Milan, 9th July 2024

GROUP 9

OLBIA - ABBASANTA TRAINLINE

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FLOW OF PRESENTATION

PART 1	INTRODUCTION
PART 2	ROUTE DEFINITION
PART 3	DYNAMIC ANALYSIS
PART 4	COMFORT AND VIBRATION
PART 5	ECONOMIC ANALYSIS
PART 6	CONCLUSIONS

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CASE STUDY

Millions of travellers enter in Sardinia, particularly during the summer season, registering a high travel demand.
The tourism data indicates a substantial influx of visitors, expecially along the east coast.

This influx makes it necessary to create an efficient transport system that can manage the movement of people and improve connections between places of interest.

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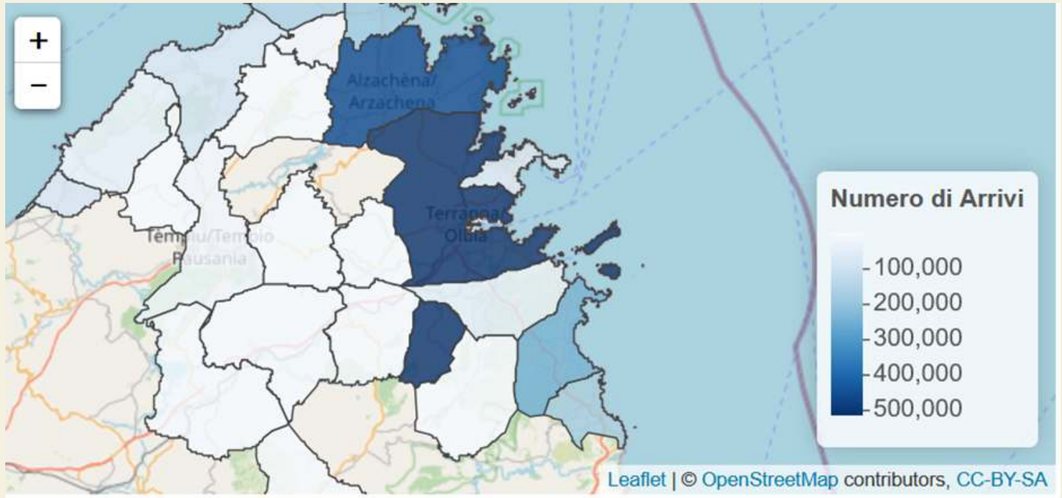
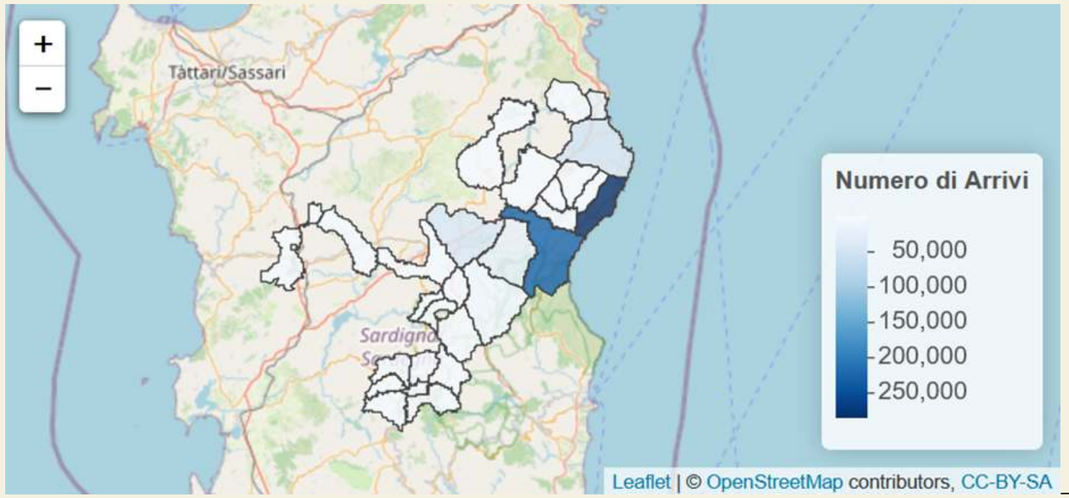
TOURIST FLOW

Province of Olbia



Province of Nuoro



[sardegnaturismo.it]

Both provinces register more arrivals in coastal regions, highlighting the importance of tourism in Sardinia.

Investments in infrastructure and services in these high arrival areas could enhance their attractiveness and receive an increasing number of tourists.

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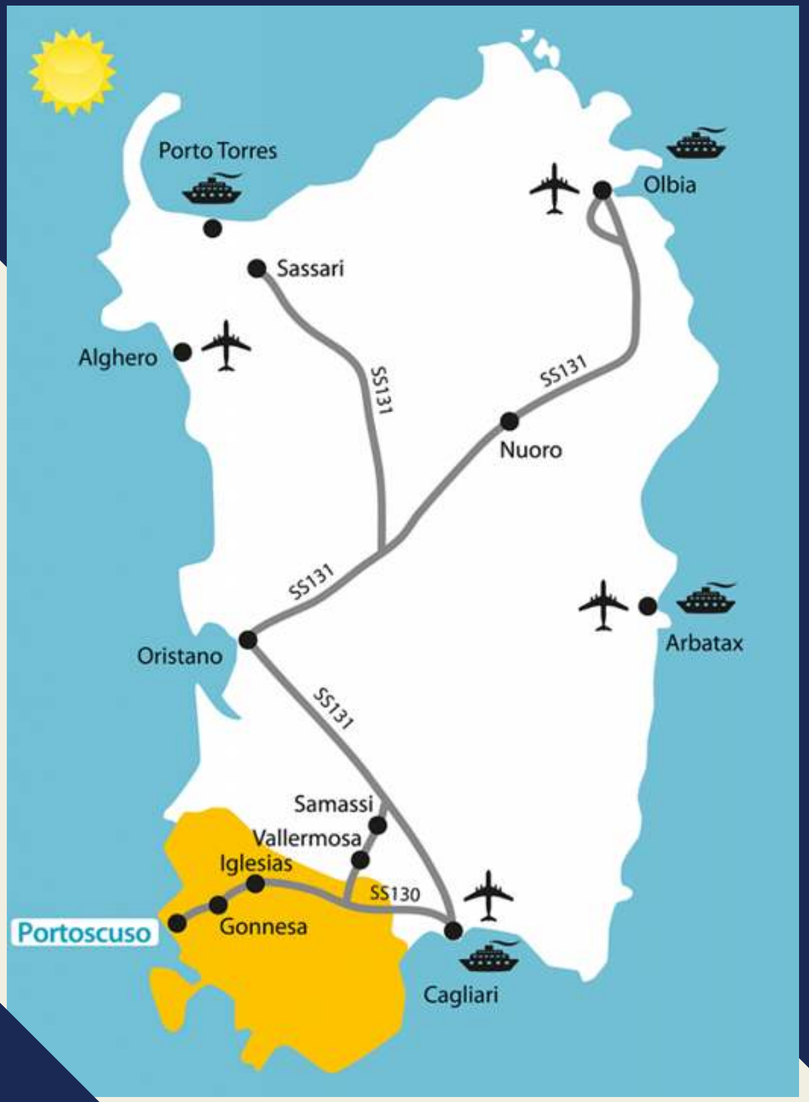
DIFFERENT WAYS OF MOVING

- Actually, the main way to visit places of interest and cross through the major cities is by bus (ARST) or private car.

- This causes traffic congestion on the roads and an increase in CO2 emissions, with consequent negative impacts on the environment.



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ISSUES WITH BUS SERVICE

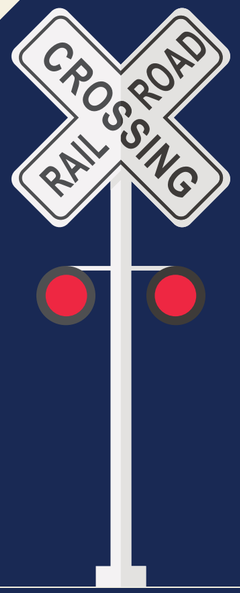
1. **Low Frequency and Long Travel Times**
   - Only six buses per day for the itinerary Nuoro-Olbia with a single ticket price of €8.10
   - Only two buses per day for the itinerary Nuoro-Cagliari with a single ticket price of €14
   - The low frequency makes the service non-competitive, increasing total travel times.

2. **Inadequacy of "ARST" and "Deplano" Lines**
   - ARST Lines (public) and Deplano (private): Low frequency, aging fleet, manual ticket validation and delays due to the inadequacy of motorway network too.

The absence of a train service between Olbia and Abbasanta highlights the urgent need for a more efficient and reliable transport solution.

ACTUAL RAILWAY SITUATION

- The current railway network is limited and not well equipped, with few connections between the main cities and tourist areas.
- Train frequency is low and some routes are not electrified, making the trips inefficient and very long, which negatively affects the region's economy and tourism.



