Analysis of the dynamic effects in the S&C

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This project has received funding from the Shift2Rail Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement no 730849

Our experience

- More than 20 years of experience
- We measured…
  - Turnouts just before the failure
  - Turnouts before and after repair (welding, tamping)
  - On crossing part and on switches part
  - Mainline turnouts
  - Various constructions
    - Common fix crossing
    - Movable point
    - With and without USP
    - Turnouts on concrete and wooden bearers
    - Turnout with Elastic Ribbed Base Plate Support (ERL – BWG)
    - Turnout with new type of fastening system – DT

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Measurement methodology

- Measurement methodology is designed for in situ measurement in condition of full operation
- Measurement methodology is certified by the Ministry of Transport of the Czech Republic
- For fix crossing, switch part, movable point
- Main parts of the methodology
  - Vibration acceleration measurement
    - transmission of the vibration from rail to sleeper (baerer) and to ballast
  - Displacement measurement
    - measurement of movements of the bearers
      - Along the crossing
      - The most loaded bearer

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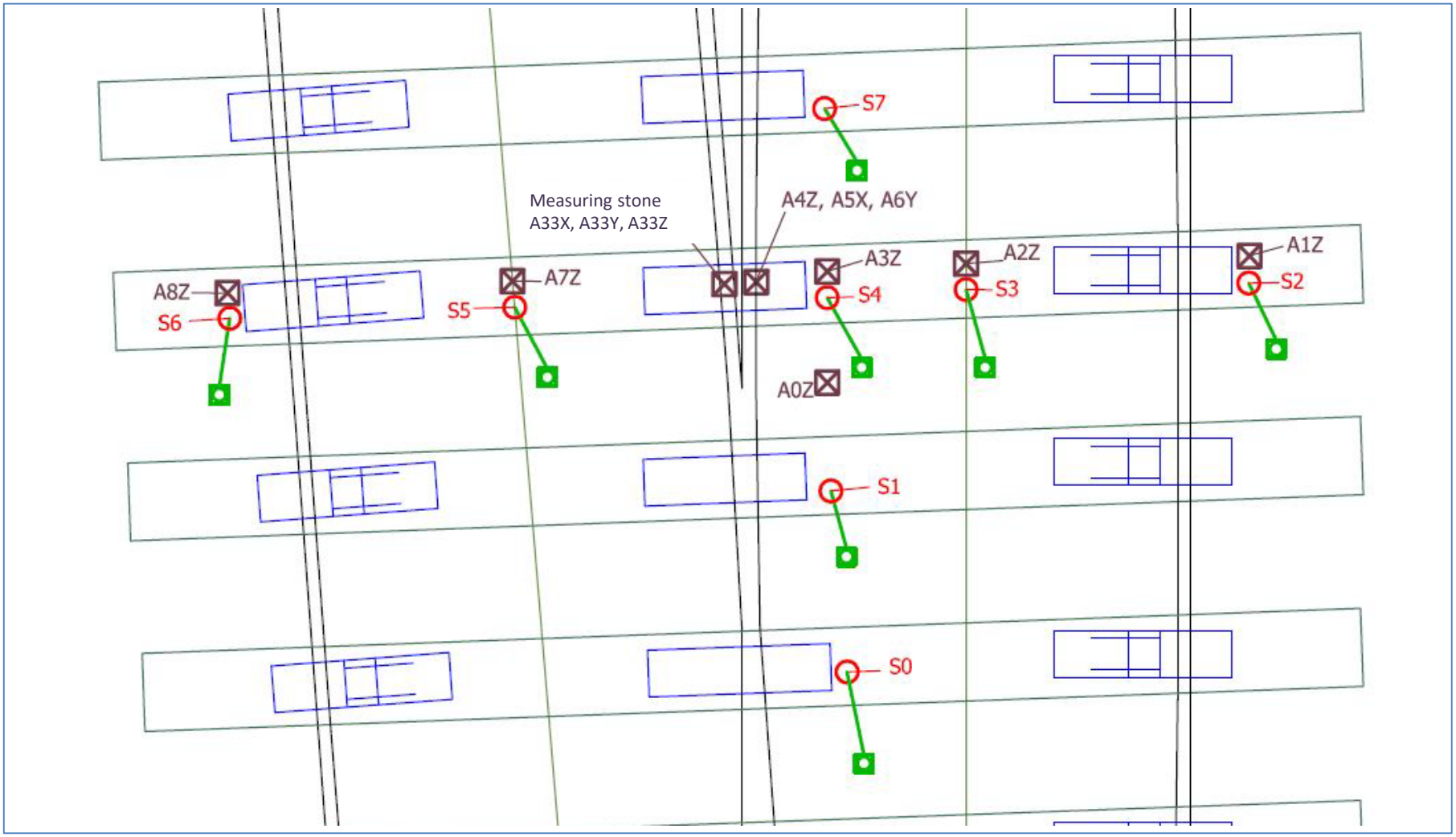
Measurement methodology



