No impact : only the vestibule is modified	Even if it can be at any position (central or not) the ramp should be minimum 1,2 m wide and 2,5m long (3,58°). ONE SIDE ONLY
3	Passenger flow	Fluid if some specific marking is foreseen	Fluid	Vertical gap is 150mm until the door closes. WU will have an impact on the non PRM passenger flow.	Fluid (150mm vertical gap one side)
4	Cycle time	We can inclinate before the door opens fo 550mm platforms, but not on 760 mm platforms	Cycle time is OK for case 2 solution (if default position corresponds to high platform), except vertical gap (lifting movement) Cycle time is much bigger for case 1 solution, except that vertical gap is anticipated	Cycle time is OK for case 2 solution (if default position corresponds to high platform), except vertical gap (lifting movement) Cycle time is much bigger for case 1 solution, except that vertical gap is anticipated	Cycle time is OK for case 2 solution (if default position corresponds to high platform), except vertical gap (lifting movement) Cycle time is much bigger for case 1 solution, except that vertical gap is anticipated
5	Obstacle detection	Obstacle detection to be managed : - Between door leaf and boarding aid - Between sliding step and boarding aid flo	Obstacle detection to be managed between door leaf and boarding aid only. For case 2, it has has to be managed on both opposite doors.	Obstacle detection to be managed between door leaf and boarding aid only. For case 2, it has has to be managed on both opposite doors.	Obstacle detection to be managed between door leaf and boarding aid only. For case 2, it has has to be managed on both opposite doors.
6	Availability of door	A manual mode + lock-out in horizontal position is necessary to close the gap	Availability for wheelchair user will be affected on both doors of the vestibule. Difficult to imagine a lifting manual mode on such big device (Can be with a driller), necessary for case2.	Both doors of the vestibule will be affected by any defect and it also affects the circulation onbard. Difficult to imagine a lifting manual mode on such big device (Can be with a driller), necessary for case2.	Both doors of the vestibule will be affected by any defect and it also affects the circulation onbard. Difficult to imagine a lifting manual mode on such big device (Can be with a driller), necessary for case2.
7	Load (passengers to lift)	P = (1,3m x 1,6m) / 2 x 700kg/m² **P = 7142 N + weight of device**	(3m x 1,6m + 2 x (1,2m x 2,5m)/2) x 700kg/m² **P = 53 563 N + weight of device** (3,58° ramps) (43 322 N considering 6° ramps)	P=(3m x 1,6m) x 700kg/m² **P = 32 962 N + weight of device**	(3m x 1,6m + (1,2m x 2,5m)/2) x 700kg/m² **P = 43 262 N + weight of device** (3,58° ramps) (39 142 N considering 6° ramps)
8	Integration in carbody (interfaces)	Complex but cassette mounting is possible	Very complex (Cassette mounting not possible)	Complex but cassette mounting is possible + very heavy	Very complex (Cassette mounting not possible)
9	Slope for wheelchai (No cant)	Slope (Y direction) = ramp angle = 6° Slope (X direction) = 0° Cumulated slope = 6°	Slope (Y direction) = cant = 0° Slope (X direction) = ramp angle = 3,58° Cumulated slope = 3,58°	Slope (Y direction) = 0° Slope (X direction) = 0°	Slope (Y direction) = 0° Slope (X direction) = 0°
10	Slope for wheelchai (cant 3°)	Slope (Y direction) = cant = 6+3= 9° Slope (X direction) = 0° Cumulated slope = 9°	Slope (Y direction) = cant = 3° Slope (X direction) = ramp angle = 3,58° Cumulated slope = 4,7° (Not used by WU)	Slope (Y direction) = 3° Slope (X direction) = 0° Cumulated slope = 3°	Slope (Y direction) = 3° Slope (X direction) = 0° Cumulated slope = 3°
11	Slope for wheelchai (train slope 1%)	Slope (Y direction)= ramp angle = 6° Slope (X direction) = 0,57° Cumulated slope = 6,03° (Not used by WU	Slope (Y direction) = 0° Slope (X direction) = ramp angle + slope = 3,58+0,57°= 4,15° Cumulated slope = 4,15°	Slope (Y direction) = 0° Slope (X direction) = 0,57° Cumulated slope = 0,57°	Slope (Y direction) = 0° Slope (X direction) = 0,57° Cumulated slope = 0,57°
12	Slope for wheelchai (train slope 1% + cant 3°)	Slope (Y direction)= ramp angle = 6 + 3 = 9 Slope (X direction) = 0,57° Cumulated slope 9,03° (Not used by WU)	Slope (Y direction) = 3° Slope (X direction) = ramp angle + gradient = 3,58 + 0,57°= 4,15° Cumulated slope = 5,12° (Not used by WU)	Slope (Y direction) = 3° Slope (X direction) = 0,57° Cumulated slope = 3,05°	Slope (Y direction) = 3° Slope (X direction) = ramp angle + gradient = 3,58 + 0,57°= 4,15° Cumulated slope = 5,12° (Not used by WU)
13	Vertical gap	Upon the specification < 20mm	Upon the specification < 20mm	Vertical gap is 150mm until the door closes	Upon the specification < 20mm
14	Possibility to fill the horizontal gap befor the door opens	Yes	Yes only if we consider a secondary door	Yes only if we consider a secondary door	Yes only if we consider a secondary door
15	Costs	+ (more expensive than classic sliding step)	++ (especially if we have to respect low angle ramps) +++ if we consider a secondary door	+ (more expensive than classic sliding step) +++ if we consider a secondary door	++ (especially if we have to respect low angle ramps) +++ if we consider a secondary door

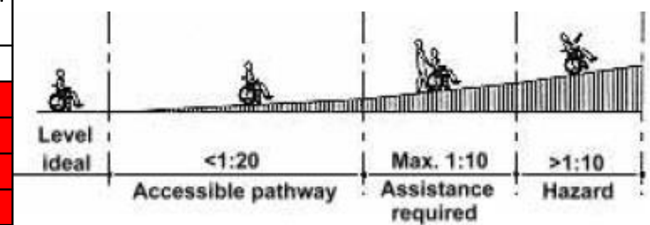
#2.1.5 Assessment of the concept (slopes)

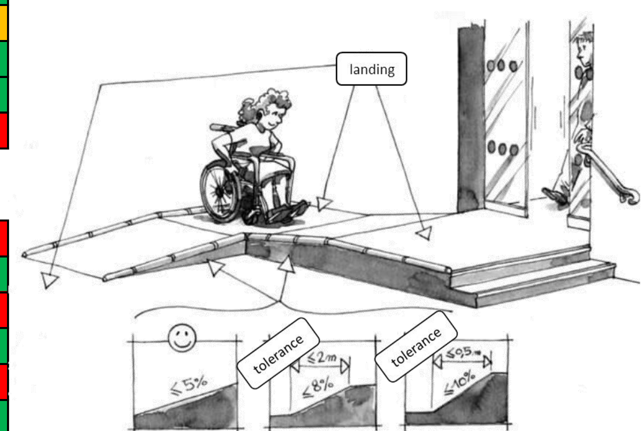
PIVOT Target

		1 platform + tolerances	2 platforms without tolerances	2 platforms with tolerances
		100 mm	200 mm	300 mm
slopes	< 5%			
	< 8%	2,6°	0°	
	< 8% - > 1 m	2,6°	0°	
	< 8% - 2 m			
	< 10%	4°	2°	0°
	< 10% - 1,25 m	2,6°	0°	0°
	< 10% - 500 mm			
	< 10% - 2 m		2°	0°
	< 12,5 % - 1,829 m	5°	3°	1°
	<13% - < 1 m	2,6°	0°	

French Law for building (new building)			
French Law for building (renovation)		2°	0°
French Law (Urban trains)	2,6°	0°	
UN recommendations	2,6°	0°	0°
COST 335	2,6°	0°	
ADA	5°	3°	1°
RISSBA	2°	1°	0°
Datasheet from suppliers	4°	2°	0°

(x°: maximum cant conditions for which the concept is compliant to the request)





#2.2 Platform solutions

Focus group discussions

Observational trips

Surveys

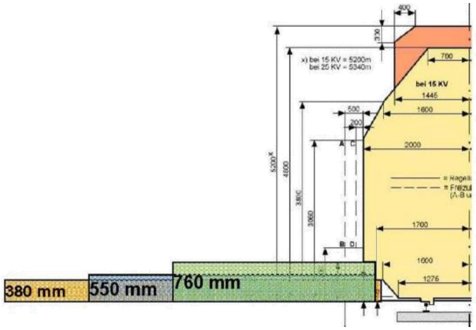
- **User needs and expectations**
- **Luggage handling**
- **Particular needs of PRMs**

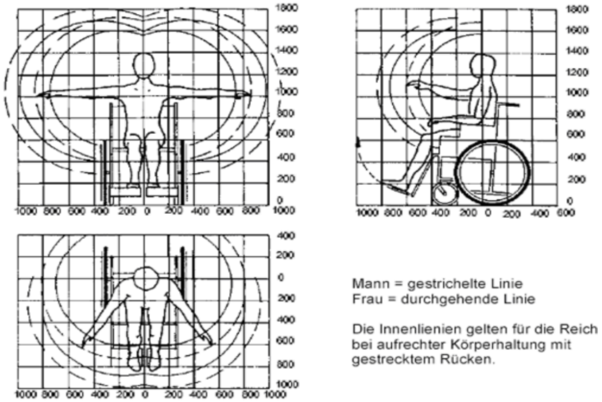
State of the art

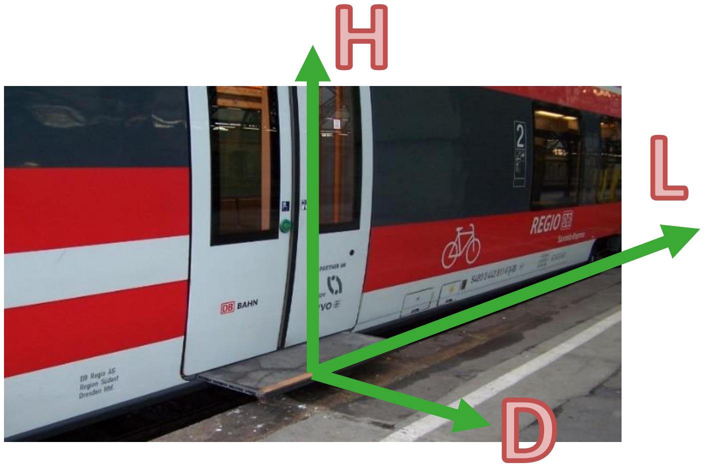
WP5 Design and Conceptualisation

T5.1 Platform-based solutions for PTI

- Special focus on PRMs
- Adaptation to H, D and L
- Fully automated device
- Suitable for existing and new stations/rolling stock





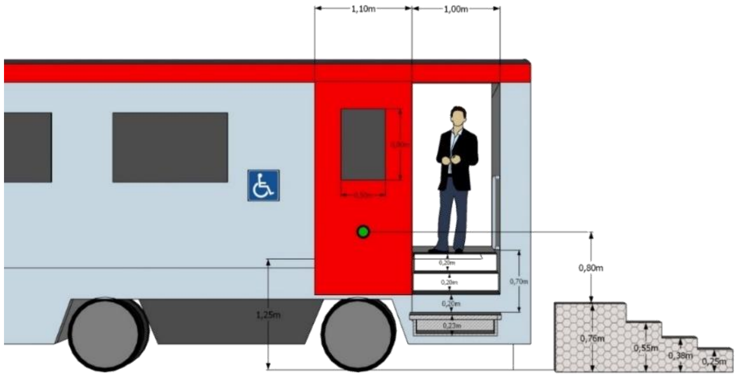


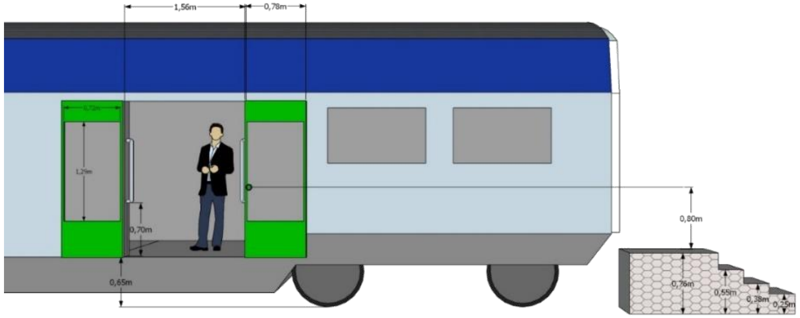
#2.2 Platform solutions

WP5 Design and Conceptualisation

T5.2 Door access system

- Worldwide benchmark on technical boarding devices
- PRMs' (dis)satisfaction with different devices
- Operators' experiences
- Information on requirements
  - Short-distance urban trains
  - Long-distance high-speed trains
- Minor upgrades for PTI system



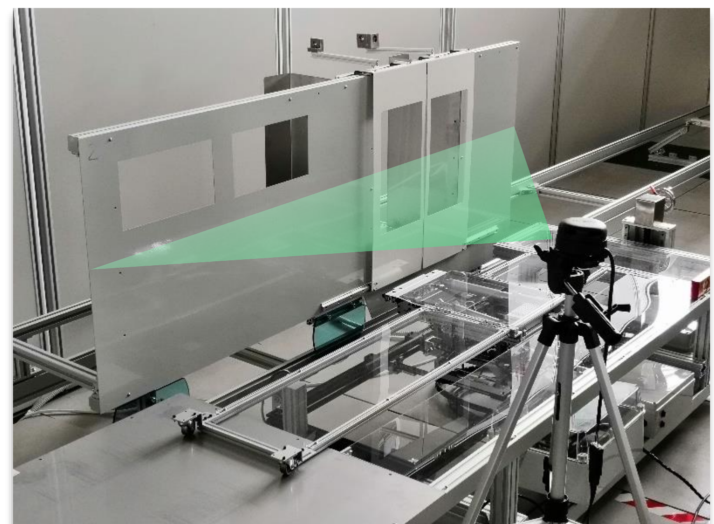


#2.2 Platform solutions

WP5 Design and Conceptualisation

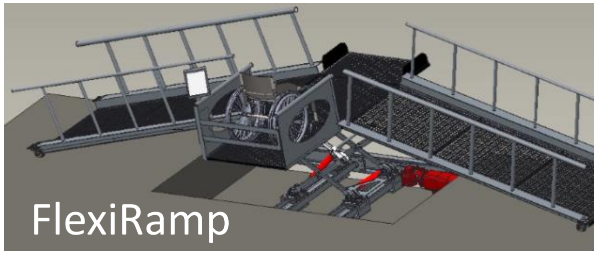
T5.3 Detection technologies

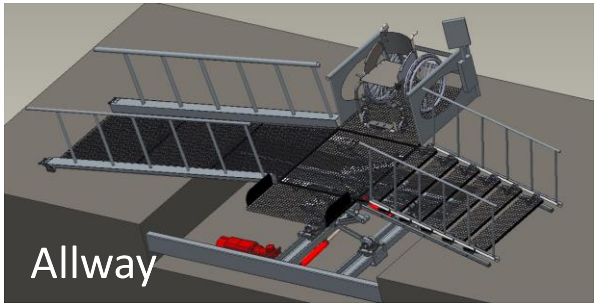
- Train and door(s) position detection
- Closed/open door detection
- Capable to operate with different trains and platforms
- Based on LIDAR and RGB + depth sensors
- No impact on train
- Dwell-time minimization

