FINE1

Reduction of **ENERGY CONSUMPTION** and **NOISE EXPOSURE** from the railways

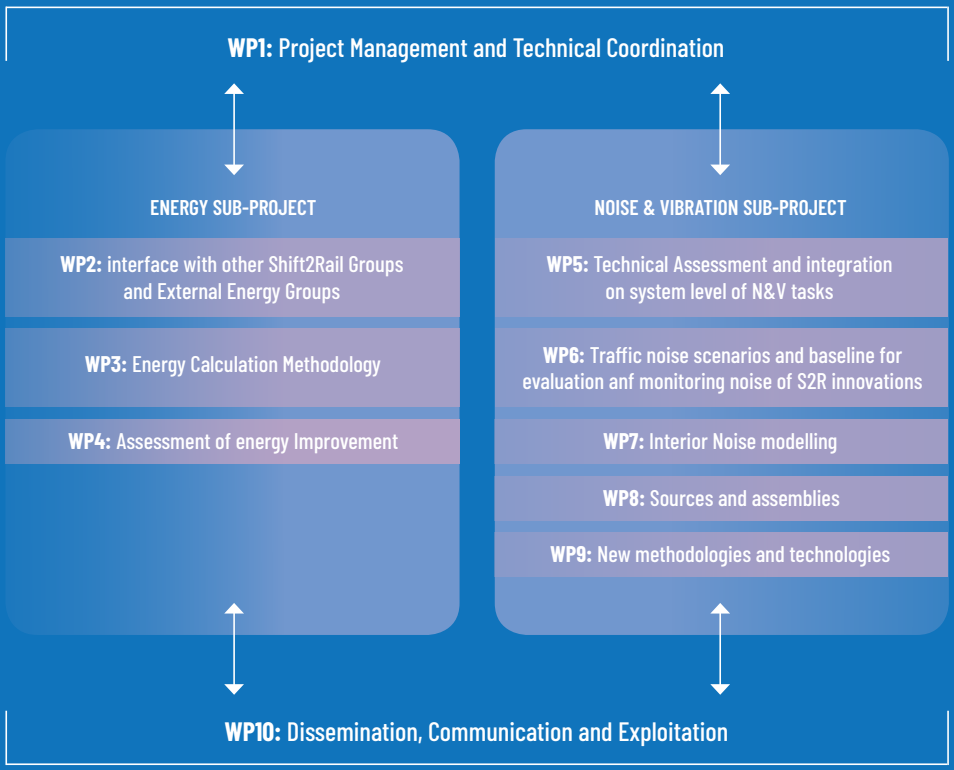
Introduction

The aim of the FINE 1 project is to support and provide leverage of the development of technologies in Shift2Rail for reduction of energy consumption and noise exposure from the railways. This will enable an increase in traffic and enhance the attractiveness of railway in relation to other modes of transport.

The FINE 1 project is interacting with the Shift2Rail Technology Demonstrators by providing a system and platform level analysis to optimise the final result of Shift2Rail from a noise and energy perspective. Parameters such as energy consumption and noise levels have a direct influence on the development of the new Shift2Rail Technology Demonstrators.

Moreover, in the Noise sub-project of FINE 1 prediction tools and characterisation methods are improved to facilitate and support this technology development and to form a basis for standardised specifications of noise sources and transmission elements.

The Energy sub-project of FINE 1 provides a transparent and harmonised process for the evaluation of energy demand of rolling stock by means of energy KPIs.



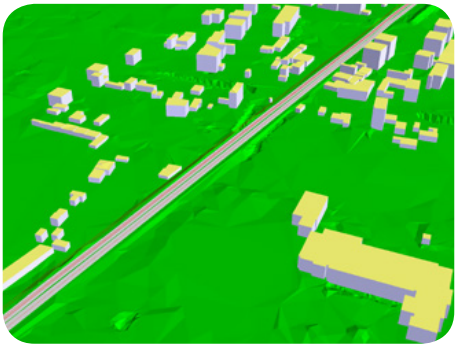
1 Key Results for Noise Sub-Project

Work Package 5 – Technical Assessment and integration on system level of N&V tasks

- The purpose of this work package is to identify all acoustically relevant components included in the technology development of Shift2Rail and set targets.
- Acoustic performance of existing rolling stock and infrastructure for a number of selected train/track combinations have been defined.
- Acoustics-related work in the Shift2Rail Technology Demonstrators have been identified.
- Baseline performance and indicative future targets have been set on a system level, including both vehicle and infrastructure, and for some cases apportioned to the sub-systems e.g. a motor or a floor construction.
- At the end of Shift2Rail the noise reductions will be assessed and used in calculations to quantify the effect in future traffic scenarios.