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OUR PROPOSAL

- The project involves the creation of a new line connecting Olbia and Abbasanta, passing through Nuoro.

- This new infrastructure is aimed at significantly improve the connectivity and efficiency of public transport in the region.

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TRAIN STOPS

Olbia and Olbia Airport

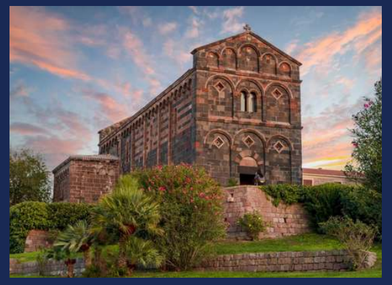
Porto San Paolo

San Teodoro

Budoni

Abbasanta

Ottana



Nuoro

Orosei

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Olbia Airport

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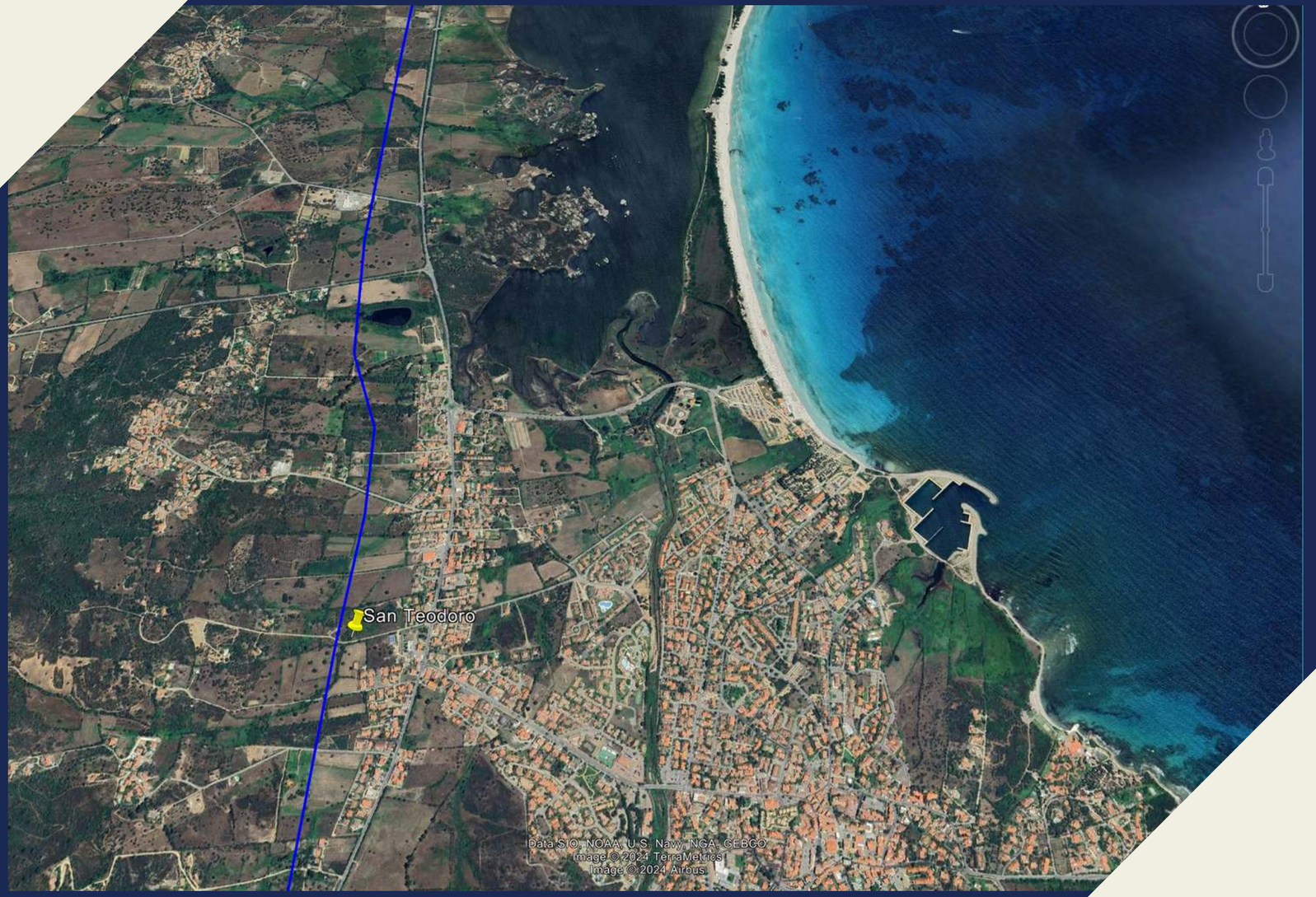
San Teodoro



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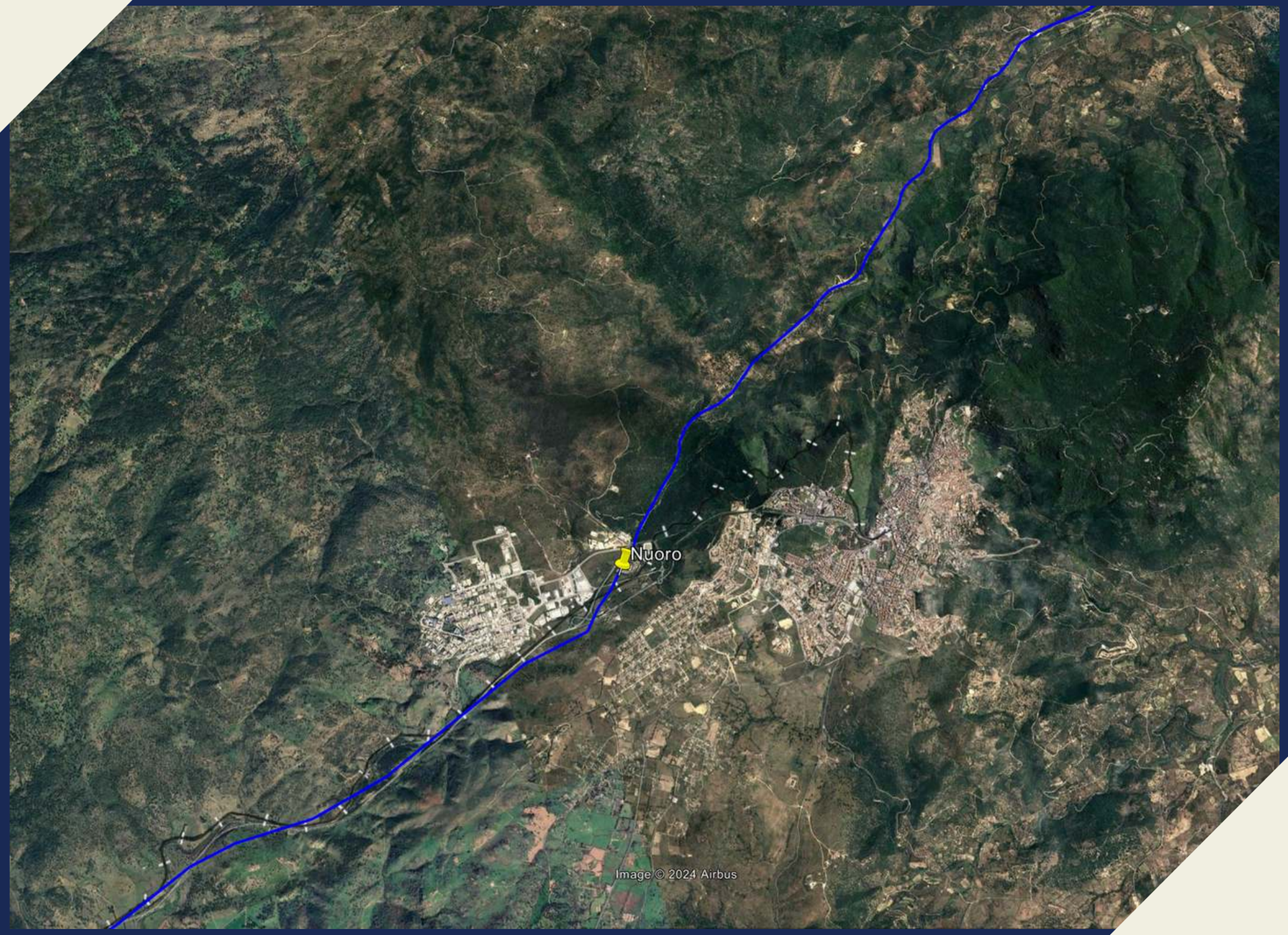
Nuoro FS