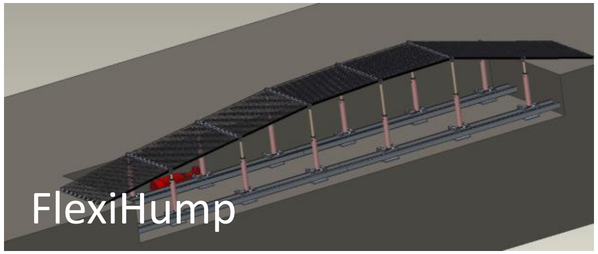


WP5 Design and Conceptualisation

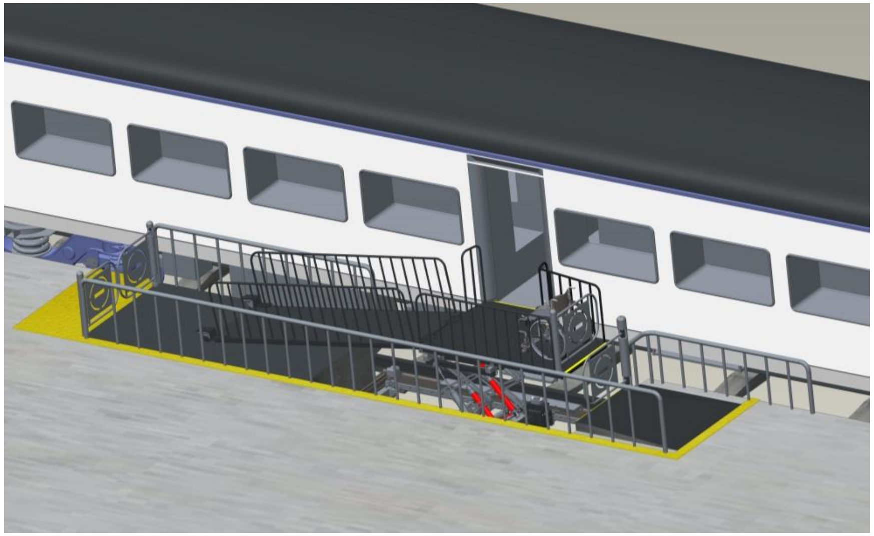
Final Concept







Gap to cover				
type		vertical	horizontal	along platform
Ref.		H	D	L
min	mm	-100	0	0
max		1000	600	2000



#2.2 Platform solutions

TRL3 proof-of-concept

video

#2.2 Platform solutions

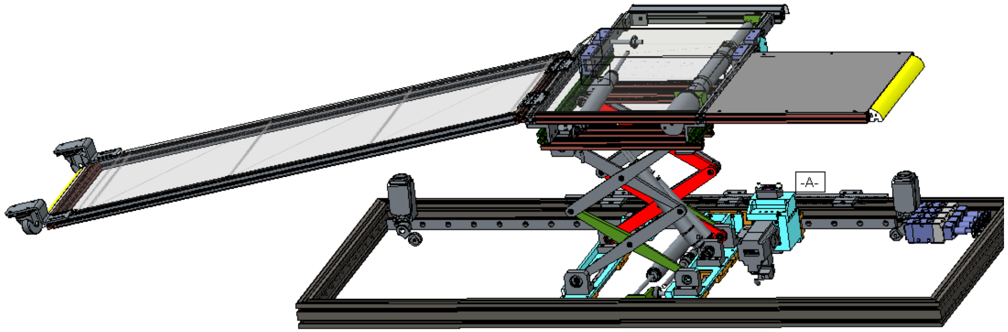
TRL3 proof-of-concept

video

#2.2 Platform solutions

FAIR STATIONS

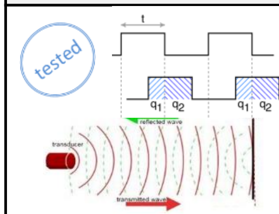
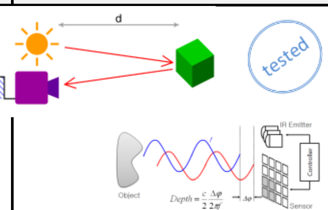
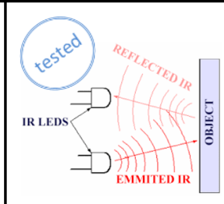
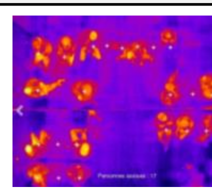
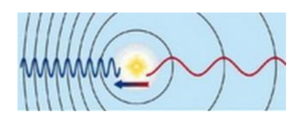
- Fully automated platform-based system for PTI
- Compliant with needs of both general users and PRMs
- Suitable for both short distance and long distance train
- Suitable for different platform heights (250 to 760 mm)
- Suitable for different rails inclinations (-6° to +6°)



#3 Door functions

#3.1 Benchmark of functions and sensors

List of targeted functions		
	1	Detection of platform edge Horizontal gap
	2	Detection of platform edge Vertical gap
	3	Virtual push-button
	4	Contactless obstacle detection during the deployment of the step
	5	Passenger detection on step
	6	Contactless obstacle detection for flat leaves
	7	Contactless obstacle detection for curved leaves
	8	Passenger counting

list of technologies				
	Ultrasonic time-of-flight	InfraRed / Red Light time-of-flight	InfraRed proximity sensors	Light Grid
				
	InfraRed Camera	Stereoscopy Camera	Capacitive Sensor	Doppler Radar
				

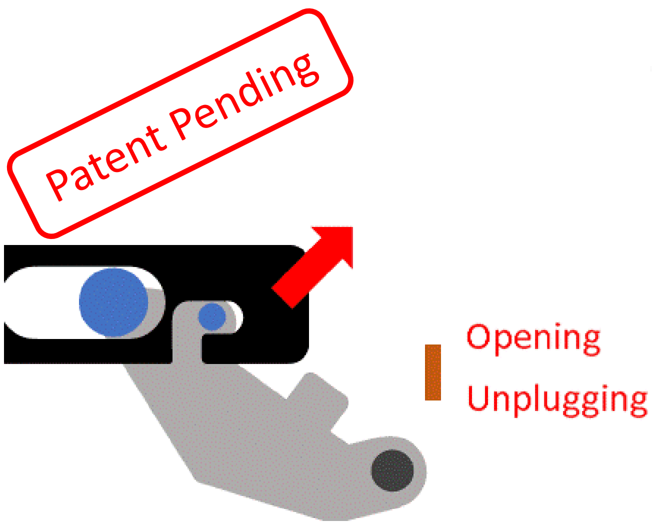
#3 Door functions

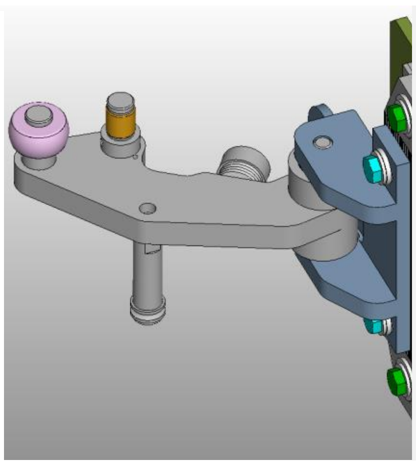
#3.2 Results

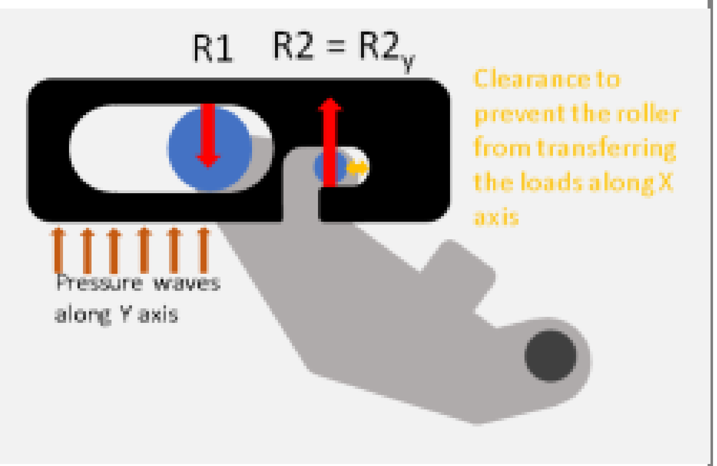
		Ultrasonic time-of-flight	InfraRed / Red Light time-of-flight	InfraRed proximity sensors	Light Grid	InfraRed Camera	Stereoscopy Camera	Capacitive Sensor	Doppler Radar
F1	Detection of platform edge - horizontal gap measurement								
F2	Detection of platform edge - vertical gap measurement								
F3	Virtual Push-Button								
F4	Contactless obstacle detection during the deployment of the step								
F5	Passengers detection on step								
F7	Contactless obstacle detection for flat leaves								
F8	Contactless obstacle detection for curved leaves								
F9	Passengers counting								

#4.1 Improvement of door leaves – operator interfaces

- New design of swinging arm ➔ for sliding-plug doors
  - Gain of 10 kg
  - Extension of limit of use of standard operators as the efforts are no more transmitted from the lower part of the leaves to the operator



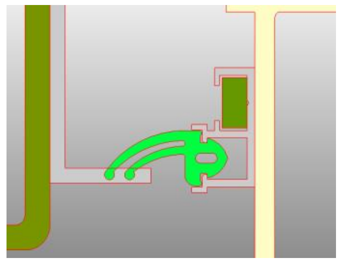
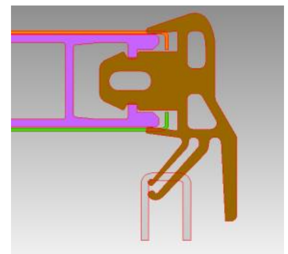
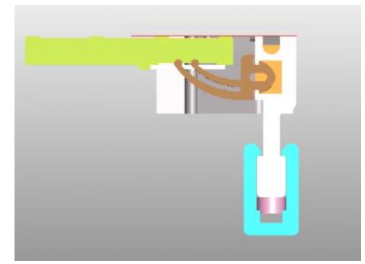




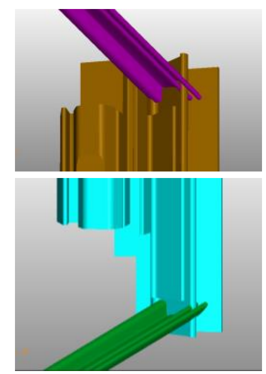
#4 Integrated solutions

#4.2 Improvement of door leaves – seal land interfaces

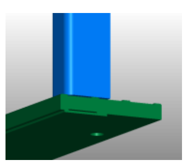
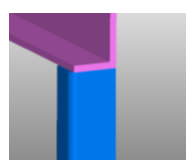
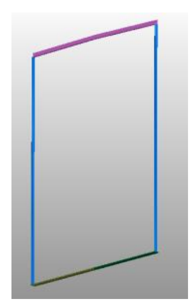
- Improved seal shapes