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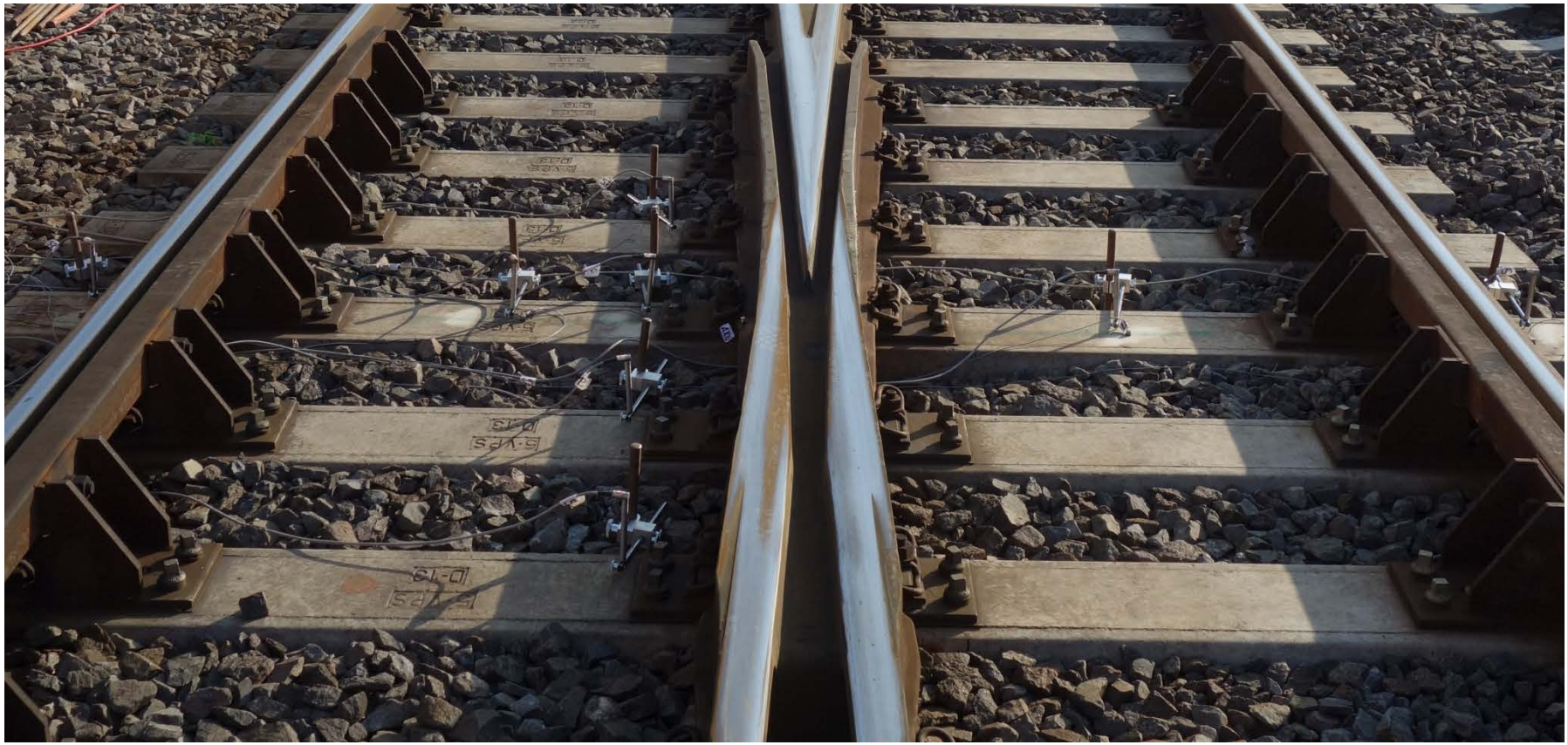
Measurement methodology



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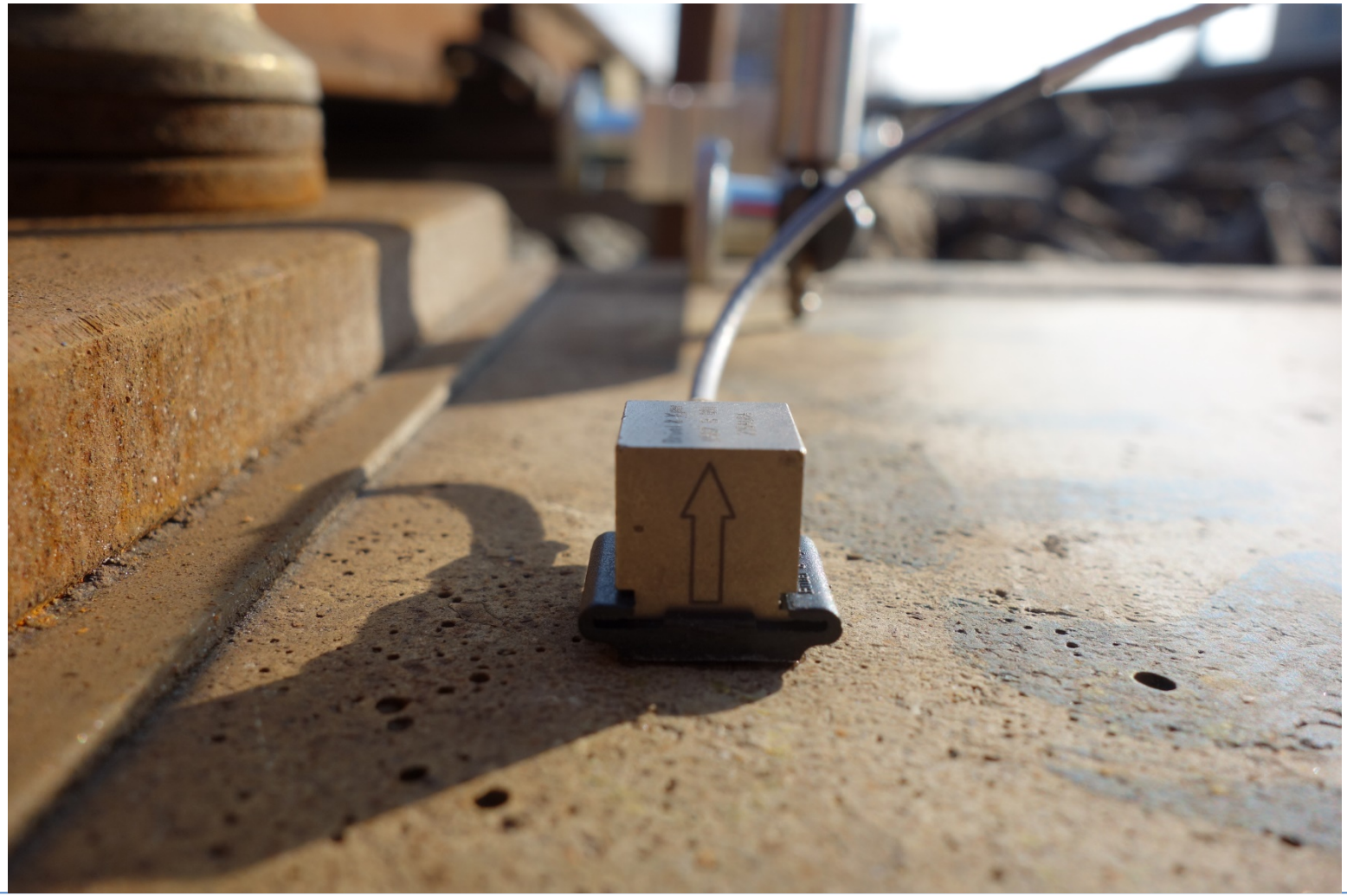

