COLLEGIO INGEGNERI
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Exchange of best practices as catalyst for interoperability

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Content

Cover Figure
Train FS ETR 400 of Trenitalia France passing on the bridge Pont de Charenton-Maisons-Alfort, 19 May 2023
(Photo: Julian Ryf)

Side Figure
Matterhorn Gotthardbahn Regionatrain by Oberalppass, 12 December 2020
(Photo: Marco Corradini)

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Origins of Railways

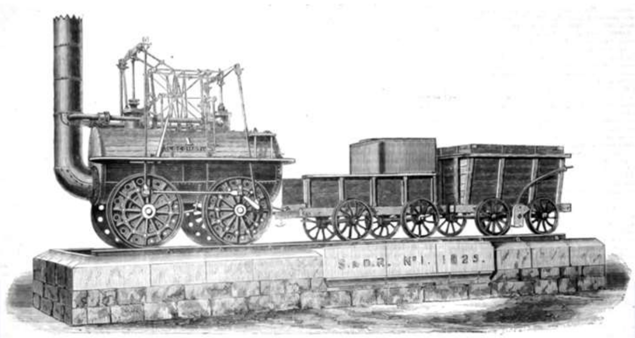

Figure 3 - The 'Locomotion N. 1 Experiment " in a drawing of 1875 (The Engineer, Author unknown).

Origins go back to the coal mines in Germany (Agricola - 1537, Münster - 1550 and Ettenhardi - 1556).

Cast-iron rails were born in 1767 with Reynolds - Co-owner of the Colebrook-Dale Ironworks.

Standard gauge 1435 mm was introduced in 1789, with Jessop, and his cast-iron edge-rail that brought flanged wheels.

Figure 4 - The 'Rocket' (not original reproduction), the first world-steam locomotive (National Railway Museum, York, 2024 - Photo M. Corradini)

- **This is the first interoperability parameters of the modern Railways, so it is more then 200 years old**.

The official birth of the railways is conventionally fixed on 27 September 1825, when George Stephenson's locomotive 'Locomotion No. 1' pull a train on the Stockton to Darlington line (top speed achieved, 24 km/h, length of the test track 13.7 km, out of 40 km of the entire line).
The first real steam locomotive, however, is considered to be the 'Rocket' (1829), with a tubular boiler and chimney draught.
The spread of the locomotives produced by George and Robert Stephenson contributed to the extension of the 1435 mm standard gauge network (today used in 60 per cent of the world's railways).

Growth and decline

19th Century - The big growth (until the beginning of World War I)

- the obvious advantages of the railway led to its rapid spread;
- The push by the private sector facilitated and supported the construction and operation of railways;
- In Europe, 190'134 km were built between 1835 and 1885, or about 3'803 km per year (*);
- The 19th century marked the success of the railways (almost worldwide).

Figure 6 - Workers and engineers pose in front of the direction tunnel in Göschenen around 1872. (ca. 1872, ETHZ Library)

Figure 5 - The station of Gora (Bosnia), 13.07.2022
(Photo: M. Corradini)

20th Century - The decline (until the '80s)

- Financial problems and high running costs;
- The high number of employees and political influence led to 'social' opposition to automation;
- In most cases, poor lines and services considered unprofitable, were cut;
- Complete absence of a medium- to long-term transport policy vision.

(*) China alone, between 2010 and 2023, built about 35,000 km of high-speed lines, or about 2'700 km per year (rising to 5'417 km if the conventional network is included).

Measures to revitalise the railways of Europe

In order to curb the inordinate development and expansion of road traffic, which took place mainly from the 1960s onwards throughout Europe, the then EEC issued a series of directives, regulations, railway packages and white papers to revive rail transport.

Among them:

- **Council Directive of 29 July 1991 (91/440/EEC)**
  Development of the Community's railways
  By imposing the separation of accounts between infrastructure management and transport service management, it laid the foundation for the liberalisation and opening of the rail transport market to competition;
- **Council Directives 96/48/EC of 23 July 1996 and 2001/16/EC of 19 March 2001**
  Interoperability of the trans-European high-speed and conventional rail systems;
- **Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008**
  Interoperability of the rail system within the Community (Recast);
- **White Paper 'European transport policy for 2010: time to decide' (12/09/2001)**
- **Railway Packages** (1st, 2001; 2nd, 2004; 3rd, 2007; recast, 2010; 4th Railway Package - 4RP, 2014)
  A Railway Package is a set of legislative texts designed to complete the single market for rail services (Single European Railway Area).
  It should revitalise the rail sector and make it more efficient and more competitive vis-à-vis other modes of transport.