- Improved seal corners

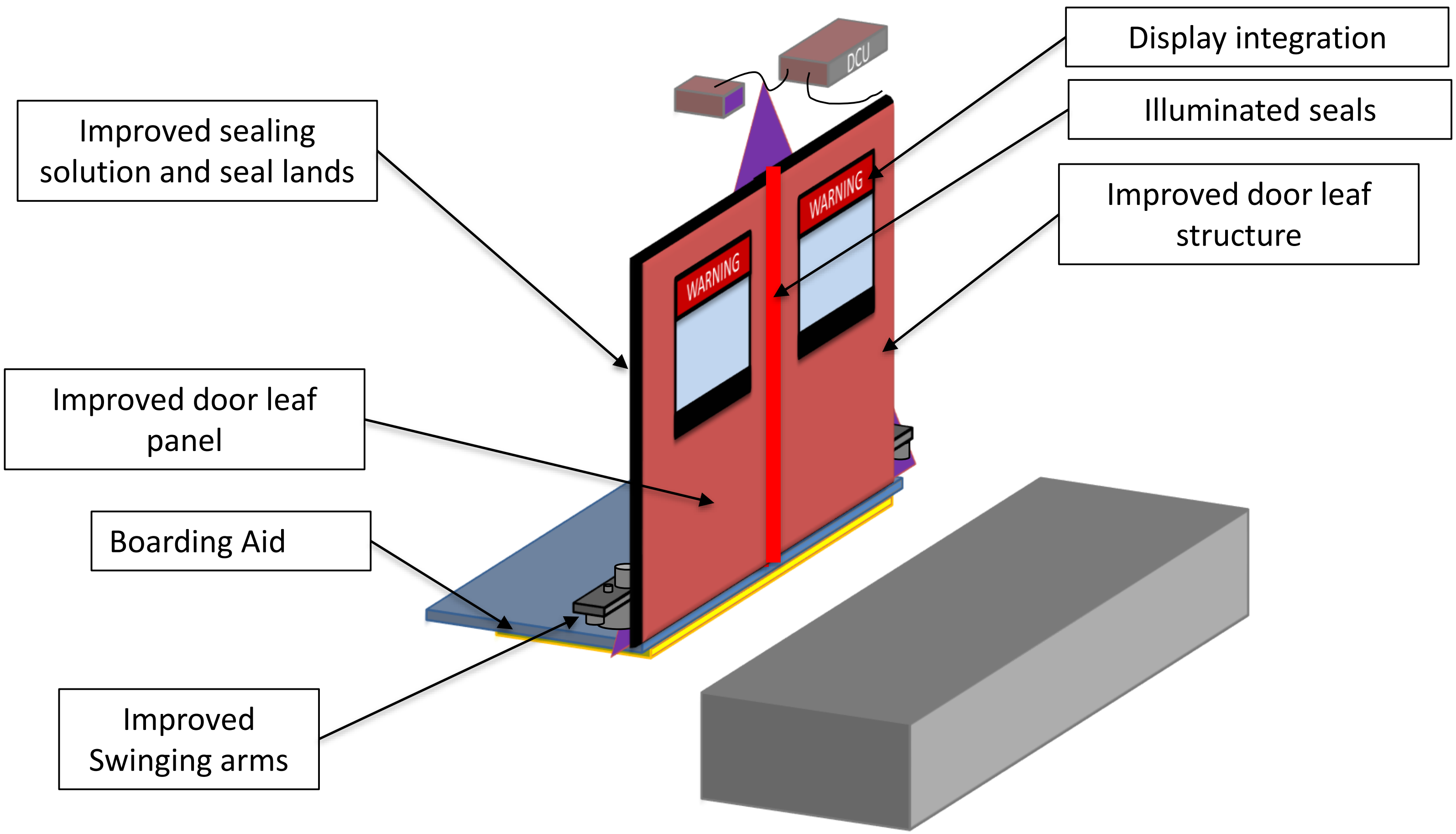


- Continuous seal land

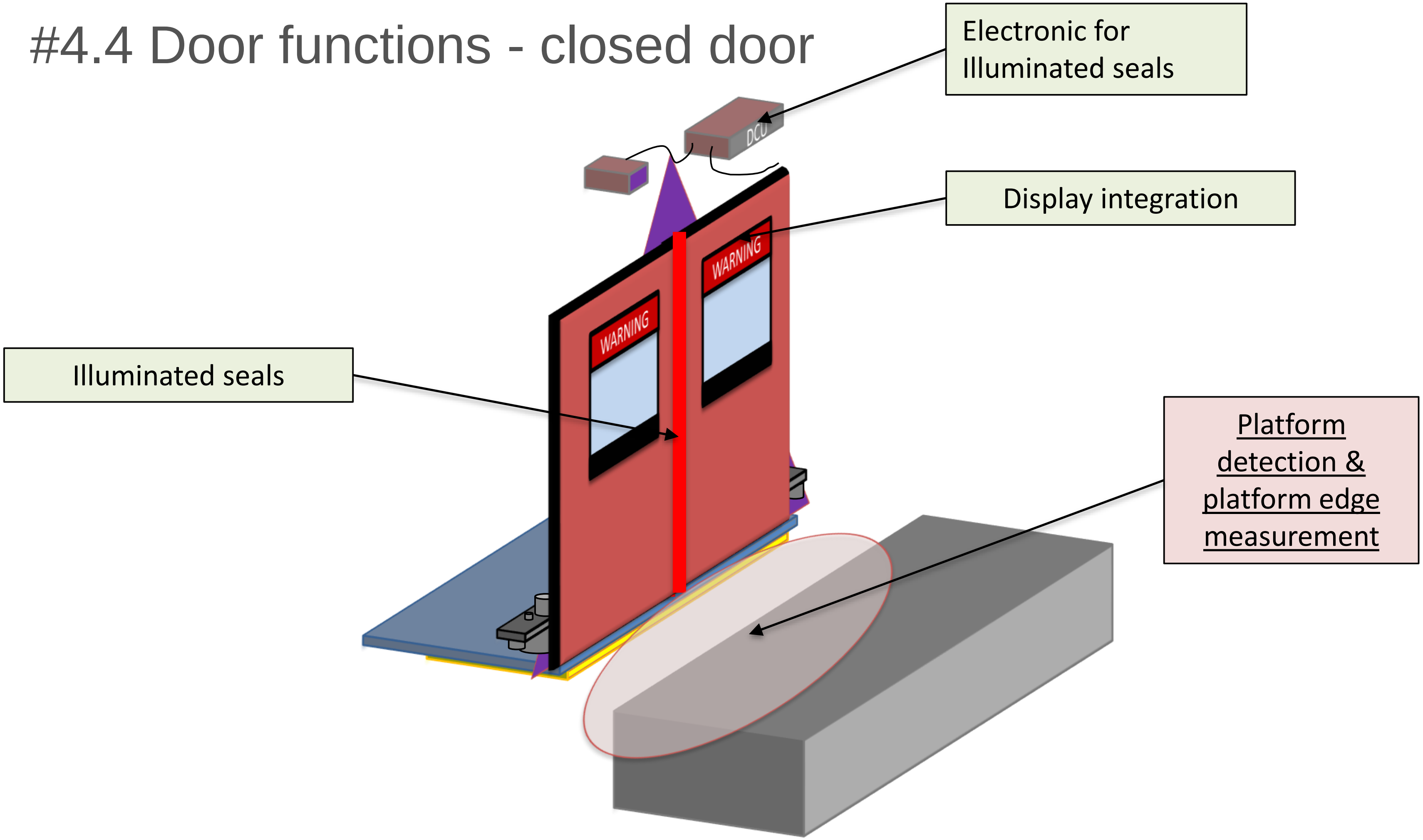
#4 Integrated solutions

#4.3 Integrated door system



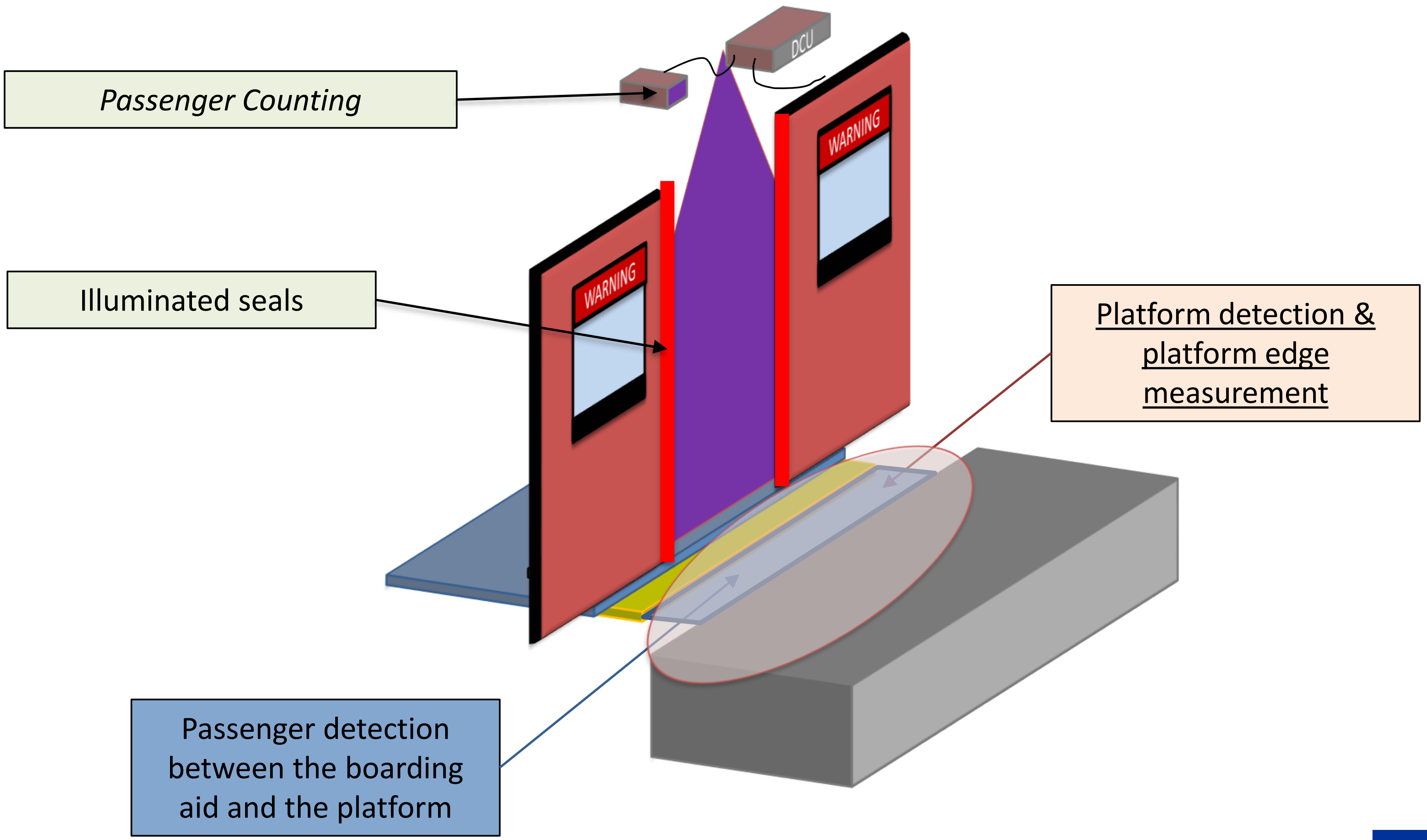
#4 Integrated solutions

#4.4 Door functions - closed door



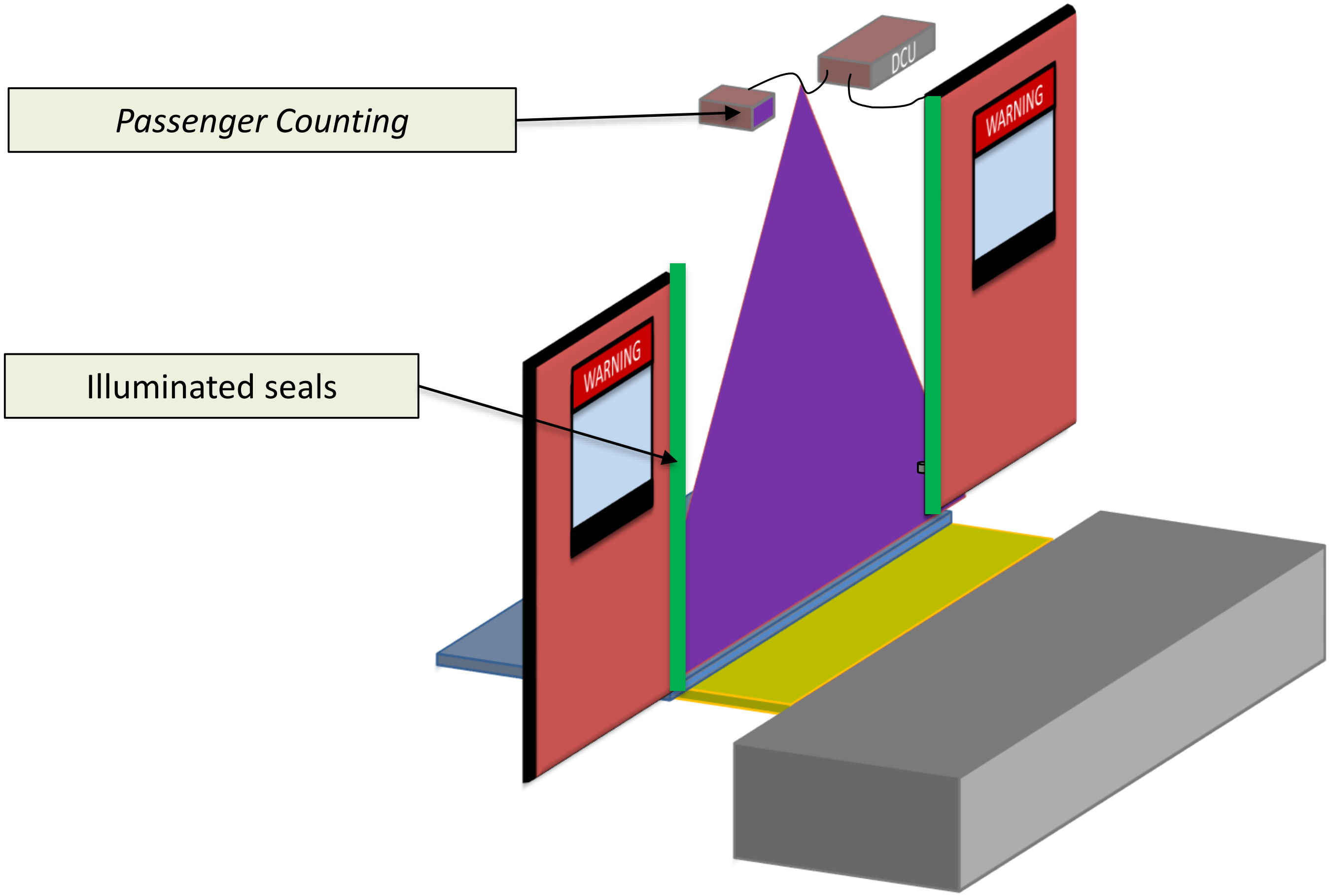
#4 Integrated solutions

#4.5 Door functions - during door opening



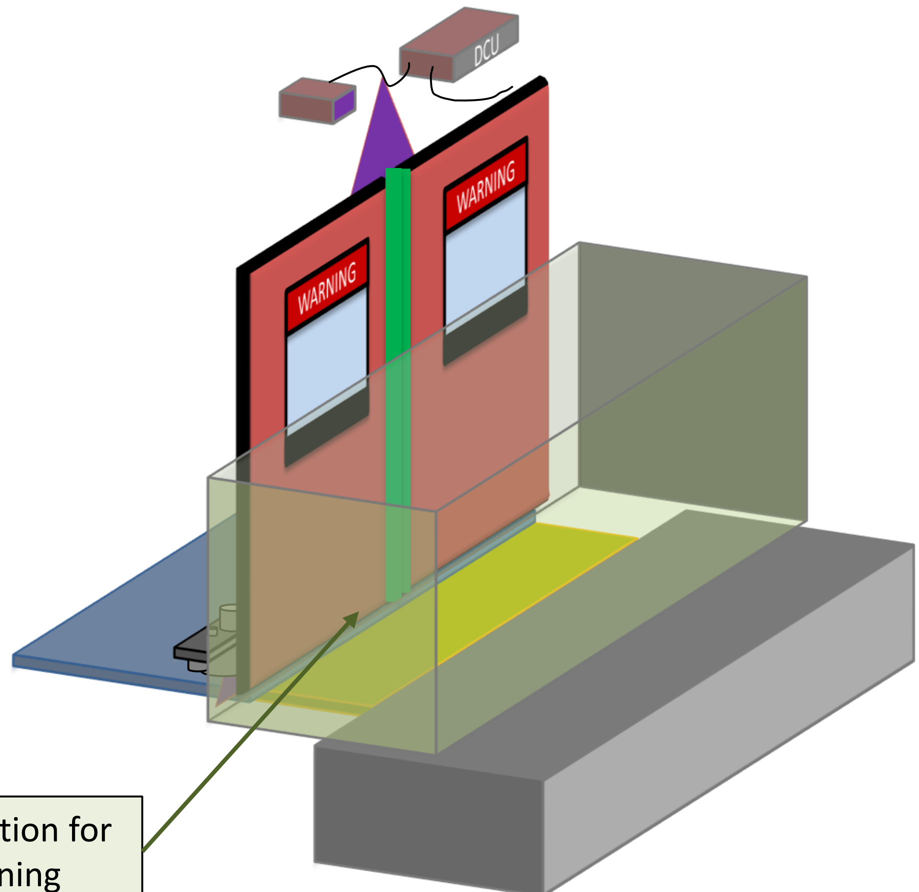
#4 Integrated solutions

#4.6 Door functions - Open door & boarding aid deployed



#4 Integrated solutions

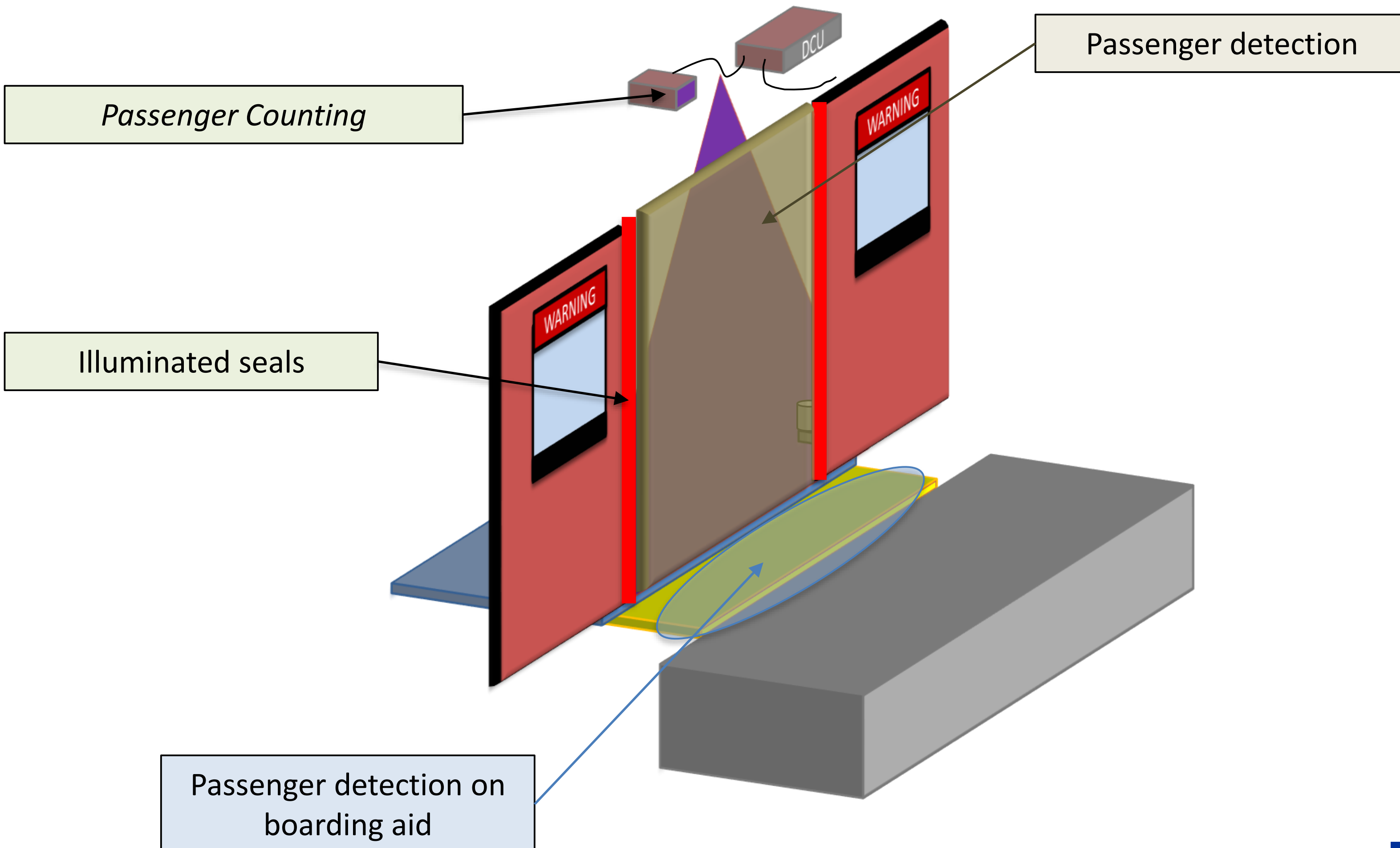
#4.7 Door functions - Closed door & boarding aid deployed



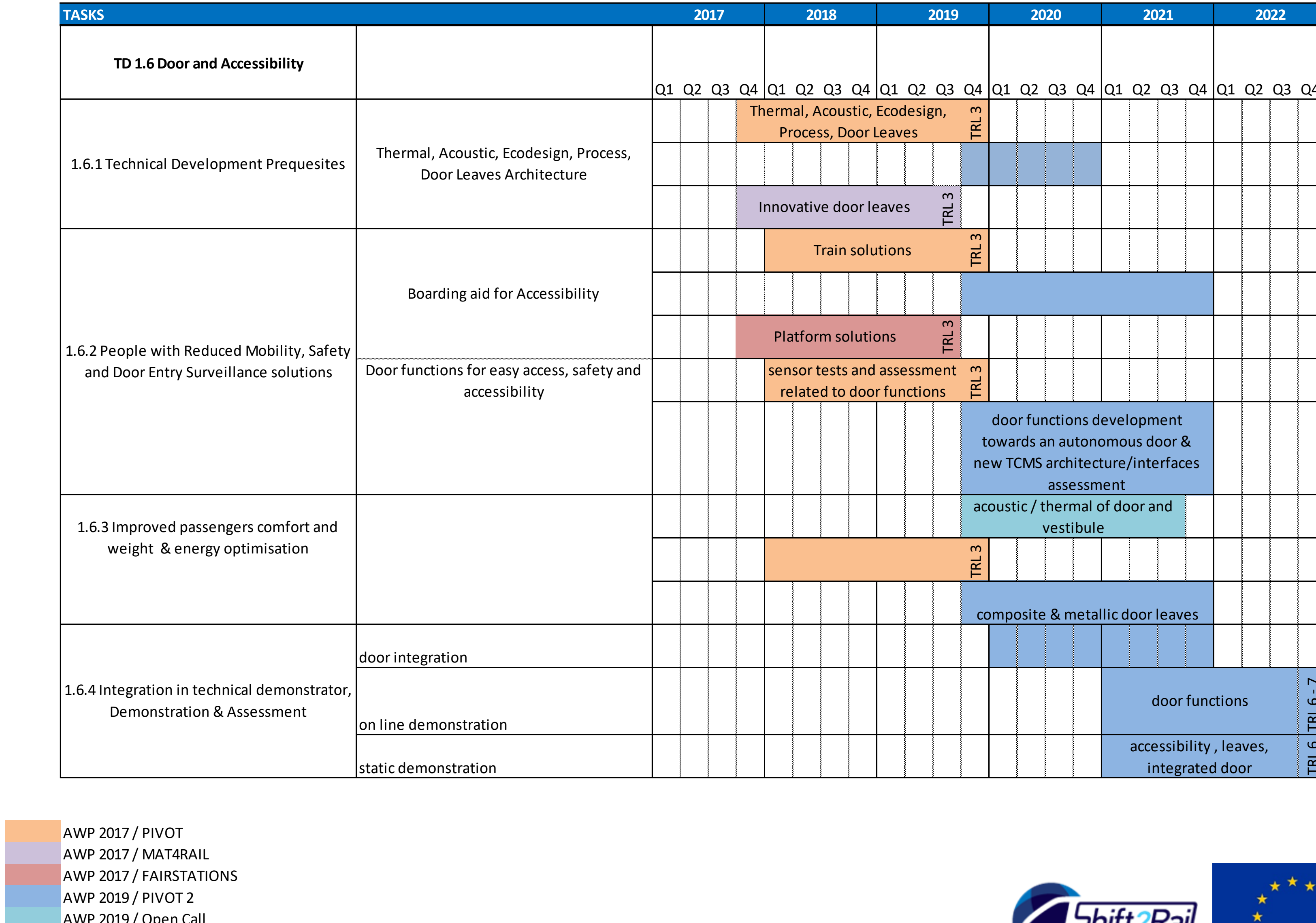
Passenger detection for door (re)opening

#4 Integrated solutions

#4.8 Door functions - During door closing



#5 Outlook



TASKS
2017
2018
2019
2020
2021
2022
TD 1.6 Door and Accessibility
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4
1.6.1 Technical Development Prequesites
Thermal, Acoustic, Ecodesign, Process, Door Leaves Architecture
Thermal, Acoustic, Ecodesign, Process, Door Leaves
TRL 3
Innovative door leaves
TRL 3
1.6.2 People with Reduced Mobility, Safety and Door Entry Surveillance solutions
Boarding aid for Accessibility
Train solutions
TRL 3
Platform solutions
TRL 3
Door functions for easy access, safety and accessibility
sensor tests and assessment related to door functions
TRL 3
