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Description of the vibration prediction tool

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¹ PU: Public; CO: Confidential, only for members of the consortium (including Commission Services)

² https://projects.shift2rail.org/s2r_matrixtd.aspx







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Executive Summary

This report presents Deliverable D1.2 "Description of the vibration prediction tool" of the Collaborative Project SILVARSTAR that is funded under the European Union's Horizon 2020 Research and Innovation Program under the open call as part of the Cross Cutting Activities of the Shift2Rail Joint Undertaking.

The work on ground vibration within SILVARSTAR aims to provide the railway community a userfriendly prediction tool for ground vibration impact studies. This tool will be used for environmental impact assessment of new or upgraded railways on a system level. It will provide access to ground vibration predictions to a wider range of suitably qualified engineers.

SILVARSTAR Deliverable D1.1 explains the concept and methodology integrated in the SILVARSTAR prototype vibration prediction tool in detail. The vibration level in a building is expressed as the product of source, propagation and receiver terms, each of which is frequency-dependent and can be represented by either numerical predictions or by experimental data. This Deliverable D1.2 describes the prototype vibration prediction tool and constitutes also a user's guide to this tool.

The software is developed and compiled from matlab. The user must first install the software tool (see Appendix 1), and must plug the USB Dongle on their computer before starting. The installation executable generates the necessary folders for the use of the tools. Folders contain the integrated data.

To ensure that the prediction tool is capable of rapid calculations and is accessible to a wide range of users, it is built around an extensive database of both measured and pre-computed data. The initial database is described in SILVARSTAR Deliverable D2.1.

The user interface provides tools to manage the database: create new source from numerical models and import new experimental data. This is done through flexible excel files that are opened by clicking on buttons in the main user interface.

The interface allows the user to select sources, propagation terms and receiver terms, define combinations between them, and compute vibration and noise levels inside buildings.

After computations, specific simple interfaces are dedicated to plot the vibration and noise spectra obtained. All results (intermediate and final) are available in .mat format. Final results (noise and vibration inside buildings) are also made available in ASCII files (see Appendix 2 for description).







List of abbreviations, acronyms, and definitions

Abbreviation / Acronyms	Description
FINE-2	Furthering Improvements in Integrated Mobility Management (I2M), Noise and Vibration, and Energy (complementary Shift2Rail project)
FP7	European Union Framework Programme 7
GUI	Graphical User Interface
ICT	Intercity Train
RIVAS	Railway Induced Vibration Abatement Solutions (FP7 project)
WP	Work Package







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1. Introduction

The overall objective of the work on ground vibration in SILVARSTAR is to provide the railway community with a commonly accepted, practical and validated methodology, and a user-friendly prediction tool for ground vibration impact studies. This tool will be used for environmental impact assessment of new or upgraded railways on a system level. It will provide access to ground vibration predictions to a wider range of suitably qualified engineers.

The SILVARSTAR prediction tool is based on a hybrid approach that combines the advantages of both numerical and experimental methods. As with international standards, the general framework adopted expresses the vibration level in buildings as the product of terms describing a source, a propagation term and a receiver; each of these terms is frequencydependent and can be represented by numerical prediction or by experimental data.

The prototype of this hybrid numerical / experimental prediction tool was developed and provided to all partners of the SILVARSTAR project. After partner feedback, improvements were added in a final version.

This document presents an overview of the underlying computation theory and provides support to those beginning to use the SILVARSTAR prototype software. This prototype is verified and validated (Deliverable D1.3) and will be fully integrated with the existing noise mapping software IMMI developed by Wölfel in WP3. The current excel format for the database will not be the same in IMMI, but the data and metadata will be the same. A specific user's guide will be written for IMMI.







2. Theory

The complete theory is presented in detail in Deliverable D1.1 [1]. This section gives an overview of the different computation schemes in the SILVARSTAR prediction tool.

2.1 Concept

The vibration level in a building is decomposed as the product of terms describing the source, the propagation and the receiver. Figure 1 illustrates the global concept with this decomposition.

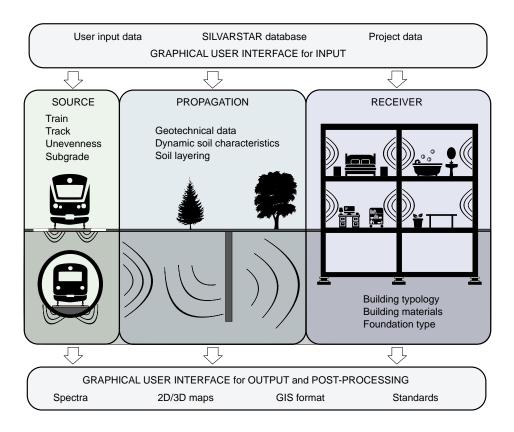


Figure 1 Ground vibration prediction process and integration of GUIs.

Each component (Source, Propagation or Receiver) may come from numerical or empirical results. The SILVARSTAR prototype deals with four computation scheme processes for combination of source and propagation:

- Fully empirical.
- Fully numerical.
- Hybrid model 1: numerical source model combined with an empirical propagation term.
- Hybrid model 2: empirical source term combined with a numerical soil model.







The receiver term (the building's coupling loss) is always calculated as a combination of adjustment factors [1]. These describe the transmission of vibration from free field to the building foundation, from the foundation to the various floors and the sound radiation into the rooms from the floor vibration.

2.2 Fully empirical computation

For the fully empirical computation, the source can be described by one of these terms:

- The force density at rail head, $L_F(X,x_1)$, with excitation on the track (rail head).
- The equivalent force density below (or next to) the track, $L_F(X_1,x_1)$ with excitation at positions X_1 under or next to the track.
- The vibration level next to the track, $L_v(x_{ref})$, at a reference distance x_{ref} from the track.

The soil propagation term has to be consistent with the source term:

- Line source transfer mobility from rail head, $TM_L(X,x_1)$.
- Line source transfer mobility from excitation below (or next to) the track, $TM_L(X_1,x_1)$.
- Difference in line source transfer mobility, $\Delta TM_L(x_{ref}, x_1)$.

The vibration levels are then computed using one of these equations, depending on the terms:

$$\begin{split} & \mathsf{L}_{v}\left(x_{1}\right) = \mathsf{L}_{\mathsf{F}}\left(X, x_{1}\right) + \mathsf{TM}_{\mathsf{L}}\left(X, x_{1}\right) \\ & \mathsf{L}_{v}\left(x_{1}\right) = \mathsf{L}_{\mathsf{F}}\left(X_{1}, x_{1}\right) + \mathsf{TM}_{\mathsf{L}}\left(X_{1}, x_{1}\right) \\ & \mathsf{L}_{v}\left(x_{1}\right) = \mathsf{L}_{v}\left(x_{\mathrm{ref}}\right) + \Delta\mathsf{TM}_{\mathsf{L}}\left(x_{\mathrm{ref}}, x_{1}\right) \end{split}$$

NB:

The user specifies the type of data when importing them, so that the tool automatically applies the appropriate combinations of source and propagation terms.

In the tool, measurements performed with impacts next to the track (force density or line source transfer mobility) are treated the same way as if they were measured below the track (i.e. where the track will be laid for new network project).







2.3 Fully numerical computation

The train-track-soil interaction problem is solved in the frequency-wavenumber domain, using train and track models, and pre-computed soil data.

The numerical source (train and track) is described by:

- a train composition and parameters (distance between axle and bogie, mass, spring and damping).
- a track composition and parameters.
- unevenness spectra for the rail and the wheel.

The numerical propagation term (soil) is described by pre-computed transfer functions and impedances. Several cases are included in the database: 5 homogeneous soils and 7 layered soils covering several types of soil in Europe [2].

Several assumptions are made:

- The track compliance is computed for a stationary load.
- The axle loads are applied at a fixed positions instead of moving along the track with the train speed. This corresponds to a low speed approximation for which the Doppler effect is neglected.
- The axle loads are assumed to be incoherent.

All assumptions were made to reduce the computation times without losing accuracy of the results. They are validated in Deliverable D1.3 [3].







2.4 Hybrid 1 computation: numerical source with empirical propagation term

For the hybrid 1 computation scheme, the same equations as for the empirical approach are used (section 2.2). The appropriate source term (force density L_F or vibration level L_v) is computed based on the same approach as in the fully numerical computation scheme (see section 2.3), and is subsequently combined with the measured propagation term (line source transfer mobility TM_L or Δ TM_L).

When importing an empirical propagation term, the user must specify several pieces of information (called metadata) to be able to combine it with an appropriate numerical model for hybrid computations.

2.5 Hybrid 2 computation: empirical source with soil numerical model

For the hybrid 2 computation scheme, the same equations as for the empirical approach are used (section 2.2). The propagation term (line source transfer mobility TM_L or ΔTM_L) is computed numerically based on the same approach as in the fully numerical computation scheme (see section 2.3), and is subsequently combined with the measured source term (force density L_F or vibration level L_v).

When importing an empirical source term, the user must specify several pieces of information (called metadata) to be able to combine it with an appropriate numerical model for hybrid computations.







3. User's guide

The installation procedure for the software is described in Appendix 1.

The prototype tool fits with the global theoretical decomposition, and is hence based on an architecture with three tabs (Source, Propagation, and Receiver).

For each term (source, propagation, or receiver), the element can be provided from the numerical or the empirical database. As presented in section 2, the SILVARSTAR prototype software is able to combine empirical and numerical databases.

Database management:

To ensure that the prediction tool is capable of rapid large-scale calculations and is accessible to a wide range of users, it was built around an extensive database of both measured and precomputed data [2]. The database includes sets of data describing vehicles, tracks, unevenness, and soil and building transfer functions.

However, if a new element is needed, the user can augment the database with their own data following sections 3.1 to 3.4:

- Section "3.1 Create a new numerical source",
- Section "3.2 Create a new empirical source",
- Section "3.3 Create a new propagation term",
- Section "3.4 Create a new receiver".

NB: a new numerical receiver (transfer functions computed externally) can be added using the "new empirical" process.

Computations and plots:

The procedure to start a computation is described in section "3.5 Start a computation".

The section "3.6 Analysis – Velocity and Noise levels" explains all steps and functionalities to plot the results.