Abbasanta

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THE INFRASTRUCTURE

TRACKS

double track with catenary

POLYCENTRIC POINTS

Shopping and attractions for better traveler experience

INTERMODALITY

Enhanced connections with other transport system

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Abbasanta

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THE VEHICLE

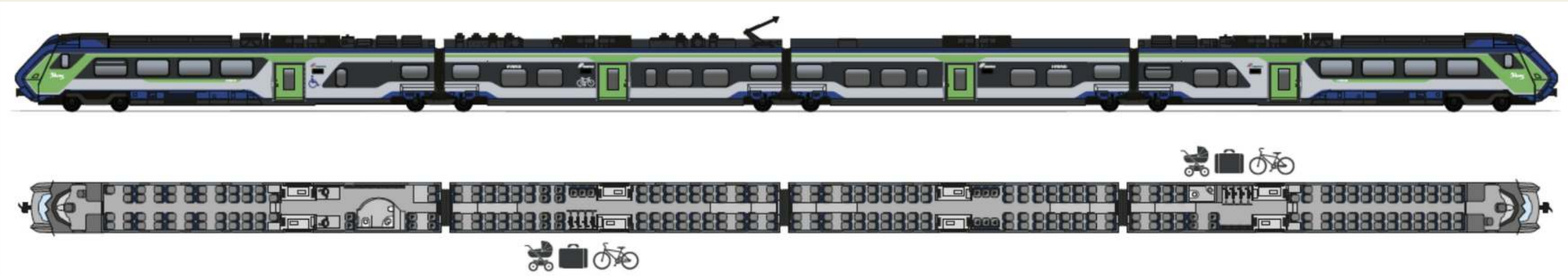
CONFIGURATION

1) Electric (EMU)
– Power supply from 3kV DC overhead line

2) 4 carriages

FEATURES

1) 300 seats
2) 8 bike spaces
3) PRM toilets



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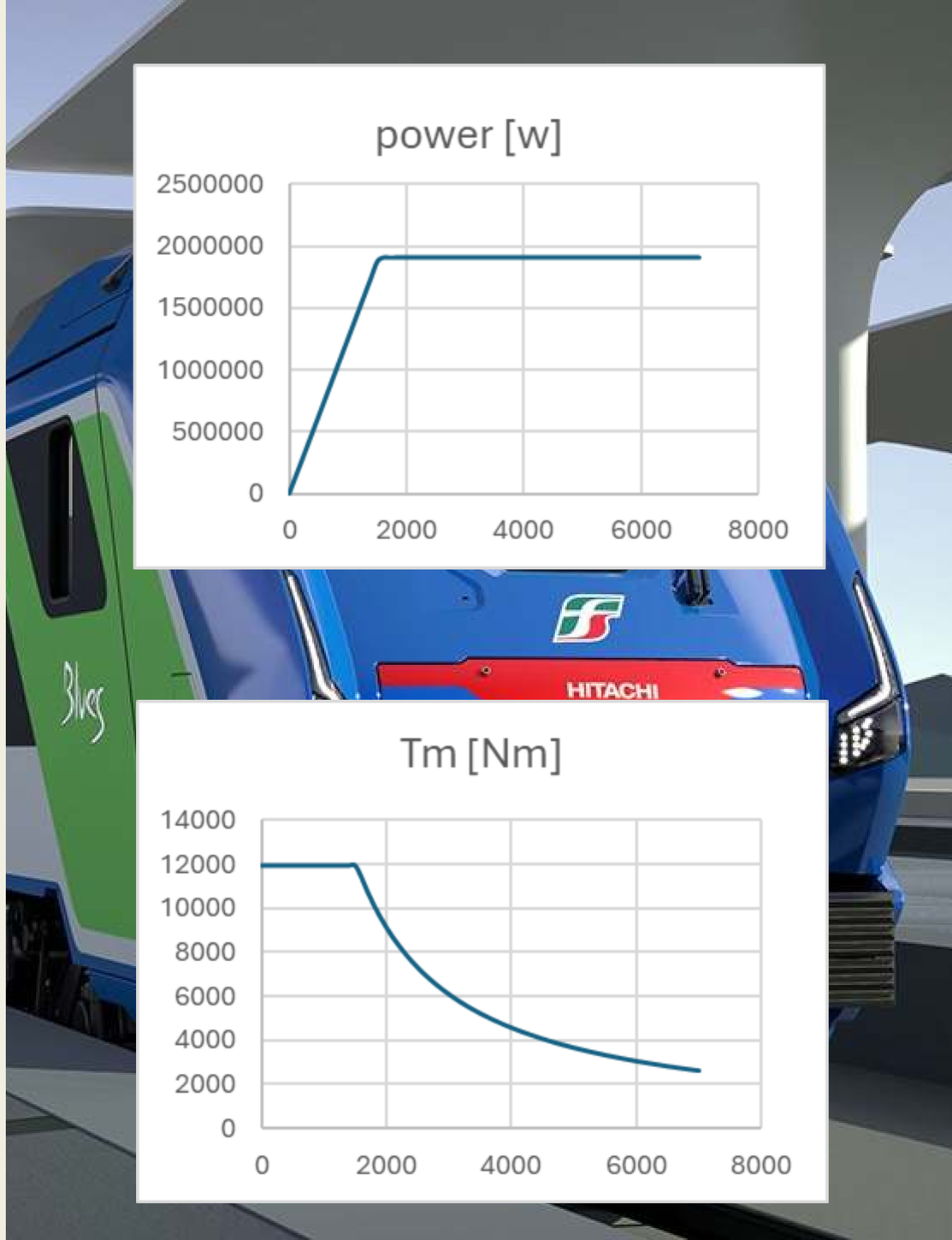
VEHICLE CHARACTERISTICS

4-car	EMU	DEMU
Length [mm]	86080	
Width [mm]	2800	
Seats	300	
Max power [kW]	1910	890
V max [km/h]	160	160
Acceleration [m/s^2]	1,08	0,78
max configuration	2 trainsets	



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DYNAMIC MODEL

POWER BALANCE AND KINETIC ENERGY THEOREM

- AVAILABLE TORQUE
- COMFORT LIMIT
- FRICTION LIMIT

3 BRAKE CONDITIONS:

- NO
- MOTOR BRAKING
- BRAKES

4 OPERATING MODES:

- ACCELERATING
- CONSTANT SPEED
- COASTING
- BRAKING

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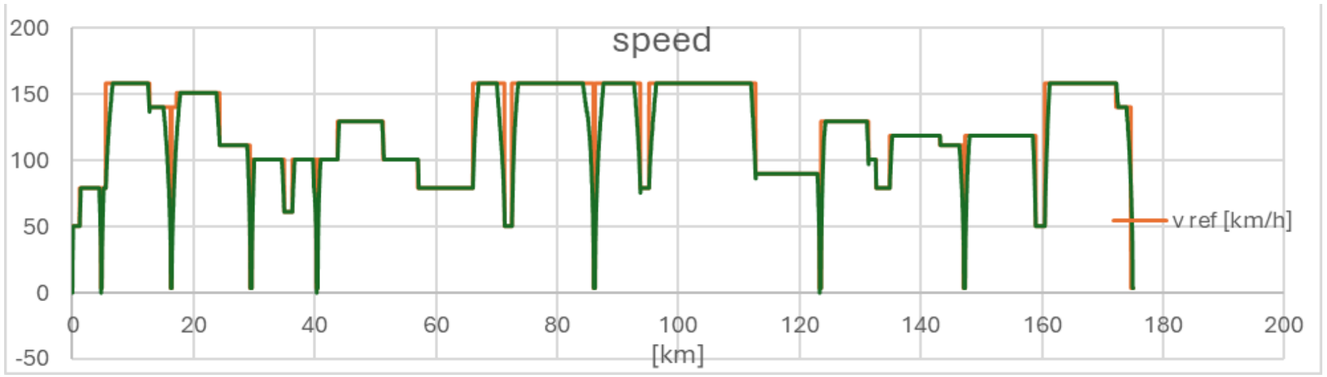
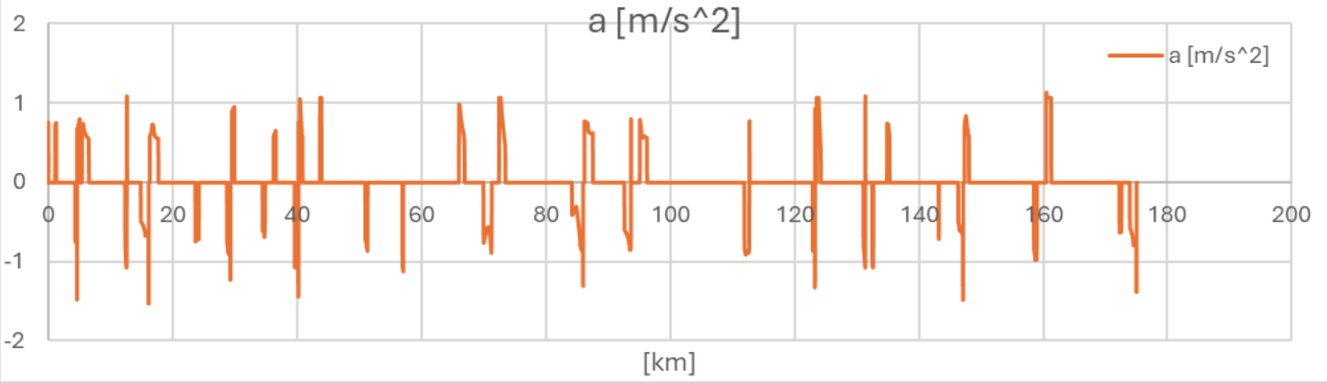
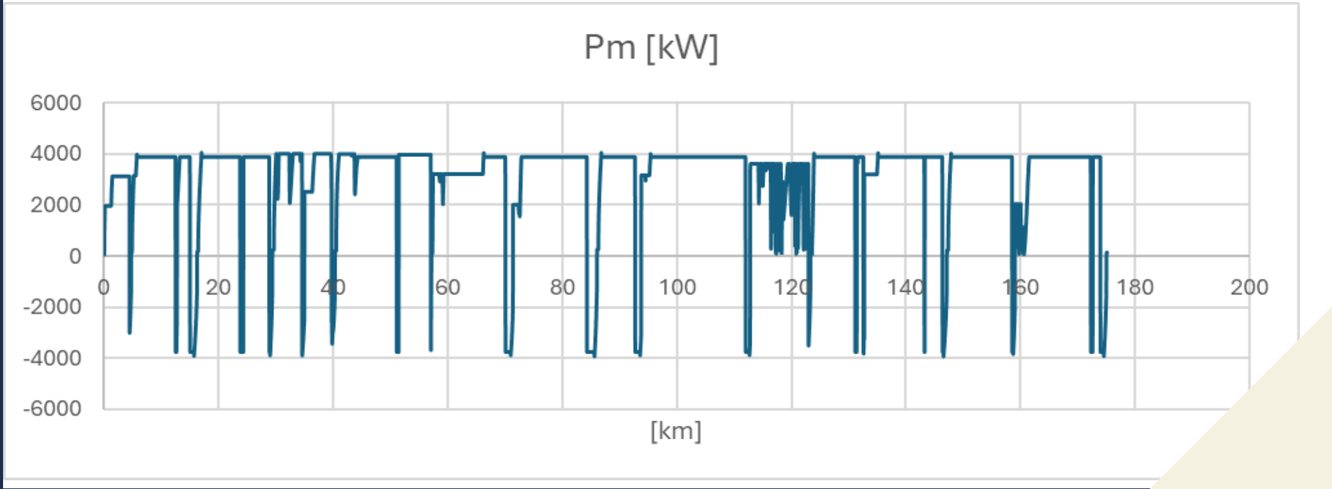
Chart Page

