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INNOTRACK

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Glossary

ADIF	Administrador de Infraestructuras Ferroviarias (Spain)
BV	Banverket (Sweden)
CD	Ceske drahy,a.s. (Czech Republic)
DB	Deutsche Bahn AG (Germany)
EN	European standard
HSL	High speed line
ÖBB	Österreichische Bundesbahn (Austria)
SNCF	Société Nationale des Chemins de Fer Français (France)
UIC	Union Internationale des Chemins de Fer
GIS	Geographic Information System
OGC	Open Geospatial Consortium
XML	Extensible Markup Language
RSMV	Rolling Stiffness Measurement Vehicle (BV)
OMWE	(Oberbaumesswageneinheit, DB) Track recording vehicle using inertial platforms
EM-Sat	Track recording vehicles acquiring irregularities using geodetic measurements (developed by Plasser & Theurer, Austria)
PANDA	lightweight hand held dynamic cone penetrometer for testing soils (developed by Dr. R. Gourves at CUST, Blaise Pascal University, Clermont-Ferrand, France)
SAW	Surface acoustic waves, e.g. Rayleigh-waves
RC-Test	Resonant-Column-Test: dynamic laboratory test for soils and rocks

Longitudinal	direction along a track-line (x-axes)
Transverse	direction perpendicular to track-line (y-axes)
Vertical	direction perpendicular to xy-plane (z-axes), negative: from surface to subgrade
Global coordinates	“fixed” points, e.g. milestones along the track-line,
Local coordinates	points relative to position of track-line (e.g. longitudinal and transverse)

1. Summary

This report reflects the state of the in-situ database in SP2.1. Showing different examples of data and data set gathered for the use in a smart database with continuous improvements. Within SP2.1 a big variety of scales have to be combined. The database should give the possibility to recognize the evolution of track irregularities using different methods of investigations of track and subsoil. Data from conventional and improved soil investigations as well as dynamic measurement methods with vehicles (e.g. OMWE) are gathered therefore.

This report, including structures and methods presented, will be used as a basis for collecting and migrating data within WP2.1 and the other subprojects. The examples shown are provided by the partners. They include data from track lines with significant track irregularities.

2. Introduction

Track support structure is considered in SP2. WP2.1 is focused on track bed quality assessment. Tasks for quality assessment of the track-bed are:

- Set out relevant parameters to be measured
- Identify the most relevant measurement techniques for each physical parameter
- Produce a methodology for variability identification and evaluation
- Devise methodologies for classification of subgrade conditions taking into account a combination of the measured parameters.

The major questions can be summarised as:

- How subgrade/subsoil Influences the long and short time behaviour of track?
- How the operated track interacts between the subgrade/subsoil?
- Which external influences have be taken into account additionally?

In order to give answers to these questions in WP2.1 methods based on measurements of subgrade parameters and track behaviour were applied. The measurements concern stiffness and its variability, track behaviour as well as the characterisation of the area below the rails by means of geophysical methods, penetrometer, endoscopy, sampling and lab testing.

The results of the in-situ measurements will be gathered in a database for internal use in SP2 at first. Since databases are the backbone of SP1, the structure of data and database will be matched. The connections with SP1 and SP6 have been established with meetings. A meeting organised by SP2 Paris, January, 11th, 2008 with participants from SP1 and SP2 concerns the topics *database and segmentation process in SP1*. Additionally models for simulations in SP1 addressed to the production of costs and to give decision support were presented. The models considered include wear and fatigue of rails and settlement of track depending on vehicle type and track irregularities. In SP1 a database connected with the models will be built up and completed with the end of the project. Then it is proposed to be transferred to a UIC-server. Three orders of magnitude of segment lengths depending on the level of detail will be used in SP1. The data segments are matched to the track. It was shown that SP4 (focused on rails) uses an adapted segmentation scheme, for large segments for straight track sections and a high level of detail for curve segments. Bottom up (detailed to global view) and top down approaches were tried in SP6. The preliminary state of the work in SP6 was presented in a meeting of SP1 and SP6 (see: int_sp1_19_071108_f_db_track_segmentation.pdf). It is intended to integrate the results of SP2 into the database of SP1 as far as possible.

In the following sections the data structures required for SP2 internal work will be introduced. A database in general is a collection of well organised data and set relations to be applied on them. Low or in extreme no redundancy is characteristic for the quality of a database. In this sense we are far away from having a high quality database at present. The reasons why will be explained in the following sections. This is related to two aspects mainly: one is the need of redundancy since methods and measurements techniques being developed have to be checked and the other concerns effects that are eventually not observable by measurements currently being performed.