Figure 7 – The Member State of the European Union (2024)

- **Directive (EU) 2016/797 on the interoperability of the EU's rail system (recast):**
  It sets out the conditions to be met to achieve interoperability within the European Union (EU) rail system and defines the subsystems, both structural and functional, that make up that system and aims to facilitate, improve and develop rail transport services within the EU and with non-EU countries, thereby contributing to the completion of the single European railway area and to the shift to more efficient types of transport

Figure 8 - The 4th Railway Package

- **Commission Implementing Regulation (EU) 2019/773 of 16 May 2019**
  TSI relating to the operation and traffic management subsystem of the rail system within the European Union and repealing Decision 2012/757/EU
- **Commission Implementing Regulation (EU) 2023/1695 of 10 August 2023**
  TSI relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919
- **Commission Implementing Decision (EU) 2023/2584 of 15 November 2023**
  Harmonised standards for the interoperability of the rail systems drafted in support of Directive (EU) 2016/797 of the European Parliament and of the Council

Experiences after 30 years: What have we reached?

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As a yardstick (Figures of Merits) for measuring the success of the regulatory measures introduced progressively since the 1990s to promote rail transport, the 'modal split' is taken as a benchmark.

FREIGHT TRANSPORT

MODAL SPLIT (%)

	ROAD	RAIL	INLAND WATERWAYS	PIPELINES	SEA	AIR
1995	47.0	15.6	5.1	4.3	28.0	0.1
2000	48.8	14.1	4.9	4.2	28.0	0.1
2005	51.3	12.8	4.5	4.1	27.3	0.1
2010	51.4	12.4	5.1	3.7	27.4	0.1
2011	50.6	13.2	4.7	3.6	27.9	0.1
2012	49.9	13.2	5.0	3.5	28.2	0.1
2013	50.3	13.0	5.1	3.4	28.2	0.1
2014	50.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2015	50.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2016	50.6	[illegible]	4.6	[illegible]	[illegible]	[illegible]
2017	51.8	12.7	4.5	3.2	27.8	0.1
2018	51.1	12.6	3.9	3.1	29.2	0.1
2019	51.9	12.2	4.1	3.0	28.8	0.1
2020	53.2	11.7	4.0	2.8	28.2	0.1
2021	53.8	12.0	3.9	2.6	27.7	0.1
2022	53.8	11.9	3.5	2.7	28.0	0.1
1995→2022		+	-	-	-	=

Figure 9 – The Freight Transport in the EU (Year 2022, Eurostat)

PASSENGER TRANSPORT

MODAL SPLIT %

	PASSENGER CARS	P2W	BUS & COACH	RAILWAY	TRAM & METRO	AIR	SEA
1995	73.0	2.4	10.4	7.0	1.4	5.3	0.5
2000	73.2	2.0	9.9	6.8	1.4	6.3	0.4
2005	73.2	2.2	9.5	6.5	1.4	6.9	0.4
2010	73.6	2.1	8.9	6.6	1.5	6.9	0.4
2011	72.8	2.2	9.0	6.7	1.5	7.4	0.4
2012	72.8	2.1	9.0	6.8	1.5	7.4	0.3
2013	73.0	2.1	8.9	6.8	1.5	7.3	0.4
2014	72.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2015	72.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2016	72.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2017	72.3	1.9	8.1	6.8	1.5	9.0	0.3
2018	71.9	1.8	8.1	6.9	1.5	9.5	0.4
2019	71.6	1.9	8.1	7.0	1.5	9.6	0.4
2020	80.2	2.3	6.7	5.2	1.2	4.0	0.2
2021	78.8	2.2	6.7	5.4	1.1	5.5	0.3
2022	73.0	2.0	7.2	7.2	1.2	9.1	0.3
1995→2022	=	-	-	+	-	+	-

Figure 10 – The Passenger Transport in the EU (Yer 2022, Eurostat)

In the time period from 1995 to 2022 (latest data from rapport 2024):

- Road freight transport increased significantly (+6.8 %);
- Rail freight transport dropped significantly (-3.7%);
- Passenger transport by road remained constant (73% share);
- Passenger transport by rail is essentially stable (+0.2%).