Model output







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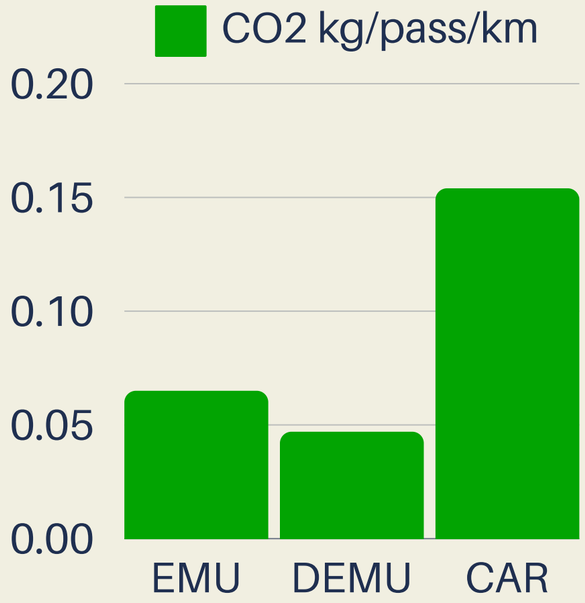
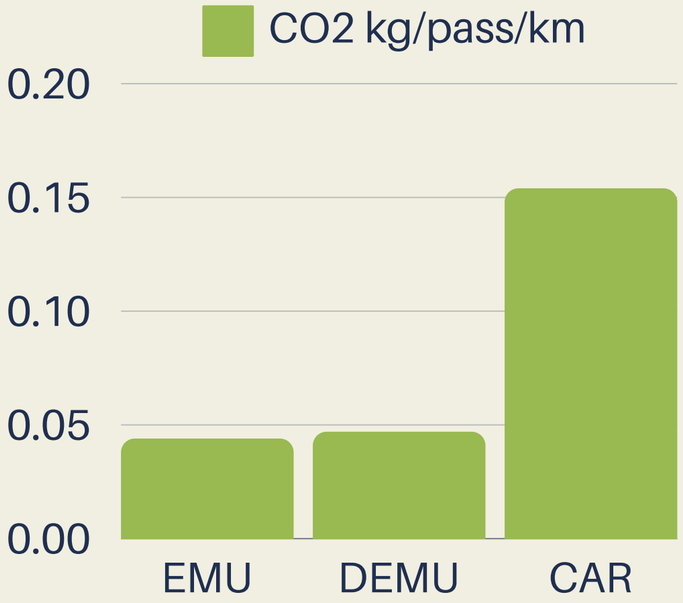
CO2 EMISSIONS

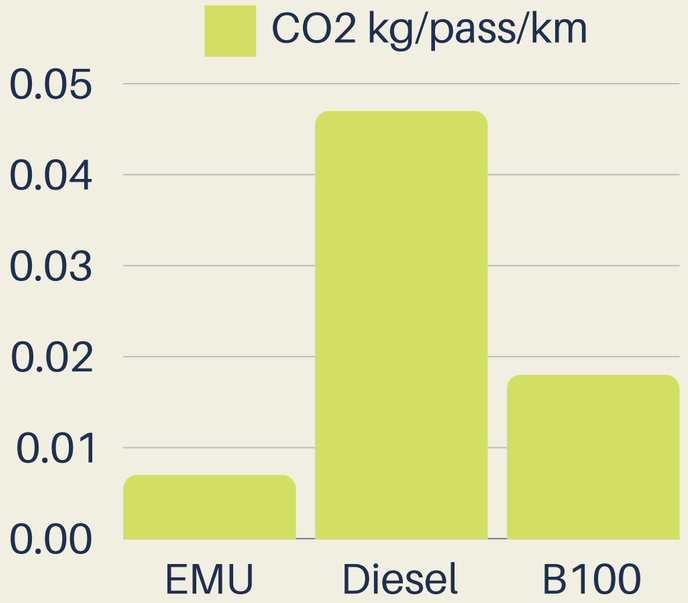
3 COMPARISONS



SARDINIAN ENERGY MIX



ITALIAN ENERGY MIX



FRENCH ENERGY MIX

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MAINTENANCE

ORDINARY MAINTENANCE

1) Routine, scheduled or unscheduled activities aimed at **replacing parts subject to wear** and tear.
2) Associated costs in the regular budget

EXTRAORDINARY MAINTENANCE

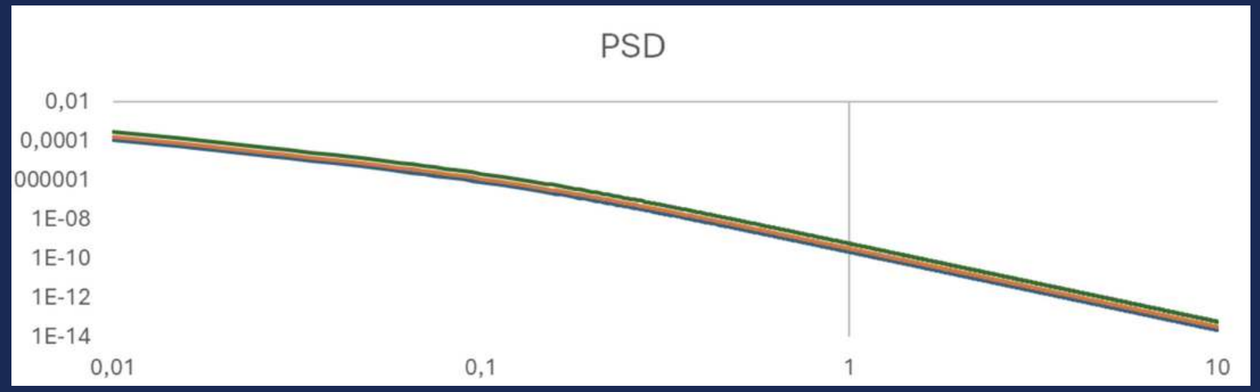
Involves major parts of the system, often for **improvements that enhance capital value**