door functions development towards an autonomous door & new TCMS architecture/interfaces assessment
1.6.3 Improved passengers comfort and weight & energy optimisation
acoustic / thermal of door and vestibule
TRL 3
composite & metallic door leaves
1.6.4 Integration in technical demonstrator, Demonstration & Assessment
door integration
on line demonstration
door functions
TRL 6 - 7
static demonstration
accessibility , leaves, integrated door
TRL 6
AWP 2017 / PIVOT
AWP 2017 / MAT4RAIL
AWP 2017 / FAIRSTATIONS
AWP 2019 / PIVOT 2
AWP 2019 / Open Call

Thank you for your kind attention

TD1.3 – Carbodyshells

Involved Projects: PIVOT, Mat4Rail

Technical Leaders: Eduardo de la Guerra (Talgo)

Alaitz Rekondo(CIDETEC)

Markus Brede (UNI-HB)

Per Blomqvist (RISE)

PIVOT – OC final conference

17th September 2019

Paris

TD1.3 Carbodies

- Current railway carbody structures close to the limit in lightweight terms
  - Steel or aluminum → Optimized structures
- New concept lightweight structure

- **The challenge is to develop lighter carbodyshells which make full use of the possibilities of composite materials including integration of functions.**

Introduction to TD1.3

Roll2Rail

REFRESCO

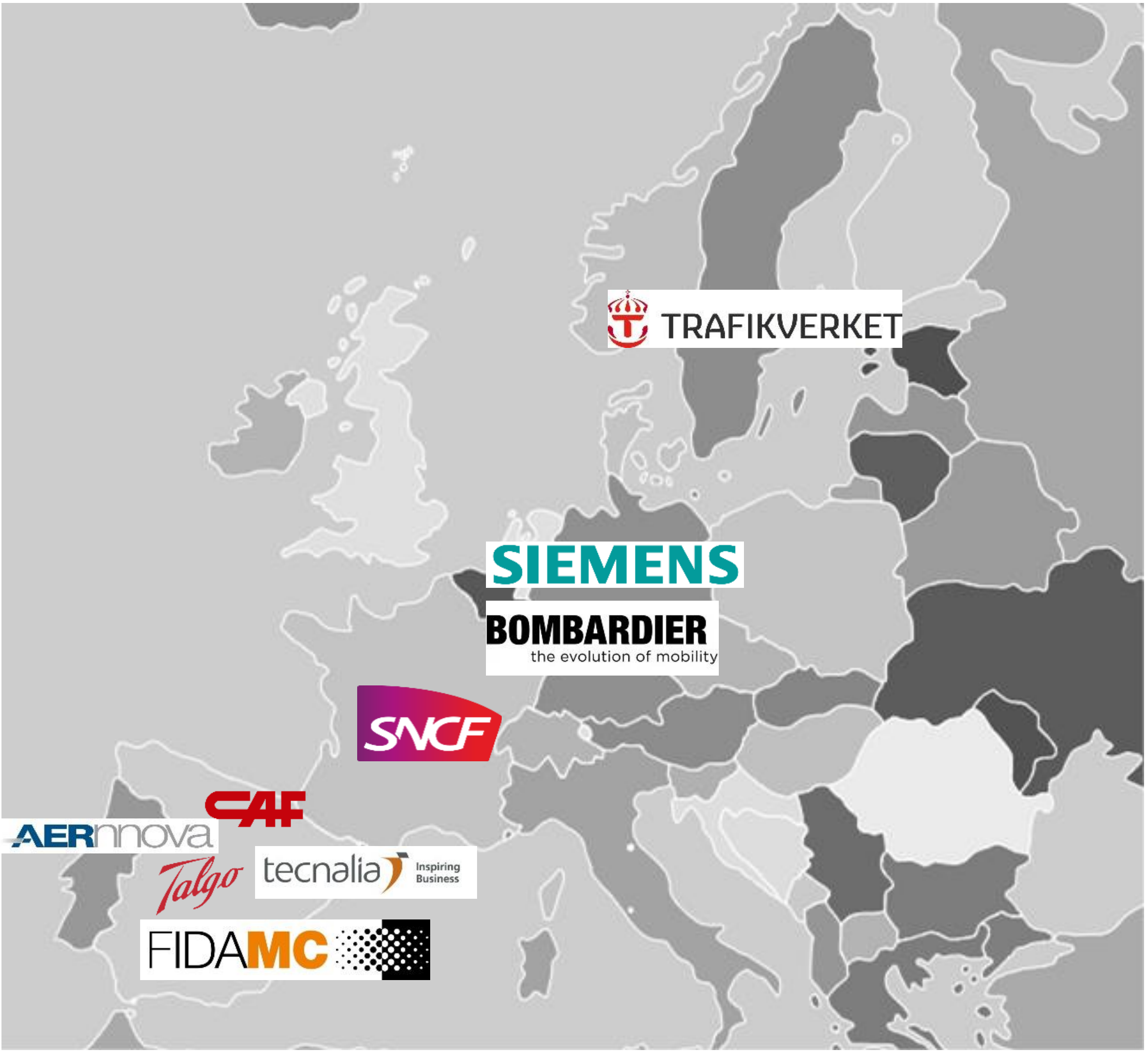
TOWARDS A REGULATORY FRAMEWORK FOR THE USE OF STRUCTURAL NEW MATERIALS IN RAILWAY PASSENGER AND FREIGHT CARBODYSHELLS

Mat4Rail a Project of the S2R JU + PIVOT

Challenges detected:

- Fire compliance
- Joints
- Standardization
- Design
- Manufacturing
- …

PIVOT TD1.3



Rolling Stock manufacturers
+
Operators
+
Composites & materials experts

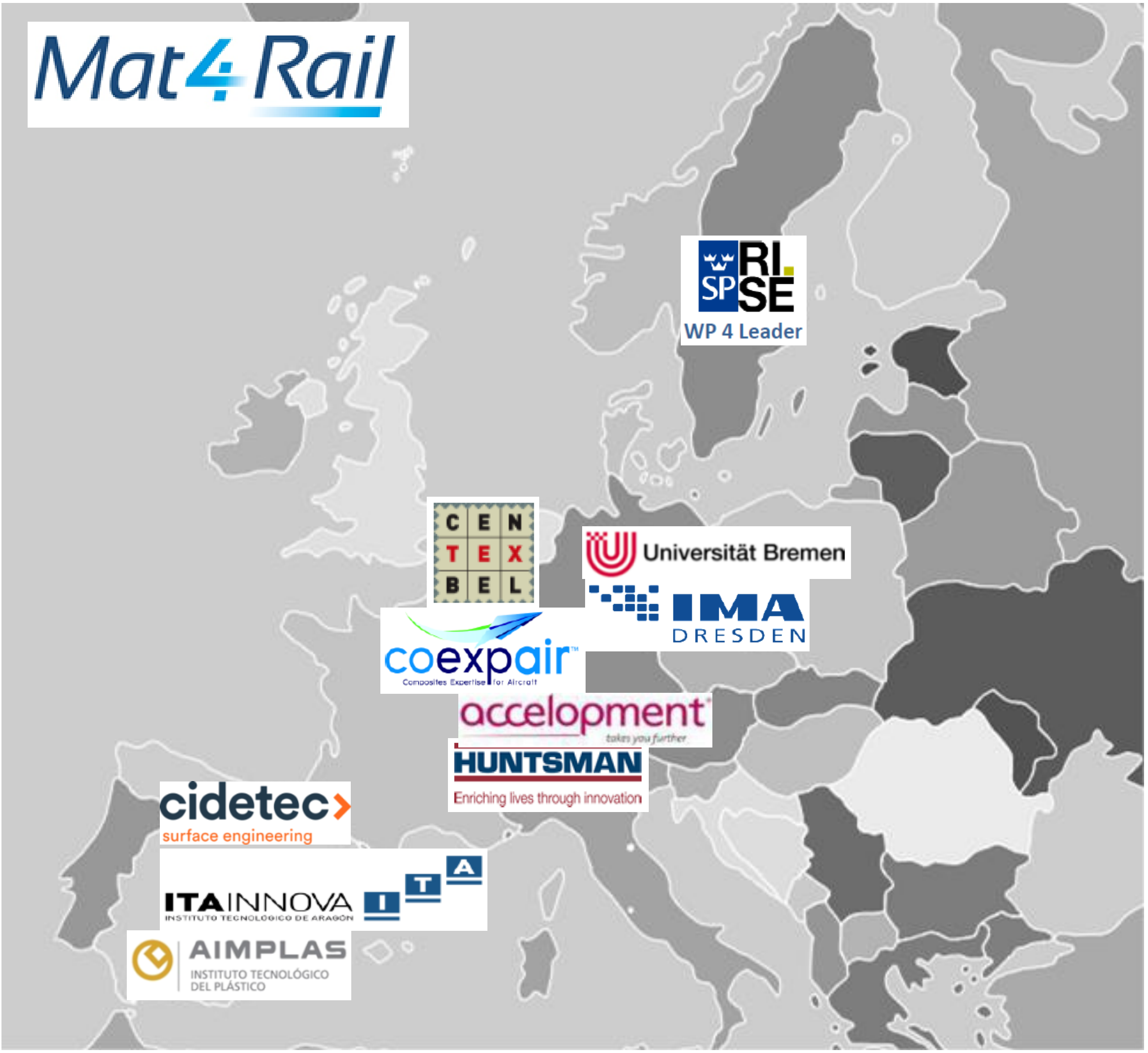
PIVOT WP1 and WP2

- WP1. The proposal will address the activities related to the specification of the demonstrators, studies involving the material requirements and manufacturing processes. In addition, an assessment methodology activity will take place throughout the project.

Original model Composite simplification

- WP2. The proposal will address the conceptual design of the demonstrator specified in WP1 and the structural and non-structural assessment together with preliminary risk analyses.

Introduction Mat4Rail



Partners involved in TD 1.3

Introduction Mat4Rail

Mat4Rail

WP's involved in TD 1.3:

- WP 2: New Materials (resins & fibres) for Rolling Stock
- WP 3: Development of Structural Joints for Railway Applications
- WP 4: Testing and Characterization of Composites and Joints

Objectives:

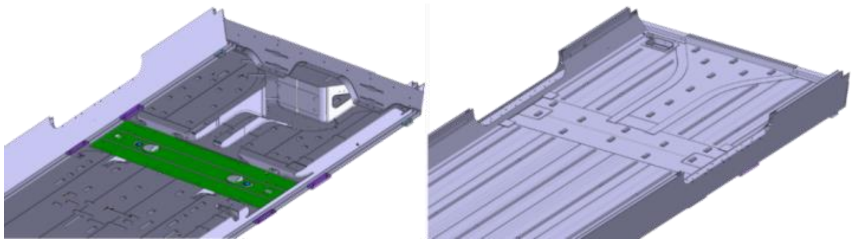
WP 2 & WP 4:
Development of novel resins for fibre reinforced composites and characterization of resins and composites (out of autoclave)

WP 3 & WP 4:
Development of structural joints for railway applications and methods for homologation procedures and characterization of joints and FRP materials

Main achievements of PIVOT WP1&2

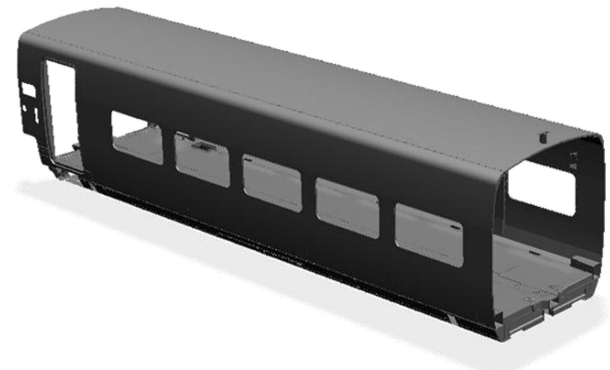
- Demonstrators was completely specified, taking into account:
  - Structural criteria
  - EMC
  - Thermal requirements
  - Maintenance
  - etc.
- Different type of products considered: HS and metro
- Different scopes, i.e. from subassemblies to complete carbody
- We will have an overview of the application of composite in railway carbody.

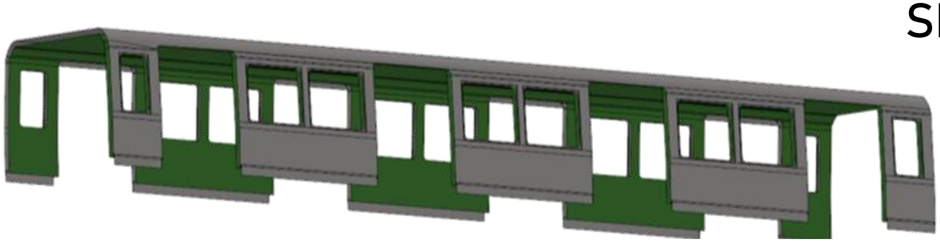
Main achievements of PIVOT WP1&2



UNDER FRAME AREA AT INTERMEDIATE END / CAR-END B

FULL COACH OF HIGH SPEED TRAIN





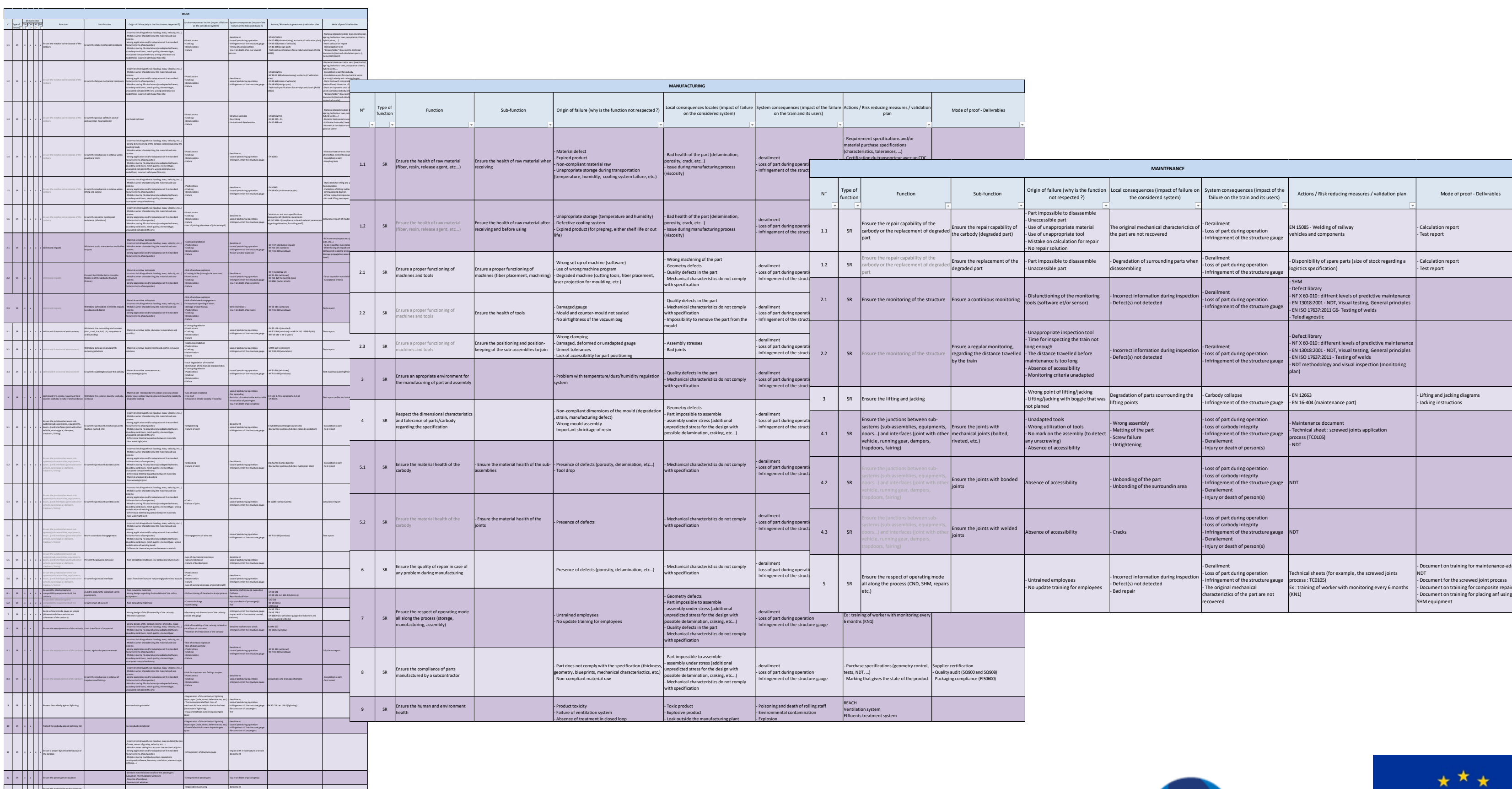
MODULAR SOLUTION FOR SIDEWALL, ROOF AND CARBODY END FOR THE INNEO

SHORT COUPLE FOR HIGH SPEED TRAIN

Main achievements of PIVOT WP1&2

- Risk Analysis (design, manufacturing and maintenance)

N°	Type of function	Function	Sub-function	Origin of failure (why is the function not respected ?)	Local consequences (impact of failure on the considered system)	System consequences (impact of the failure on the train and its users)	Actions / Risk reducing measures / validation plan	Mode of proof - Dellvrables



Main achievements of PIVOT WP1&2

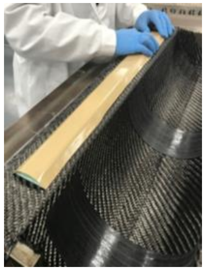
- Setting the state of the art on new materials. Standardization activities
    - CEN Survey Group
    - New Work Item Proposal for TC256
    - Process Standard for the Introduction of New materials

New Work Item Proposal	
C57/2019 – SC2/WG54 – Adoption of NWI for New materials	
TC 256 – Railway Applications	
Secretariat: DIN	Proposal documented in N xx
Date of circulation: 2019-07-04	Closing date for voting:

Railway Applications: Process standard for the introduction of new materials.

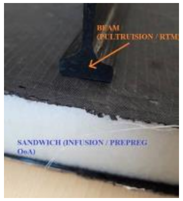
Main achievements of PIVOT WP1&2

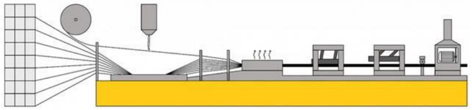
- Selection of existing solutions for material and manufacturing (cost and feasibility)
  - Hand lay-up
  - Pre-preg
  - Pultrusion



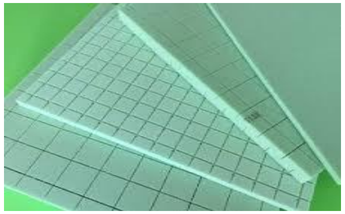
Hand lay-up

Manufacturing proposed process (Out of autoclave)





Pultrusion



PET core

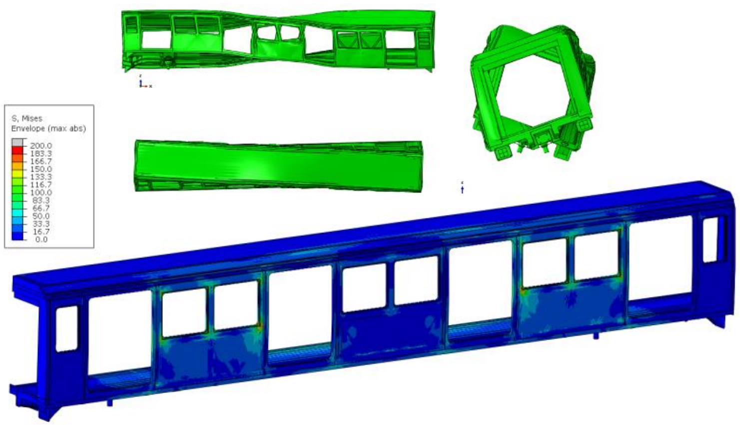
GLASS Fiber

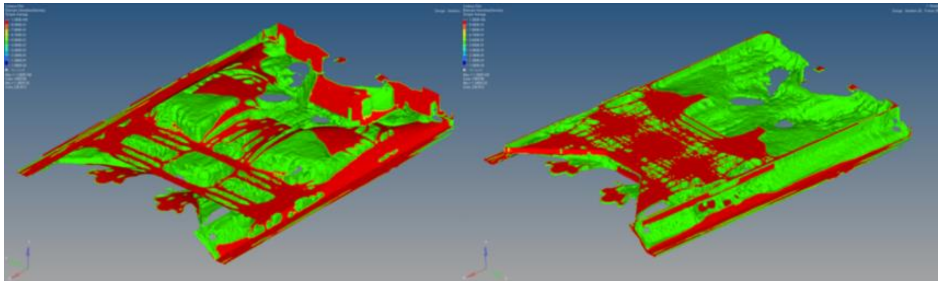
CARBON Fiber

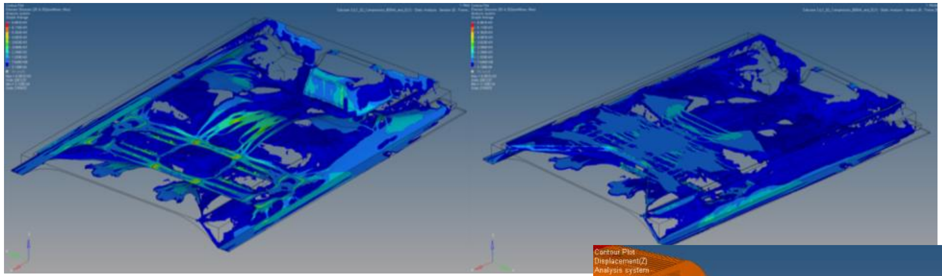
Material used (according to EN45545-2 HL2)