The data gathered in SP2 cannot be abstracted in such a way, that they can be included in a relational database. Therefore the database lacks one of its essential benefits. It will be shown that there are some missing links that will be bridged during the project. Numerical methods for signal processing and statistics will be applied for processing the data in this project. These require data sets which are equally sampled in time and/or space. This is in contrast to the compact approach applied for the database in SP1. Thus, results from processing can be adapted to the requirements of SP1. Seeing these consequences coming up, the word preliminary was added to the title of the report. A continuous update process is initiated starting with this deliverable. Filters have to be used for implementing data and results from SP2.1 to SP1.

3. Data and data-structure

For the description of the geometrical dimension only one spatial dimension (1-D, means “one co-ordinate” along the track) is sufficient. A database with two dimensional objects like a GIS-based data base is not required. Thus, the methods for including additional data, like this is done in OGC, will be checked for application. In contrast to conventional GIS the database must be able to reproduce a temporal evolution also.

3.1 Geometrical dependencies

The corresponding direction along the track is called longitudinal. The direction is positive with increasing values, e.g. position identifier of track, position of milestone. All other data are referred to a longitudinal coordinate. The local system of coordinates is a right-handed rectangular (Cartesian) system. The direction along the vertical axis is negative while going from track into subgrade.

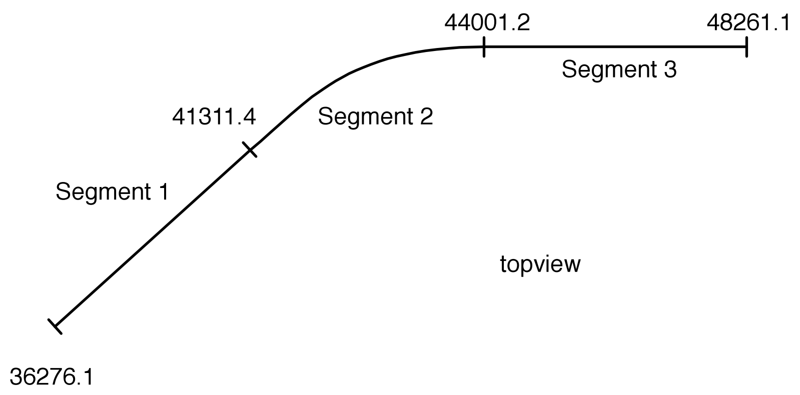

Figure 1: Track divided in three segments

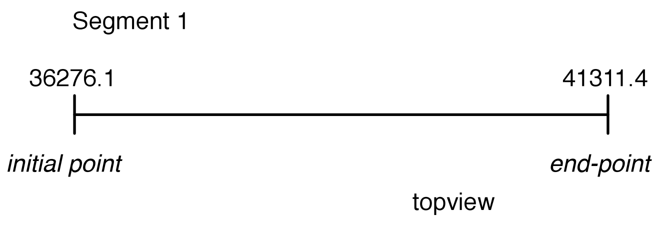

Figure 2: Track segment

The track consists of several track segments, e.g. like Figure 1. The segment is identified by reference points (initial and end points) in the global coordinate system and a segment identifier, e.g. like Figure 2. Local coordinates are used for including geometry referred data (Figure 3), e.g. results from sounding, geophysical measurements, etc.

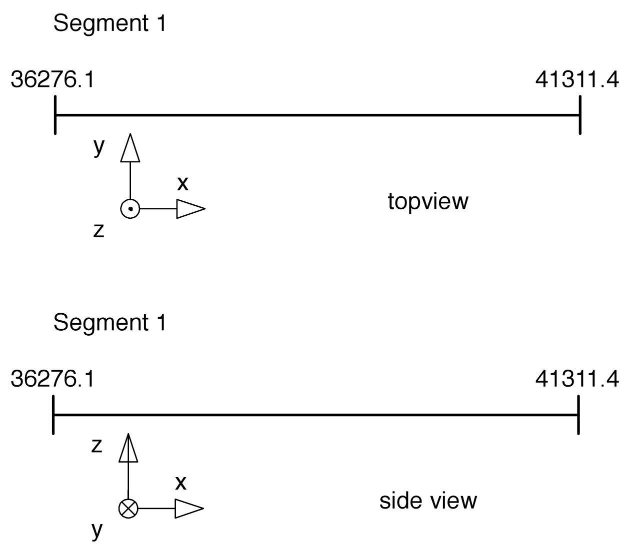

Figure 3: System of global and local co-ordinates, topview and side view

3.2 Temporal dependencies

In the time domain there are three possible conditions:

- no time dependence,
- no time dependence during individual passages of trains, but changes occur gradually (slowly varying with time, evolution) with respect to one parameter, e.g. track irregularities measured along the track at a certain date and time,
- time dependence during operation, e.g. individual passages of the trains, but also changes with time, with respect to a variable, e.g. time records of vibrations (fixed receiving sensor), raw data from measurements of track stiffness RSMV (moving sensors).