MAINTENANCE IN SARDINIA

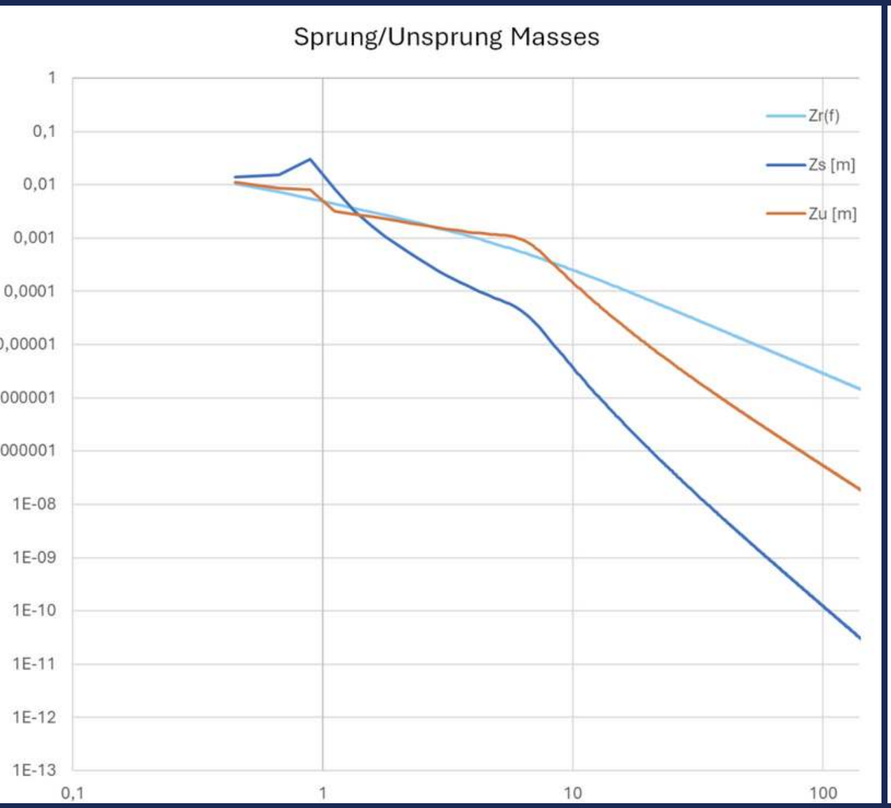
1) Railway routes are subject to **degradation** and require periodic interventions to ensure safety and operability.
2)**Trenitalia and the Sardinia Region are collaborating to improve** the conditions of railway infrastructure and increase the frequency and reliability of services.
3) **Electric solution decreases maintenance**

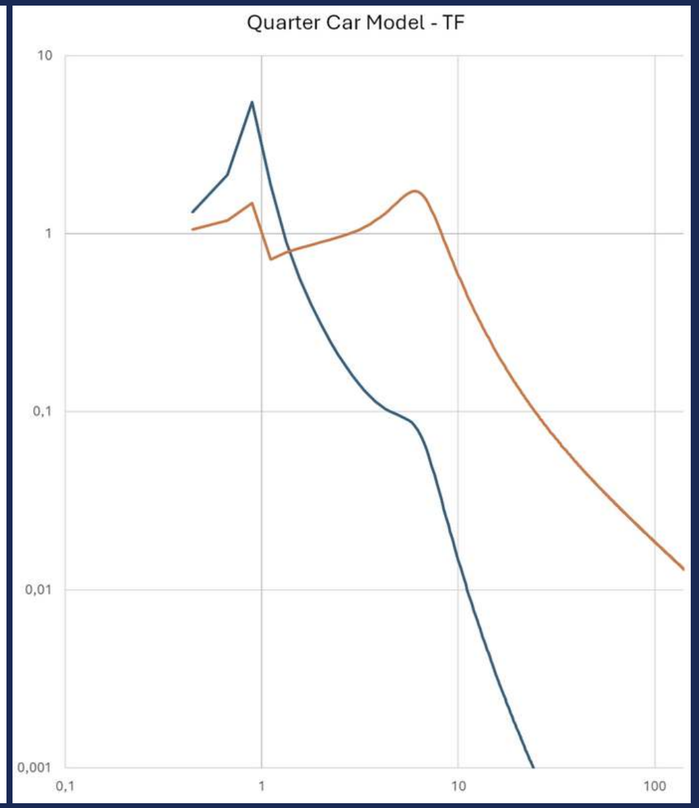
COMFORT

1 PSD



2 FRF of the quarter car model





Railway tracks are uneven due to manufacturing **imperfections and wear**, causing defects.

Suspension transfers vibrations to passengers.

Analytical models define Power Spectral Density of track irregularities, measuring power distribution across frequencies.

COMFORT

3. Third octave bands analysis and apply Wk

4. Estimate the total weighted rms acceleration

aw_rms	
small defect	0.4431
medium defect	0.5371
big defect	0.7252

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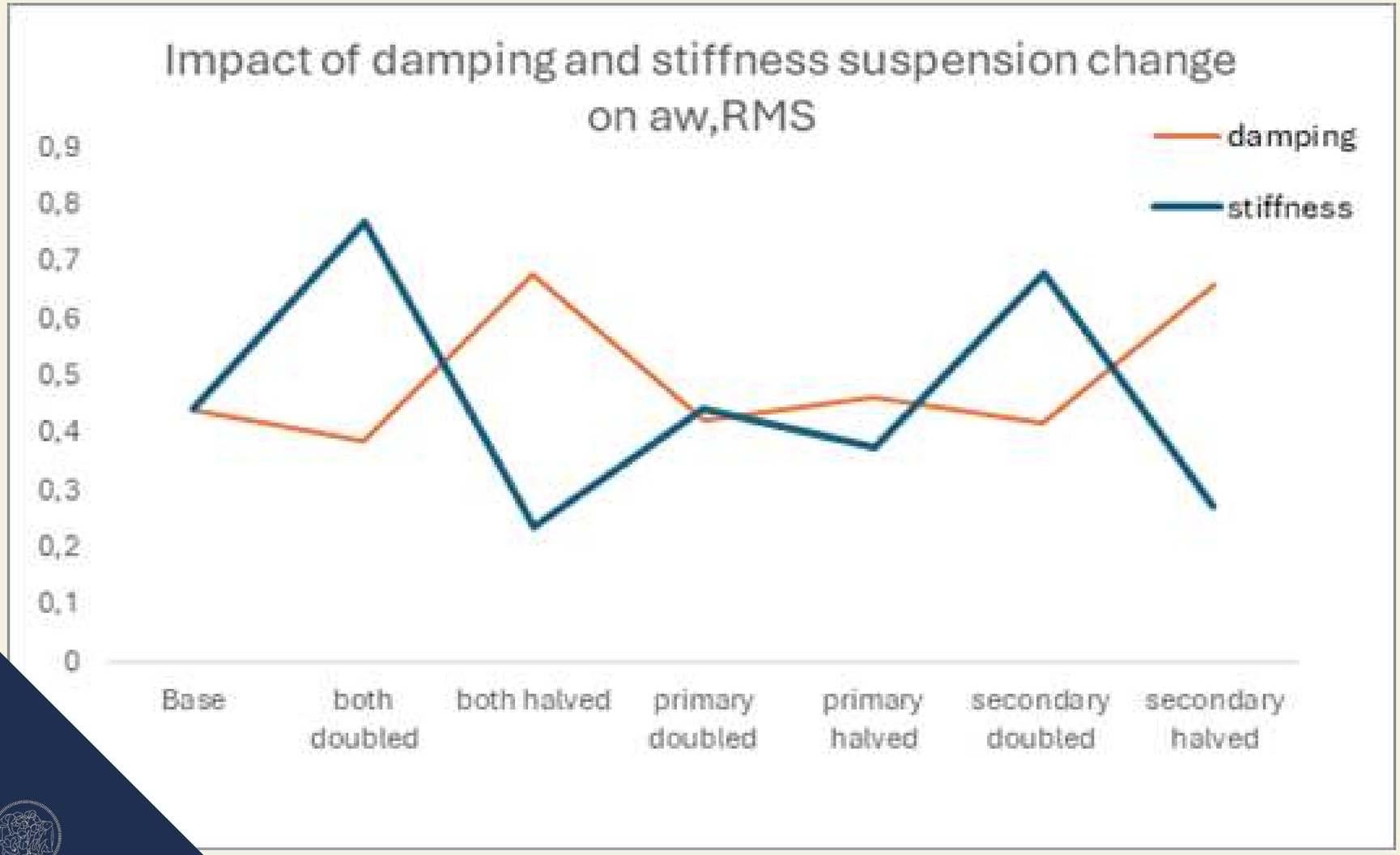
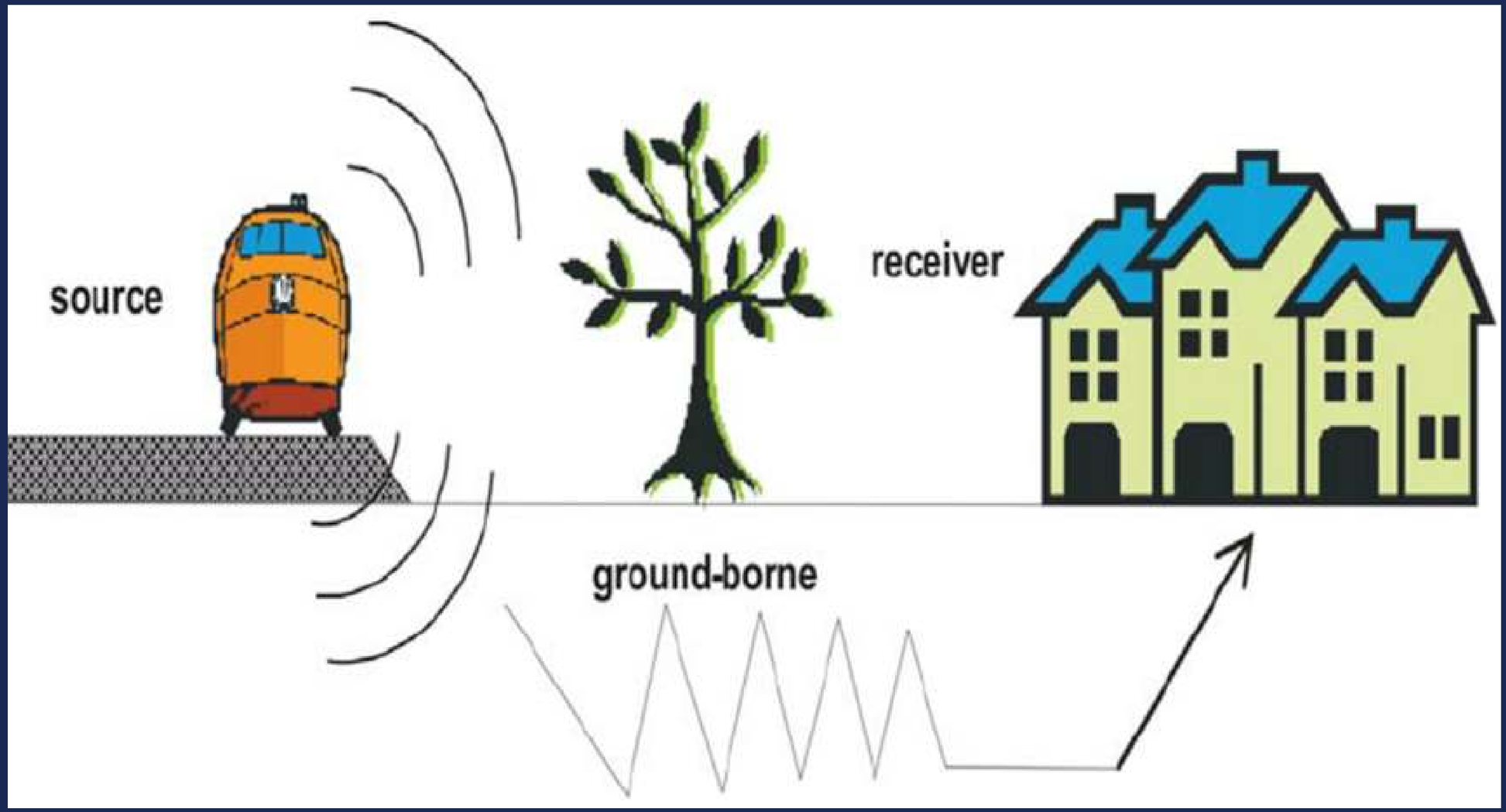
COMFORT
Sensitivity Analysis



