LÄRM FORSCHUNG EISEN BAHN
FAHRBAHNLABOR

MÜLLER-BBM
RAIL TECHNOLOGIES

Monthly report

Railway Field Laboratory

July 2022

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).
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Version:	V1
Date:	15.2.2023

1. Status railway field laboratory

Construction work on the tracks:

- none

Downtimes of the measurement systems:

- none

Downtimes of the sensors:

- MQ REF: a-ref-3-bl-u-x
- MQ 1_3: a-mq13-3-bl-l-z
- MQ 1_2: a-mq12-5-bl-l-z
- MQ 1_2: a-mq12-5-bl-u-y
- MQ 1_2: v-mq12
- MQ 2_2: v-mq22

Maintenance and sensor exchange:

- none

Modifications to the data, database, or analysis:

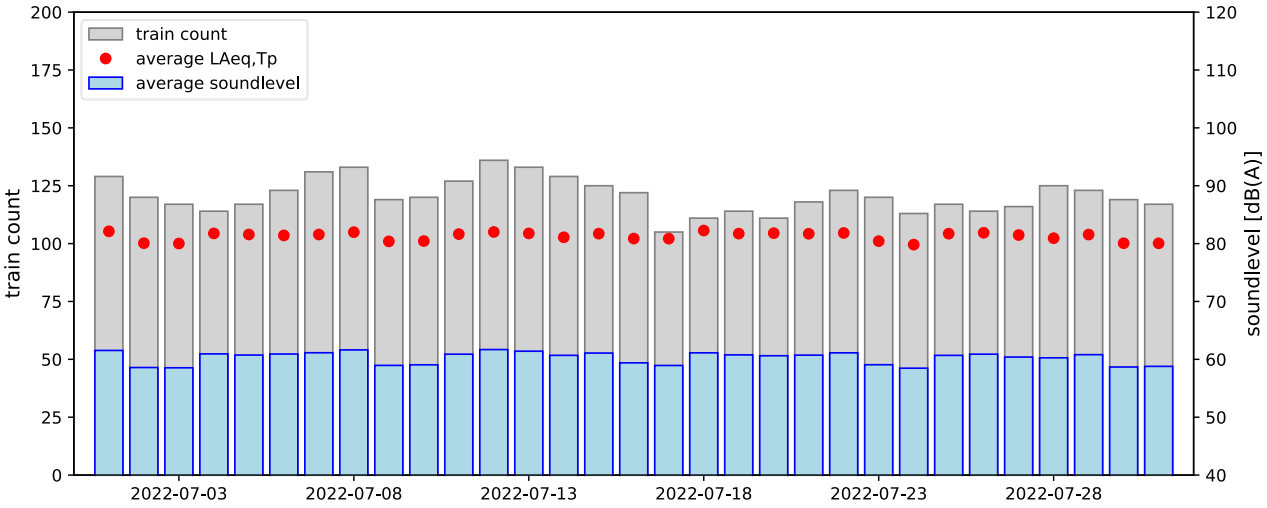
- none

Monthly data volume collected:

- 219 GB

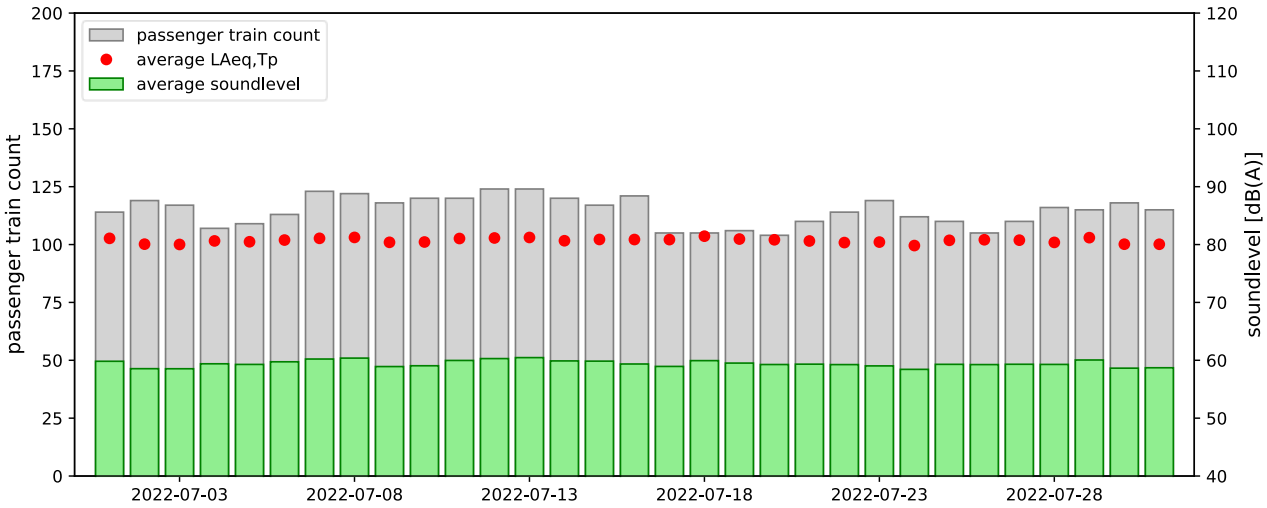
2. Measurement data

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



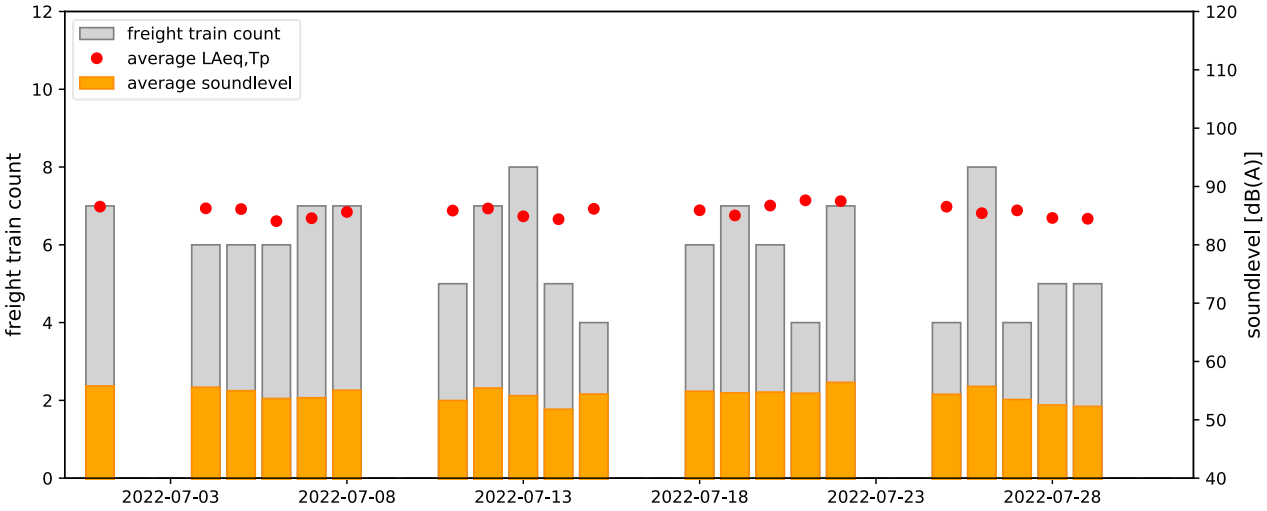
date	location	train count	passenger train count	freight train count	service train count	average LAeqTp	average soundlevel
01.07.2022	REF	129	114	7	1	82.1	61.5
02.07.2022	REF	120	119	0	0	80.1	58.6
03.07.2022	REF	117	117	0	0	80.0	58.5
04.07.2022	REF	114	107	6	0	81.8	60.9
05.07.2022	REF	117	109	6	2	81.6	60.7
06.07.2022	REF	123	113	7	2	81.4	60.9
07.07.2022	REF	131	123	7	0	81.6	61.1
08.07.2022	REF	133	122	7	1	82.0	61.6
09.07.2022	REF	119	118	0	0	80.4	59.0
10.07.2022	REF	120	120	0	0	80.4	59.1
11.07.2022	REF	127	121	5	1	81.6	60.9
12.07.2022	REF	136	124	8	0	82.0	61.7
13.07.2022	REF	133	124	8	0	81.8	61.4
14.07.2022	REF	129	120	6	1	81.1	60.7
15.07.2022	REF	125	117	5	1	81.7	61.1
16.07.2022	REF	122	121	0	0	80.9	59.4
17.07.2022	REF	105	105	0	0	80.9	58.9
18.07.2022	REF	111	105	6	0	82.3	61.1
19.07.2022	REF	114	107	7	0	81.7	60.8
20.07.2022	REF	111	104	6	0	81.8	60.6
21.07.2022	REF	118	110	5	1	81.7	60.7
22.07.2022	REF	123	114	7	1	81.8	61.1
23.07.2022	REF	120	119	0	0	80.4	59.1
24.07.2022	REF	113	112	0	0	79.8	58.5
25.07.2022	REF	117	110	5	1	81.7	60.7
26.07.2022	REF	114	105	8	0	81.9	60.9
27.07.2022	REF	116	110	4	0	81.5	60.4
28.07.2022	REF	125	116	6	1	80.9	60.3
29.07.2022	REF	123	116	5	1	81.6	60.8
30.07.2022	REF	119	118	0	0	80.1	58.7
31.07.2022	REF	117	116	0	0	80.1	58.8
month	**REF**	**3741**	**3556**	**131**	**14**	**81.4**	**60.4**