Main achievements of PIVOT WP1&2

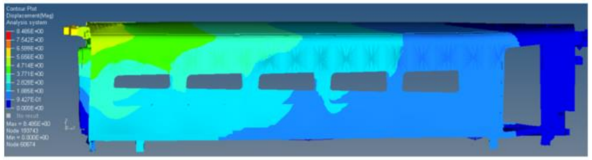
- Design activities

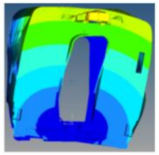


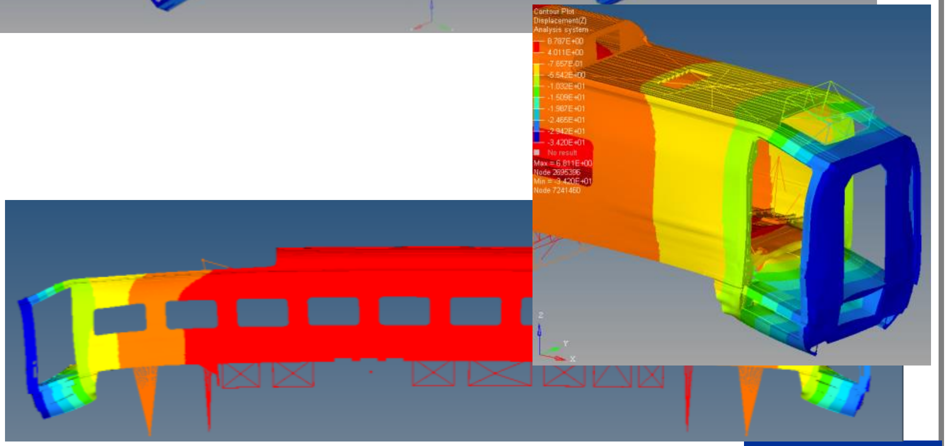




Performing FEM for sizing and optimization process

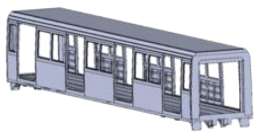


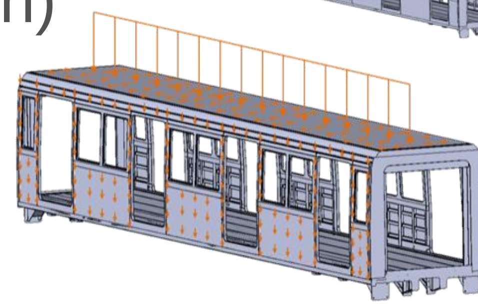


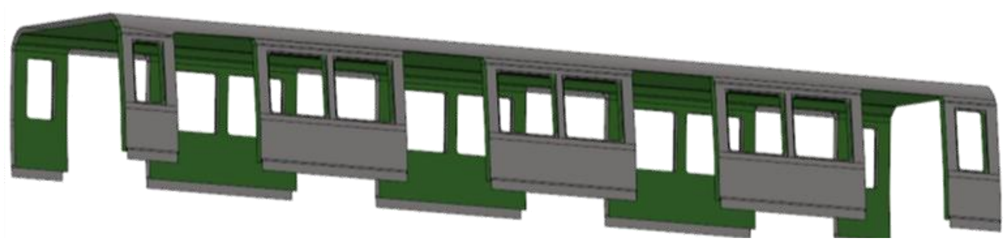


Main achievements of PIVOT WP1&2

- Modular solution for sidewall, roof and carbody end for the INNEO
- Looking for:
  - Weight reduction (↓15%)
  - Cost reduction (functional integration)







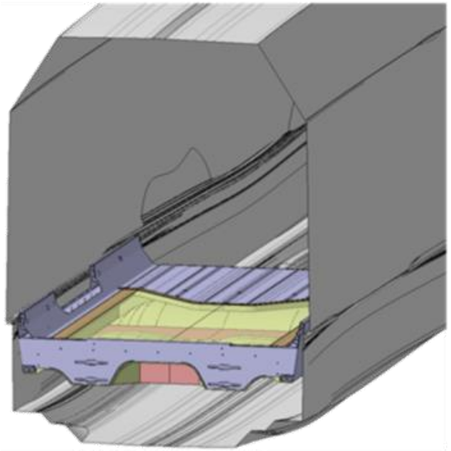
Current 2.642 kg → Forecast 2.092 kg

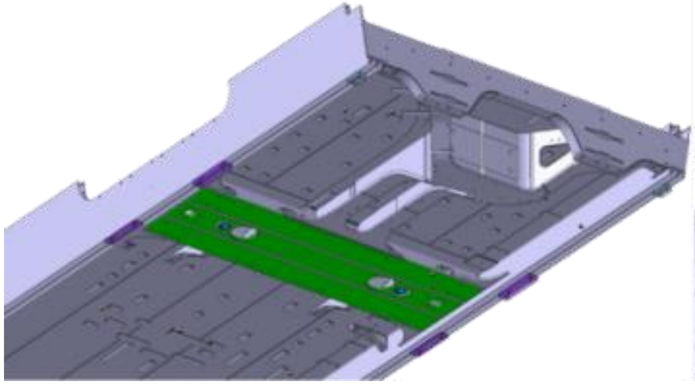
21%↓

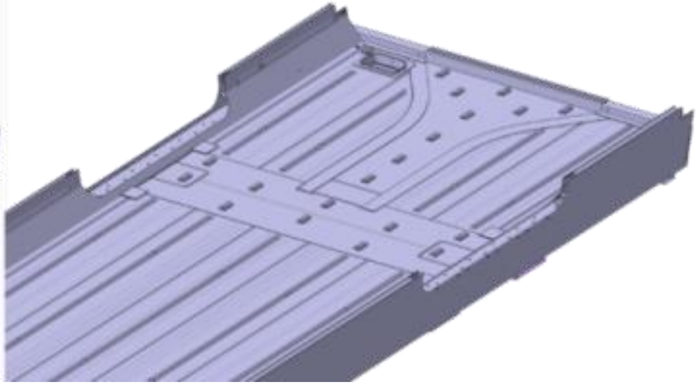
Main achievements of PIVOT WP1&2

Under frame area at intermediate end / car-end B

- Looking for:
  - Weight reduction (↓15%)
  - Cost reduction (functional integration)







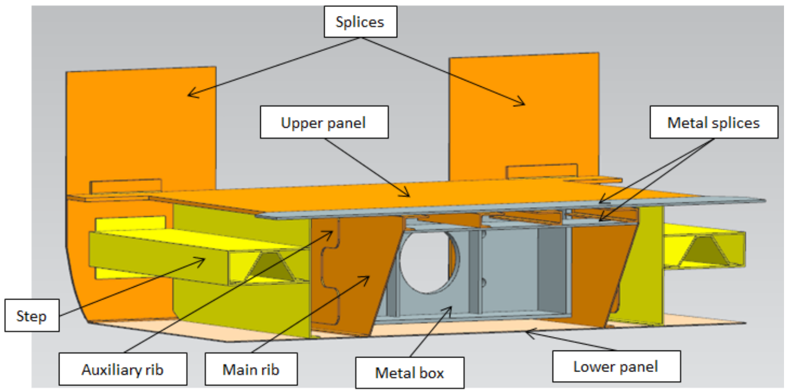
Current 485 kg → Forecast 410 kg

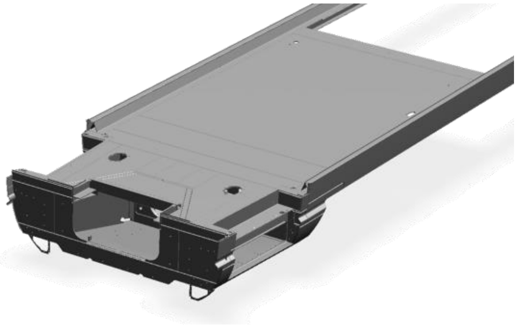
15.4%↓

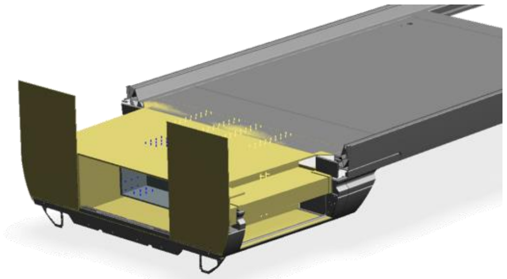
Main achievements of PIVOT WP1&2

Short Coupler box of High Speed vehicle

- Looking for:
  - Weight reduction
  - Simplification of manufacturing process







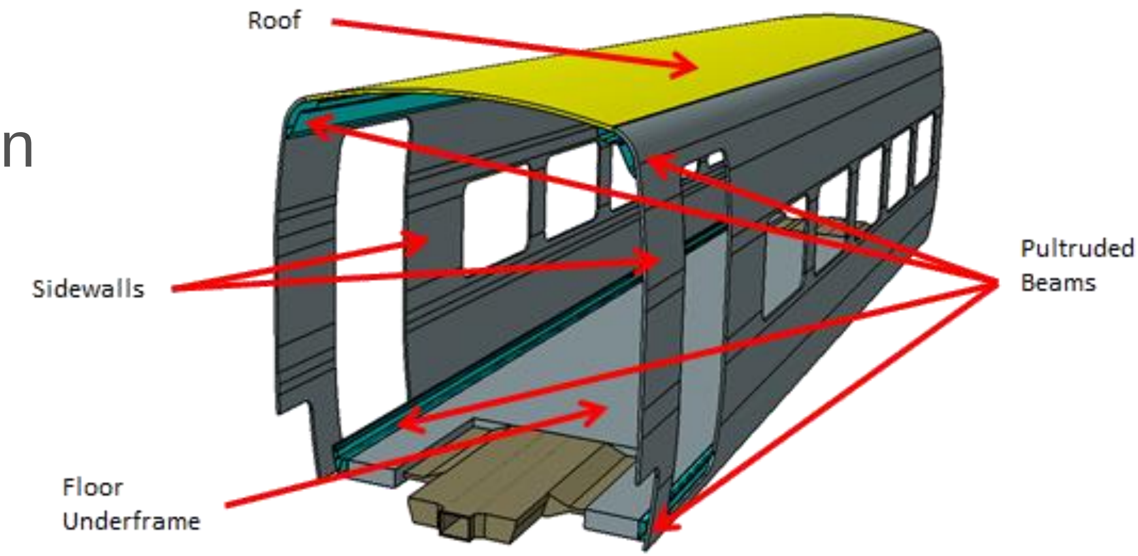
24,3%↓

Main achievements of PIVOT WP1&2

Full Carbody of High Speed vehicle

- Looking for:
  - Weight reduction (↓15-30%)

TRL 6 at the end of Shift2Rail



Current 3.815 kg → Forecast 2.671 kg

29%↓

Main achievements of PIVOT WP1&2

Dissemination

TRA2020 (sent).

- Hybrid High-Speed railway Carbodies: the next generation of light rolling-stock.

Composites in Rail

- Challenges for composites in primary structures and running gear frames- putting them to test on track.

ICCM22 Twenty-second International Conference On Composite

- New Composite Materials For Railway Applications.

Main achievements of Mat4Rail WP2-4

- Novel epoxy, benzoxazine and hybrid chemistry-based resins have been developed with improved fire performance

- EN45545-2 compliance of 6 novel composites based on glass, basalt and carbon fiber reinforcements have been developed and validated

- Thermal and mechanical characterization of the composites have demonstrated great potential of these composites for railway applications

- Homologation procedure for polymeric materials for operational loads, damage accumulation validated for structural adhesive

- Joining technologies for dissimilar materials, concepts for combined technologies, assembly, repair and refitting

Main achievements of Mat4Rail WP2-4

➢ Novel **epoxy, benzoxazine and hybrid chemistry resins** with improved FST performance

Performed tests according to EN45545-2

Test method	Test mode (kW/m²)	Relevant requirement sets	Components in train (examples)
ISO 5660-1	25	R8 (R7 equivalent)	External roof
	50	R1 R7 R17	Internal surfaces etc. External walls, under-frame Cab housing
ISO 5659-2	25 + pilot	R8 (R7 equivalent)	*See above*
	50	R1, R7, R17	*See above*

Smoke chamber (ISO5659-2)

Cone calorimeter (ISO5660-1)

Best resin formulations developed

Resin	M4R ID	MAHRE	Ds, max	Ds (4)	CIT_G
Epoxy - prepreg	M4R 0014	+	+	-	0
Hybrid chemistry	M4R 0010	0	0	0	+
Polybenzoxazine	M4R 0015	0	+	+	+

+ = promising
0 = average
- = problematic

Main achievements of Mat4Rail WP2-4

- ✓ A screening phase was carried out with 25 composite compositions.
- ✓ **6 best candidates were selected** for complete FST and mechanical characterization*.

	Resin type	Fibre type	Manufacturing process	T_g (ASTM D7028)	Density	FVC (ASTM D3171)	Cured Ply Thickness (ASTM D3171)
Composite 1	Epoxy	Basalt	Prepreg+SQ-RTM	144	1,98	48,56%	0,270mm
Composite 2	Polybenzoxazine	Basalt	Infusion	164	2,02	52,34%	0,250mm
Composite 3	Hybrid chemistry	Carbon	DFCM	287	1,48	48,85%	0,230mm
Composite 4	Polybenzoxazine	Glass	Infusion	163	1,96	51,48%	0,300mm
Composite 5	Hybrid chemistry	Basalt	DFCM	304	2,03	56,18%	0,233mm
Composite 6	Hybrid chemistry	HP Carbon	DFCM	301	1,56	59,07%	0,263mm

* All composites were manufactured with ~4 mm thickness.

