LÄRM FORSCHUNG EISEN BAHN
FAHRBAHNLABOR

MÜLLER-BBM
RAIL TECHNOLOGIES

Monthly report

Railway Field Laboratory

November 2023

Client:	Swiss confederation; Federal Offices for the Environment (FOEN) and Transport (FOT), CH-3003 Bern The FOEN and the FOT are offices of the Federal Department of the Environment, Transport, Energy and Communications (DETEC).
Consultant:	Müller-BBM Rail Technologies GmbH Helmut-A.-Müller-Straße 1 - 5 82152 Planegg www.MuellerBBM-Rail.com
Author:	Natan Isert, Stefan Lutzenberger
Supervision BAFU / BAV:	Fredy Fischer Franz Kuster, Christoph Dürig
Remarks:	This report was published on behalf the Swiss Federal Office for the Environment (FOEN) and Transport (FOT). The consultant is responsible for the content and all data displayed.
Version:	V2 Data basis: Database V3
Date:	26.2.2024

1. Status railway field laboratory

Construction work on the tracks:

- none

Downtimes of the measurement systems:

- none

Downtimes of the sensors:

- MQ 1_1: a-mq11-2-rh (probably caused by parts of a train hanging down) 7.10.- 8.12.
- MQ 1_2: a-mq12-4-rf (due to defect) 14.10. – 17.11
- MQ 1_3: a-mq13-2-rh (probably caused by parts of a train hanging down) 7.10.- 8.12.
- MQ 2_1: a-mq21-2-rh (probably caused by parts of a train hanging down) 7.10.- 8.12.
- MQ 2_2: a-mq22-2-rh (probably caused by parts of a train hanging down) 7.10.- 8.12.
- MQ 2_3: a-mq23-2-rh (probably caused by parts of a train hanging down) 7.10. -
- REF: a-ref-2-rh (probably caused by parts of a train hanging down) 23.10.- 8.12.
- REF: a-ref-4-rh (probably caused by parts of a train hanging down) 23.10.- 8.12.

Maintenance and sensor exchange:

- MQ 1_2: a-mq12-4-rf (due to defect) 17.11

Modifications to the data, database, or analysis:

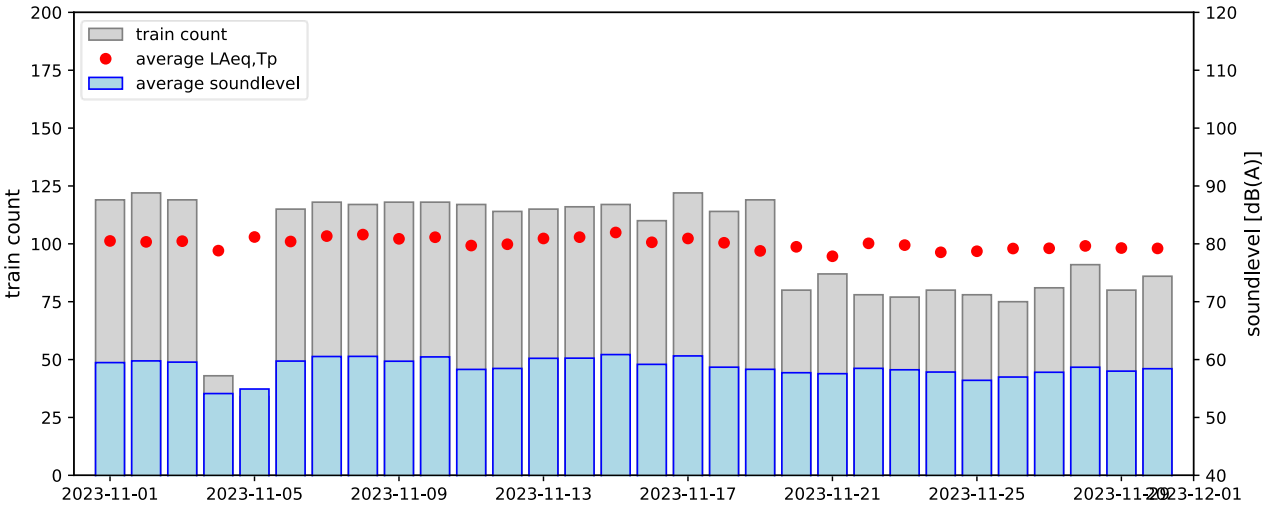
- none

Monthly data volume collected:

- 470 GB

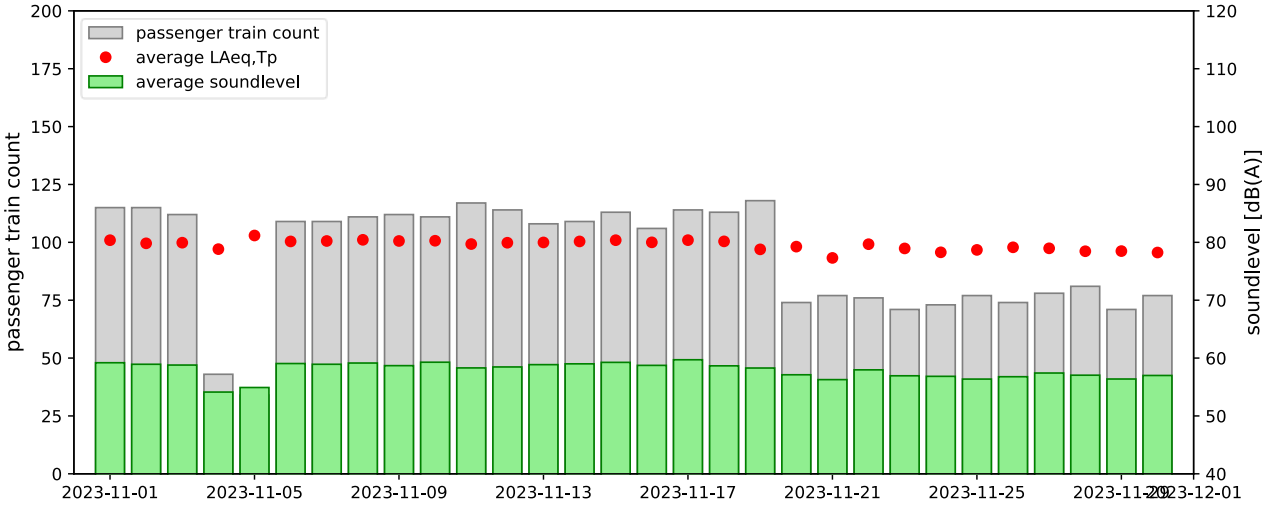
2. Measurement data

Daytime averages (24h) for all train passages at reference section (REF)