Additionally a transfer from time domain to spatial domain is performed by e.g. RSMV-data for constant speed with Galilean transformation.

3.3 Requirements for input

The data being placed in a database require an index to be accessed. In general two categories of data have to be considered:

1. Unstructured data: pictures, plans, scans, Portable-Document-Format (PDF), etc. For these data a keyword index is necessary to be used in a database. It requires time consuming manual pre-processing.

2. Structured data: These are tables can contain data like geometry, measurement results and interpretation of results, material properties, track irregularities, etc. For these data indexing is possible. Automated scripting can be applied.

The database itself contains a master-table. The first dimension divides the different track segments; the second contains the different data types. For slowly time varying processes the third dimension is used for time. The fields store information specifying, if the specific data is available and where it is stored. Empty fields have to be allowed to indicate that the data is not captured.

3.4 Track data and subgrade/subsoil data

Data proposed to be used in SP2. The list will be updated according to definitions for database in SP1 and further needs in SP2.1. A major aspect is the detection of the evolution of irregularities referred to subgrade/subsoil. The partitioning follows these guidelines. It is divided in track data and soil data from subgrade/subsoil.

- Track data
  - General description
    - type of railway line (speed, axle load, mixed traffic,..)
    - track type (ballasted track, slab track)
    - additional information: types of sleepers, rails, under sleeper pads, …
    - …
  - Geometry and material properties along track
    - placement (plain, embankment, cut, bridge, tunnel, …)
    - referenced to rail (switches, crossings, isolations cuts, level-crossing, …)
    - position, survey (curvature, inclination, …)
    - thickness, profile and state of ballast layer
    - type, thickness and state of sub-ballast layer
    - soil layers
    - drainage
    - …
  - Track irregularities, stiffness
    - stiffness and stiffness variations (RSMV-data)
    - inertial measurements (OMWE)
    - geodetic measurements (EM-Sat)
    - settlement profiles
    - …
- Soil data from field investigations
  - soil profile (drillings)
  - soundings (dynamic penetration tests, PANDA)
  - sampling (disturbed / undisturbed)
  - groundwater table and its variations
  - plate bearing tests (stiffness)
  - determination of density index
  - shear-wave velocity (SAW-method)

- Soil data from laboratory investigations
  - soil classification
    - grain size distribution
    - classification of soil type
    - index tests (minimum & maximum weight)
    - grain density
  - penetrability, degree of saturation
  - compression test
    - Stiffness → settlements
  - shear test
    - triaxial tests (higher shear strain amplitude) → stability survey
    - RC-test (small shear strain amplitude) → long term behaviour

A new EN ISO Standard concerning documentation of field testing is under preparation, but until now not ready for use.

4. Data and Methods

4.1 Data gained / used in SP2.1

Scope of interest within SP2.1 is the section below the rails beginning from ballast layer to subsoil. The measurements performed in SP2.1 concern stiffness and its variability, track behaviour as well as the characterisation of the area below the rails by means of geophysical methods, penetrometer, endoscopy, sampling and lab testing.

Data is divided in various categories:

Partitioning the soil material referred data in two categories is useful:

1. material content (type of soil, e.g. gravel)
2. state (e.g. density of subsoil).

The content of the data should be separated in:

- parameters to be constant:
    - overall geometry
    - composition of sections and layers
- state / slowly varying with time:
    - density of ballast and subsoil
    - water content of subsoil
    - track geometry (settlements, transverse deviations, …)
    - stiffness

Gaining the data is divided in two main variants:

- Measurements related to global coordinates

  Field investigations (soil data) are usually performed at specific points of interest.

- Moving observer

  Repeated measurement are taken along the track to observe the evolution of changes in state near the surface. The data must be gained longitudinal with referenced initial point and time.

  Since the measurement is taken by vehicles moving on the rails interactions, e.g. boogie/track, wheel/rail-contact can influence the results.