The regulatory measures introduced by the EU aimed at facilitating rail transport, including the liberalisation of rail transport (freight, 2001; international passenger traffic, 2007) have certainly allowed rail transport to be more competitive and to limit its share of the total volume of traffic circulated by land, **but they have by no means been effective enough so far to allow rail to gain the ground lost to road**.

- **identify other exploitation potentials;**
- **be more cohesive, both between infrastructure managers and with rail transport companies, encouraging exchanges of 'best practices'(*) as much as possible;**
- **Best practices can enable:**
  - **immediate production gains, without large investments;**
  - **promote the spread of uniformity in working procedures.**

Figure 11 - Best practices can influence numerous fields of application in our daily activities

(*) P.S.: Exchanges of best practices are not new, but are still mainly limited to restricted geographical areas, for cultural, linguistic and historical reasons, and often take place between professionals who are distant from the operative.
Large-scale acceleration is needed on this very important catalyst of the system.

One simple example in the track maintenance: Best Practice in rail renewal

Replacing rails on lines travelled at speeds higher than 160 km/h:
The case of the SBB CFF SBB.

SBB CFF SBB has had its own section with v>160 km/h since 2004 (NBS Mattstetten-Rothrist), with v_{max} 200 km/h, part of the Olten-Bern line.

Having never had any experience with v>160 km/h, and not having its own regulations, SBB CFF SBB has always considered what DB did in Germany as a reference ever since.

During each maintenance window, new rails are then brought on site, existing rails are replaced, and old rails are recovered. The entire work process must be completed before the section affected by the work is reopened for operation.

Figure 12 - NBS Mattstetten-Rothrist, Wanzwil Junction
Photo: Stefan Wohlfahrt, 08.07.2024

- **The future replacement of rails in the Gotthard Base Tunnel must reach better production;**
- **Production will be all the greater the longer the new rails used in the shift. It is therefore essential to be able to bring the new rails to the site in advance, using separate windows from the next replacement.**

Unloading of free rails next to tracks used by trains travelling at speeds exceeding 160 km/h

It was not enought to justify the safety of railway operation with free rails on the ground by taking the examples of RFI in Italy (which allows v < 250 km/h) and SNCF-R in France (which allows v < 300 km/h, with adaptations). In addition, these operators have no experience with a rigid superstructure, and neither did BLS in the Lötschberg Base Tunnel (perfectly comparable to GBT), so SBB CFF SBB decided to carry out its own test to analyse the behaviour of a free rail and assess possible safety measures to be applied as train speeds increased.

a. Aim

The aim of the test was to check the movements of freely laid rails next to and in the centre of a track at speeds of up to 230 km/h.

b. Equipment and other test parameters

- Test carried out near a cross-passage in the west tunnel, in the centre of the CBT, where the RABe 501 multiple units can reach the target speed of 230 km/h;
- Test point: Km 335+272, track 7000 (west tube);
- 18 m rail sections (type 60 E1 weight of 60,340 kg/m, weight of one section approx. 1,086 kg). Initial kilometre of test 335+251 and final kilometre of test 335+293;
- Free laying of two 18 m long rail sections. One rail section was laid between the platform and the running rail and the other between the two running rails.

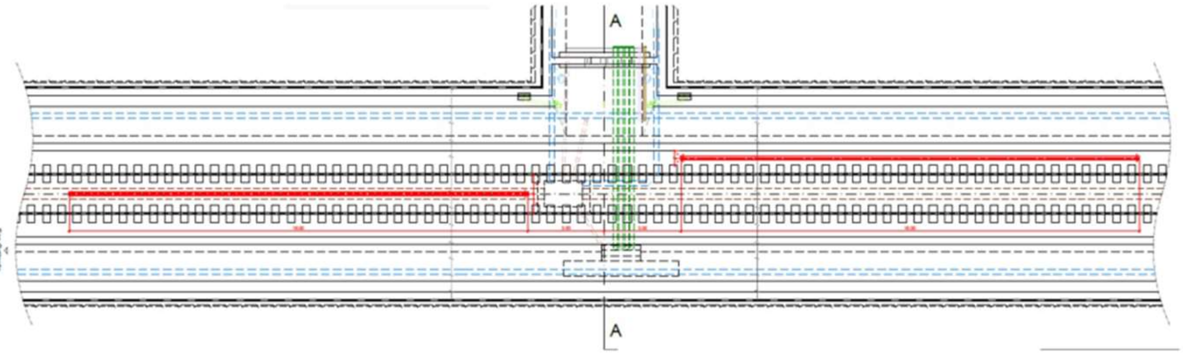


Figure 13 - Plan of the west tube showing the position of the two rails (CIPM2020)