** DFCM is Dynamic Fluid Compression Moulding. Could be also processed by infusion.

Main achievements of Mat4Rail WP2-4

➢ **Complete accredited EN45545-2 (FST) classification tests conducted with the 6 composites.** Requirements for R7 (R8) and R17* railway **external applications** shown below:

Test method	**Parameter**	**Hazard levels** requirements		
		HL1	**HL2**	**HL3**
ISO 5660-1	MAHRE (kW/m²)	-	90	60
ISO 5659-2	D_S max (-)	-	600	300
	CIT_G (-)	-	1,8	1,5
ISO 5658-2	CFE (kW/m²), min	20 (13*)	20 (13*)	20 (13*)

Cone calorimeter (ISO5660-1), 50 kW/m²

Smoke chamber (ISO5659-2), 50 kW/m²

Flame spread (ISO5658-2)

Main achievements of Mat4Rail WP2-4

➢ **EN45545-2 compliance of** fibre reinforced composites based on **glass, basalt and carbon fibre reinforcements** have been developed and validated

Composite 1: Epoxy/Basalt				Composite 2: Polybenzoxazine/Basalt				Composite 3: Hybrid/Carbon			
Cone calorimeter: R7, R8, R17 (HL2 < 90)				**Cone calorimeter: R7, R8, R17 (HL2 < 90)**				**Cone calorimeter: R7, R8, R17 (HL2 < 90)**			
	MAHRE				MAHRE				MAHRE		
Mean	93,9			Mean	49,7			Mean	67,1		
Smoke chamber: R7, R8, R17				**Smoke chamber: R7, R8, R17**				**Smoke chamber: R7, R8, R17**			
	Ds,max	CIT (4 min)	CIT (8 min)		Ds,max	CIT (4 min)	CIT (8 min)		Ds,max	CIT (4 min)	CIT (8 min)
Mean	629	0,2	0,36	Mean	299	0,07	0,2	Mean	577	0,01	0,26
Spread of flame: R1, R7, R8 (CFE >20);R17 (CFE >13)				**Spread of flame: R1, R7, R8 (CFE >20);R17 (CFE >13)**				**Spread of flame: R1, R7, R8 (CFE >20);R17 (CFE >13)**			
	CFE				CFE				CFE		
Mean	26			Mean	39			Mean	36		
Final classification				**Final classification**				**Final classification**			
R7, R8, R17:	**HL1**			**R7, R8, R17:**	**HL3**			**R7, R8, R17:**	**HL2**		

Composite 4: Polybenzoxazine/Glass				Composite 5: Hybrid/Basalt				Composite 6: Hybrid/HP-carbon			
Cone calorimeter: R7, R8, R17 (HL2 < 90)				**Cone calorimeter: R7, R8, R17 (HL2 < 90)**				**Cone calorimeter: R7, R8, R17 (HL2 < 90)**			
	MAHRE				MAHRE				MAHRE		
Mean	58,4			Mean	78,2			Mean	75,2		
Smoke chamber: R7, R8, R17				**Smoke chamber: R7, R8, R17**				**Smoke chamber: R7, R8, R17**			
	Ds,max	CIT (4 min)	CIT (8 min)		Ds,max	CIT (4 min)	CIT (8 min)		Ds,max	CIT (4 min)	CIT (8 min)
Mean	342	0,01	0,06	Mean	459	0,16	0,31	Mean	427	0,06	0,19
Spread of flame: R1, R7, R8 (CFE >20);R17 (CFE >13)				**Spread of flame: R1, R7, R8 (CFE >20);R17 (CFE >13)**				**Spread of flame: R1, R7, R8 (CFE >20);R17 (CFE >13)**			
	CFE				CFE				CFE		
Mean	33			Mean	33			Mean	34		
Final classification				**Final classification**				**Final classification**			
R7, R8, R17:	**HL2**			**R7, R8, R17:**	**HL2**			**R7, R8, R17:**	**HL2**		

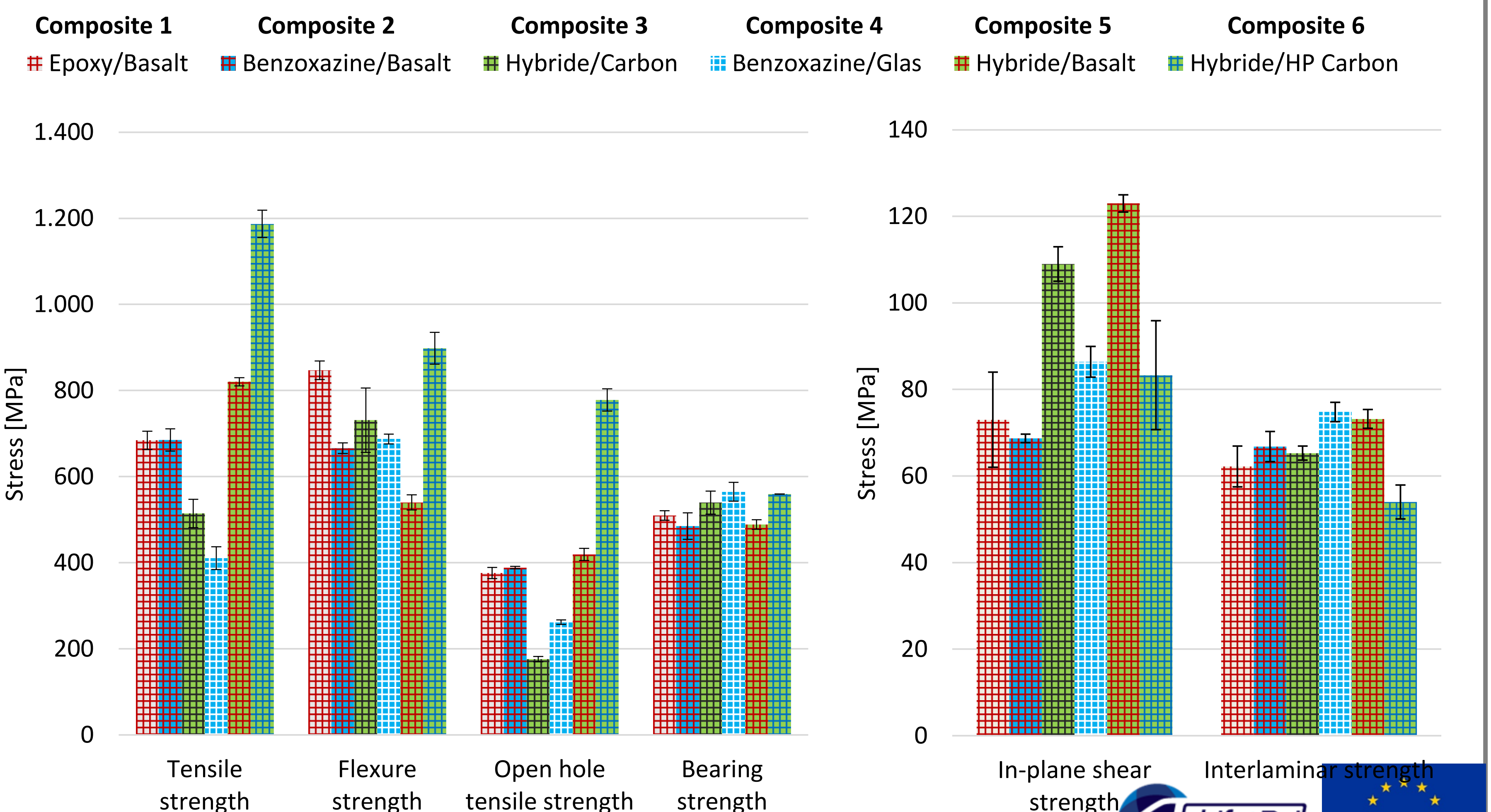
HL1
HL2
HL3

➢ **Mechanical characterization** of materials have demonstrated their suitable performance for application in railway requirements

	Test method	
Property	**Standard**	**Test specimen**
Tensile strength	ISO 527-4	5 repetitions
Flexture strength	ISO 14125	5 repetitions
Interlaminar shear strength	ISO 14130	5 repetitions
Compression strength	ASTM D6641	5 repetitions
In plane shear strength	ISO 14129	5 repetitions
Bearing strength	ASTM D 5961 procedure A	6 repetitions
Open hole tensile strength	ASTM D 5766 procedure A	6 repetitions
Open hole compression strength	ASTM D 6484	6 repetitions
Interlaminar fracture toughness	EN 6033	10 repetitions
Fatigue strength	ISO 13003	36 specimen

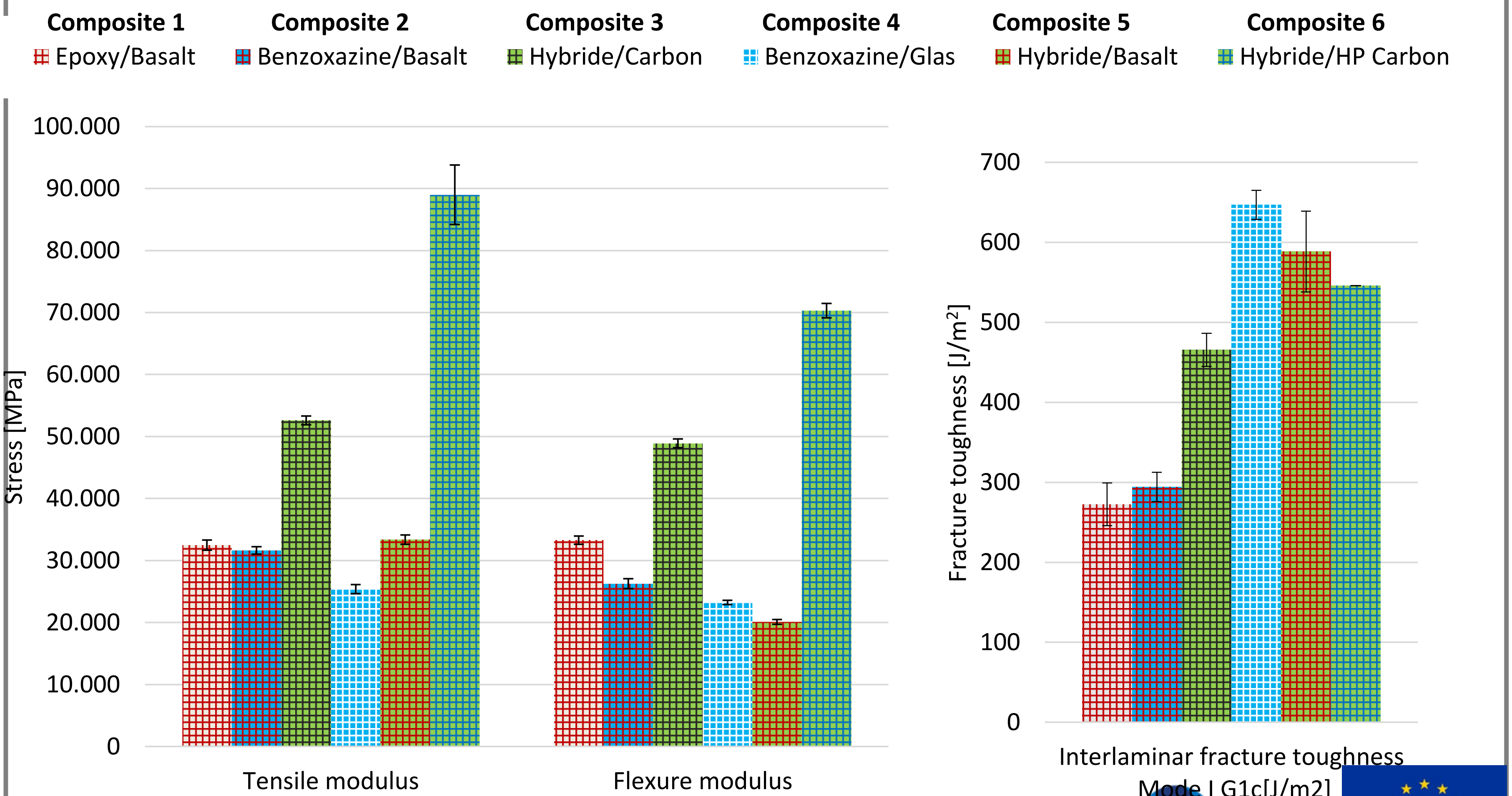
Main achievements of Mat4Rail WP2-4

- **Mechanical characterization of materials have demonstrated their suitable performance for application in railway requirements**



Main achievements of Mat4Rail WP2-4

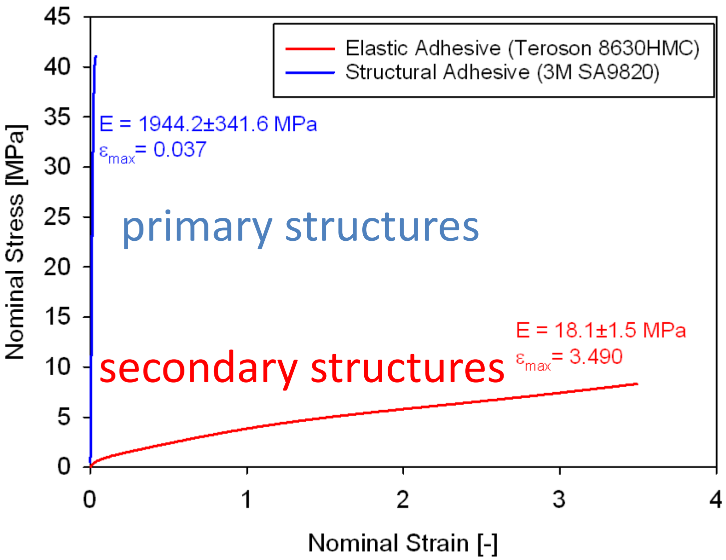
➤ **Mechanical characterization of materials have demonstrated their suitable performance for application in railway requirements**