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



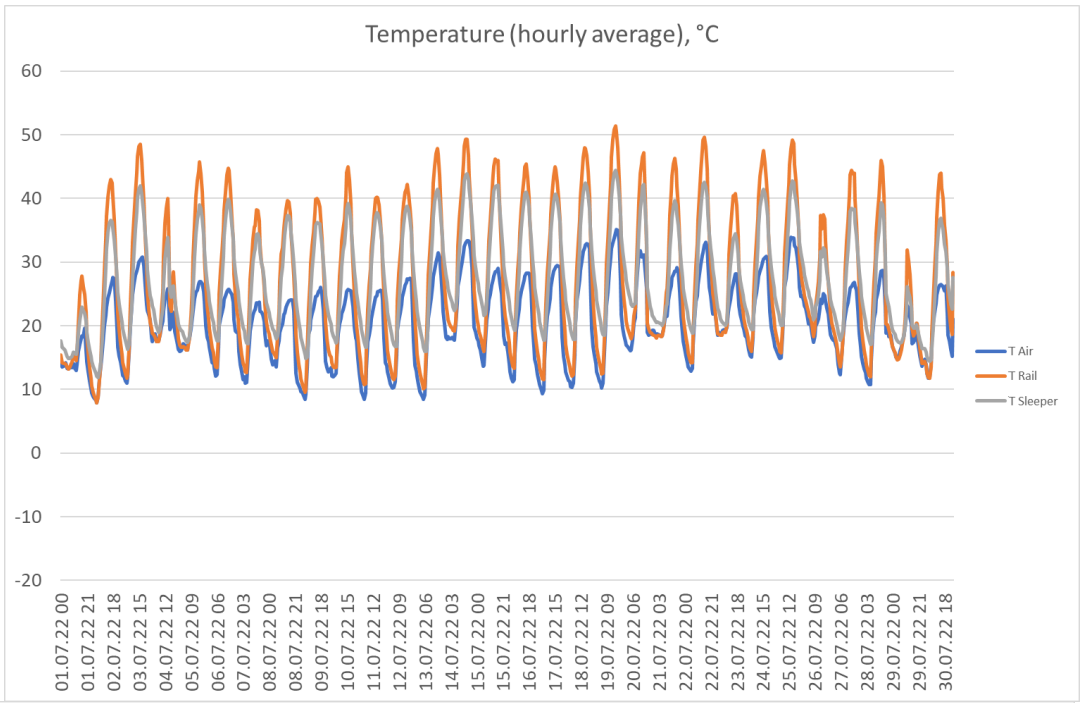
date	location	passenger train count	average speed	average length	average axlecount	average LAeqTp	average soundlevel
01.07.2022	REF	114	113	163	24	81.1	59.8
02.07.2022	REF	119	111	140	20	80.1	58.6
03.07.2022	REF	117	111	140	21	80.0	58.5
04.07.2022	REF	107	109	161	24	80.6	59.4
05.07.2022	REF	109	110	162	24	80.5	59.3
06.07.2022	REF	113	110	162	24	80.8	59.7
07.07.2022	REF	123	112	160	23	81.1	60.2
08.07.2022	REF	122	112	163	24	81.2	60.4
09.07.2022	REF	118	113	142	21	80.4	58.9
10.07.2022	REF	120	111	138	20	80.4	59.1
11.07.2022	REF	121	112	155	23	81.0	60.0
12.07.2022	REF	124	110	155	23	81.1	60.3
13.07.2022	REF	124	111	156	23	81.2	60.5
14.07.2022	REF	120	110	157	23	80.7	59.9
15.07.2022	REF	117	112	159	23	80.9	59.9
16.07.2022	REF	121	111	139	20	80.9	59.4
17.07.2022	REF	105	111	141	21	80.9	58.9
18.07.2022	REF	105	113	157	23	81.4	59.9
19.07.2022	REF	107	112	159	23	80.9	59.5
20.07.2022	REF	104	111	161	24	80.8	59.3
21.07.2022	REF	110	111	158	23	80.6	59.3
22.07.2022	REF	114	112	163	24	80.3	59.3
23.07.2022	REF	119	111	138	20	80.4	59.0
24.07.2022	REF	112	111	146	21	79.8	58.4
25.07.2022	REF	110	112	159	23	80.7	59.3
26.07.2022	REF	105	111	159	23	80.8	59.3
27.07.2022	REF	110	113	159	23	80.8	59.3
28.07.2022	REF	116	112	160	24	80.4	59.3
29.07.2022	REF	116	112	163	24	81.2	60.1
30.07.2022	REF	118	111	142	21	80.1	58.6
31.07.2022	REF	116	110	144	21	80.1	58.7
month	**REF**	3556	**111.3**	**153.4**	**22.5**	**80.7**	**59.5**