- The rails were secured with special steel rings that equalised and prevented any displacement in the three directions x - y and z;
- The rings were fitted at both ends of the rail section and 15 mm away from the rail, simulating a free but secure installation;
- The retaining rings were attached to the concrete slab of the tunnel floor with M10 stainless steel anchors and secured in the concrete with a chemical anchor;
- A monitoring system was installed to enable continuous monitoring of the position of both rail sections in the three directions and temperature measurement in the test area.

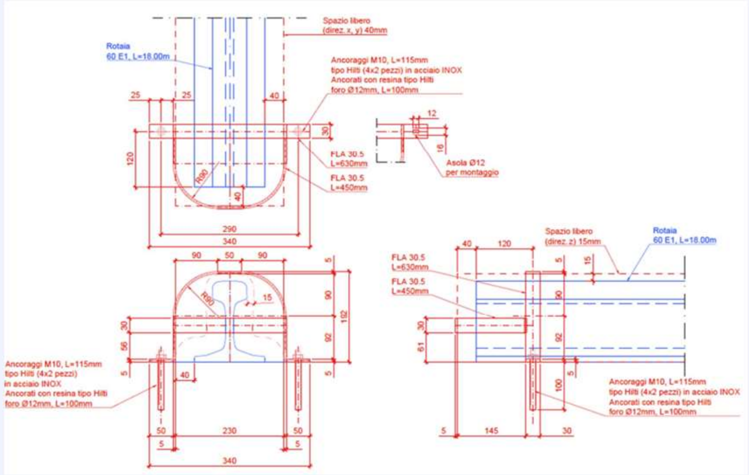


Figure 14 - Details of safety steel ring to prevent rail displacement (CIPM2020)

- 6 Crack R sensors (3 per rail section) measured the displacement of the receiver to the counter plate (transmitter);
- Measuring accuracy + / - 0.1mm ;
- The internal battery ensured autonomous operation without cabling;
- Each sensor sent the measurement data independently via the GSM network. Every two minutes, an independent measurement was triggered for each sensor between the foundation and the free rail section;
- To determine the relative displacement of the free rail, all measured values were set to zero after installation.

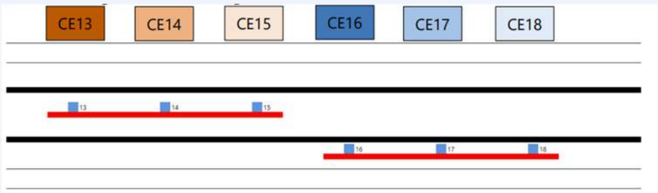


Figure 15 - Position of the 6 sensors (3 for each rail) that were used in the test (Trigonet)

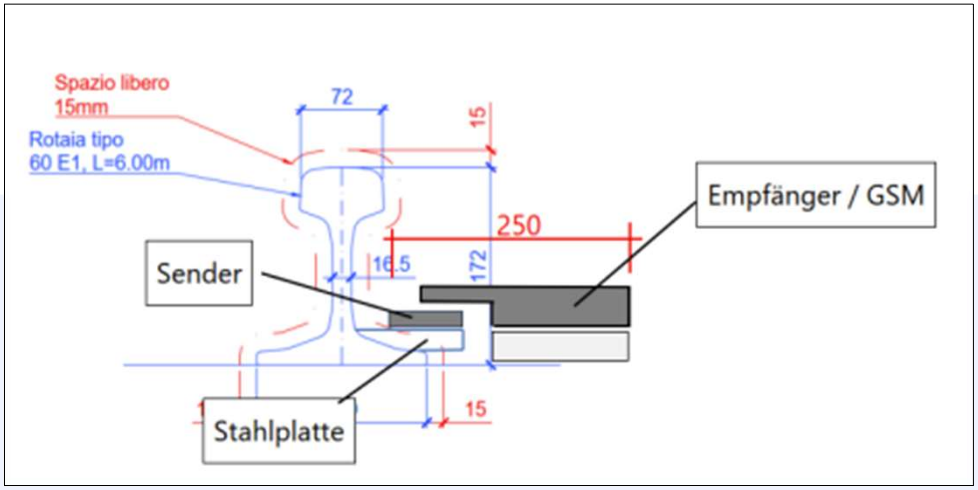


Figure 16 - Detail of the connection between the transmitter (on the rail) and the receiver (on the fixed part of the superstructure) (Trigonet)