4.2 Methods applied to data

Most of the raw data has to be linked to each other and has to be interpreted, e.g. data from sampling and results from penetrometer measurements. A further aspect being considered during the project is the generalisation of these data.

A more detailed view is necessary for longitudinal data, e.g. track irregularities and stiffness variations. The data is processed by means of signal analyses, filtering and statistical analyses, e.g. correlations, distributions, spectral analysis. The processing will be performed outside the database, since the operations are to complex.

The processing of data requires that the data is identically sampled in spatial and time domain. Otherwise re-sampling followed by low-pass filtering has to be performed. Point orientated data, e.g. position of isolation cuts, switches, etc. have to be treated in similar way to generate time series. Then the same statistical methods can be applied.

The results of calculation will be linked to/placed in the database.

4.3 Exchange of data

During development it is advantageous to have the data on a local server. The partners in SP2.1 have access over two interfaces. In a first step data will be transferred by a WEB-Interface and is available for processing and exchange within SP2.1, Figure 4. Alternatively a SSH-based interface to login and file-transfer with up and download is provided.

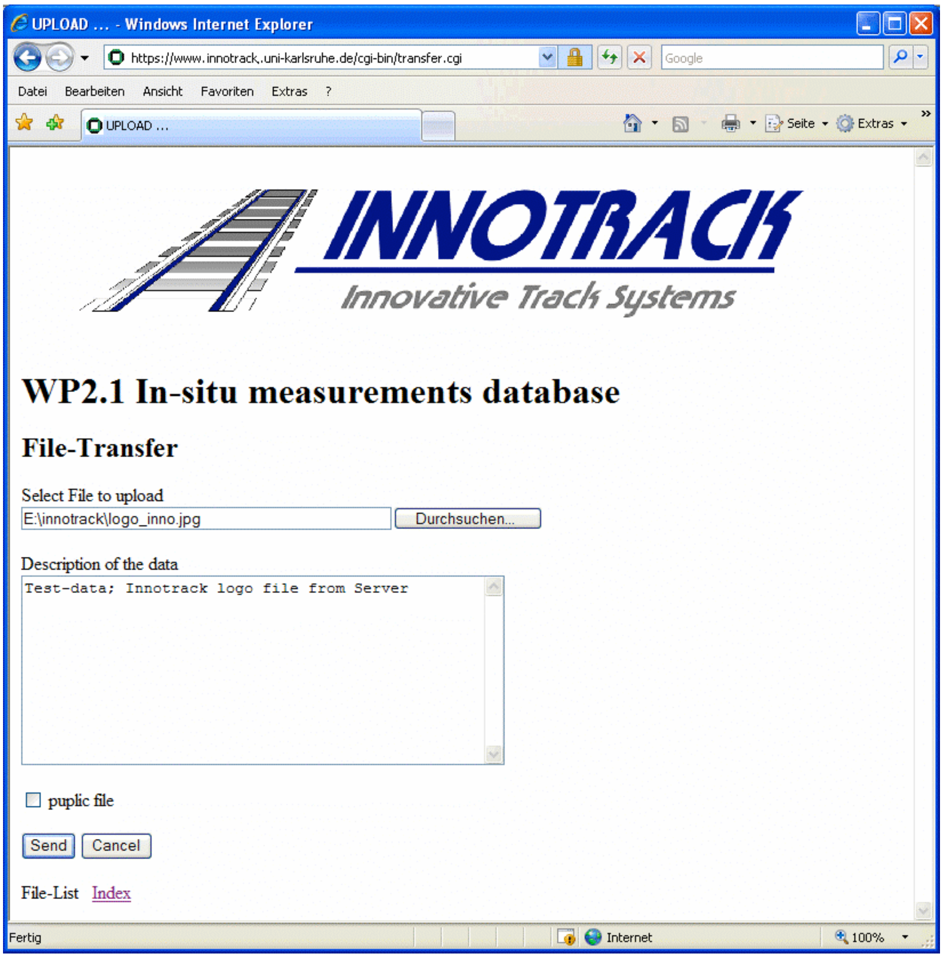

Figure 4: Web-Interface for file-upload

Currently the data input format for simple table is text based. Finally an XML based input will be preferred. XML-based tables are text based, therefore experts need no additional front-end for reading. For the input a smart interface is needed for hand-operated and automated input. Both will be built up from the same EXCEL-sheet schemes.

4.4 Examples of input-data

Four examples of datasets show the different types of data to be captured. Errors resulting from typical inconsistencies will be pointed out.