The sections are written as step-by-step procedures to enable any user to easily perform a computation.





3.1 Create a new numerical source

To create a new numerical source, click on "New Source Numerical" in the main Menu, in the "Source" tab.

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	New Source Numerical			New S	ource Empirical			Set-up compute	slions Compute

Figure 2 Main Menu – create a new numerical source.

The creation of a new numerical source requires the user to fill in the three new tabs "Train", "Track" and "Unevenness" before clicking on "Validate" (or "Cancel") at the end. These tabs are described in the following paragraphs.







Train information

Step 1: select the type of train to be used as the basis of your new train.

- "Unsprung mass" for an axle alone. The mass is editable (step 3).
- "Generic vehicles" is an open vehicle model, enabling to associate and combine several types of vehicle (e.g. 1 Loco, 5 Wagons, ..., 1 Loco). Lengths, mass, stiffness and damping are editable (step 3). Some examples below describe this case in more detail.
- "ICT 1 wagon" for coaches carried by 2 bogies with 2 axles each. Lengths, mass, stiffness and damping are editable (step 3).
- "ICT 4 wagons" for 4 coaches carried by 8 bogies with 2 axles each. Lengths, mass, stiffness and damping are editable (step 3).
- "Tram 1" and "Tram 2" are complete train compositions with some suspended coaches. Lengths, mass, stiffness and damping are editable (step 3).
- "Metro 1 wagon" for coaches carried by 2 bogies with 2 axles each. Lengths, mass, stiffness and damping are editable (step 3).
- "Metro 5 wagons" for 5 coaches carried by 10 bogies with 2 axles each. Lengths, mass, stiffness and damping are editable (step 3).

Step 2: click on "1 - Load" to add the train type to be used as the base of the new train.

Step 3: clicking on "2 – Edit (Open Excel)" will open an Excel file called "SourceNumInit.xlsx (see Figure 4) to edit parameters (length, mass, stiffness and/or damping). Whenever you want to modify a parameter, you have to click on the "2 – Edit (Open Excel)" button.

Stiverstar - proto Analysis SILVARSTAR Source Propagation Receiver New numerical source Train Track Unevenness Lood train data	2	Computation INSTRUCTIONS SELECTION OF SOURCE, PROPAGATION, RECEIVERS In the main table, select Sources, Propagations, Receivers.
Available data - One choice only	Loaded data Train name 1 2 3 5tep 2 2 - Esti (Open Excel) 3 - OK Step 3	In each tab, you load one or several Benns and define parameters (speeds, last on on specify one shource). Not can define several speeds for each source). Not you can offer several speeds for each source). Not you can offer several speeds for each source. Not you can offer several speeds for each source). Not you can only specify one shour receivers. Not you can information of the parameters of the you can information of the you can information. SET_UP AND RIN COMPUTATIONS With one and case if less specify which groups are computations? The read of the you can information of you can citic on "Set-up computations" The read of the the source if less specify which groups are computations? The read of the the source if less specify which groups are computation to lawnch computations. Wrouge final the computations are done for C1+04+07. Set-up computations Compute

Figure 3 "New source numerical" interface – "Train" tab.







It is possible to change any of the values (green cells):

- Model name: name of the vehicle.
- Train type: select one of proposed terms.
- Mass, stiffness, damping, length, etc.

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16 17 18 19 20		10 property Vehicle name vehicle length car body mass	Several vehicles symbol lv mc	Intercity unit m kg	value vehicle_1 18.5 55000	value vehicle_2 15.8 90000	value vehicle_3 18.5 55000
16 17 18 19 20 21		10 property Vehicle name vehicle length car body mass bogie mass (without axles)	Several vehicles symbol lv mc mb	Intercity unit m kg kg	value vehicle_1 18.5 55000 15000	value vehicle_2 15.8 90000 2100	value vehicle_3 18.5 55000 15000
16 17 18 19 20 21 22		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread)	Several vehicles symbol lv mc mb mw	Intercity unit m kg kg kg	value vehicle_1 18.5 55000 15000 2100	value vehicle_2 15.8 90000 2100 1400	value vehicle_3 18.5 55000 15000 2100
16 17 18 19 20 21 22 23		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass	Several vehicles symbol lv mc mb mw mwt	Intercity unit m kg kg kg kg	value vehicle_1 18.5 55000 15000 2100 0	value vehicle_2 15.8 90000 2100 1400 0	value vehicle_3 18.5 55000 15000 2100 0
16 17 18 19 20 21 22 23 24		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance	Several vehicles symbol lv mc mb mw mwt lw	Intercity unit m kg kg kg kg m	value vehicle_1 18.5 55000 15000 2100 0 0 2.6	value vehicle_2 15.8 90000 2100 1400 0 1.8	value vehicle_3 18.5 55000 15000 2100 0 2.6
16 17 18 20 21 22 23 24 25		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance	Several vehicles symbol lv mc mb mw mwt lw lb	Intercity unit m kg kg kg kg m m	value vehicle_1 18.5 55000 15000 2100 0 2.6 10.5	value vehicle_2 15.8 90000 2100 1400 0 1.8 9	value vehicle_3 18.5 55000 15000 2100 0 2.6 10.5
16 17 18 19 20 21 22 23 24 25 26		10 property Vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness	Several vehicles symbol lv mc mb mw mwt lw lb k1	Intercity unit m kg kg kg kg m m m N/m	value vehicle_1 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06	value vehicle_2 15.8 90000 2100 1400 0 1.8 9 5.00E+06	value vehicle_3 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06
16 17 18 19 20 21 22 23 24 25 26 27		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension damping	Several vehicles symbol lv mc mb mw mwt lw lb k1 c1	Intercity unit m kg kg kg kg m m M/m N/m N/(m/s)	value vehicle_1 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04	value vehicle_2 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04	value vehicle_3 18.5 55000 15000 2100 0 0 2.6 10.5 4.00E+06 3.30E+04
16 17 18 20 21 22 23 24 25 26 27 28		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension stiffness	Several vehicles symbol lv mc mb mw mwt lw lb k1 c1 k2	Intercity unit m kg kg kg kg m m N/m N/m N/(m/s) N/m	value vehicle_1 18.5 55000 15000 2100 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05	value vehicle_2 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08	value vehicle_3 18.5 55000 15000 2100 0 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05
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16 17 18 20 21 22 23 24 25 26 27 28 29 30		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension stiffness secondary suspension damping wheel resilient ring stiffness	Several vehicles symbol lv mc mb mw mwt lw lb k1 c1 k2 c2 kr	Intercity unit m kg kg kg kg m M N/m N/(m/s) N/m N/(m/s) N/m	value vehicle_1 18.5 55000 15000 2100 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05	value vehicle_2 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08	value vehicle_3 18.5 55000 15000 2100 0 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05
16 17 18 20 21 22 23 24 25 26 25 26 27 28 29 30 30 31		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension stiffness secondary suspension damping wheel resilient ring stiffness wheel resilient ring damping	Several vehicles symbol lv mc mb mw mwt lw lb k1 c1 k2 c2 kr c2 kr	Intercity unit m kg kg kg kg m m N/m N/m N/(m/s) N/m N/(m/s)	value vehicle_1 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04	value vehicle_2 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08 2.00E+04	value vehicle_3 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 31 32		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension stiffness secondary suspension stiffness secondary suspension damping wheel resilient ring stiffness wheel resilient ring damping number of axles	Several vehicles symbol lv mc mb mw mwt lw lb k1 c1 k2 c2 kr c2 kr c7 na	Intercity unit m kg kg kg kg m M N/m N/(m/s) N/m N/(m/s) N/m	value vehicle_1 18.5 55000 15000 2100 0 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04	value vehicle_2 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08 2.00E+04	value vehicle_3 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04
16 17 18 19 20 21 23 23 24 25 26 27 28 29 30 31		10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension stiffness secondary suspension damping wheel resilient ring stiffness wheel resilient ring damping	Several vehicles symbol lv mc mb mw mwt lw lb k1 c1 k2 c2 kr c2 kr	Intercity unit m kg kg kg kg m M N/m N/(m/s) N/m N/(m/s) N/m	value vehicle_1 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04	value vehicle_2 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08 2.00E+04	value vehicle_3 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04 4 2

Figure 4 Train parameters for the new numerical source – example of a model with generic vehicles.

NB: The most important value is the unsprung (wheelset + wheeltread) mass. If there is no wheel tread, leave the value of "Wheeltread mass" as 0 kg.

When the train definition is finished, save and close the Excel file. Click on "3 - OK" (from the "Train" tab). The following pop-up message will appear to confirm train creation. Click on "OK".



Figure 5 Pop-up message after train validation.







Some examples are presented in the following figures, based on the generic vehicle model.

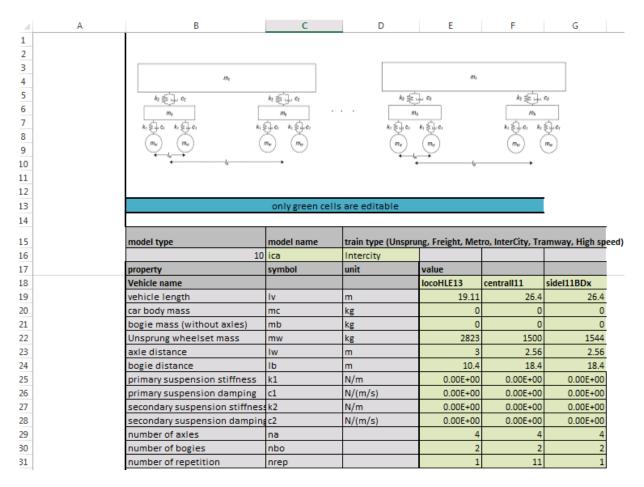


Figure 6 Example with an IC-A train composed of 1 locomotive, 11 intermediate vehicles and one side vehicle.