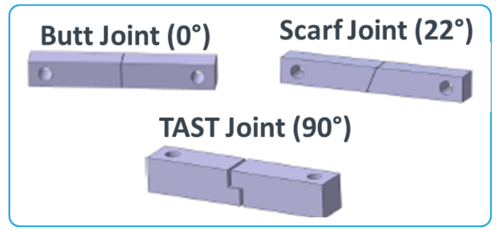
Main achievements of Mat4Rail WP3-4

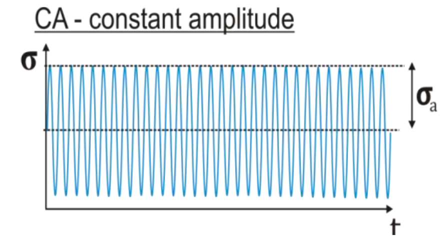
WP3 - Development of structural joints for railway applications

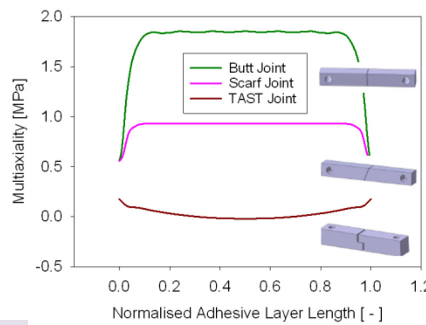
two classes of adhesives

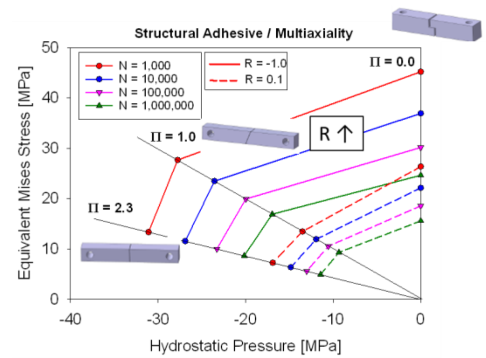


three joint types









multiaxiality = hydrostatic/deviatoric stress

bonding

testing

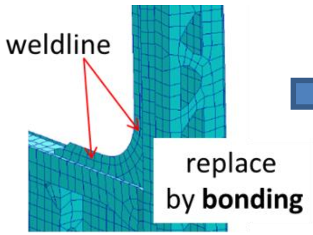
effects on strength:

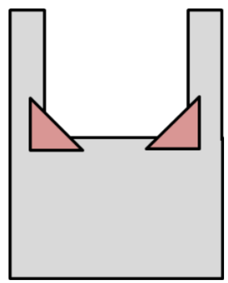
- temperature/moisture
- load ratio
- creep

Main achievements of Mat4Rail WP3-4

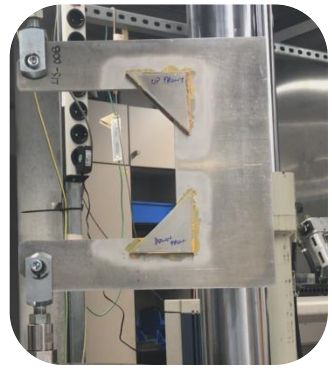
Methodology for static strength and fatigue assessment (example joints)

Homologation
- window corner

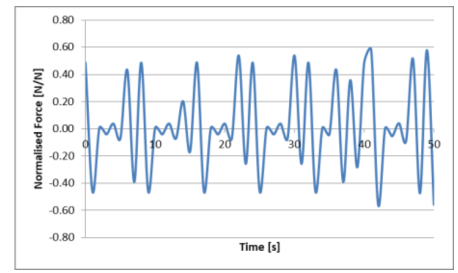




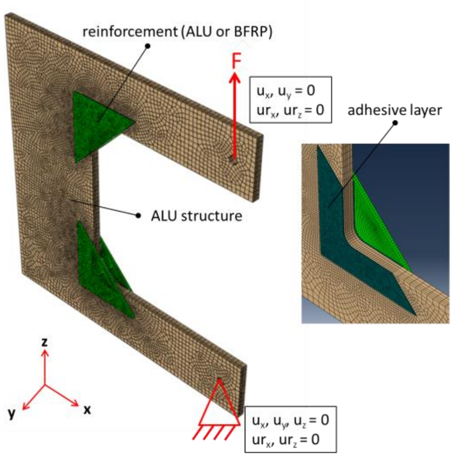
static & fatigue testing



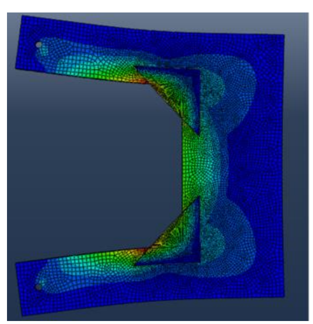
load cases - DIN EN 12663



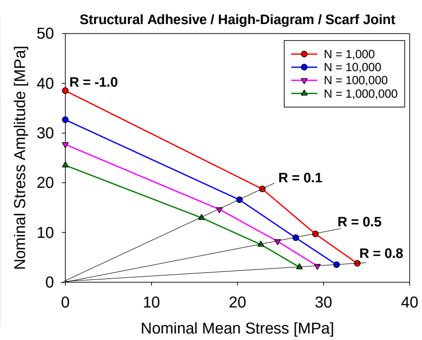
FEA Model



Development of numerical method based on damage

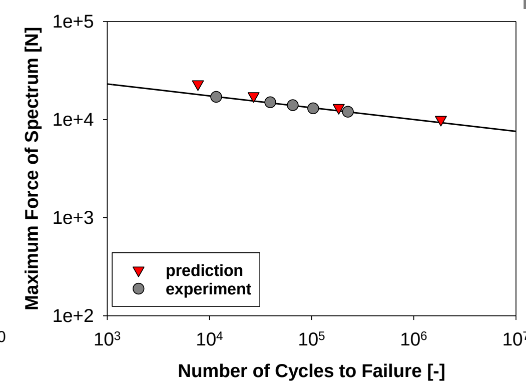


stress distribution



Haigh diagram

Accurate prediction

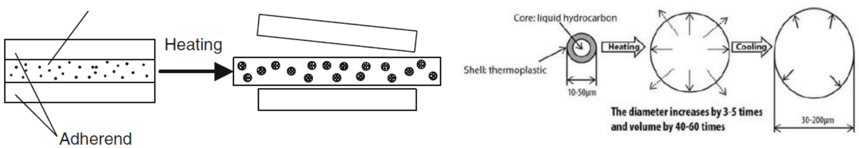


Main achievements of Mat4Rail WP3-4

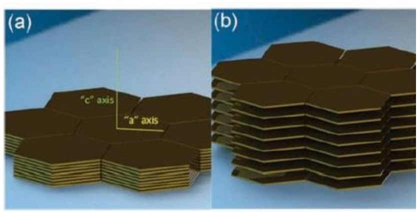
Joint concepts for refitting for dissimilar and/or polymeric materials

debonding on command

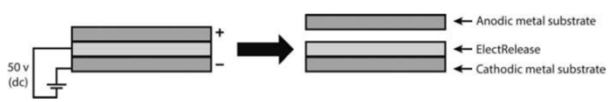
thermally expandable particles



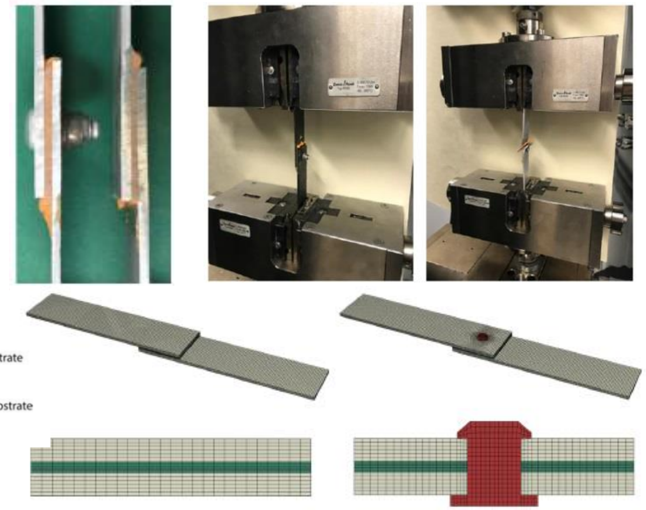
chemically reactive materials



eletrically reactive

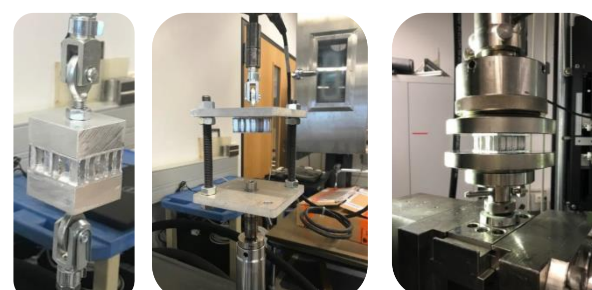


hybrid joints



rivet removal

sandwich structures/inserts



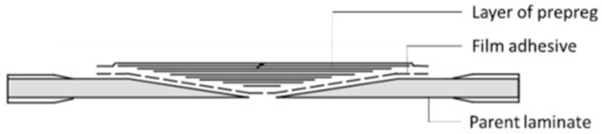
Images source: Handbook of Adhesion Technology, Springer,2011

Main achievements of Mat4Rail WP3-4

Compatibility of the developed composites with the type of maintenance and repair

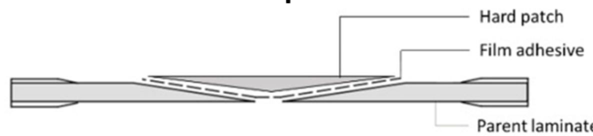
Repair execution: two main technologies analysed

Soft patch



Less complex and less expensive option

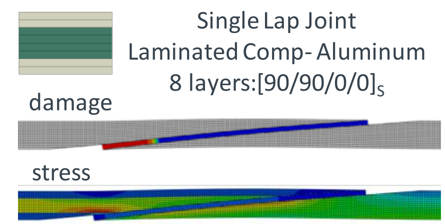
Hard patch



Approach preferred in aeronautics (higher level of quality control)

Repairs analysis/design

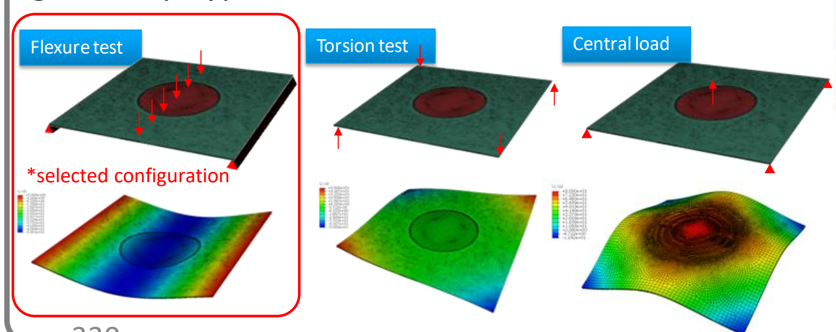
Study of different modelling strategies



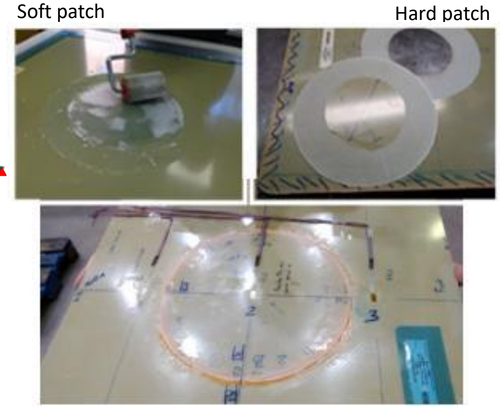
Evaluation through different repairs demonstrators

Demonstrators design

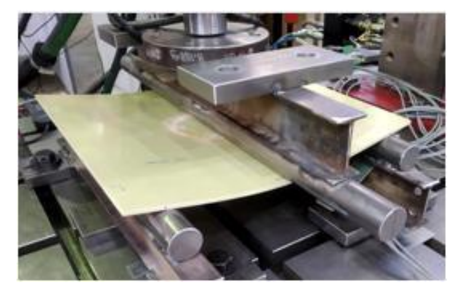
Parameters: thickness, overall dimensions, repair geometry, type of test....



Fabrication



Testing



Dissemination

Publications

(2019). Paving the way for a wider use of composites in railway industry. J. of Thermal Analysis and Calorimetry 1-12. doi: https://doi.org/10.1007/s10973-019-08286-6

Presentations

- March 2018, Fire protection of rolling stock FPRS 2018, Berlin, "Mat4Rail: Research on fire safe composite materials within the Shift2Rail programme"
- May 2018, Epoxy and Resins Technology Conference, Stockholm, "Towards a composite based carbody: Improving the FST properties of epoxy resins".
- June 2019, FPRM2019, Fire Retardant Polymeric Materials "Manufacturing of fiber reinforced polybenzoxazine with advanced fire, smoke and toxicity properties".
- July 2019, AB2019 Conference, 5th International Conference on Structural Adhesive Bonding, Porto, "Analysis of fracture toughness characterization for a structural high crash resistance adhesive".
- July 2019, MATCOMP 2019 XIII National Congress of Composite Materials, Galicia, Spain, "Study of the influence of flame-retardant additives on the mechanical properties of epoxy-fiberglass and basalt composites"
- September 2019, EUROMAT 2019, European Congress and Exhibition on Advanced Materials and Processes, "Composite materials for railways".

Outlook

- At the end of Shift2Rail, we will present the first designs of the demonstrators!
- First step for manufacturing and prove the concept in PIVOT-2
- Pave the way for testing on track. Methodology to set the State of the art and standardization

  (Design+Calculation+Manufacturing+Testing)
- Impact on railway sector: increasing capacity, improve passenger experience, reduce energy consumption…

Thank you for your kind attention

WP 4 Leader

Agenda for today

Time	Topic of discussion	Speaker
12:05 – 12:55	*TD1.5 – New braking system*	J. Brackovic (KB) A. Boggione (Faiveley) S. Ferrara (Faiveley)
12:55 – 14:10	*Lunch / poster / demo session*	
14:10 – 15:00	*TD1.6 – Innovative doors*	T. Montanié (Faiveley) J. Arrabal (ANN) U. Battista (STAM) P. Severin (Coexpair) J. M. Bielsa (ITA)
15:00 – 15:50	*TD1.3 – The new generation of car body shells*	E. de la Guerra (Talgo) J. Arrabal (ANN) A. Rekondo (CIDETEC) M. Brede (Fraunhofer-IFAM, UNI-HB) P. Blomqvist (RISE)
15:50 – 16:00	*Wrap-up / end of the meeting*	

General Discussion

Q&A

It was very nice to have you!

Joint Final Event

Projects coordinated by:

Mat4Rail by E. Jubete (CIDETEC)
RUN2Rail by M. Andreoni (UNIFE)
FAIR Stations by U. Battista (Stam)
PIVOT by P. Böttcher (BT)