- MORE SENSITIVE TO STIFFNESS ADJUSTMENTS COMPARED TO DAMPING ADJUSTMENTS

SECONDARY SUSPENSIONS HAS A MUCH GREATER EFFECT ON COMFORT THAN TUNING THE PRIMARY SUSPENSIONS

GROUND-BORNE VIBRATION



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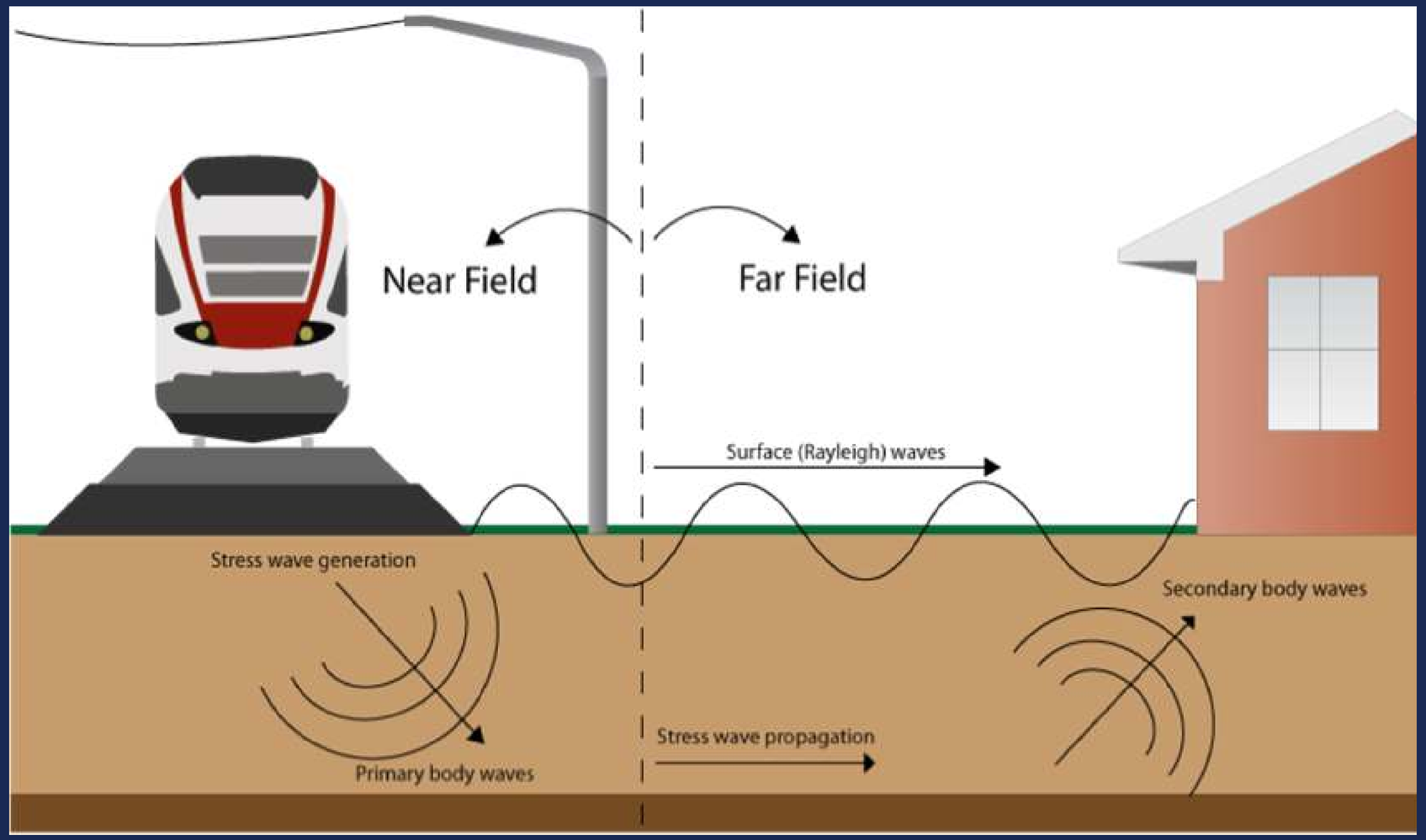
GROUND-BORNE VIBRATION