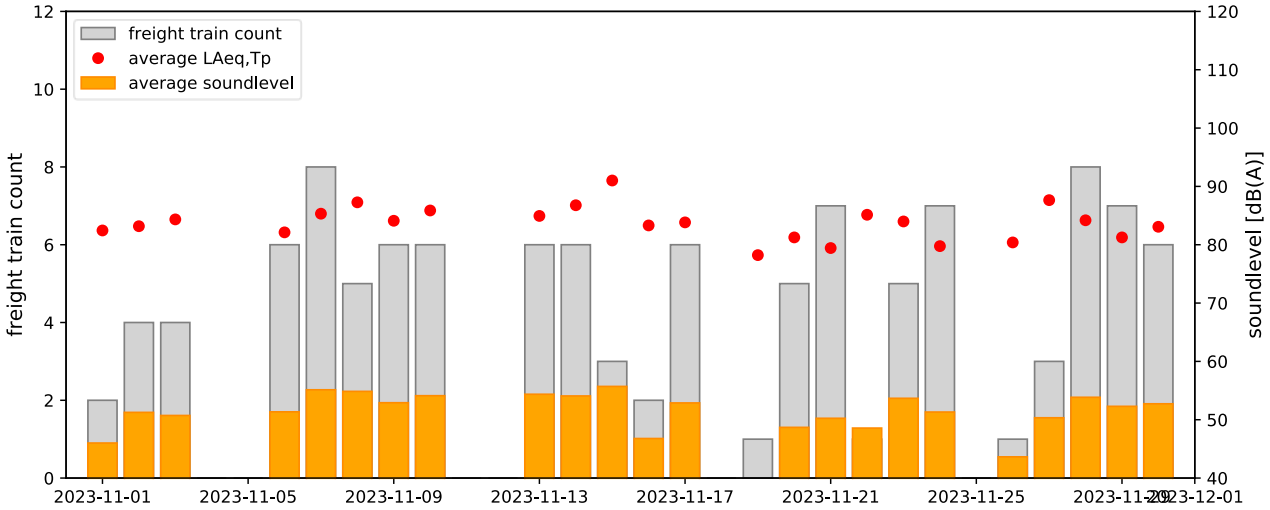
date	location	train count	passenger train count	freight train count	service train count	average LAeqTp	average soundlevel
01.11.2023	REF	119	115	2	2	80,5	59,5
02.11.2023	REF	122	115	4	3	80,3	59,8
03.11.2023	REF	119	112	4	3	80,5	59,6
04.11.2023	REF	43	43	0	0	78,8	54,1
05.11.2023	REF	34	34	0	0	81,2	54,9
06.11.2023	REF	115	109	6	0	80,4	59,7
07.11.2023	REF	118	109	8	1	81,3	60,5
08.11.2023	REF	117	111	5	1	81,6	60,6
09.11.2023	REF	118	112	6	0	80,9	59,7
10.11.2023	REF	118	111	6	1	81,1	60,5
11.11.2023	REF	117	117	0	0	79,7	58,3
12.11.2023	REF	114	114	0	0	79,9	58,5
13.11.2023	REF	115	108	6	1	80,9	60,2
14.11.2023	REF	116	109	6	1	81,2	60,2
15.11.2023	REF	117	113	3	1	82	60,9
16.11.2023	REF	110	106	2	2	80,3	59,2
17.11.2023	REF	122	114	6	2	80,9	60,6
18.11.2023	REF	114	113	0	1	80,2	58,7
19.11.2023	REF	119	118	1	0	78,8	58,3
20.11.2023	REF	80	74	5	1	79,5	57,7
21.11.2023	REF	87	77	7	3	77,9	57,6
22.11.2023	REF	78	76	1	1	80,1	58,5
23.11.2023	REF	77	71	5	1	79,8	58,2
24.11.2023	REF	80	73	7	0	78,5	57,8
25.11.2023	REF	78	77	0	1	78,7	56,4
26.11.2023	REF	75	74	1	0	79,2	57
27.11.2023	REF	81	78	3	0	79,2	57,8
28.11.2023	REF	91	81	8	2	79,6	58,7
29.11.2023	REF	80	71	7	2	79,3	58
30.11.2023	REF	86	77	6	3	79,2	58,4
month	**REF**	**2953**	**2792**	**121**	**40**	**80,2**	**58,9**

Daytime averages (24h) for all passenger train passages at reference section (REF)