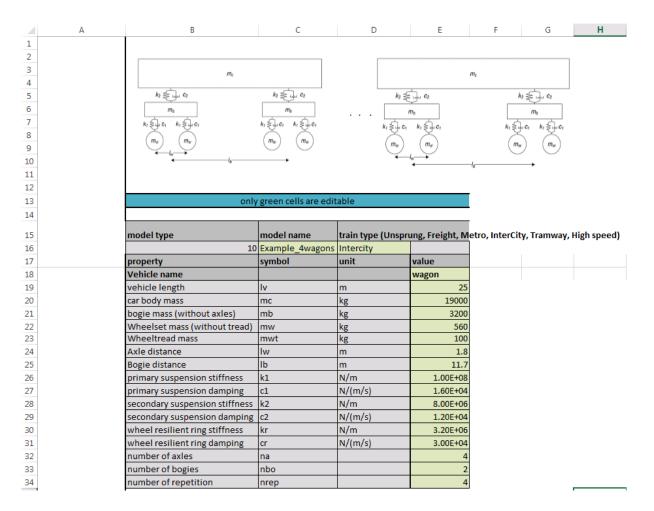


Figure 7 Example with a 4 wagon train with resilient wheels.

Shi	ft2Rail			n 2020 an Union Fund earch & Innov			SILV	ARSTAR
	А	В	С	D	E	F	G	н
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3						me		
4		m ₀				ing.		
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6		mb	mb		mb		mb	
7		K, = 4 C, K, = 4 C,	k, \$ 0, k, \$ 0,	 k, ≨⊒ c	k,≦⊒.c,	k, ≦	1.c, k, ≨.1.c,	
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15		model type	model name Several vehicles	train type (Unspr	ung, Freight, M	etro, InterCit	y, Tramway, H	ligh speed)
		model type	model name		ung, Freight, M	etro, InterCit value	y, Tramway, H value	ligh speed)
15 16		model type 10	model name Several vehicles	train type (Unspr Intercity				ligh speed)
15 16 17		model type 10 property	model name Several vehicles	train type (Unspr Intercity	value	value	value loco_2	ligh speed)
15 16 17 18		model type 10 property Vehicle name	model name Several vehicles symbol	train type (Unspr Intercity unit	value loco_1	value f_wagon	value loco_2	ligh speed)
15 16 17 18 19		model type 10 property Vehicle name vehicle length	model name Several vehicles symbol Iv	train type (Unspr Intercity unit m	value loco_1 18.5	value f_wagon 15.8	value loco_2 18.5 55000	ligh speed)
15 16 17 18 19 20		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread)	model name Several vehicles symbol Iv mc	train type (Unspr Intercity unit m kg	value loco_1 18.5 55000	value f_wagon 15.8 90000	value loco_2 18.5 55000	ligh speed)
15 16 17 18 19 20 21 22 23		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass	model name Several vehicles symbol lv mc mb mw mwt	train type (Unspr Intercity unit m kg kg kg kg	value loco_1 18.5 55000 15000 2100 0	value f_wagon 15.8 90000 2100 1400 0	value loco_2 18.5 55000 15000 2100 0	ligh speed)
15 16 17 18 19 20 21 22 23 24		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance	model name Several vehicles symbol lv mc mb mw mwt lw	train type (Unspr Intercity unit m kg kg kg kg kg m	value loco_1 18.5 55000 15000 2100 0 0 2.6	value f_wagon 15.8 90000 2100 1400 0 1.8	value loco_2 18.5 55000 15000 2100 0 2.6	ligh speed)
15 16 17 18 19 20 21 22 23 24 25		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance	model name Several vehicles symbol lv mc mb mw mwt lw lb	train type (Unspr Intercity unit m kg kg kg kg kg m m	value loco_1 18.5 55000 15000 2100 0 0 2.6 10.5	value f_wagon 15.8 90000 2100 1400 0 1.8 9	value loco_2 18.5 55000 15000 2100 0 2.6 10.5	ligh speed)
15 16 17 18 19 20 21 22 23 24 25 26		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness	model name Several vehicles symbol lv mc mb mw mwt lw lb k1	train type (Unspr Intercity unit m kg kg kg kg kg m m N/m	value loco_1 18.5 55000 15000 2100 0 0 2.6 10.5 4.00E+06	value f_wagon 15.8 90000 2100 1400 0 1.8 9 5.00E+06	value loco_2 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06	ligh speed)
15 16 17 18 19 20 21 22 23 24 25 26 27		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension damping	model name Several vehicles symbol lv mc mb mw mwt lw lb k1 c1	train type (Unspr Intercity unit m kg kg kg kg m m m N/m N/m N/(m/s)	value loco_1 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04	value f_wagon 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04	value loco_2 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04	ligh speed)
15 16 17 18 19 20 21 22 23 24 25 26 27 28		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheelset mass Axle distance Bogie distance primary suspension stiffness primary suspension damping secondary suspension stiffness	model name Several vehicles symbol lv mc mb mw mwt lw lb k1 c1 k2	train type (Unspr Intercity unit m kg kg kg kg m m N/m N/m N/(m/s) N/m	value loco_1 18.5 55000 15000 2100 2.6 10.5 4.00E+06 3.30E+04 1.80E+05	value f_wagon 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08	value loco_2 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05	ligh speed)
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension damping secondary suspension damping	model name Several vehicles symbol Iv mc mb mw mwt Iw Ib k1 c1 k2 c2	train type (Unspr Intercity unit m kg kg kg kg m m N/m N/m N/(m/s) N/m N/(m/s)	value loco_1 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04	value f_wagon 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04	value loco_2 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04	ligh speed)
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheelset mass Axle distance Bogie distance primary suspension stiffness primary suspension damping secondary suspension damping wheel resilient ring stiffness	model name Several vehicles symbol Iv mc mb mw mwt Iw Ib k1 c1 k2 c2 kr	train type (Unspr Intercity unit m kg kg kg kg m m N/m N/m N/(m/s) N/m N/(m/s) N/m	value loco_1 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05	value f_wagon 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08	value loco_2 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05	ligh speed)
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension damping secondary suspension damping wheel resilient ring stiffness wheel resilient ring damping	model name Several vehicles symbol Iv mc mb mw mwt Iw Ib k1 c1 c1 k2 c2 kr cr	train type (Unspr Intercity unit m kg kg kg kg m m N/m N/m N/(m/s) N/m N/(m/s)	value loco_1 18.5 55000 15000 2100 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04	value f_wagon 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08 2.00E+04	value loco_2 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04	ligh speed)
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension damping secondary suspension damping wheel resilient ring stiffness wheel resilient ring damping number of axles	model name Several vehicles symbol Iv mc mb mw mwt Iw Ib k1 c1 k2 c2 kr c2 kr c7 na	train type (Unspr Intercity unit m kg kg kg kg m m N/m N/m N/(m/s) N/m N/(m/s) N/m	value loco_1 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04	value f_wagon 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08 2.00E+04 4 4	value loco_2 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04	ligh speed)
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31		model type 10 property Vehicle name vehicle length car body mass bogie mass (without axles) Wheelset mass (without tread) Wheeltread mass Axle distance Bogie distance primary suspension stiffness primary suspension damping secondary suspension damping wheel resilient ring stiffness wheel resilient ring damping	model name Several vehicles symbol Iv mc mb mw mwt Iw Ib k1 c1 c1 k2 c2 kr cr	train type (Unspr Intercity unit m kg kg kg kg m m N/m N/m N/(m/s) N/m N/(m/s) N/m	value loco_1 18.5 55000 15000 2100 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04	value f_wagon 15.8 90000 2100 1400 0 1.8 9 5.00E+06 4.00E+04 1.00E+08 2.00E+04	value loco_2 18.5 55000 15000 2100 0 2.6 10.5 4.00E+06 3.30E+04 1.80E+05 4.50E+04	ligh speed)

Figure 8 Example with a freight train composed of 1 locomotive, 4 freight wagons and 1 locomotive.







Track information

Step 1: select the type of track to be used as the basis of your new track, from the 9 possible choices (Table 1).

BALLAST	SLAB
bt01	st01
(standard rail pads)	(main line Rheda slab track with standard rail pads)
bt02	st02
(soft rail pads)	(tramway slab track with standard rail pads – level 0)
bt03	st03
(very soft rail pads)	(tramway slab track with soft rail pads – level 1)
bt04	fst01
(standard rail pads, stiff under sleeper pads)	(floating slab track – level 2)
bt05	
(standard rail pads, soft under sleeper pads)	

Table 1 Track database to create a new track

Detailed parameters are listed in the deliverable D2.1. All parameters are editable (step 3).

Step 2: click on "1 - Load" to add the type of track to be used as the basis of the new track.

Step 3: clicking on "2 – Edit (Open Excel)" will open an Excel file called "SourceNumInit.xlsx (see Figure 4) to edit track parameters (track type, masses, stiffness and/or damping). Whenever you want to modify a parameter, you have to click on the "2 – Edit (Open Excel)" button.





Source Programments Source Programments Trail Strice Name Type Comments Trail Step 1 Step 1 Step 1	Image: Structure in the image in t
---	---

Figure 9 "New source numerical" interface – "Track" tab.







It is possible to change any of the following values (green cells): Young's modulus, mass, stiffness, damping, etc. to transform the existing track (used as a basis) into the new track. The shadowed cells are not editable, and depend on the type of track.

For ballast track, the soil width interface is needed (cell "D34"). For slab or floating slab tracks, the width of the slab is required (cell "D25")

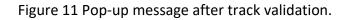
eu	lauen (cen	D25 J	
	А	В	С	D
1				
2			Project:	name
3			Track name:	bt01
4			Track description:	ballast
5			Track type:	2
6			Track ID n°:	2
7			Comments	std railpad
8			Type:	UIC60
9		Er	Young modulus (GPa)	210
10		Elr	Vertical bending stiffness (M.m^2)	6.4
11	RAIL	Mr	Mass per unit length (kg/m)	60
12	NAIL	η _r	Vertical damping factor	0.02
13		vr	Poisson's coefficient	0.3
14		ρr	Mass density per unit volume (kg/m^3)	7850
15		κr	Shear coefficient	0.4
16				
17				
18	PADS	d	Pad distance (sleeper distance) (m)	0.6
19	PAUS	ηρ	Vertical damping factor (C/Ccrit)	0.2
20		Kp	Vertical stiffness (MN/m = kN/mm)	300
21				
22	SLEEPER	Ss	Surface (1/2 sleeper) (m²)	0.325
23	(half) M _s Mass (1/2 sleeper) (kg)		162.5	
24				
25		Ws	Width (m)	
26		н	Height (m)	
27	SLAB	Е	Young's modulus (MPa)	
28	JLAD	Elvs	Vertical bending stiffness (N.m^2)	
29		ρ	Density(kg/m^3)	
30		Ms	Mass per unit length (kg/m)	
31				
32	BALLAST	ηg	Vertical damping factor (C/Ccrit)	0.4
33	or MAT	Kg	stiffness per unit area (MN/m3)	462
34	or ment	b	soil interface width(m)	3

Figure 10 Track parameters for the new numerical source.