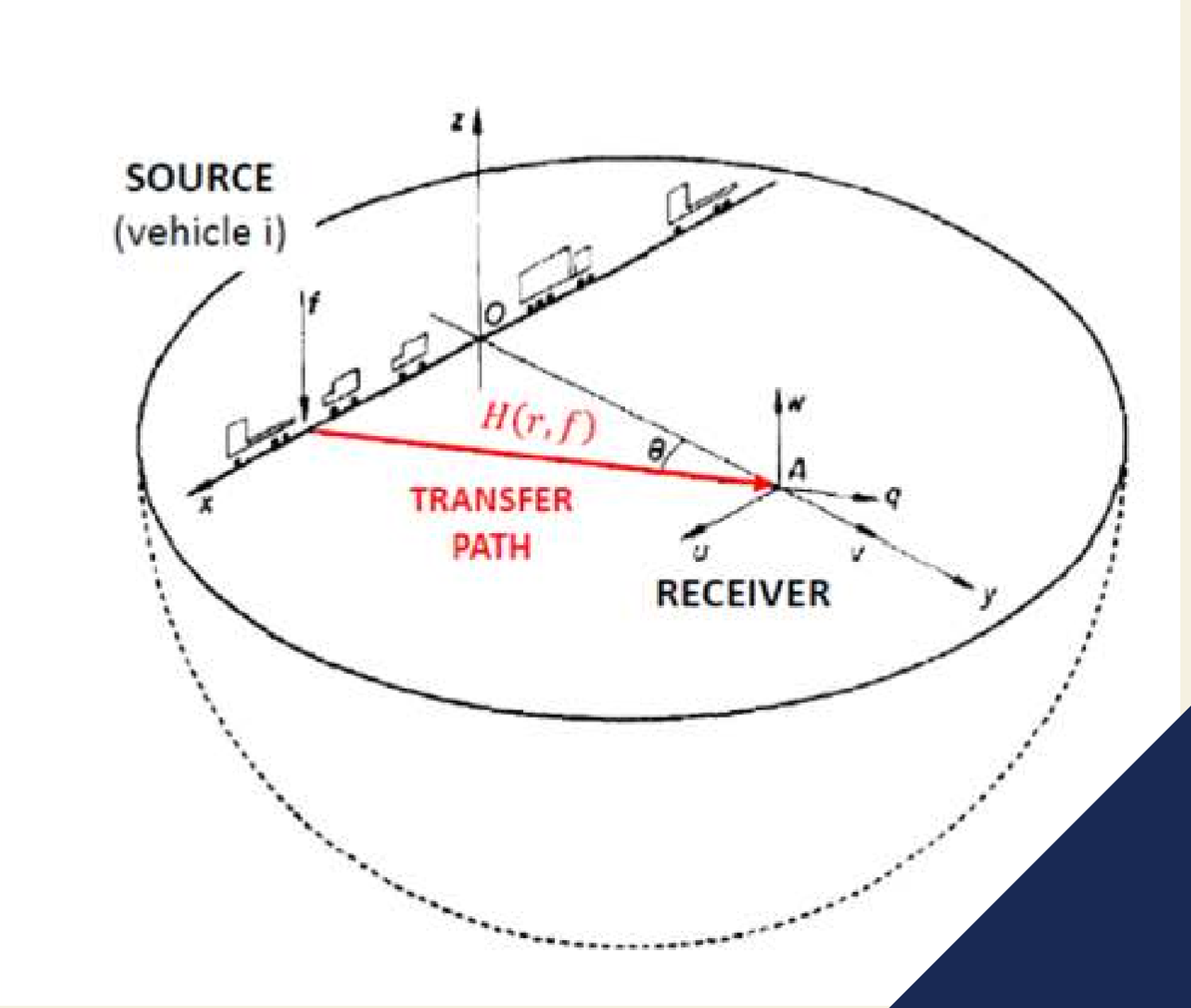
1. RAYLEIGH WAVES
2. FLOATING SLAB TRACK
3. TIMOSHENKO DOUBLE LAYER MODEL
4. F-SOIL CALCULATION
5. USE HUNT MODEL

HUNT MODEL

1. Assessing the cumulative impact of the train's wheelsets on the surrounding environment.

2. Turn power spectrum (displacement) of the receiver into the power spectrum of acceleration.

3. Applying a Ponderation Filter, and computing the weighted RMS acceleration.



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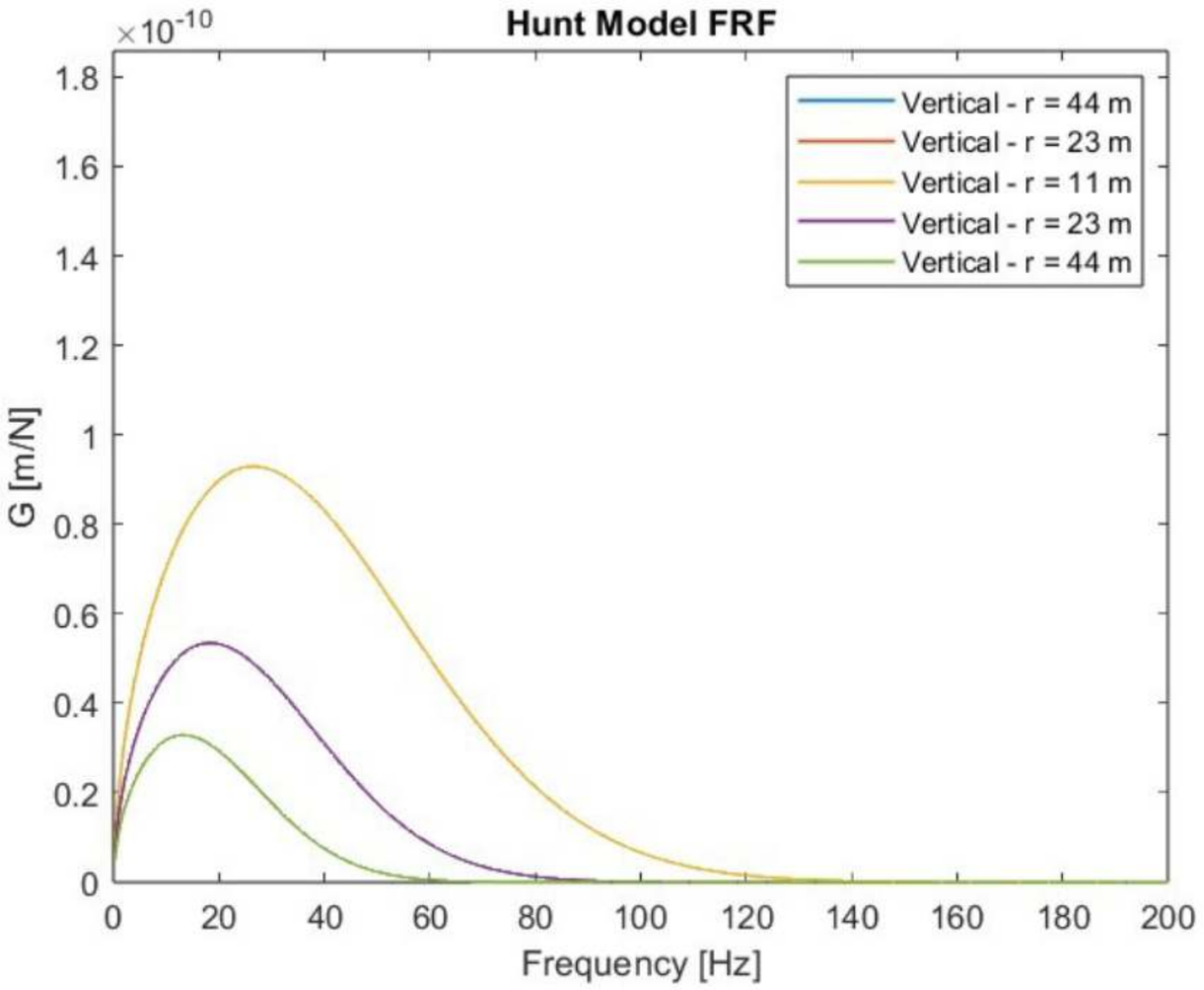
RESULTS



$$a_{W,RMS} = 0.1357 \text{ [m/s^2]}$$

Area Type	Acceleration a [m/s²]
Critical areas	$5*10^{-3}$
Residential areas (night)	$7*10^{-3}$
Residential areas (day)	$10*10^{-3}$
Office	$20*10^{-3}$
Factories	$40*10^{-3}$

Mitigation solution needed

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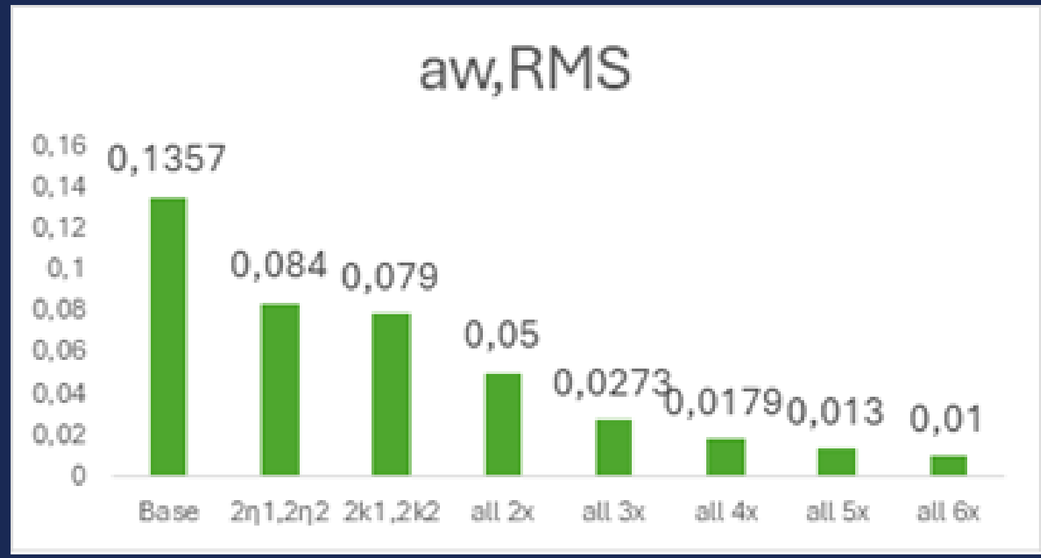
Ground-borne Sensitivity Analysis



The effect of distance is much more powerful in comparison to speed and rail pad, slab stiffness, rail pad loss factor, and slab support loss factor.