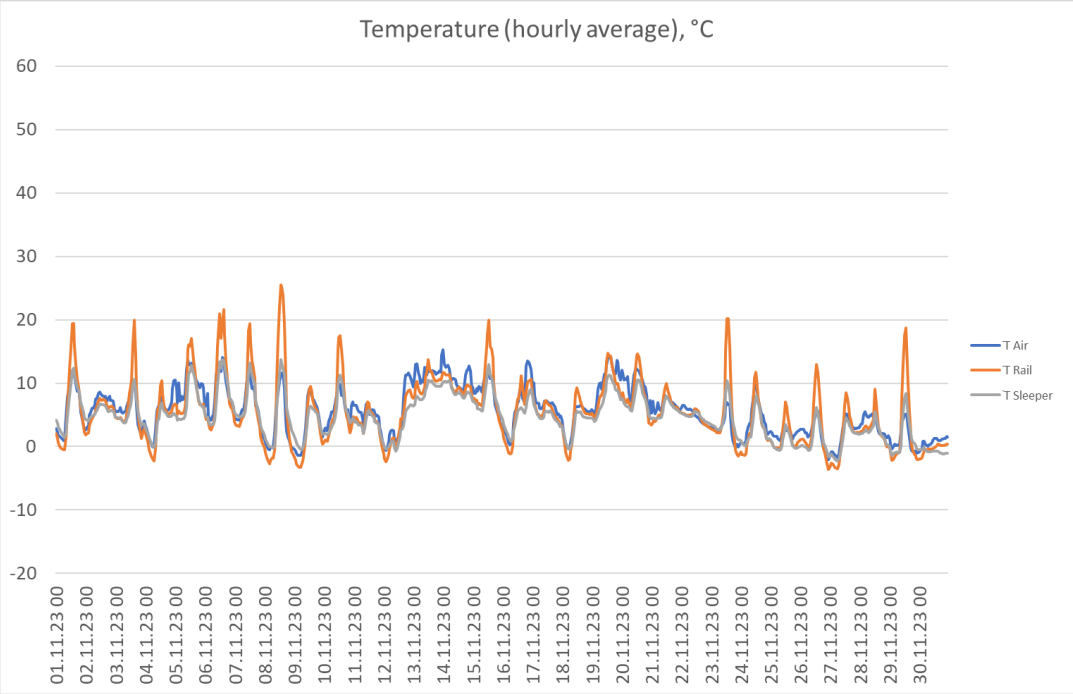
date	location	passenger train count	average speed	average length	average axlecount	average LAeqTp	average soundlevel
01.11.2023	REF	115	111,4	162	23,5	80,4	59,2
02.11.2023	REF	115	110,7	164,6	23,8	79,8	58,9
03.11.2023	REF	112	113	169,1	24,3	79,9	58,8
04.11.2023	REF	43	89,3	144,2	20	78,8	54,1
05.11.2023	REF	34	89,5	131,3	17,9	81,2	54,9
06.11.2023	REF	109	110,9	168	24,1	80,2	59,1
07.11.2023	REF	109	111,5	164,9	23,9	80,2	58,9
08.11.2023	REF	111	109,6	160,2	23,2	80,4	59,1
09.11.2023	REF	112	111	149,5	21,5	80,2	58,7
10.11.2023	REF	111	111	174,6	25,1	80,3	59,3
11.11.2023	REF	117	111,3	147,6	21,1	79,7	58,3
12.11.2023	REF	114	111,7	149,3	21,5	79,9	58,5
13.11.2023	REF	108	111	171,8	24,9	80	58,9
14.11.2023	REF	109	110,1	163,4	23,7	80,2	59
15.11.2023	REF	113	111,6	164,3	23,8	80,4	59,3
16.11.2023	REF	106	110,7	165,6	24,1	80	58,7
17.11.2023	REF	114	106,4	172,7	24,8	80,4	59,7
18.11.2023	REF	113	111,9	150,6	21,5	80,2	58,7
19.11.2023	REF	118	104,8	150,3	21,4	78,8	58,3
20.11.2023	REF	74	98,6	173,4	26,7	79,3	57,1
21.11.2023	REF	77	86,1	170,7	26,2	77,3	56,3
22.11.2023	REF	76	95,6	169,3	26,4	79,7	58
23.11.2023	REF	71	96,2	176,4	27,3	78,9	56,9
24.11.2023	REF	73	88	168,5	25,9	78,3	56,8
25.11.2023	REF	77	98	151,3	23	78,7	56,4
26.11.2023	REF	74	98,5	163,6	24,9	79,1	56,8
27.11.2023	REF	78	93,1	171	26,4	79	57,4
28.11.2023	REF	81	95,5	171,1	26,4	78,5	57
29.11.2023	REF	71	95	174,4	26,7	78,5	56,4
30.11.2023	REF	77	90,1	170,5	26	78,2	57
month	**REF**	**2812**	**105,1**	**163,1**	**24**	**79,6**	**58,1**