In addition to the displacements, the sensor temperature was measured and recorded. This was done in order to determine any dependence of the movements on temperature changes.

c. Railway Safety Monitoring Thresholds

- **Attention threshold (5 mm):**
  always in view, as it was monitored during the test (the data was made available on an internet platform);

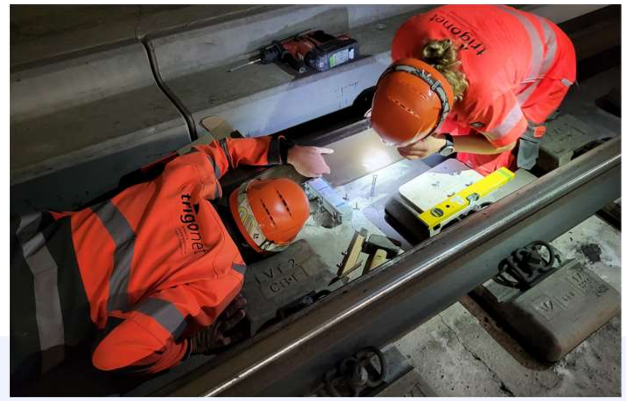
- **Intervention threshold (15 mm):**
  15 mm in the z-direction and/or 40 mm in the x- and y-directions, a meeting would have been scheduled after the intervention threshold was reached, to decide whether the test should be suspended or continued. If the monitoring system had registered a movement corresponding to the threshold value in one of the three directions, this would have meant that the rings have stopped and they were in the planned rail removal state;

- **Immediate intervention threshold (>15 mm):**
  A displacement of more than 15 mm in the z-direction or more than 40 mm in the x- and y-directions would have triggered the standby (i.e. the retaining rings would not have held and the rails would be in the danger zone).

Figure 17 - Sensor 18 with the metal cage to protect against accidental blows and impacts from trains (Photo: Trigonet, 17.06.2024)

d. Test site installation - night shift 17-18.06.2024

Figure 18 - The highlights, part 1, of the test installation
(Photo: M. Corradini, 17.06.2024)



Orario	Attività impresa ferroviaria	Attività Trigonet
00:00	Entrata impresa ferroviaria in CbT	
00:30	7 km per arrivare sul posto e successivo sbarramento del binario	
01:00	Rotaie scaricate. Inizio attività di fissaggio (1h)	Inizio attività da parte di Trigonet (3h)
01:30	-	Montaggio sensori
02:00	Rotaie fissate ed assicurate	Montaggio sensori
02:30	*Riserva sull'attività di fissaggio delle rotaie*	Montaggio sensori
03:00	*Riserva sull'attività di fissaggio delle rotaie*	Montaggio sensori
03:30	*Riserva sull'attività di fissaggio delle rotaie*	Montaggio sensori
04:00	*Riserva sull'attività di fissaggio delle rotaie*	Sensori installati e assicurati
04:30	*Riserva sull'attività di fissaggio delle rotaie*	Prova di funzionamento
05:00	*Riserva sull'attività di fissaggio delle rotaie*	*Riserva sulla prova di funzionamento*
05:30	Ricomposizione treno di manutenzione, rimozione sbarramento del binario e svolgimento della corsa di controllo	Ricomposizione treno di manutenzione, rimozione sbarramento del binario e svolgimento della corsa di controllo
06:00	Uscita da CbT	Uscita da CbT