MITIGATION SOLUTION

COMFORT

- Reduce the secondary suspension stiffness by 30 percent

GROUND BORNE

- Improve infrastructure by enhancing the constituent materials 3 times:
  - k1 = rail-pad stiffness [N/m2]
  - k2 = ballast stiffness [N/m2]
  - η1 = rail-pad loss factor (structural damping)
  - η2 = ballast loss factor (structural damping)
- Additionally, it is proposed to impose a speed limit of 40 km/h.

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SIGNALLING

CURRENT SIGNALLING IN SARDINIA

Traditional Block Signaling

PROPOSED SIGNALLING

Sistema di Controllo della Marcia del Treno (SCMT) and the European Rail Traffic Management System (ERTMS)

ADVANTAGES

- Continuous speed monitoring and automatic braking interventions
- Sustainable Development
- Seek EU funding

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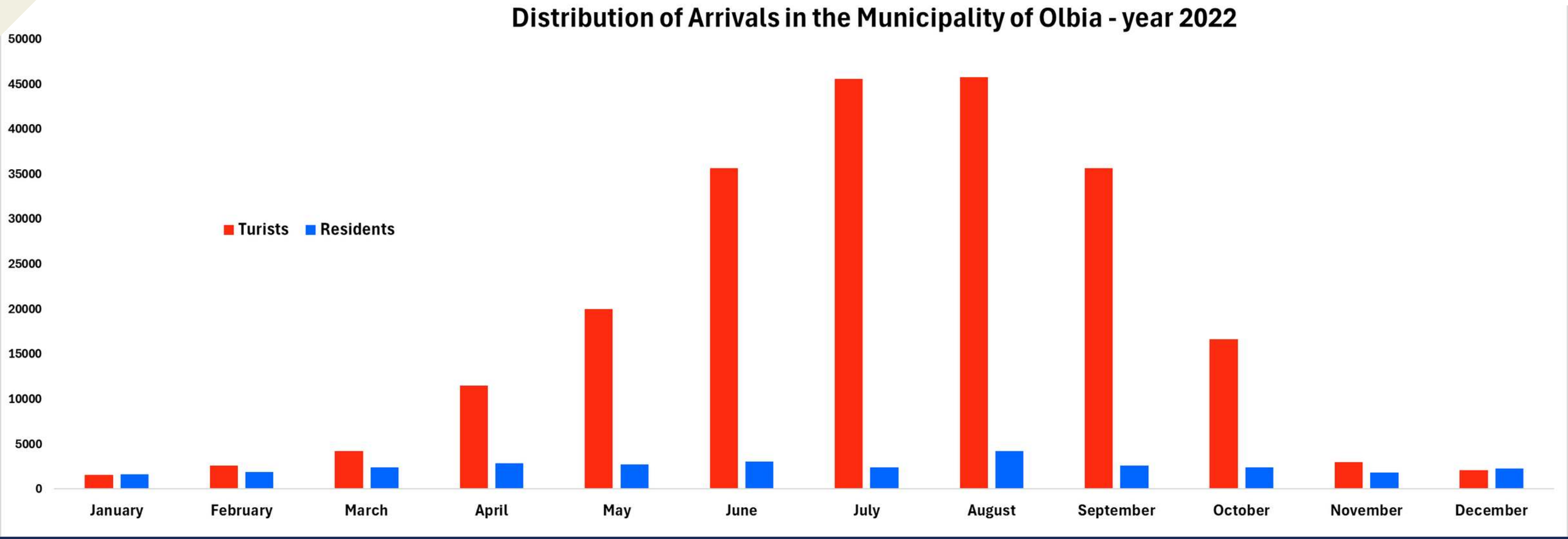
ECONOMIC ANALYSIS

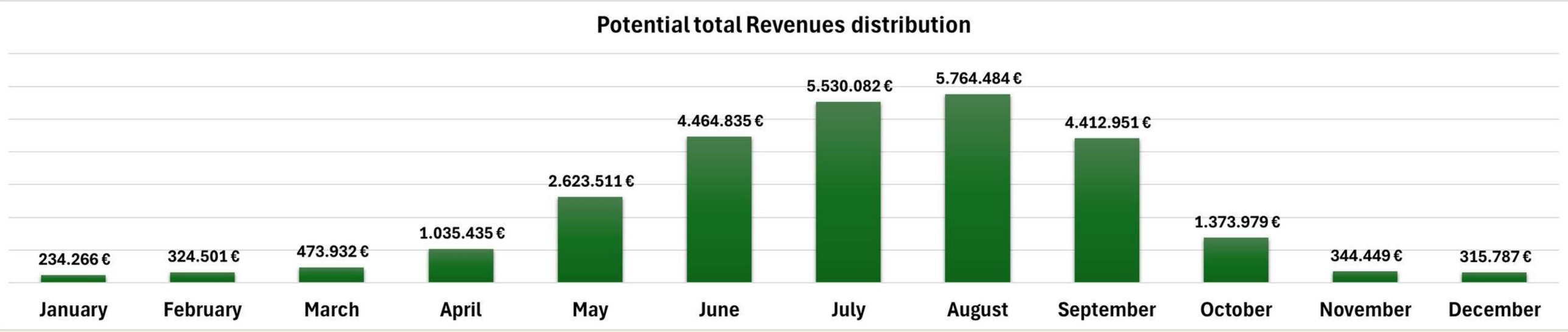
- Demand Analysis

% Fares	Single ticket	Daily ticket	Weekly ticket	Monthly ticket	Annual ticket
LOW Demand	0,2	0,15	0,05	0,2	0,4
HIGH Demand	0,4	0,2	0,25	0,1	0,05



FARE REVENUES:

- The maximum train seating capacity is 300.
- Occupied seats are weighted based on monthly arrival data for Sardinia.
- During peak periods, trains are assumed to be fully occupied, while off-peak periods have reduced load factors.
- Average capacity is calculated by multiplying the load factor by the maximum seats.
- Ticket fares are calculated from terminal to terminal, using official Trenitalia fare tables.
  A weighted approach is used for ticket types, considering single tickets, daily tickets and subscriptions.



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BOTH OPERATIONAL (OPEX) AND CAPITAL EXPENDITURES (CAPEX) ARE TAKEN INTO ACCOUNT TO PROVIDE A COMPREHENSIVE OVERVIEW

- The operating costs include personnel, energy consumption, maintenance, administration, and vehicle depreciation.
- 59 journeys per day, totaling 21,535 journeys per year.
- Total OPEX amounts to **€21,788,564** annually.

one-way ride

Cost item	*Units*	*Value*	*Unitary cost*	*Cost*
Train Driver	2	1,95 h	17 €/h	66 €
Station Staff	5	1,95 h	12 €/h	117 €
Energy Cost	4,69 MWh		0,075 €/kWh	352 €
Maintenance	1	1,95 h	14 €/h	27 €
Overheads				210 €
Administrative costs				70 €
Other				30 €
Amortization				139 €
			Total	**1.012 €**

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CAPEX estimates cover construction, stations, electrification, signaling, and vehicle purchases.

Major cost components:

- Double-track rail: €263mln
- Viaducts: €500mln
- Tunnels: €315mln
- New stations: €69mln
- Renewal of stations and depots: €100mln
- ERTMS equipment*: €154mln
- Electrification & TPSSs: €155mln
- 10 Vehicles: €61mln
- Total extimated **CAPEX** is **€1.6mld**

*that include Track side implementation, ETCS onboard equipment, integration and testing

CONCLUSIONS

SOCIAL IMPACT

- Enhanced access and integration with public transport.
- Benefits for local residents, commuters, and tourists.
- Improved connectivity for isolated regions.
- Facilitation of regular commuting and tourism.

ECONOMIC BENEFITS

- Revenue could covers operating costs.
- Significant public service benefit.
- Improvement in quality of life.
- Easing of traffic on main roads.
- Enhanced regional attractiveness

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TECH ADVANTAGES

- Improved maintenance and operations efficiency.
- Advanced signaling and control systems.
- Predictive and condition-based maintenance.
- Enhanced safety and reliability of service.

ENVIRONMENTAL IMPACT

- Reduction in greenhouse gas emissions per passenger-kilometer.
- Electrification promotes renewable energy use.
- Energy storage systems to manage production and demand peaks.
- Decrease in reliance on fossil fuels.

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Thank you for your attention

Q&A