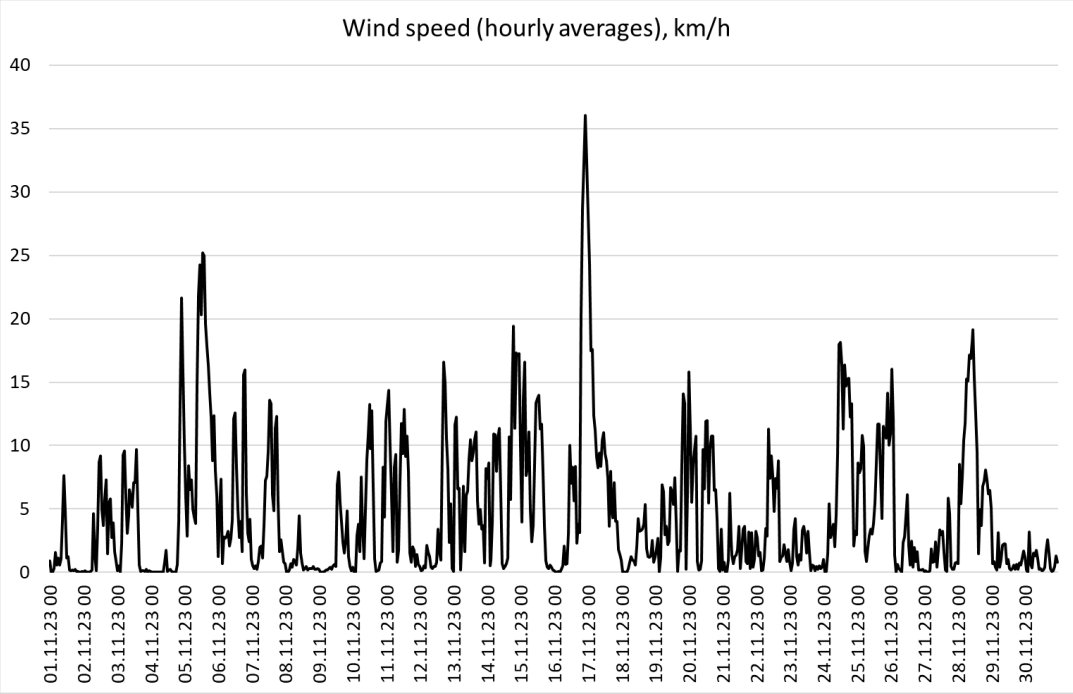
Daytime averages (24h) for all freight train passages at reference section (REF)



date	location	freight train count	average speed	average length	average axle count	average LAeqTp	average soundlevel
01.11.2023	REF	2	77,5	187,3	27	82,4	46
02.11.2023	REF	4	70,7	264,6	65	83,2	51,3
03.11.2023	REF	4	91	213,7	52	84,3	50,7
04.11.2023	REF	0					0
05.11.2023	REF	0					0
06.11.2023	REF	6	75,8	228,7	47,3	82,1	51,4
07.11.2023	REF	8	82,9	225,9	51,8	85,3	55,1
08.11.2023	REF	5	82,5	220,5	49,2	87,3	54,9
09.11.2023	REF	6	87,2	244,1	52,3	84,1	52,9
10.11.2023	REF	6	86,4	220,8	50,7	85,9	54,1
11.11.2023	REF	0					0
12.11.2023	REF	0					0
13.11.2023	REF	6	74,4	239,9	59	84,9	54,4
14.11.2023	REF	6	88,1	188,5	42	86,8	54,1
15.11.2023	REF	3	93,7	218,6	45,3	91	55,7
16.11.2023	REF	2	62	172,6	44	83,3	46,8
17.11.2023	REF	6	77,2	238,3	55,7	83,8	52,9
18.11.2023	REF	0					0
19.11.2023	REF	1	33,9	62,9	12	78,2	37,3
20.11.2023	REF	5	62,3	137,7	27,6	81,3	48,7
21.11.2023	REF	7	52,6	177,1	47,7	79,4	50,2
22.11.2023	REF	1	83	432,7	104	85,1	48,6
23.11.2023	REF	5	70,4	299,4	69,3	84	53,7
24.11.2023	REF	7	53,6	217,2	54,3	79,8	51,3
25.11.2023	REF	0					0
26.11.2023	REF	1	47,4	208,7	54	80,4	43,6
27.11.2023	REF	3	97	141	38	87,6	50,3
28.11.2023	REF	8	72,1	176,5	39,7	84,2	53,8
29.11.2023	REF	7	65	258,4	57,4	81,3	52,3
30.11.2023	REF	6	76,3	258,9	62	83,1	52,7
month	**REF**	**115**	**74,4**	**219,6**	**50,6**	**84,1**	**51,3**