When the track is finished, save and close the Excel file.

Click on "3 - OK". The following pop-up message appears to validate track creation. Click on "OK".









Unevenness information

Several unevenness spectra are selectable. Rail and Wheel unevenness both have to be defined. If necessary, a 'None' (wheel or track) unevenness is selectable. However, something has to be selected for both components.

The 'select' column accepts only one choice, which will be applied. The 'Display' column enables several choices to visualize different unevennesses.

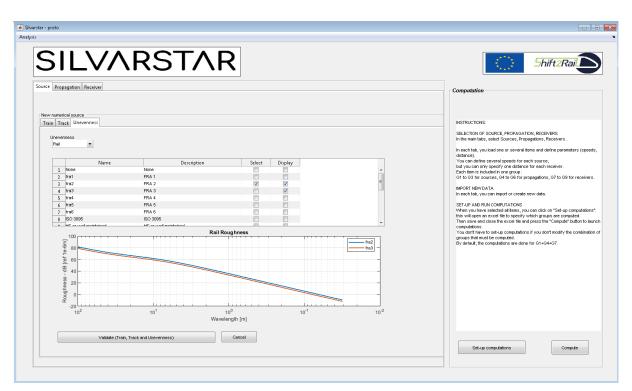


Figure 12 "New source numerical" interface – "Unevenness" tab.

Uneve Whe	nness el 🔻			
	Name	Description	Select	Display
1	None	None		
2	Cast-iron tread	Cast-iron tread		V
3	Composite	Composite		V
4	Disc brake	Disc brake		
5	Tram	Tram		

Figure 13 "New source numerical" interface – "Unevenness" tab – zoom.



Shift2Rail



Table 2 lists the unevennesses available in the pre-defined database. The database can be enriched by user inputs. The user will simply add a line in the corresponding excel file (\Database\Roughness_database.xlsx)

Name	Description	Туре
None	None	Rail
fra1	FRA 1	Rail
fra2	FRA 2	Rail
fra3	FRA 3	Rail
fra4	FRA 4	Rail
fra5	FRA 5	Rail
fra6	FRA 6	Rail
iso3095	ISO 3095	Rail
bt_hs_or_well_maintained	HS or well maintained – ballasted	Rail
bt_normally_maintained	Normally maintained – ballasted	Rail
bt_not_well_maintained	Not well maintained – ballasted	Rail
bt_freight_line	Freight line	Rail
bt_tram_line	Tram line –ballasted	Rail
bt_normally_maintained_and_corrugated	Normally maintained and corrugated – ballasted	Rail
bt_not_well_maintained_and_corrugated	Not well maintained and corrugated – ballasted	Rail
st_hs_or_well_maintained	HS or well maintained – slab	Rail
st_normally_maintained	Normally maintained – slab	Rail
st_not_well_maintained	Not well maintained – slab	Rail
st_tram_line	Tram line (embedded) – slab	Rail
st_normally_maintained_and_corrugated	Normally maintained and corrugated – slab	Rail
st_not_well_maintained_and_corrugated	Not well maintained and corrugated – slab	Rail
fra-lincent	Fra lincent	Rail
None	None	Wheel
Cast_iron_tread	Cast-iron tread brake	Wheel
Composite	Composite brake	Wheel
Disc_brake	Disc brake	Wheel
Tram	Tram	Wheel

Table 2 Rail and wheel unevenness list in database





Creation of the new numerical source

When the three components (Train, Track and Unevenness) have been selected and edited, the new numerical source is ready to be validated. Click on the "Validate (Train, Track and Unevenness)" button. This will create and add the new numerical source to the "Current_project" folder. This source appears and is now selectable in the main tab "SOURCE".

Source Propagation Receiver	\RST∧F	2		Computation
New numerical source Train Track Unevenness				INSTRUCTIONS:
Unevenness Rai				SELECTION OF SOURCE, PROPAGATION, RECEIVERS In the main take, select Sources, Propagations, Receivers . In each tab, you load one or several tems and define parameters (speeds,
	D 1 1		0.1	distance). You can define several speeds for each source,
1 None	Description	Select	Display	but you can only specify one distance for each receiver.
2 fra1	FRA 1			Each item is included in one group : Of to O3 for sources, O4 to O6 for propagations, O7 to O9 for receivers.
3 fra2	FRA 2	V	V	E Contraction of the second
4 fra3	FRA 3		V	IMPORT NEW DATA
5 fra4	FRA 4			In each tab, you can import or create new data.
6 fra5	FRA 5			SET-UP AND RUN COMPUTATIONS
7 fra6	FRA 6	(m)		When you have selected all items, you can click on "Set-up computations": this will open an excel file to specify which arouas are computed.
8 ISO 3095	ISO 3095	[***]		 this will open an excel file to specify which groups are computed. Then save and close the excel file and press the "Compute" button to laun
0 WC or wall maintained	hoolotoion llour vo 34	toughness		Computations. You don't have to set-up computations if you don't modify the combination
E 00 4 0 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0 0 6 0 6 0 7 0 8 20 0 0 0 0 0 0 0 0 0 0 0 0 0		100		a2 m2 m3 m3 10 ⁻² aroupt bot must be computed. By default, the computedons are done for 01+04+67.
Validate	Wave	Cancel		Set-up computations Compute

Figure 14 "New source numerical" interface – "Unevenness" tab – for VALIDATION.

The "Cancel" button goes back to the main menu without adding the new numerical source.





3.2 Create a new empirical source

To create a new empirical source, click on "New Source Empirical" in the main Menu, in the "Source tab".

Figure 15 Main Menu – create a new empirical source.







An empirical source may be defined by:

- An equivalent force density at the rail head,
- An equivalent force density below (or next to) the track,
- A vibration level next to the track.

Depending on the type of new empirical source, click on the corresponding "Excel open" button.

SILVARSTAR	Computation
New empirical source You can import data by clicking on one of the button Excel open. Then Fill in the excel file, save it and close it. Then press Validate to save and go back to the main tab Load new empirical source Import equivalent force density rail heads (dB) Import equivalent force density next to track (dB) Import equivalent force density next to track (dB) Import vibration level next to track (dB) Validate Validate	INSTRUCTIONS: SELECTION OF SOURCE, PROPAGATION, RECEIVERS In the main tabs, select Sources, Propagations, Receivers In each tab, you load one or several items and define parameters (speeds, distance). You can define several speeds for each source, but you can only specify on distance for each receiver. Each tem is included in one group: G1 to G3 for sources, G4 to G6 for propagations, G7 to G3 receivers. MPORT INEW DATA In each tab, you can import or create new data. SET-UP AND RUN COMPUTATIONS When you have selected all items, you can click on "Set-u computations": this will open an excel file to specify which groups are computed. Then save and close the excel file and press the "Computed but no to launch computations. You don't have to set-up computations if you don't modify t combination of groups that must be computed. By default, the computations are done for G1+G4+G7.

Figure 16 "New source empirical" interface.

To go back to the main menu without adding a new empirical source, click on "Validate".







A new interface page is opened: fill in the new empirical source information (name and metadata), and click on "OK". The metadata are presented in Figure **17**, and detailed in Table 3 below.

The Cancel button returns to the "new empirical source menu".

🔺 Input 📃 🗖 🗾	🔺 Input 📃 🖃 💌	🔺 Input 📃 🗉 🗾
Enter empirical source name without space and with Lf_rail_head mp_source_name_Lf_rail_head	Enter empirical source name without space and with extent "_Lf_below_track" Emp_source_name_Lf_below_track	Enter empirical source name without space and with extent *_Lv* Emp_source_name_Lv
Train type (Freight, Metro, InterCity, Tramway, High speed)	Train type (Freight, Metro, InterCity, Tramway, High speed)	Train type (Freight, Metro, InterCity, Tramway, High speed)
Freight	Freight	Freight
Speed (kph)	Speed (kph)	Speed (kph)
100	100	100
Train length [m]	Train length [m]	Train length [m]
25	25	25
Number of axles	Number of axles	Number of axles
18	18	18
Track model (bt01, bt02, bt03, bt04, bt05, st01, st02, st03, fst01)	Track model (bt01, bt02, bt03, bt04, bt05, st01, st02, st03, fst01)	Track model (bt01, bt02, bt03, bt04, bt05, st01, st02, st03, fst01)
bt01	bt01	bt01
Soil (soft, medium, stiff)	Soil (soft, medium, stiff)	Soil (soft, medium, stiff)
medium	medium	medium
Wheel roughness	Wheel roughness	Wheel roughness
Rail roughness	Rail roughness	Rail roughness
ОК Сапсе	OK Cancel	OK Cancel

Figure 17 New source empirical" name and metadata.

NB: Be careful with the name length. The total maximum characters allowed is 31. An equivalent force density measured next to the track can be imported as "Lf_below_track".

After clicking on "OK", the Excel file "Empirical_source.xlsx" is opened, and adds a new tab with the name and metadata on the left side based on the information provided (Figure **18**).





The metadata sets are described in Table 3. They are mostly important for hybrid computation, to ensure compatibility with the soil numerical model. If the user does not specify one of the metadata, the default value (if available) is used by the tool.