Work Package 6 – Traffic noise scenarios and baseline for evaluation and monitoring noise effects of Shift2Rail Innovations

- The objective is to monitor and evaluate the activities of Shift2Rail as a whole with respect to their noise relevance and to demonstrate their impact on residential areas adjacent to railways.
- A 3D-calculation model has been applied to estimate exterior noise emissions for pass-by and stand-still/ parking-noise. The 3D model is suitable to demonstrate the influence of the terrain, the different traffic scenarios and different noise mitigation measures. A good balance between feasibility and realism is important.
- Example of calculations for pass-by and parking/ stand-still noise have been made including a base line case. Noise maps have been produced to visualize the effects.
- In the last step, a procedure for a cost-benefit analysis has been detailed for pass-by noise. Hence an initial assessment of the cost-effectiveness of mitigation proposals in comparison to the state-of-the-art measures could be undertaken, in addition to comparing the acoustic relevance of the measures. This procedure will be used at the end of Shift2Rail to optimize proposed noise mitigation actions including new technologies.



▲ **Figure 1** — Digital terrain model with double track railway and buildings (for pass-by-noise calculations)

Work Package 7 - Interior Noise Modelling

- The objective of this work package is to develop methodologies for efficient and accurate predictions of interior noise in railway vehicles.

- A generic framework for interior noise predictions in an industrial context has been elaborated to find a harmonised basis for the definition and validation of the inherent acoustic processes. It consists of two branches representing the airborne noise and structure-borne noise contributions to the interior noise.

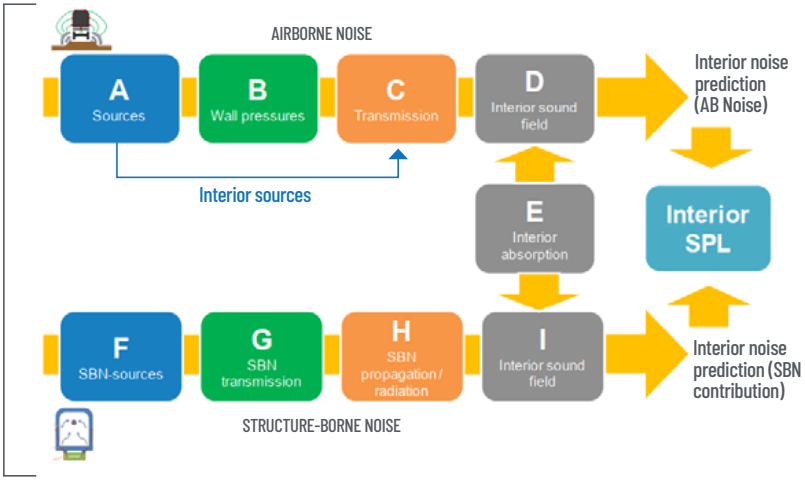
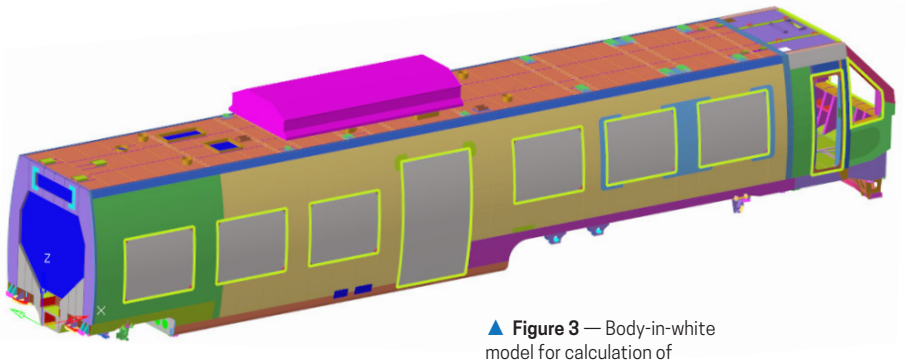


Figure 2 ▶ Generic framework for interior noise predictions

- Approaches and methods for calculation of the pressure field around the carbody have been developed and experimentally validated.

- New methods for prediction of structure-borne noise contribution to the overall interior noise of a railway vehicle were applied and optimised.



▲ **Figure 3** — Body-in-white model for calculation of structure-borne noise contribution

Work Package 8 – Sources and Assemblies

- The objective is to develop characterisation and specification methodologies for acoustically relevant sources and train assemblies. Using these methodologies will help to improve the accuracy of acoustic prediction models developed in Shift2Rail and provide standardized models to improve its deployment.

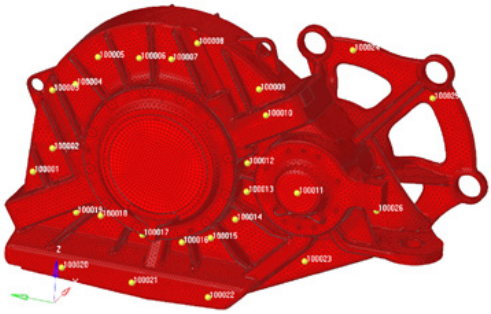
- Activities performed to apply and validate proposal of improvements are summarized in the table below:

TYPE OF SOURCE	TYPE OF CHARACTERISATION	TYPE OF METHOD
Air compressor	Structure borne	Test
HVAC	Structure borne	Test
Elect. Traction Motor	Structure borne	Test
Train assemblies	Airborne	Test
Bogie	Rolling Structure Borne	Numerical
Track	Rolling Airborne	Numerical
Gearbox	Airborne	Hybrid

- For structure borne noise, a great effort has been made on the improvement of test methodologies mainly because there is no ISO standard available yet.