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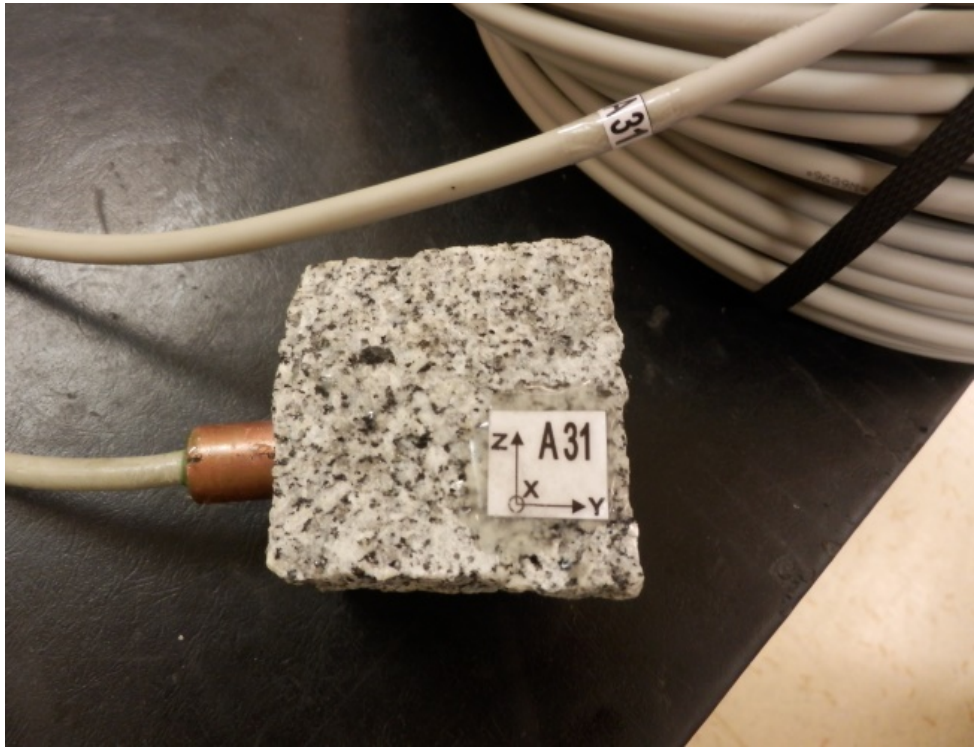
Measurement methodology

- Measuring stone



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Measurement methodology

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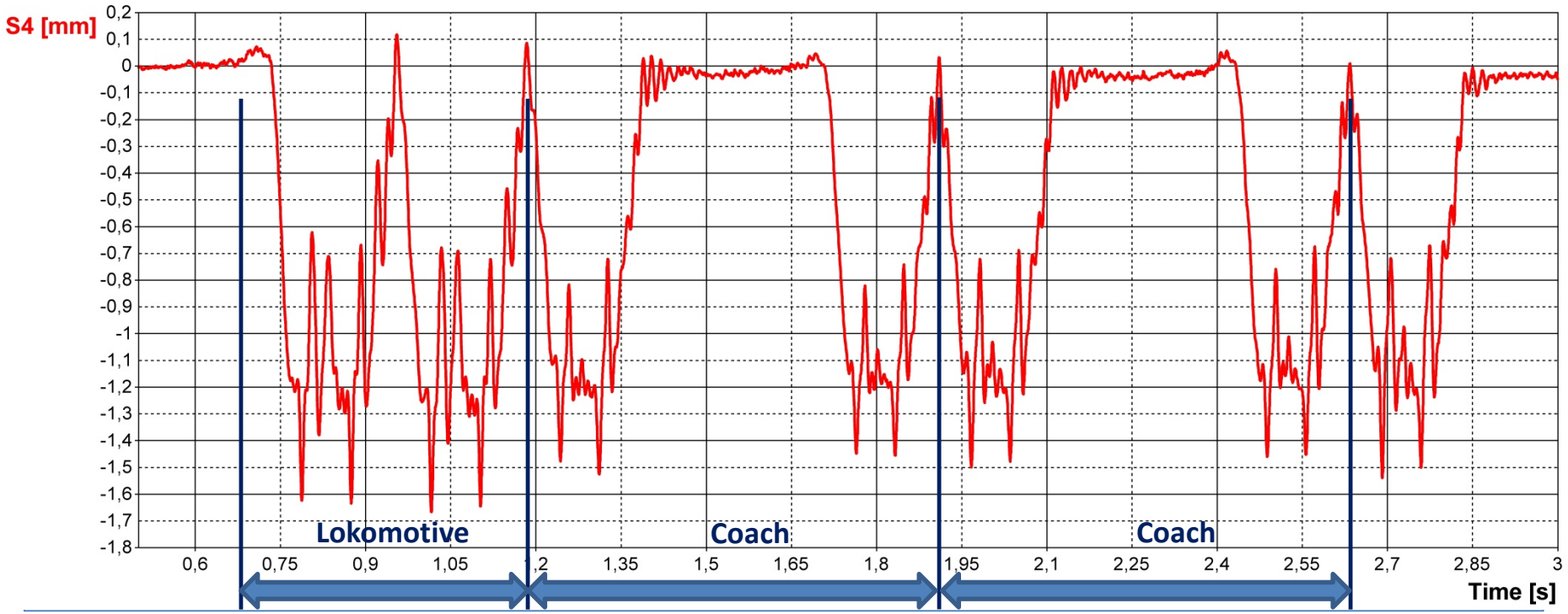
Evaluation of measured data

- Bearer movements
  - Bearer near the crossing nose - movement
  - Bearer with bad support