Table 3 Data and associated metadata for empirical source terms

Data type	Metadata (cell in excel file - Figure 18)	Possible values Default value in bold	Comments
	Train Type ("D9")	Freight / Tramway / Intercity / Metro / High speed	No default value, must be specified
L _F (X,x1), at	Train speed ("D10"), length ("D11") and number of axles ("D12")	Any number	No default value, must be specified
rail head Or LF (X1,X1),	Track model ("D15")	bt01 / /bt02 st01	btXX: ballasted tracks stXX: slab tracks See descriptions in the excel files when importing data, and in Table 1
below the track Or	Soil model ("D16")	soft / medium / stiff	Based on the RIVAS project, this depends on the Cs wave of the main soil layer - Cs < 180 m/s => 'soft' - 180 < Cs < 360 m/s => 'medium' - Cs > 360m/s => 'stiff'
L _v (x _{ref}) next to the track	Wheel unevenness ("D17")	None / Cast-iron tread / Composite / Disc brake / Tram	Choose one of the wheel unevenness in the excel database (extract in Table 2) (\Database\Roughness_database.xlsx)
	Rail unevenness ("D18")	bt_normally_maintained / bt_hs_or_well_maintained st_normally_maintained /	Choose one of the rail unevenness in the excel database (extract in Table 2) (\Database\Roughness_database.xlsx)

NB: The default value for rail unevenness depends on the track form (ballast or slab).







As illustrated in Figure 18, enter the values (third octave band spectra in dB, the reference information is written in cell "D7") in the green cells (column "J").

	А	В	С	D	E	F	G	Н	I	J
1										
2		Inf	ormation					Mea	sured data	
3										distance (m)
4			ITEM	VALUE	UNIT				frequency (Hz)	4
5			Type of source:	Lv					1	
6			Unit of measured data	dB					1.25	
7			dB ref.	5.00E-08	m/s				1.6	
8									2	
9			Train type						2.5	
10			Train speed		kph				3.15	
11			Train length		m				4	
12			Train number of axles						5	
13									6.3	
14			iated models in database (used for hybrid computa					8	
15			Track						10	
16			Soil						12.5	
17			Wheel roughness						16	
18			Rail roughness						20	
19									25	
20									31.5	
21			Track model						40	
22			see D1.2 and detail below	1					50	
23									63	
24			Soil model						80	
25			See D2.1 chapter 5.1 and o	detail below					100	
26			Roughness						125	
27			- if not measured -> chose	roughness in the databa	se.				160	
28			("Path" \Database\Roughr						200	
29			default roughness data wi						250	
30			maintained).	. ,					315	
31										
32			- if measured : first add me		ase, then					
33			select the corresponding r	ame here						

Figure 18 "New source empirical" values and parameters – example for source defined by measured vibration levels

NB: the input units cannot be changed. If the user has data in other units, they must convert it before importing.

For types "Lv" and "Lf below the track", the distance parameters have to be added above the source values (cell "J4").

When the data is complete, save and close the Excel file.





3.3 Create a new propagation term

To create a new propagation term, click on "New Propagation" in the main Menu, in the "Propagation tab".

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SI ource Prop		leceiver	ΆF	RS	17	\R		Loaded defa	Computation NSTRUCTIONS
	1 2 3 4 5 6 7 8 9		Name soft_soft attr_soft incert_soft incert_soft Medium_soft_TML_h. Medium_soft_TML Medium_soft_TM	Emp Emp Emp	Soil type Soft Medium Stiff Lincent Lincent Medium Medium Medium	Transfer function type TML rai head TML rai head TML below track TML below track TML rai head	Losd	Name Group 1 * 2 * 3 * 4 *	SELECTION OF SOURCE, FROMACATION, RECEVENS In the most tide, sole Sources, Programmation, Receivers . In each tab, you load one or serveral teme and define parameters (sp distance). You can define serveral speed for each source, but you can impeding out and the serveral speed of the 30 for source, 30 to 56 for programmations, 07 to 09 for receiv MPORT NeW DATA In each tab, you can import or create new data. SETLP JAR RNI COMPUTATIONS When you have sateled all items, you can click on "Set-up compatibility this will open an excel fels to pacity which groups are computed. Then save and obset the excel field and press the "Computed" button to computations. You can the set one compatibility you dant modity the combin by default, the computations are done for 01+04+07.
			Import new pro	pagation					Set-up computations Compute

Figure 19 Main Menu – create a new propagation term.







A new propagation term may be defined by:

- A line source transfer mobility at the rail head,
- A line source transfer mobility below (or next to) the track,
- A difference in line source transfer mobility.

Depending on the type of new propagation term, click on the corresponding "Excel open" button.

SILVARST/	NR	Shift2Rai
rrce Propagation Receiver		Computation
lew propagation You can import data by clicking on one of the button Excel open. Then Fill in th	e excel file, save it and close it. Then press Validate to save and go back to the main tab	INSTRUCTIONS: SELECTION OF SOURCE, PROPAIGATION, RECEIVERS In the main take, select Sources, Propagations, Receivers.
Load new propagation	Excel open	In each tab, you bad use or everyal items and attime parameters (spo distance). You can developed padds for each source, You can device yeardy need to device to each receiver. Each tem is not each or en you- G1 to G3 for sources, Q4 to G6 for propagations, G7 to G9 for receiv
Import line source transfer mobility next to track (dB)	Excel open Excel open Valide	NeOCIT NEV DATA In each tab, you can import or create new data. SET-LP AND RUN COMPUTATIONS When you have set-cled all terms, you can click on "Set-up computati this will open an each file to specify which groups are computed to compute the set the excel file and the and press the "Compute" battom to computerism. You don't new to each up computations by you don't modify the combining groups that must be computed. By default, the computations are done for 01+04+07.

Figure 20 "New propagation term" interface.

To go back to the main menu without adding a new propagation term, click on "Validate".





A new interface page is opened: fill in the new propagation term information (name and metadata), and click on "OK". The metadata is described in Figure **21**, and detailed in Table 4.

The Cancel button returns to the "New propagation term" menu.

🖌 Input 📃 📼 💌	🔺 Input 📃 📼 💌	🔺 Input 📃 🗉 🗾				
Enter new empirical propagation name without space with extent _TML_hammer_rail hew_propa_emp_name_TML_hammer_RH	Enter new empirical propagation name without space with extent _TML_hammer hew_propa_emp_name_TML_hammer	Enter new empirical propagation name without space with extent 				
Reference point : distance from	Reference point : distance from	Reference point : distance from				
excitation	excitation	excitation				
8	8	8				
Soil type (soft, medium, stiff)	Soil type (soft, medium, stiff)	Soil type (soft, medium, stiff)				
medium	medium	medium				
OK Cancel	OK Cancel	OK Cancel				

Figure 21 "New propagation term" name and metadata.

NB: Be careful with the name length. The total maximum characters allowed is 31.

After clicking on "OK", the Excel file "Empirical_propagation.xlsx" is opened, and adds a new tab with the name and metadata on the left side based on the information provided (Figure 22).

The metadata sets are described in







Table 4. They are mostly important for hybrid computations to ensure compatibility with the source numerical model. If the user does not specify one of the metadata, the default value is used by the tool.





Table 4 Data and associated metadata for empirical propagation terms

Data type	Metadata (cell in excel file - Figure 22 "New propagation term" values and parameters – example for a line source transfer mobility measured with impact at rail head)	Possible values Default value in bold	Comments			
	Reference point distance ("D8")	Any number	Must be set			
TM_L and ΔTM_L	Soil type ("D9")	soft / medium / stiff	Based on the RIVAS project, this depends on the Cs wave of the main soil layer - Cs < 180 m/s => 'soft' - 180 < Cs < 360 m/s => 'medium' - Cs > 360m/s => 'stiff'			
TM∟with impact at rail heads	Track model ("D10")	bt01 / /bt02 st01	btXX: ballasted tracks stXX: slab tracks See descriptions in the excel files when importing data (Figure 22), and in Table 1			







As illustrated in Figure 22, enter the values (third octave band spectra in dB; the reference information is written in cell "D7") in the green cells (column "J" to "ii", depending on the distance).

	Α	BC	D	E	F G	н	Ι	J	К	L	М
1											
2	Information				Measured data						
3							TML (dB)			distance (m)	
4		ITEM	VALUE	UNIT			frequency (Hz)	4	8	15	20
5		Type of transfer function:	TML rail head				1				
6		Unit of measured data	dB				1.25				
7		dB ref.	5.00E-08	(m/s)/(N/sqrt(m))			1.6				
8		Reference point : distance from excitation	4	m			2				
9		Soil type	medium				2.5				
10		Track model					3.15				
11							4				
12							5				
13		In the 'Soil type' value 3 possibility are expe	In the 'Soil type' value 3 possibility are expected :				6.3				
14		"Soft", "Medium", "Stiff".				8					
15			Based on the RIVAS project, this depend of the Cs wave on the main soil layer. - Cs < 180 m/s => 'Soft'				10				
16		wave on the main soil layer.					12.5				
17		- Cs < 180 m/s => 'Soft' - 180 < Cs < 360 m/s => 'Medium'					16				
18		- 180 < Cs < 360 m/s => "Medium" - Cs < 360m/s => 'Stiff'					20				
19		- cs < 300m/s => 30m					25				
20							31.5				
21							40				
22							50				
23							63				
24							80				
25							100				
26							125				
27							160				
28							200				
29							250				
30							315				

Figure 22 "New propagation term" values and parameters –example for a line source transfer mobility measured with impact at rail head

The distance parameters for each measurement point have to be added in line "4" (see examples in columns J, K, L, M in Figure 22). In the example, the measured distances are 4, 8, 15 and 20 m. The user can add any number of columns: one column per measured distance.

NB: the units (cells "D6" and "D7" in *Figure 22*) cannot be changed. If the user has data in other units, they must convert it before importing.

When the data is complete, save and close the Excel file.





3.4 Create a new receiver

To import a new receiver, click on "Import new receiver" in the main Menu, in the "Receiver tab".