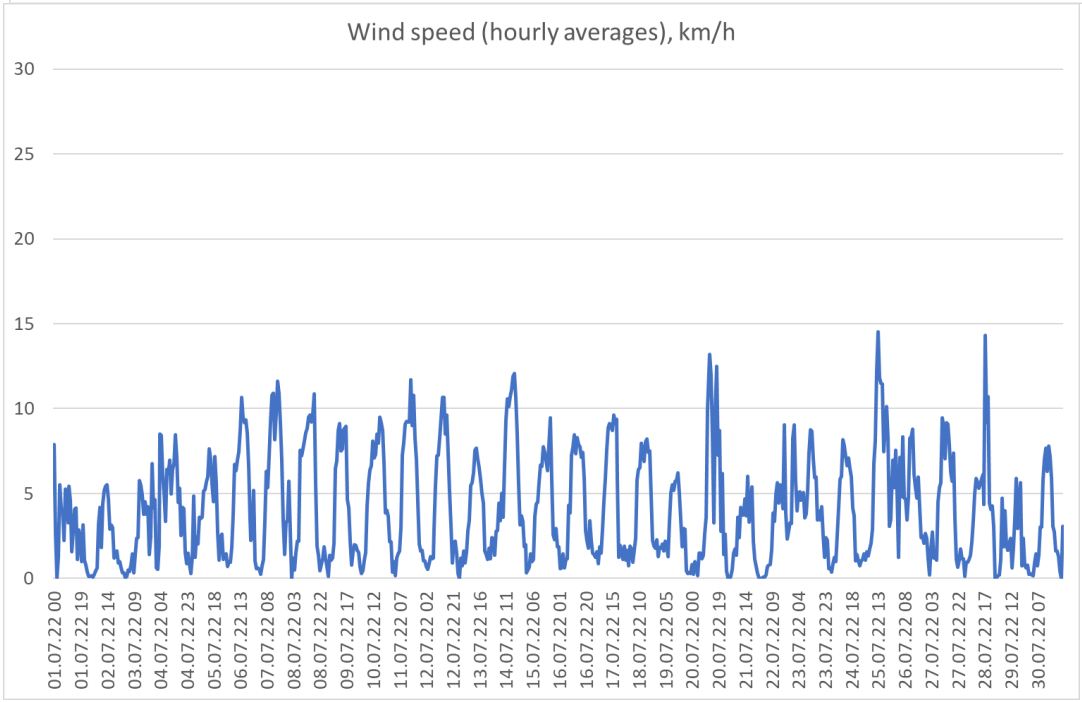
Daytime averages (24h) for all freight train passages at reference section (REF)



date	location	freight train count	average speed	average length	average axle count	average LAeqTp	average soundlevel
01.07.2022	REF	7	89	245	58	86.5	55.8
02.07.2022	REF	0					
03.07.2022	REF	0					
04.07.2022	REF	6	87	282	67	86.3	55.6
05.07.2022	REF	6	89	257	56	86.1	55.0
06.07.2022	REF	7	77	261	63	84.1	53.6
07.07.2022	REF	7	83	216	41	84.6	53.8
08.07.2022	REF	7	84	227	49	85.6	55.1
09.07.2022	REF	0					
10.07.2022	REF	0					
11.07.2022	REF	5	89	217	48	85.9	53.3
12.07.2022	REF	8	90	244	52	86.2	55.4
13.07.2022	REF	8	81	194	40	84.9	54.1
14.07.2022	REF	6	81	198	41	84.4	51.8
15.07.2022	REF	5	76	298	73	86.2	54.4
16.07.2022	REF	0					
17.07.2022	REF	0					
18.07.2022	REF	6	83	248	59	85.9	54.9
19.07.2022	REF	7	85	250	54	85.0	54.6
20.07.2022	REF	6	91	200	42	86.7	54.7
21.07.2022	REF	5	92	263	60	87.6	54.6
22.07.2022	REF	7	91	224	51	87.5	56.4
23.07.2022	REF	0					
24.07.2022	REF	0					
25.07.2022	REF	5	87	273	60	86.5	54.4
26.07.2022	REF	8	89	269	62	85.4	55.7
27.07.2022	REF	4	84	255	55	85.9	53.5
28.07.2022	REF	6	83	228	46	84.6	52.5
29.07.2022	REF	5	86	238	49	84.5	52.3
30.07.2022	REF	0					
31.07.2022	REF	0					
month	REF	131	85.7	240.1	52.9	85.8	52.8

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