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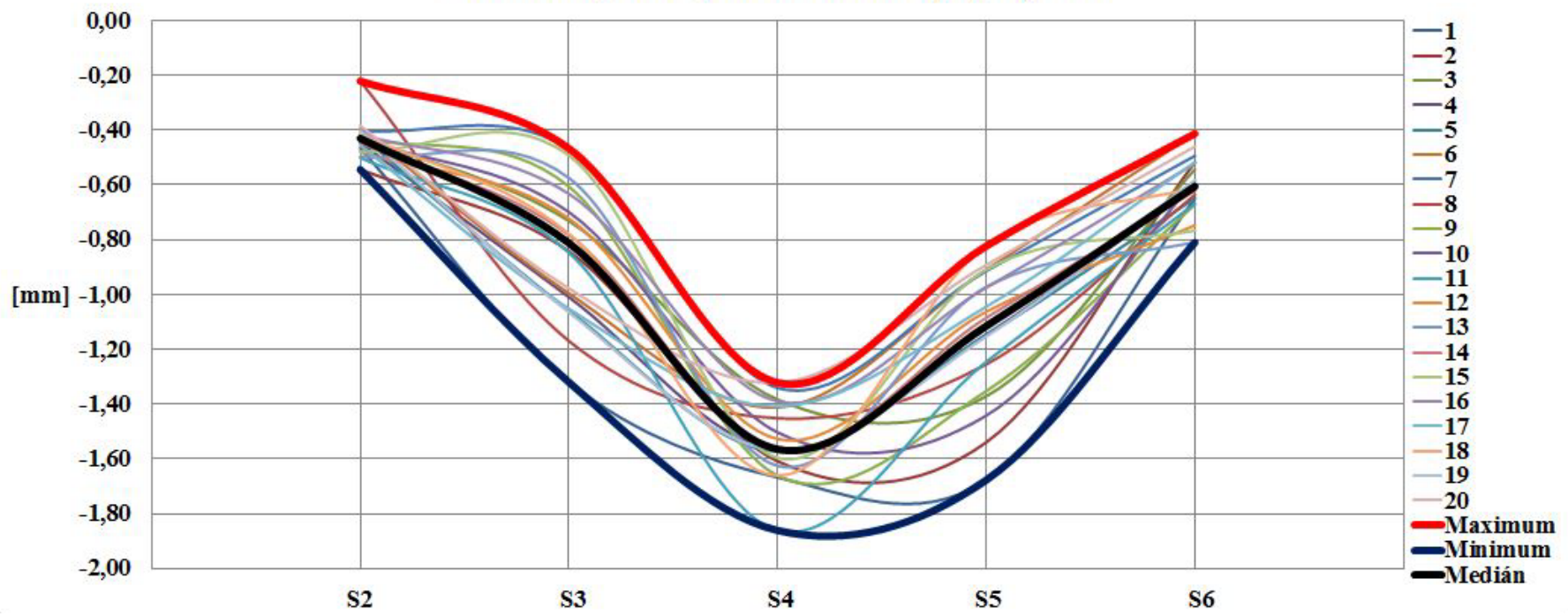
Evaluation of measured data

- Construction movement under the load – bearer under the crossing nose



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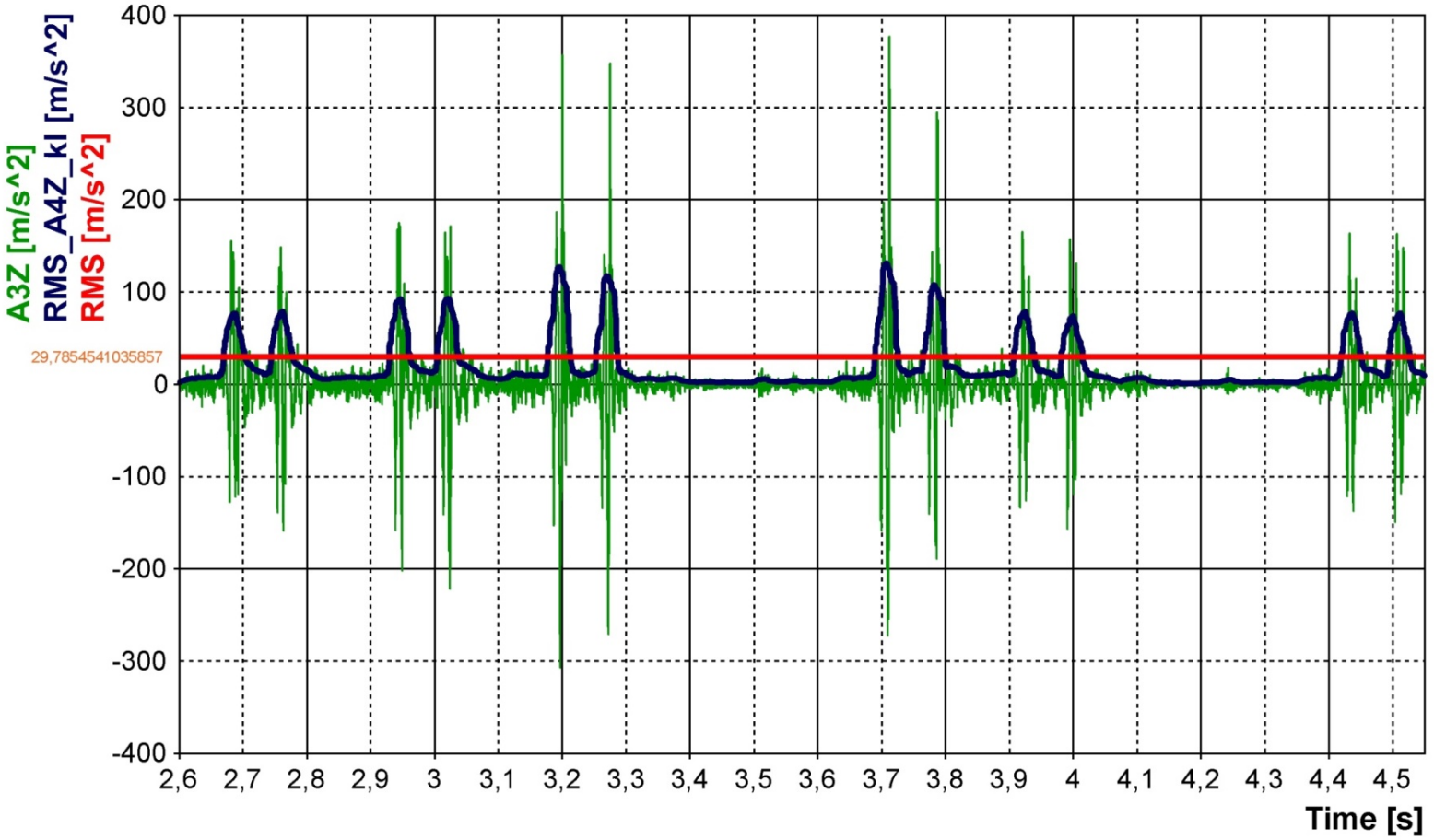
Evaluation of measured data

- Time area - RMS area under curve



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Evaluation of measured data

- Construction movement under the load
  - Envelope curves
- Transmission of the vibration from wing rail to bearer and to ballast
  - Time area
    - RMS – area under curve
  - Frequency area
    - FFT
    - Welch Method
    - Area under frequency curve (0 – 150 Hz, 150 – 600 Hz)
  - Time-frequency area
    - STFT

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Evaluation – Station Chocen

- Comparison of two crossings
  - The chosen crossings were the fix common crossings of turnout number 59 and 63 in railway station Chocen
  - track system: rails UIC 60 on concrete bearers, fastening system Vossloh Skl 24 and ballast
  - trains run in trailing direction (max. speed 160 km/h)
  - turnout crossing angle is 1:14 and radius 760 m
  - Crossing no. 59 had fatigue defect
  - Crossing no. 63 was new but with bad support