					Computation
Available data	ct Name T	Type Database name Cb2 - Building type RIVAS 1 Houses	Cb2 - Soil type C Soft soil Cr A	Loaded data Name Group Distance (m	SELECTION OF SOURCE, PROPAGATION, RECEIVERS in the main tabs, select Sources, Propagations, Receivers . in each tab, you load one or several items and define parameters
2		RIVAS 2 Houses	Soft soil Co	2	distance).
3		RIVAS 3 Houses	Soft soil W	3 -	You can define several speeds for each source, but you can only specify one distance for each receiver.
4		RIVAS 4 Houses RIVAS 5 Houses	Medium soil Co	4 +	Each item is included in one group :
6		RIVAS 5 Houses	Medium soil W		G1 to G3 for sources, G4 to G6 for propagations, G7 to G9 for re
7		RIVAS 7 Houses	Stiff soil Co		MPORT NEW DATA
8		RIVAS 8 Houses	Stiff soil Cr		In each tab, you can import or create new data.
9		RIVAS 9 Houses	Stiff soil W		SET-UP AND RUN COMPUTATIONS
10		RIVAS 10 Small buildings	Soft soil Cr		When you have selected all items, you can click on "Set-up compu- this will open an excel file to specify which groups are computed
11		RIVAS 11 Small buildings	Soft soil Cr		Then save and close the excel file and press the "Compute" butto
					computations. You don't have to set-up computations if you don't modify the com groups that must be computed. By default, the computations are done for 01+04+07.

Figure 23 Main Menu – create a new receiver.





A new receiver may be added based on measurements or simulation. Click on "Excel Open" to add a new receiver database.

SILVARSTAR	□
Aurce Propagation Receiver	Computation
Vou can import data by cicking on one of the button Excel open. Then Fil in the evod file, save it and close it. Then press Validate to save and go back to the main tab	SELECTION OF SOURCE, PROPAGATION, RECEIVERS In the main table, setel Sources, Programation, Receivers . In sech halp, you load one or several items and define parameters (spee defined). You can define several speeds for each issues, but you can only speed/you distance do each receiver. Each tem is included in one group: Of to Q3 for sources, Q4 to Q6 for propagations, Q7 to Q9 for receiver INPORT NEW OATA In each table, you can import or create deat. SET-LIP AND RMX COMPUTATIONS When you have selected all tems / you can click on "Sel-up computation the will open an excell file and press the "Compute" hauton to la vou and Thine is a de-up computation. By default, the computations are done for C1+Q4+Q7.
	Set-up computations Compute

Figure 24 "New receiver" interface.

To go back to the main menu without adding a new receiver, click on "Validate".







A new interface page is opened: fill in the new receiver database name and click on "OK".

The receiver database can correspond to one measurement campaign on given sites for a line construction project. Several buildings can hence be included in the same database.

The Cancel button send back to the "new receiver menu".

承 Input	- • •
Enter new receiver na space	mewithout
new_receiver	
	OK Cancel

Figure 25 "New receiver" name and metadata.

After clicking on "OK", the Excel file "Empirical_receiver.xlsx" is opened, adding a new tab with the input name.

As illustrated in Figure 26, Enter values (third octave band spectra in dB; the reference information is written in cell "D7") in the green cells (from column "J").

When creating a new receiver database, each new receiver needs to be added following the same process: Cb2, Cb3, Cb4 values in 3 columns ([J,K,L] for the first receiver, then: [M,N,O], etc.). Several new receivers may be added at the same time in the new receiver database. For example, the beginning of the RIVAS database is presented for illustration (Figure 27).

NB: The units cannot be changed.





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1	Α	В	С	D	E	F	G	н	Ι	J	Receiver r	name
2		Inf	ormation					Mea	sured data		name	
3										1	1	1
4			ITEM	VALUE	UNIT				transfer function:	Cb2	Cb3	Cb4
5									name:	name	name	name
6									information:	info	info	info
7			Database name	Name_sheet					frequency (Hz)	dB	dB	dBA
8									1	0.0	Ch. na	me and
9			Number of receivers						1.25	0.0		
10			INPUT						1.6	0.0	inform	ation
11			Cb2, Cb3, Cb4 input unit	dB					2	0.0	0.0	0.0
12			Cb2, Cb3, Cb4 - dB ref	5.00E-08	m/s				2.5	0.0	0.0	0.0
13			OUTPUT						3.15	0.0	0.0	0.0
14			Cb2, Cb3 output unit	dB					4	0.0	0.0	0.0
15			Cb2, Cb3 - dB ref	5.00E-08	m/s				5	0.0	0.0	0.0
16			Cb4 output unit	dBA					6.3	0.0	0.0	0.0
17			Cb4 - dB ref	2.00E-05	Pa				8	0.0	0.0	0.0
18									10	0.0	0.0	0.0
19									12.5	0.0	0.0	0.0
20									16	0.0	0.0	0.0
21			Cb2 = vibration trans	sfer function fr	om the				20	0.0	0.0	0.0
22			threshold building to						25	0.0	0.0	0.0
23									31.5	0.0	0.0	0.0
24			Cb3 = vibration trans						40	0.0	0.0	0.0
25			foundation building	to the building	floor				50	0.0	0.0	0.0
26			Cb4 = vibra-acoustic tra	ansfer function	from the				63	0.0	0.0	0.0
27			building floor to the ac						80	0.0	0.0	0.0
28			<u> </u>		1				100	0.0	0.0	0.0
29									125	0.0	0.0	0.0
30									160	0.0	0.0	0.0
31									200	0.0	0.0	0.0
32									250	0.0	0.0	0.0
33									315	0.0	0.0	0.0
34												
35												
36												
37												
38												
39			Database name									
4	Þ		None +									

Figure 26 "New receiver" values and parameters.



	А	В	С	D	E	F	G	Н	I.	J	К	L	М	Ν	Ο	Р
1																
2		Info	ormation					Mea	isured data		RIVAS 1			RIVAS 2		
3										1	1	1	1	1	2	1
4			ITEM	VALUE	UNIT				transfer function:	Cb2	Cb3	Cb4	Cb2	Cb3	Cb4	Cb2
5									name:	Houses	Concrete floo	rypical roo	Houses	Concrete floor	Typical room	Houses
6									informations:	Soft soil	31.5 Hz	ncrete flo	Soft soil	31.5 Hz	ight-weigth floor	Soft soil
7			Database name	RIVAS					frequency (Hz)	dB	dB	dBA	dB	dB	dBA	dB
8									1	NaN	NaN	NaN	NaN	NaN	NaN	NaN
9			Number of receivers	21					1.25	NaN	NaN	NaN	NaN	NaN	NaN	NaN
10			INPUT						1.6	NaN	NaN	NaN	NaN	NaN	NaN	NaN
11			Cb2, Cb3, Cb4 input unit	dB					2	NaN	NaN	NaN	NaN	NaN	NaN	NaN
12			Cb2, Cb3, Cb4 - dB ref	5.00E-08	m/s				2.5	NaN	NaN	NaN	NaN	NaN	NaN	NaN
13			OUTPUT						3.15	NaN	NaN	NaN	NaN	NaN	NaN	NaN
14			Cb2, Cb3 output unit	dB					4	-3.0	3.5	-93	-3.0	3.5	-103	-3.0
15			Cb2, Cb3 - dB ref	5.00E-08	m/s				5	-2.5	2.5	-93	-2.5	2.5	-103	-2.5
16			Cb4 output unit	dBA					6.3	-2.2	2.5	-93	-2.2	2.5	-103	-2.2
17			Cb4 - dB ref	2.00E-05	Pa				8	-2.8	2.2	-93	-2.8	2.2	-103	-2.8
18									10	-4.0	2.5	-63.4	-4.0	2.5	-73.4	-4.0
19									12.5	-5.8	3.5	-56.4	-5.8	3.5	-66.4	-5.8
20									16	-6.8	4	-49.7	-6.8	4	-59.7	-6.8
21						÷.			20	-8.0	8	-43.5	-8.0	8	-53.5	-8.0
22			Cb2 = vibration transfer fu			a			25	-12.5	14	-37.7	-12.5	14	-47.7	-12.5
23			building to the fo	bundation buildi	ng				31.5	-13.0	16	-32.4	-13.0	16	-42.4	-13.0
24			Cb3 = vibration trans	fer function fro	m the				40	-14.5	12	-27.6	-14.5	12	-37.6	-14.5
25			foundation building						50	-16.8	10	-23.2	-16.8	10	-33.2	-16.8
26									63	-14.5	10	-19.2	-14.5	10	-29.2	-14.5
27			Cb4 = vibra-acoustic tra						80	-12.5	6	-15.5	-12.5	6	-25.5	-12.5
28			building floor to the ac	oustic level in t	he room				100	-7.8	5	-12.1	-7.8	5	-22.1	-7.8
29									125	-6.2	4	-9.1	-6.2	4	-19.1	-6.2
30									160	-7.5	3	-6.4	-7.5	3	-16.4	-7.5
		RIV	AS (+)								-		E 4	-		

Figure 27 "New receiver" values and parameters - example.

Save and exit the Excel file and "Validate" to go back to the main menu, with the new receiver database available.







3.5 Start a computation

All computations will be saved into the folder "Projects\Current_project". Results are written in the subfolder "\Results", in the files "VelocityLevels.mat" and "Results.txt" (see Appendix 2 for description). The sub sub folder "\Results\Current_run" contains intermediate results in matlab format. All the results will be overwritten when a new computation is performed.

→ If you want to save results after each computation, copy the "Current project" folder in a "new name project" folder in the "Projects" folder.

Computation overview

Computations are performed on a combination of sources, propagation terms, and receivers, which are:

- Selected and loaded sources, propagation and receivers from the available data.
- A group is associated with each component (source, propagation or receiver):
 - G1, G2, G3 for Sources,
 - G4, G5, G6 for Propagation terms,
 - G7, G8, G9 for Receivers,
 - Several sources, propagations or receivers may be included in each group.
- Some information is needed, such as speed, distance, ... in the right table (after loading the component):
 - Only one distance is permitted,
 - Several speeds are allowed.
- Set up the computation table by creating "Variants" (Vi).

1 2 3 4	the i	part is fill user to combin	set up		E This	۶ part is	G autom	H atically filled in, ba	sed on interface	software
5	ant by selecti	ng groups - gr	oups are de	tailled fron						
6	Variants	source	ropagatior	receiver		Gro	ups		Group con	
7	V1	G1	G4	G7			G1	LINCENT_ICA_Lf_rail_head	Lincent_Thalys	List of loaded sources and
8	V 2	G2	G4	G8		Sources	G2	Lincent_Thalys_soft_pads		their groups
9	V 3	G2	G5	G7			G3		-	U
10			1				G4	soft_soil	LINCENT_TML_hammer	List of loaded propagation
11						ropagation	G5	medium_soil		terms and their groups
12							G6		-	8 P
13	List of	variants					G7	RIVAS 1	RIVAS 2	List of loaded receivers
14						Receivers	G8	RIVAS 3		
15							G9			and their groups
16										

Figure 28 "Computation set-up" overview.