4.4.1 Field-investigation: soil profile

The soil profile includes the ballast layer. Usually only a narrow area below the sleeper is investigated. Graphs are labelled in national languages, Figure 5. For exchange a structured data like in Table 1 is more convenient. Each profile needs a position in the local or the global coordinate system.

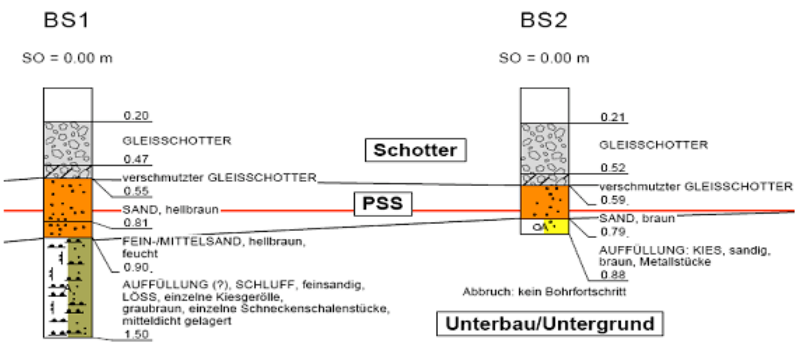

Figure 5: Soil profile, graphs of soil profiles, unstructured data (in German)

Nr.	Depth	Classification		lab test
BS1	0.20	ballast	G	sieving
	0.47	messy ballast	G	-
	0.55	sand light brown	S	sieving, index
	0.81	fine sand, wet	fS	-
	0.90	silt, fine sand	U, fs	sedimentation
	1.50			
	…	…	…	
BS2	0.21	ballast	G	
	0.52			

Table 1: Soil profile, structured data

4.4.2 Field-investigation: sounding

The starting points of 4 soundings are shown in Table 2. The data type is structured data. The data is time invariant or only slowly varying with time. The column named point(x,y,z) contains global coordinates for data in x-direction. Local coordinates are used for y and z directions. They are referred to longitudinal axes of the closest rail. The z-direction is measured relative to rail-level. Since the values in Table 2 are positive sounding was performed on a slope in an embankment (negative indicates a cut section).

Nr.	type	depth	point (x,y,z)
1	DPL	5.0	34 100.001, 1.025, 4.000
2	DPL	6.5	34 100.012, 2.120. 3.800
3	DPL	2.3	34 095.321, 2.274, 3.812
4	DPH	7.1	34 075.457, 1.985, 2.815
…	…	…	…

Table 2: positions of sounding, depth, and type of sounding

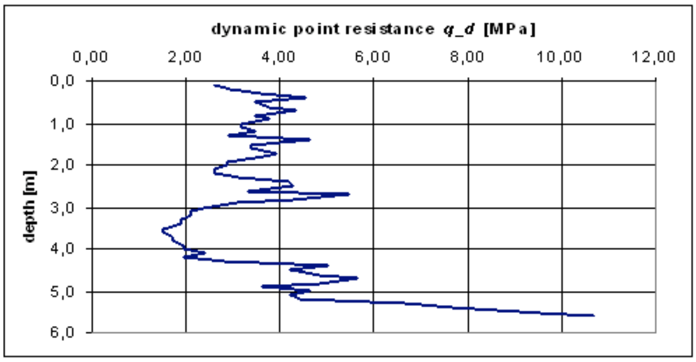

Figure 6: results from sounding, dynamic point resistance

The results from sounding are structured (Table 3) and unstructured data (Figure 6). For a quick overview figures are very helpful. Errors due to national specialities, e.g. decimal, list separators etc., have to be avoided. In table 3 the German decimal separator comma was used in the basic Excel sheet. In the next step rule-based input using XML as an input language will result in consistent datasets. Language specific characters are included in XML also making the data transferable.

Nr.	Depth	N_{10}	q_d [MPa]
1	0,1	8	2,61
	0,2	9	2,94
	0,3	11	3,59
	0,4	14	4,57
	0,5	12	3,49
	0,6	13	3,78
	0,7	15	4,36
	0,8	12	3,49
	0,9	13	3,78

Table 3: results from sounding, dynamic point resistance at point Nr. 1, see Table 2

4.4.3 Evolution of track irregularities

Track irregularities were acquired by means of inertial or geodetic systems. The irregularities reflect the processes within the track eventually down to the subsoil. These measurements are not only of importance for SP1, they are of high importance for SP2.1 also.