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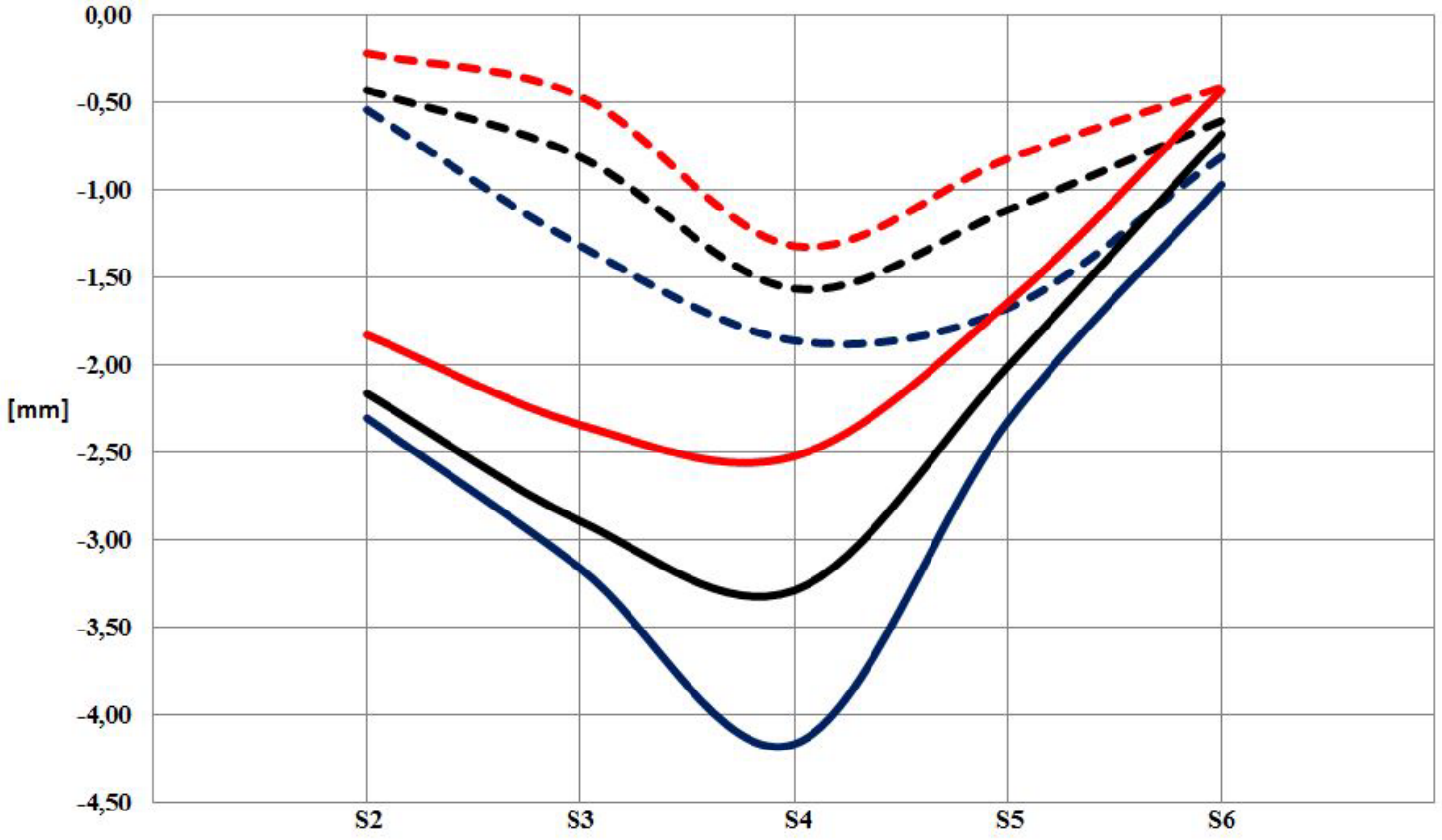
Evaluation – Station Chocen

- Construction movement under the load – bearer under the crossing nose
  - Dashed crossing no. 59, solid line crossing no. 63



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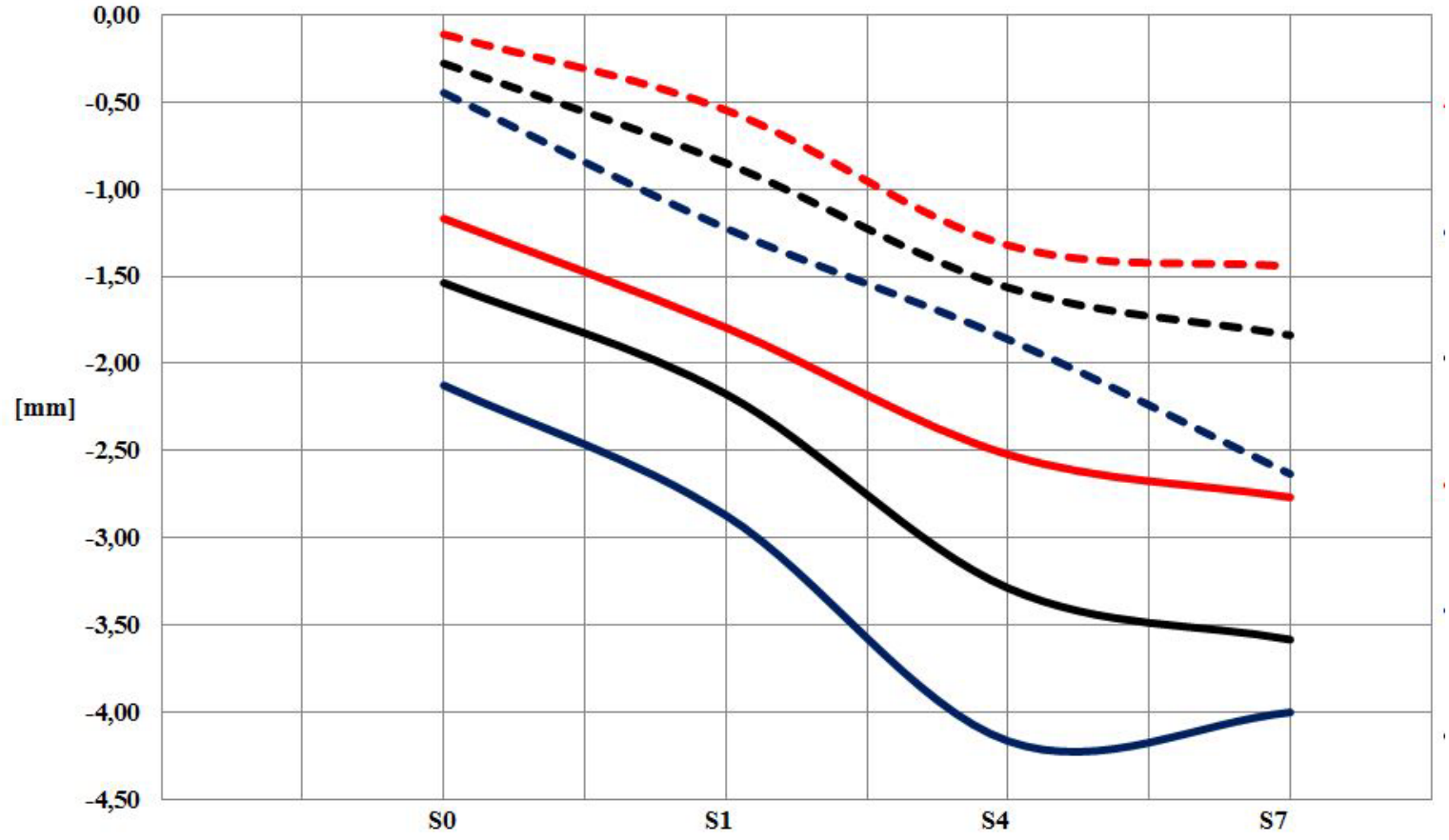
Evaluation – Station Chocen