In this example:

- 3 sources are loaded; they are associated to two groups:
 - G1: "LINCENT ICA Lf rail head" & "Lincent Thalys",
 - G2: "Lincent Thalys soft pads".
- 3 propagations terms are loaded; they are associated to two groups:
 - G4: "soft_soil" & "LINCENT_TML_hammer_rail",
 - G5: "medium soil".
- 3 receivers are loaded, and associated to 2 groups:
 - G7: "RIVAS 1" & "RIVAS 2",
 - G8: "RIVAS 3".

Based on these groups, the user decided to create 3 variants:

- V1 = G1, G4, G7,
- V2 = G2, G4, G8,
- V3 = G2, G5, G7.

For each variant, all sources are combined with all propagation terms, and with all receivers, which can make a lot of computations.

The above example involves the following computations for each variant:

- V1: "LINCENT_ICA_Lf_rail_head", "soft_soil", "RIVAS 1",
- V1: "LINCENT_ICA_Lf_rail_head", "soft_soil", "RIVAS 2",
- V1: "LINCENT_ICA_Lf_rail_head", "LINCENT_TML_hammer_rail", "RIVAS 1",
- V1: "LINCENT_ICA_Lf_rail_head", "LINCENT_TML_hammer_rail", "RIVAS 2",
- V1: "Lincent_Thalys", "soft_soil", "RIVAS 1",
- V1: "Lincent_Thalys", "soft_soil", "RIVAS 2",
- V1: "Lincent_Thalys", "LINCENT_TML_hammer_rail", "RIVAS 1",
- V1: "Lincent_Thalys", "LINCENT_TML_hammer_rail", "RIVAS 2",
- V2: "Lincent_Thalys_soft_pads", "soft_soil", "RIVAS 3",
- V2: "Lincent_Thalys_soft_pads", "LINCENT_TML_hammer_rail", "RIVAS 3",
- V2: "Lincent_Thalys_soft_pads", "soft_soil", "RIVAS 3",
- V2: "Lincent_Thalys_soft_pads", "LINCENT_TML_hammer_rail", "RIVAS 3",
- V3: "Lincent_Thalys_soft_pads", "medium_soil", "RIVAS 1",
- V3: "Lincent_Thalys_soft_pads", "medium_soil", "RIVAS 2".





Sources

From the « Source » tab in the main menu, select the sources to be used for the computations from the available data, select the group to which sources will be associated, and select the speed (several speeds are allowed, separated by ';').

1 V LNCENT_C Emp intercty NMI titincent NonessuredV 2 LNCENT_D Emp help speed NMI titincent Not ressuredV 1 NCENT_C. 01 3 D11_CT_ET Num intercty KCT_J_vrogon None 2 s01_Lrcst_T. 02 s01_Lrcst_T. 02	NSTRUCTONS: support Speed (tph) The main table, select Sources, Propagations, Receivers. 150 The each table, you load one or several tens and define parameters (s distance). Voice0 You can define several tens and define parameters (s distance).
10 t01_tra6_jcNum intercity ict04 ct01 None 4 m * *	We do not an object provide the device of a value

Figure 29 Load Sources.





Propagation terms

From the « Propagation » tab on the main menu, select the propagation terms to be used for the computations from the available data, and select the group to which the propagation terms will be associated.

SIL rce Propagati		ΆF	RS	ST/	۸R		Co	mputation	ift2Rail
	valable data	medium_soil stiff_soil	Emp Emp Emp Emp Emp Emp	Soit type soft medium medium medium medium medium trave medium medium	Transfer function type DML below track DML below track DML below track DML below track TAL self read	Loaded data	s s s s s s s s s s s s s s	STRUCTONS: ELECTION OF SOURCE, PROPAGATION, RECEM- termain take, acked Sources, Propagatione, R. each taky, you bad one or several items and de- termain. The source of the source of the source of the source ack tam is included in one group. Into 30 to sources, 41 to 30 to	eceivers . fine parameters (s , , 67 to 69 for receiver, , 77 to 69 for
		Import new pr	opagation					Set-up computations	Compute

Figure 30 Load Propagation terms.







Receivers

From the « Receiver » tab on the main menu, select the receivers to be used for the computations from the available data, select the group to which receivers will be associated, and select the distance. The user can compute for several distances for one receiver, by writing for instance "10, 12, 14" in the "Distance" column. **In this case, the Analysis menu will not be available for post-processing**. The results can then be read from the ASCII file (see Appendix 2).

Propagation	 Name	RS					Loaded data		Computation INSTRUCTIONS SELECTION OF SOURCE, PR Ib the method source source of the source source source of the source	2004TON, RECEIVERS
1 2 3 4 5 6 7 8 9 10 11	RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS	Emp Emp Emp Emp Emp Emp Emp Emp Emp Emp	RIVAS1 RIVAS2 RIVAS3 RIVAS3 RIVAS5 RIVAS5 RIVAS7 RIVAS7 RIVAS9 RIVAS9 RIVAS9 RIVAS10 RIVAS11	Houses Houses Houses Houses Houses Houses Houses Houses Smal buildings Smal buildings	Soft soil Soft soil Soft soil Medium soil Medium soil Medium soil Stiff soil Stiff soil Stiff soil Stiff soil Soft soil Soft soil	Losd	Name 1 RIVAS2 2 RIVAS3 3 RIVAS4	Group Distance 67 + 10 67 + 12 68 - 15	In each tab, you load one or distance). You can define serveral spee but you can only specify one of to 30 for sources, Q4 to NMPORT NEW DATA In each tab, you can import of SETLEP AND RNN COMPUT Vent you have selected all the will open an excel the to Then save and close the exc computations.	distance for each receiver. group: G6 for propagations, G7 to G9 for re- r create new data. TONS tems, you can click on "Set-up comp specify which groups are computed el file and press the "Compute" butto reputations if you don't modify the cond.
	Import ne	w receiver								

Figure 31 Load Receivers.





Set up computations

Click on "Set up the computations": an Excel file is opened.

Fill in all variants in the corresponding table (variants list, based on the groups), see Figure 28 "Computation set-up" overview.

	Bable data	RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS RIVAS	Type Emp Emp Emp Emp Emp Emp Emp Emp Emp Emp	Database na RIVAS 1 RIVAS 2 RIVAS 3 RIVAS 3 RIVAS 3 RIVAS 5 RIVAS 5 RIVAS 6 RIVAS 6 RIVAS 10 RIVAS 11	me Cb2 - Building ty Houses Houses Houses Houses Houses Houses Houses Smal buildings Smal buildings	pe Cb2 - Soil t Soft soil Soft soil Medum soil Medum soil Siff soil Siff soil Soft soil Soft soil		Losded data Narm 1 RTVAS 2 2 RTVAS 3 3 RTVAS 4	2 Gr 07 07 08	pup Dittance (10 12 15	Computation Sector Computation NSTRUCTONS: SECTION OF SOURCE, PROPAGATION, N In the main take, odel: Sources, Propagato Autor of the several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; Value on define several speeds for excels, and deterrol; value on excels, and deterrol; detero; detero; deterrol;	ns, Receivers . nd define parameters (sper- urce, ach receiver. tions, G7 to G9 for receive ata. : tick on "Set-up computed ata. s the "Compute" button to la u don't modify the combined
--	------------	--	--	--	--	---	--	--	------------------------	----------------------------------	--	---

Figure 32 Main menu – "Set up computations".

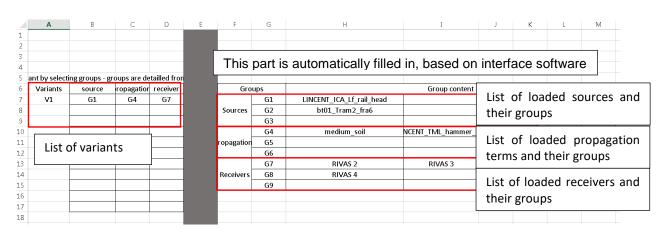


Figure 33 Set up computations Excel file





Computations

To start a computation, click on "Compute"; this launches the computations chosen in the "Set up computations" window.

												Computation
Availa	ible data								Loaded data			INSTRUCTIONS: SELECTION OF SOURCE, PROPAGATION, RECEIVERS
	Select	Name	Type	Database nan	ne Cb2 - Building typ	e Ch2 - Soil tyr	e C		Name	Group	Distance (m)	In the main take, select Sources, Pronagations, Receivers
1		RIVAS	Emp	RIVAS 1	Houses	Soft soil	C(A		1 RIVAS 2		 Distance (m) 10 	In each tab, you load one or several items and define parameters
2		RIVAS	Emp	RIVAS 2	Houses	Soft soil	C		2 RIVAS 3		 12 	distance).
3	1	RIVAS	Emp	RIVAS 3	Houses	Soft soil	W		3 RIVAS 4		15	You can define several speeds for each source,
4	V	RIVAS	Emp	RIVAS 4	Houses	Medium soil	Ce E	Load				but you can only specify one distance for each receiver. Each item is included in one group :
5		RIVAS	Emp	RIVAS 5	Houses	Medium soil	Cc					G1 to G3 for sources, G4 to G6 for propagations, G7 to G9 for re-
6		RIVAS	Emp	RIVAS 6	Houses	Medium soil	W					MPORT NEW DATA
7		RIVAS	Emp	RIVAS 7	Houses	Stiff soil	Cr					In each tab, you can import or create new data.
8		RIVAS	Emp	RIVAS 8	Houses	Stiff soil	Ct					
9		RIVAS	Emp	RIVAS 9	Houses	Stiff soil	w					SET-UP AND RUN COMPUTATIONS When you have selected all items, you can click on "Set-up compu-
10		RIVAS	Emp	RIVAS 10	Small buildings	Soft soil	C					this will open an excel file to specify which groups are computed.
11	•	RIVAS	Emp	RIVAS 11	Small buildings	Soft soil	C(*					Then save and close the excel file and press the "Compute" butto
												computations. You don't have to set-up computations if you don't modify the com groups that must be computed. By definid, the computations are some for 61=64+67.