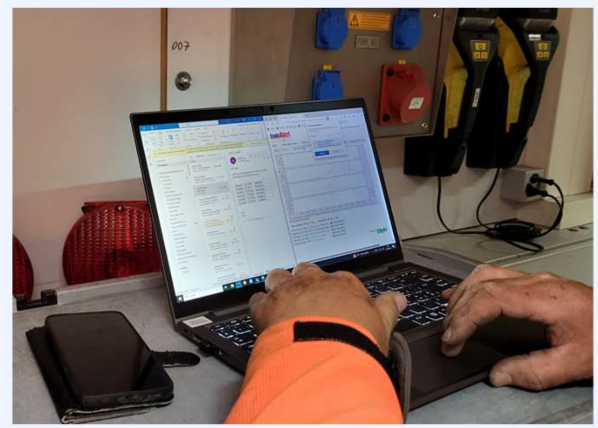
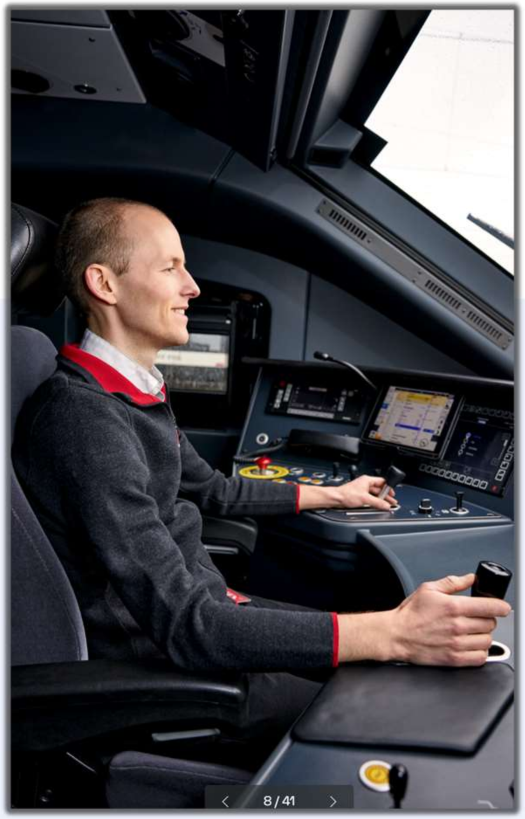


Figure 19 - The highlights, part 2, of the test installation
(Photo: M. Corradini, 17.06.2024)

Figure 20 - 18.06.2024, 06.00 a.m. – At the end of the outage for the installation of the test equipment, a speed reduction of 160 km/h was applied (Photo: M. Corradini, 18.06.2024)

e. Advice to drivers



Stimati macchinisti,

nelle prossime settimane sono pianificati dei test nella CBT che coinvolgeranno i nostri treni. Di seguito, vi fornisco le informazioni utili per il buon funzionamento delle prove.
Il test si concluderà il 05.08.2024.

Modalità esecutiva:

Il test è pianificato a tappe con variazione di velocità progressiva dei convogli ferroviari, secondo la seguente sequenza e durata:
-160 km/h per 1 settimana dal 18.06 al 24.06.2024 (rallentamento ordinato e confermato)
-200 km/h per 1 settimana dal 25.06 al 01.07.2024 (rallentamento ordinato e confermato)
-230 km/h dal 02.07 al 05.08.2024

I test saranno effettuati nella canna Ovest della galleria CBT (binario 7000).
Se le condizioni lo permettono vi invito a raggiungere la velocità di 230 km/h con i treni "Giruno" durante il periodo dal 2 luglio al 5 agosto, per favorire la buona riuscita dei test.

Vi ringrazio per la vostra collaborazione.
Cordiali saluti.

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In den kommenden Wochen sind im CBT Tests geplant, die unsere Züge betreffen werden. Im Folgenden gebe ich Ihnen nützliche Informationen für den reibungslosen Ablauf der Tests.
Die 2 x 18 m Schienen werden in der Nacht vom 17. auf den 18.06.2024 im CBT verlegt, gesichert (ohne physischen Kontakt) und kontinuierlich überwacht.
Der Test endet am 05.08.2024, wenn sie wieder entfernt werden.

Art der Durchführung:

Der Test ist in Etappen mit progressiver Geschwindigkeitsänderung der Triebzüge geplant, und zwar in folgender Reihenfolge und Dauer:
-160 km/h für 1 Woche vom 18.06. bis 24.06.2024 (langsameres Fahren angeordnet und bestätigt)
-200 km/h für 1 Woche vom 25.06. bis 01.07.2024 (langsameres Fahren angeordnet und bestätigt)
-230 km/h vom 02.07. bis 05.08.2024

Die Tests werden in der Weströhre des CBT-Tunnels (Gleis 7000) durchgeführt.
Wenn es die Umstände erlauben, möchte ich Sie bitten, mit den "Giruno"-Zügen in der Zeit vom 2. Juli bis 5. August eine Geschwindigkeit von 230 km/h zu erreichen, um erfolgreiche Tests zu ermöglichen.