- Construction movement under the load – bearer along the crossing
  - Dashed crossing no. 59, solid line crossing no. 63



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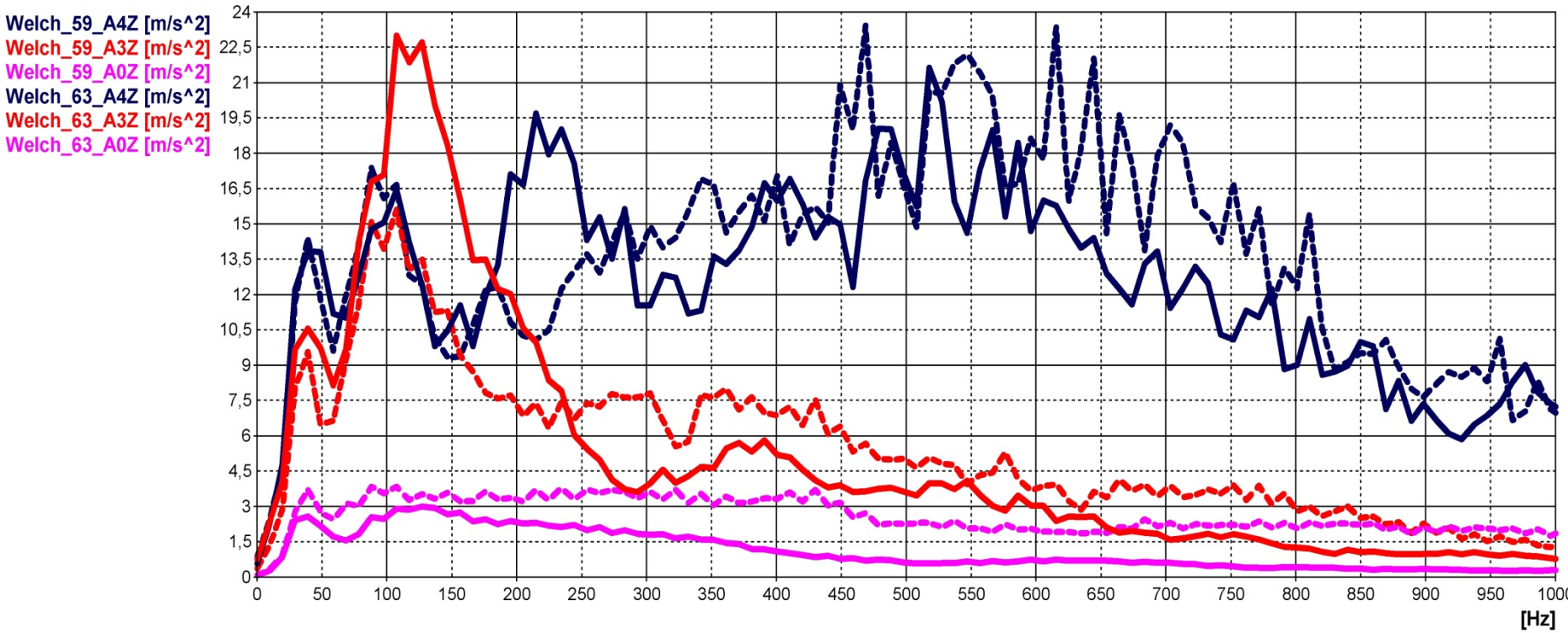
Evaluation – Station Chocen

- Construction under the load – transmission of vibration from wing rail (A4Z) through bearer (A3Z) to the ballast (A0Z)
- Welch method – dark blue – wing rail, red – bearer, purple - ballast
  - Dashed crossing no. 59, solid line crossing no. 63