Figure 34 Main menu – start a computation.

A progress bar will appear to indicate the advancement of computation.

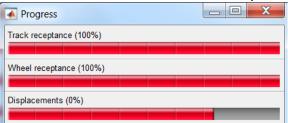


Figure 35 Progress bar for numerical sources.

When computations are finalized, a pop-up message appears.



Figure 36 End computation message.







Results are written in Matlab using the following structure / nomenclature:

- Calcul_input: Input parameters used for the computation,
- Lp_building: Noise level inside the building in dB(A),
- Lv_building_floor: Vibration level on the building floor (dB),
- Lv_building_fondation: Vibration level on the building foundation (dB),
- Lv_soil: Vibration level at the soil surface (free-field) (dB).





3.6 Analysis – Velocity and Noise levels

To plot the results, click on the "Analysis" menu:

- "Velocity levels..." for vibration analysis,
- "Noise levels..." for acoustic analysis.

Ievels rets Ie Propagation Receiver	^	RS	ST/	۸R]			Loaded data			Computation
Select 1 2 4 4 5 6 7 8 9 10 11 11 4 5 6 10 11 10 11 4 5 10 10 10 10 10 10 10 10 10 10	Name RVAS RVAS RVAS RVAS RVAS RVAS RVAS RVAS	vr receiver	Database na RYAS1 RYAS2 RYAS3 RYAS3 RYAS3 RYAS5 RYAS5 RYAS5 RYAS5 RYAS5 RYAS5 RYAS1 RYAS1 RYAS1	me Cb2 - Building ty House House House House House House House House House Smalt Luttors	ppe Cb2 - Soit by Soft soit Soft soit Soft soit Medum soit Medum soit Medum soit Medum soit Shiff soit Shiff soit Shiff soit Soft soit	pe C ∧ C ∧ C ∧ C ∧ C ∧ C ∧ W ≡ W ∧ C ∧ C ∧ C ∧	Load	Name 1 RIVA5 2 2 RIVA5 3 3 RIVA5 3	Group 07 → 0 07 → 0 08 → 0	12	SELECTION OF SOLRCE, PROPAGATION, RECEVERS In the non-time, select Sources, Propagation, Receivers . Not can define several speeds for each source, but you can define several speeds for each source, 10 con define several speed for each source, 10 con define several speeds for each speeds for each source, 10 con define several speeds for each speed several speeds for each speed 10 con define several speeds for each speeds for each speed

Figure 37 Main menu – Analysis.





Velocity levels

The file "VelocityLevels.mat" is automatically loaded from the "Current_project" folder (corresponding to the last run).

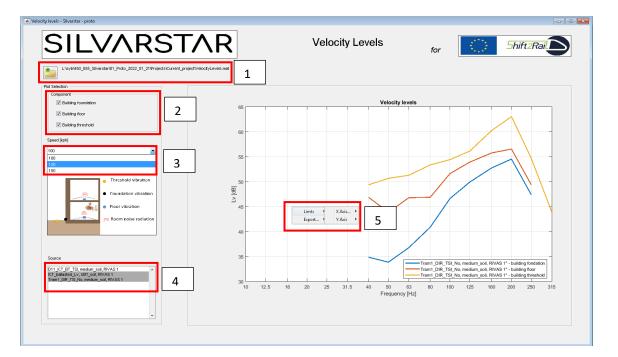


Figure 38 Velocity analysis window.

- 1- Open results "VelocityLevels.mat" file (to view another saved result).
- 2- Select where vibrations have to be analysed (Threshold, Foundation, Floor).
- 3- Select the speed (depending on the input parameters given by the user, some speeds may not be available for each source).
- 4- Select sources to visualise.
- 5- Right click on the figure to modify limits or export the figure.





Acoustic analysis

The noise analysis window is very similar to the velocity analysis window. Only the noise (inside the building) is selectable.

	Noise Levels	for	<u>Shift2Rai</u>
Pid Selection Seed Park 12	Noise level	Limt +	T. TSI, medum, soit, RIVAS 1° - building 1, TSI, medum, soit, RIVAS 1° - building 1, 125 180 200 250 315

Figure 39 Acoustic analysis window.

- 1- Open results "VelocityLevels.mat" file.
- 2- Select the speed (depending on the input parameters given by the user, some speeds may not be available for each source).
- 3- Select sources to visualise.
- 4- Right click on the figure to modify limits or export the figure.





4. References

G. Degrande, G. Lombaert, E. Ntotsios, D. Thompson, B. Nélain, P. Bouvet, S. Grabau,
 J. Blaul, A. Nuber. State-of-the-art and concept of the vibration prediction tool.
 SILVARSTAR Deliverable D1.1, May 2021.

Horizon 2020

European Union Funding for Research & Innovation

- [2] D. Thompson, E. Ntotsios, G. Degrande, G. Lombaert, G. Herremans, T. Alexiou, B. Nélain, S. Barcet, P. Bouvet, B. Fröhling and A. Nuber. Database for vibration emission, ground transmission and building transfer functions, SILVARSTAR Deliverable D2.1, January 2022.
- [3] P. Reumers, G. Degrande, G. Lombaert, F. Seyfaddini, G. Herremans, E. Ntotsios, D. Thompson, B. Nélain, P. Bouvet, A. Nuber. Validation of the prototype vibration prediction tool against documented cases, SILVARSTAR Deliverable D1.3, June 2022.







APPENDICES



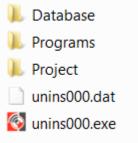




APPENDIX 1: Installation procedure

A set-up file "Silvarstar_setup_1.1.exe", is dedicated to the set-up. During installation, the user may install the software in any Windows path. However, the user must have access to this folder with administrator rights.

The following architecture will be implemented at the designated location:



The application to start the software is in the "Programs" folder.

Silvarstar_prototype.exe

The user must plug the USB Dongle provided by VIBRATEC in order to use the software tool.

To uninstall the tool, simply double-click on the unins000.exe file.







APPENDIX 2: Description of result file "Results.txt"

The results are written in ASCII, and can be opened with excel. It is located in the folder \Project\Current_project\Results

Figure 41 shows an example, with 10 results (line 2). Only the first result is presented in the figure.

The data for result 1 is listed from line 5 to line 51.

Metadata sets are listed from line 6 to 20, and the data values are listed from lines 24 to 51. The data consists in the building vibration and noise levels.

The file can be opened in excel for plotting or post-processing, as illustrated in Figure 40.

	А	В	С	D	E	F	G	н	Ι	J	К
1	Comma separated file	CSV									
2	number of results =	10									
3											
4						c					ĹĘ
5	RESULT	1				80.00					
6		SOURCE description				70.00					
7	1	. 1				70.00	Ν				
8	source name	LINCENT_ICA_Lf_rail_head				60.00					
9	train speed	100				50.00					
10	wheel unenvenness	None				50.00	M				
11	track name	btlincent				40.00					
12	rail unenvenness	Ballasted	track - Norm	ally maintain	ed	30.00					
13		PROPAGATION description				30.00					
14	1	. 1				20.00					
15	propagation name	LINCENT	TML_hamme	er_rail		10.00					
16		RECEIVER	description			10.00					
17	1	. 1				0.00					
18	database name	RIVAS				0.00	100.00	200.00	300.00	400.00 500.0	0 600.00
19	receiver name	RIVAS 3				C					í í
20	receiver distance	10									
21		DATA									
	freq(Hz)			Lv (dB re 5e							
23			-	ubuilding flo	-	om					
24	1	10.58	NaN	NaN	NaN						
25	1.25	12.54	NaN	NaN	NaN						
26	1.6	14.55	NaN	NaN	NaN						
27	2	18.02	NaN	NaN	NaN						
28	2.5	22.4	NaN	NaN	NaN						

Figure 40 result file opened in excel







⊢---+----6----+----7----+----8----+---Comma separated file, csv 1 2 number of results = ,10 3 4 5 ERESULT,1 6 ,SOURCE description 1,1 7 8 source name ,LINCENT_ICA_Lf_rail_head 9 train speed ,100 10 wheel unenvenness ,None 11 track name ,btlincent 12 🗄 rail unenvenness ,Ballasted track - Normally maintained 13 , PROPAGATION description 14 1,1 15 B propagation name ,LINCENT TML hammer rail 16 ,RECEIVER description 17 1,1 18 database name ,RIVAS
19 receiver name ,RIVAS 3 20 ⊟receiver distance,10 , DATA ۲ 22 = freq(Hz), Lv (dB re 5e-8 m/s), Lv (dB re 5e-8 m/s), Lv (dB re 5e-8 m/s), Lp (dBA re 2e-5 Pa) 23 ,free field,building foundation,building floor,building room 24 1,10.58,NaN,NaN,NaN 25 1.25,12.54,NaN,NaN,NaN
26 1.6,14.55,NaN,NaN,NaN 27 2,18.02, NaN, NaN, NaN 28 2.5,22.4, NaN, NaN, NaN 29 3.15,28.55,NaN,NaN,NaN 30 4,32.01,29.01,36.51,-66.49 31 5,33.92,31.42,38.42,-64.58 6.3,39.87,37.67,44.17,-58.83 32 33 8,36.31,33.51,40.51,-62.49 34 10,36.22,32.22,43.22,-30.18 35 12.5,46.1,40.3,56.3,-10.1 36 16,55.81,49.01,69.01,9.31 20,59.93,51.93,65.93,12.43 37 38 25,53.5,41,51,3.3 39 31.5,53.48,40.48,47.98,5.58 40 40,60.67,46.17,52.17,14.57 41 50,71.74,54.94,60.94,27.74 42 63,70.69,56.19,61.19,31.99 43 80,62.96,50.46,56.46,30.96 100,60.4,52.6,56.1,34 44 45 125, 43.37, 37.17, 39.17, 20.07 46 160,34.47,26.97,24.97,8.57 47 200,29.83,21.33,17.83,3.93 48 250, 25.24, 17.94, 12.94, 1.34 49 315,21.71,NaN,NaN,NaN 50 400,16.92,NaN,NaN,NaN 51 500,14.79,NaN,NaN,NaN 52 53 54 ERESULT, 2 55 SOUDCE description

Figure 41: example of result file in ASCII format, to be opened by excel