- For airborne interior noise, numerical method has been developed for track characterisation at low frequencies.

- A new method for air-borne sound source characterization based on vibration measurements - with as few vibration sensors as necessary- is developed, tested with a computer simulation, verified and validated for a railway gear unit.



▲ **Figure 4** — Model for characterisation of an air-borne sound source

2 Key Results for Energy Sub-Project

The major objective of reducing energy consumption and CO2-impact can be successfully evaluated by using energy KPIs.

The energy KPI (key performance indicators) is an appropriate key reference for benchmarking the impact of future technologies on their energy saving potential. Therefore, they are calculated and simulated within the FINE1 project, which provides a reference method for energy saving quantification. An energy simulation tool developed by the complementary Shift2Rail project OPEUS has been used. The tool allows maximum comparability between the considered technologies. The results of the comparisons show an energy KPI increase or decrease. It represents the difference between the calculated values based on a defined representative baseline scenario and simulated values of new technological solutions. Equal service profiles and ambient conditions are considered during the simulation to assure accurate values.

With respect to energy demand, four KPIs are defined, which can be used as a reference for freight and passenger trains.

The KPIs are:

1 – Energy usage per train-kilometer [Wh/km] (for freight and passenger trains)

2 – Energy usage per passenger-kilometer [Wh/p.km] (for passenger trains)

3 – Energy usage per seat-kilometer [Wh/s.km] (for passenger trains)

4 – Energy usage per ton-kilometer [Wh/t.km] (for freight trains)

The improved energy KPIs calculated within FINE1 are based on the gathered data reported by the TDs (Technology Demonstrator). The achieved KPI-impact depends on the traffic segments / SPDs (System Platform Demonstrators), see figure 5.

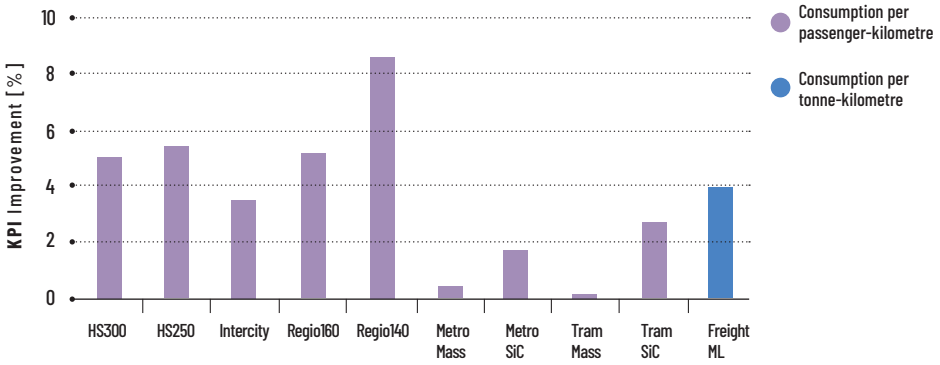
Some examples of considered technologies are:

- **Mass reduction** of 15-30% on component (system) level by using lighter materials (carbody shell, doors and braking systems).
- **PM synchronous motor/ independently rotating motor-wheel-system (IRMW)** based on permanent magnet technology increasing operational speed and service reliability. The IRMW allows the omitting of the gearbox between motor and wheel.
- **Independent wheel running gears (IWRG)** have a higher overall efficiency and lower friction losses in the traction chain.
- **SiC- semiconductors** used in Line Converters and Motor Converters allow passive cooling. Due to increased converter switching frequency transformer and motor losses are reduced as well.
- **Smart Power Supply** is an infrastructure improvement that allows the double side feeding of the vehicles and eliminates neutral sections of 50Hz power supply systems.

Improvements mentioned in energy demand and KPI are presented for driving style "timetable with coasting".

Figure 5 visualises the effects on the KPIs by the used combination of technologies for each System Platform Demonstrator (SPD). Combinations are considered where the technologies can interfere with each other in a positive or a negative way. The overall KPIs are mainly influenced by mass reductions and improved line and motor converters (SiC).

Figure 5
Energy KPI per SPD



In summary, several KPIs have been considerably improved and in addition there is still a high potential for further improvement, with new technologies that will be considered in the coming parts of the Shift2Rail project.

FACTS AND FIGURES

Total Budget
3M

9 Partners

Start Date
01/09 2016

Duration
38 Months

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SWEDISH TRANSPORT ADMINISTRATION

Shift2Rail

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No: 730818