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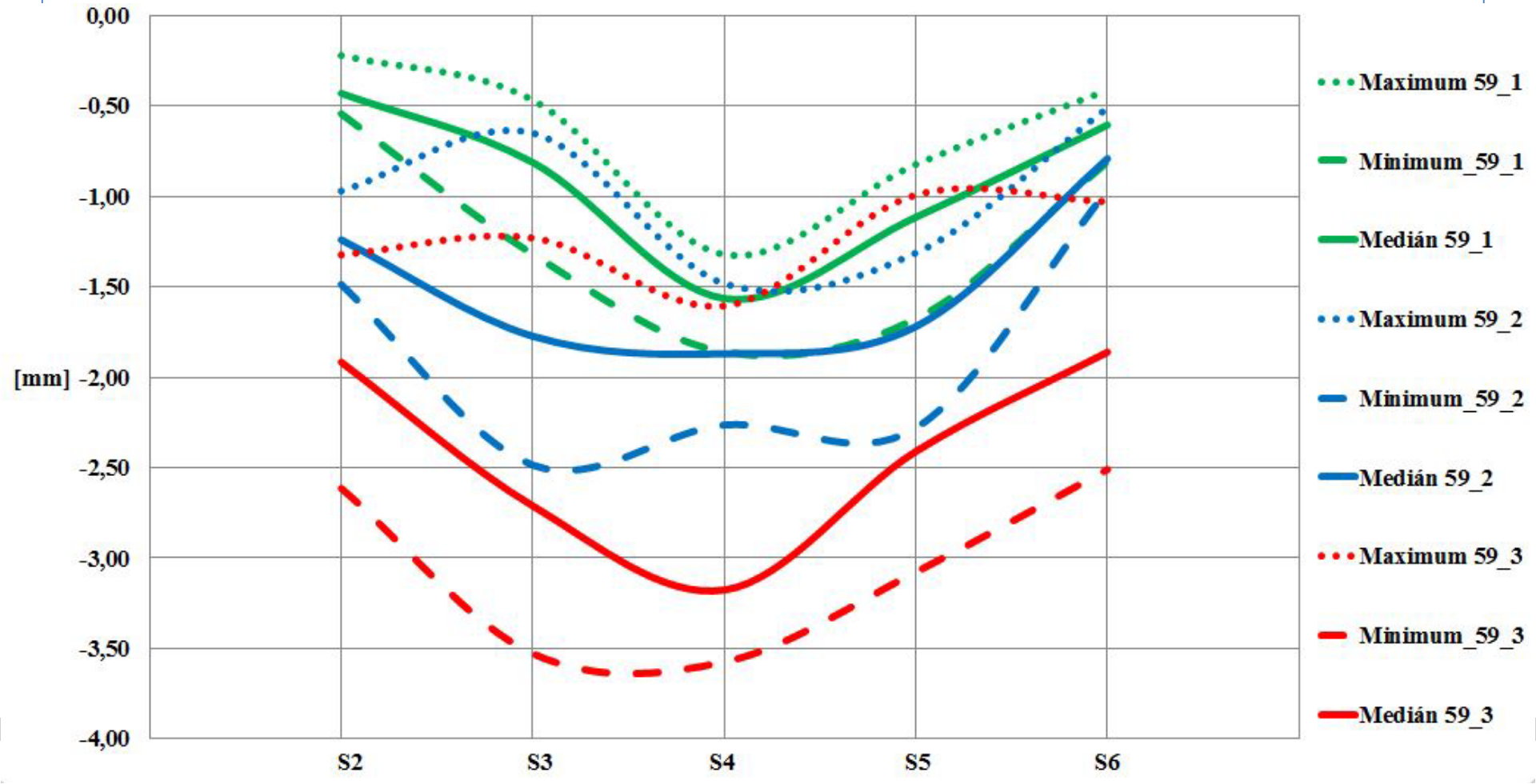
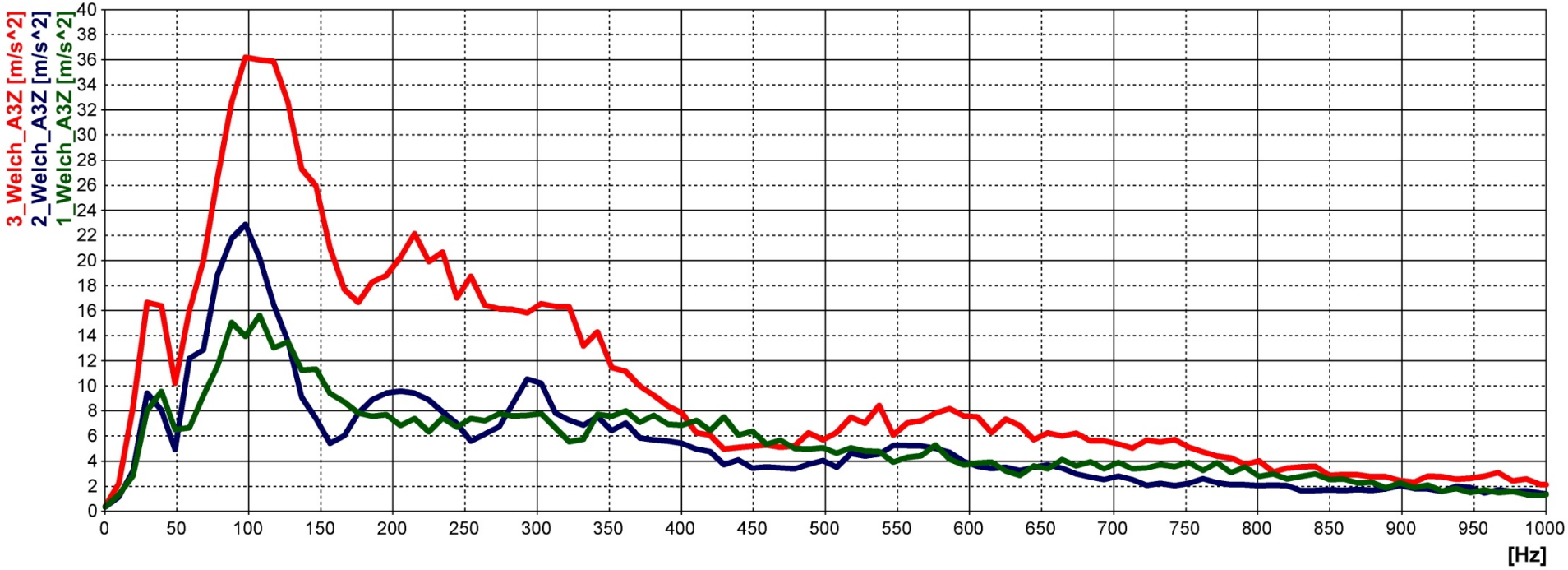
Evaluation – Station Chocen

- Construction movement under the load – bearer under the crossing nose – comparison of three measurements on crossing no. 59



Evaluation – Station Chocen

- Construction under the load –vibration on the bearer (A3Z)
- Welch method – green – 1. measurement, blue – 2. measurement, red - 3. measurement