Inertial systems (dynamic systems) are characterised by a transfer function of a bandpass-filter with lower and upper limiting frequencies. Indicators fixed to the track are used as an additional spatial synchronisation for the continuously acquired data. At least data for both rails in vertical deflection are available. The measurements can be performed with higher vehicle speeds.

Systems using geodetic measurements show a transfer function of a high pass filter. The track data is taken in sections (local coordinates). The positions of reference points, e.g. catenary poles, link local to global coordinates. The vehicle speed is relatively low, but results can be directly compared with those of stationary geodetic measurements.

The evolution of irregularities can be identified with both systems. Data is given in global coordinates equally or unequally spaced. Unstructured data, like plots, are helpful in practise, Figure 7 and Figure 8.

Figure 7: evolution of track irregularities measured by inertial systems

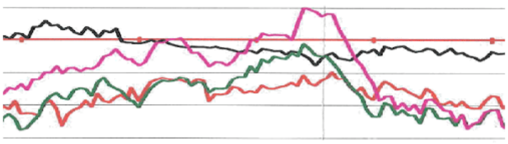

Figure 8: evolution of track irregularities measured by geodetic system

4.4.4 RSMV data

The stiffness and its variations is calculated from RSMV data. Data is taken from measurements with or without excitation. The arrangement of data is explained in a read-me-File. The data is organised in various manners. Figure 9 shows a 2D-matrix for a passage without additional excitation. Additionally two 1D-arrays are needed for mapping. The spatial index is mapped to the global coordinates. The frequency index is mapped to frequency. Data need not to be equally spaced.

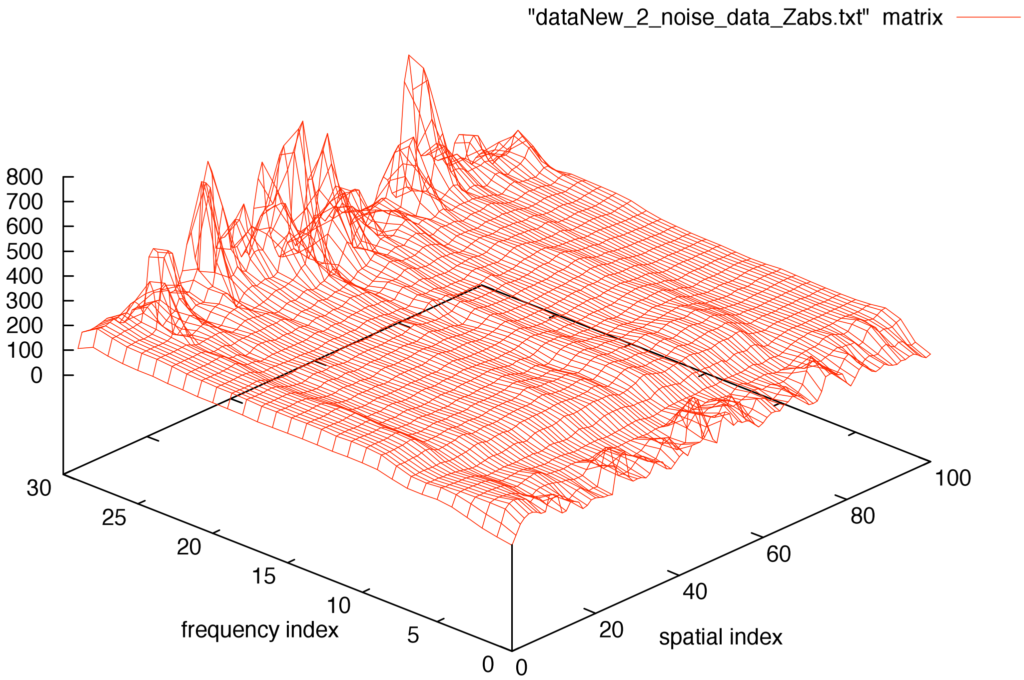

Figure 9: RSMV Stiffness data vs. position and frequency

5. Conclusions

This report is the basis for collecting and distributing data within SP2.1. This is an evolving process growing during the project. The partners in the project want to have a compact, flexible and easy to use system. In the next step an Excel spreadsheet for data gathering will be available. A server hosted by the University of Karlsruhe will be available for the partners in SP2.1 at the beginning of May 2008. The database will be further influenced by the evolutions SP1. This report should serve as a basis for further exchange of concepts, ideas and results between SP2.1, SP1 and SP6.

6. Bibliography

Track segmentation, Top down and bottom up approach, DB Systemtechnik, TZF62 (int_sp1_19_071108_f_db_track_segmentation.pdf)