3. Weather data





Appendix: measurement quantities

Transit Exposure Level *TEL*

A-weighted sound pressure level of a single train pass-by as energetic average over the entire exposure duration *T* and averaged over the pass-by duration T_p.

$$TEL = 10\,log\left(\frac{1}{T_p}\int_0^T \frac{p_A^2(t)}{p_0^2}dt\right) \quad (1)$$

Where

$p_A(t)$ = the A-weighted sound pressure, [Pa]

$p0 = 20\,\mu Pa$ (reference pressure), [Pa]

$Tp = T_2 - T_1$ = pass-by duration of the train, time interval during which a train is within the measurement cross-section and which starts with the entry time T_1into the measurement cross-section and ends with the exit time T_2, [s]

$T =$ time interval which starts when the smoothed sound pressure level (sound pressure level smoothed as a function of time with the frequency weighting A and a time weighting F („fast“) or averaging over a duration period of time, e.g. 100 ms) is for the last time 10 dB below that prevailing at the time of entering the measurement cross-section and which ends when the smoothed sound pressure level is for the first time 10 dB below the one at the time of leaving the measurement cross-section. [s]

A-weighted equivalent sound pressure level of the train pass-by $L_{Aeq,Tp}$

The A-weighted equivalent sound pressure level equals the (energetic) average of the sound pressure level over the train pass-by time T_p according to the following equation:

$$L_{Aeq,Tp} = 10\,log\left(\frac{1}{T_p}\int_{T_1}^{T_2} \frac{p_A^2(t)}{p_0^2}dt\right) \quad (2)$$

where

$p_A(t)$ = the A-weighted sound pressure, [Pa]

$p0 = 20\,\mu Pa$ (reference sound pressure), [Pa]

$Tp = T_2 - T_1$ = pass-by duration of the train, [s]

Sound Exposure Level *SEL*

The sound exposure level *SEL* references the acoustic energy of the entire pass-by event to one second. The SEL is used in calculating average sound level contributions from trains over longer periods of time (i.e. days/months/year). The SEL is related to the transit exposure level TEL through:

$$SEL = \mathrm{TEL} - 10\log(T_0 / T_p) \quad (3)$$

where

T_0 = 1 [s]

Tp = pass-by duration of the train, [s]

Average sound level (period)

Average (energetic) A-weighted sound pressure level measured over a given period of time.

For the average sound level contributions from train pass-byes this equals the sum (energetic) of all sound exposure levels during the period for a given measurement position:

$$average\ soundlevel = 10 \cdot log10\left(\sum 10^{\frac{SEL}{10}}\right) - A1 \quad (4)$$

where

A1 = $10 \cdot log10(n \cdot 24 \cdot 3600)$ for a 24-hour period

SEL (see equation 3) taken from measurement data

n = number of days being averaged over

Average $L_{Aeq,Tp}$

Average (energetic) sound level of all the A-weighted sound pressure levels from the individual equivalent sound level of all train pass-byes in a given period of time (day/month/year).

Calculated per train category and per period day/night, month, year, etc. and per measurement location:

$$average\ L_{Aeq,Tp} = 10 \cdot log10\left(\sum T_p \cdot 10^{\frac{L_{Aeq,Tp}}{10}}\right) + 10 \cdot log10\left(\frac{1}{\sum T_p}\right) \quad (5)$$

where

Tp = pass-by duration of the train [s]

$L_{Aeq,Tp}$ (see equation 2) is calculated directly from the measurement data