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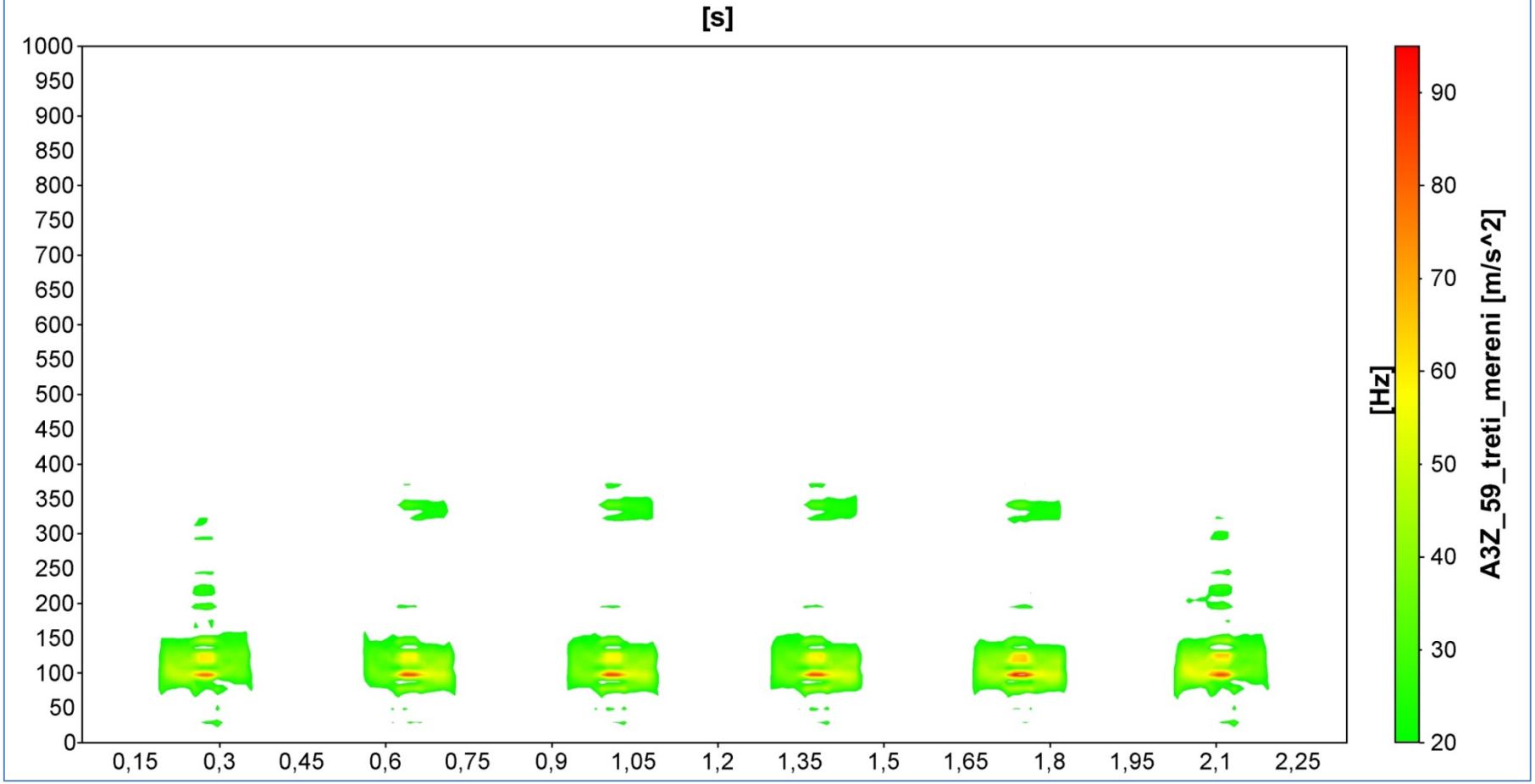
Evaluation of measured data

- Time – frequency (STFT)



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Evaluation – Station Usti nad Orlici

- Comparison of two crossings
  - The chosen crossings were the fix common crossings of turnout number 3 and 4
  - track system: rails UIC 60 on concrete bearers, fastening system Vossloh Skl 24 and ballast
  - trains run in trailing direction (max. speed 130 or 160 km/h)
  - turnout crossing angle is 1:12 and radius 500 m
  - Crossing no. 3 has new fastening system (higher elesticity)

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Evaluation of measured data

- Time area - RMS area under curve

Area under curve of moving RMS [m/s]							
Measurement	Train	A4Z on crossing no.		A3Z on crossing no.		A33Z on crossing no.	
		3	4	3	4	3	4
1	loko 380	49	43	12	13	3	3
				24	31	6	6
2	loko 380	45	34	8	10	3	3
				18	29	7	10
3	loko 380	64	40	11	14	4	3
				17	35	6	8
1	LEO Express	123	93	31	34	4	4
				26	36	3	5
2	LEO Express	121	89	27	30	5	6
				22	33	4	6
3	LEO Express	152	105	32	37	4	4
				21	35	3	4
1	Pendolino	217	308	74	116	11	13
				34	38	5	4
2	Pendolino	264	229	74	76	15	14
				28	33	6	6
3	Pendolino	312	239	85	104	16	23
				27	44	5	10
Average		**149,7**	**131,1**	**39,4**	**48,1**	**7,1**	**8,1**
				24,1	**34,8**	**4,9**	**6,6**

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Evaluation of measured data

- Area under curve – frequency
  - 150 – 600 Hz and 0 – 150 Hz

Area under curve of frequency spectrum Hz · m/s^2									
Measurement	Train	**A4Z** on crossing no.				**A3Z** on crossing no.		**A33Z** on crossing no.	
		3		4		3	4	3	4
		0 - 150 Hz	150 - 600 Hz	0 - 150 Hz	150 - 600 Hz	0 - 150 Hz	0 - 150 Hz	0 - 150 Hz	0 - 150 Hz
1	loko 380	1735	6413	1340	4555	988	986	328	344
2	loko 380	1206	5854	1438	4688	621	855	314	391
3	loko 380	1620	6428	1747	4635	864	1311	199	153
1	LEO Express	675	3461	500	2463	502	448	72	75
2	LEO Express	449	2402	489	1932	293	379	66	90
3	LEO Express	604	3463	616	2750	421	604	47	32
1	Pendolino	1018	3731	737	2718	634	816	96	135
2	Pendolino	1000	3615	853	3074	642	626	132	126
3	Pendolino	1085	3985	991	4008	794	1175	83	72
Average		**1044**	**4372**	**968**	**3425**	**640**	**800**	**149**	**158**

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S-CODE

- Small and smart measurement device
  - Base on vibration acceleration measurement
  - Embedded sensors
  - Online monitoring
  - Planning of maintenance (minimising time into track, decision support – renewal or maintenance, what kind of maintenance – surface built up welding, component replacement, tamping)

- We want to focus on…
  - Immune system – self diagnostic of turnouts
    - Time area
      - Minimum and maxim values (extreme values)
      - RMS – area under curve
      - Crest Factor – extreme value / RMS
    - Frequency area
      - Areas under curve
      - Natural frequency such as 100 Hz on a bearer

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