Figure 21 – A train driver on a RABe 501 Unit ("Giruno" EMU) (Photo: SBB)

f. Railwaytraffic during the test

During the 49 test days, a total of **6’695 trains** passed through the test site.

In particular:

- 1’419 Intercity/Eurocity (of which 529 Eurocity);
- 1’349 long-distance freight trains (weighing up to 2014 tonnes);
- 1’864 Regio Express;
- 1’743 S-Bahn;
- 11 express trains / Interregio;
- 309 other services.

During this time, a total of **3’614’251 tonnes** travelled on the tracks.

Figure 22 – A freight trains in the Ceneri Base Tunnel (Photo: SBB)

Bericht 1

Betriebstag Abs	Abfahrtsze	Ankunftsze	Abschnitt	Abschnitt	Hauptgleis Ar	Hauptgleis Ab	Zugnumm	Bezeichnung	Bezeichnung De	Bruttotonn
18.06.2024	00:02	00:24	CAMO	VEZB	7081	7011	34215	Lokzug	übrige DienstZ (Infra)	160
18.06.2024	00:52	01:02	VEZB	CAMO	7011	932	40046	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1670
18.06.2024	01:15	01:24	VEZB	CAMO	7011	932	41518	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	609
18.06.2024	04:44	04:54	VEZB	CAMO	7011	932	40030	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1782
18.06.2024	04:54	05:03	VEZB	CAMO	7011	932	40124	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1662
18.06.2024	05:31	05:45	VEZB	CAMO	7011	932	34216	Lokzug	übrige DienstZ (Infra)	160
18.06.2024	06:03	06:09	VEZB	CAMO	7011	932	10664	Intercity/Eurocity	InterCity	781
18.06.2024	06:05	06:12	VEZB	CAMO	7011	932	25754	S-Bahn	S-BahnZ	273
18.06.2024	06:07	06:14	VEZB	CAMO	7021	932	25500	RegioExpress	RegioExpress	361
18.06.2024	06:12	06:23	VEZB	CAMO	7011	932	60210	Ferngüterzug	FerngüterZ	834
18.06.2024	06:27	06:34	VEZB	CAMO	7011	932	25108	S-Bahn	S-BahnZ	178
18.06.2024	06:32	06:39	VEZB	CAMO	7011	932	1466	Intercity/Eurocity	InterCity	390
18.06.2024	06:37	06:45	VEZB	CAMO	7021	932	25804	RegioExpress	RegioExpress	178
18.06.2024	06:43	06:50	VEZB	CAMO	7011	932	29146	Lokzug	Lokzug	84
18.06.2024	06:46	06:56	VEZB	CAMO	7011	932	45014	Ferngüterzug	GüterZ WLV international	1444
18.06.2024	06:57	07:04	VEZB	CAMO	7011	932	25756	S-Bahn	S-BahnZ	273
18.06.2024	07:05	07:11	VEZB	CAMO	7011	932	668	Intercity/Eurocity	InterCity	390
18.06.2024	07:07	07:14	VEZB	CAMO	7021	932	25502	RegioExpress	RegioExpress	314
18.06.2024	07:14	07:24	VEZB	CAMO	7011	932	40344	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1626
18.06.2024	07:27	07:34	VEZB	CAMO	7011	932	25110	S-Bahn	S-BahnZ	356
18.06.2024	07:33	07:39	VEZB	CAMO	7011	932	1468	Intercity/Eurocity	InterCity	390
18.06.2024	07:37	07:44	VEZB	CAMO	7021	932	25806	RegioExpress	RegioExpress	361
18.06.2024	07:58	08:04	VEZB	CAMO	7011	932	25758	S-Bahn	S-BahnZ	314
18.06.2024	08:05	08:11	VEZB	CAMO	7011	932	870	Intercity/Eurocity	InterCity	781
18.06.2024	08:07	08:15	VEZB	CAMO	7021	932	25506	RegioExpress	RegioExpress	360
18.06.2024	08:11	08:18	VEZB	CAMO	7011	932	25706	RegioExpress	RegioExpress	314
18.06.2024	08:28	08:35	VEZB	CAMO	7011	932	25112	S-Bahn	S-BahnZ	314
18.06.2024	08:37	08:45	VEZB	CAMO	7021	932	25808	RegioExpress	RegioExpress	178

Bericht 1 +

Figure 23 - An extract of the list with the main data of the trains that passed through the test site during the 49-day observation period

g. Test site removal - Night shift on 05-06/08/2024

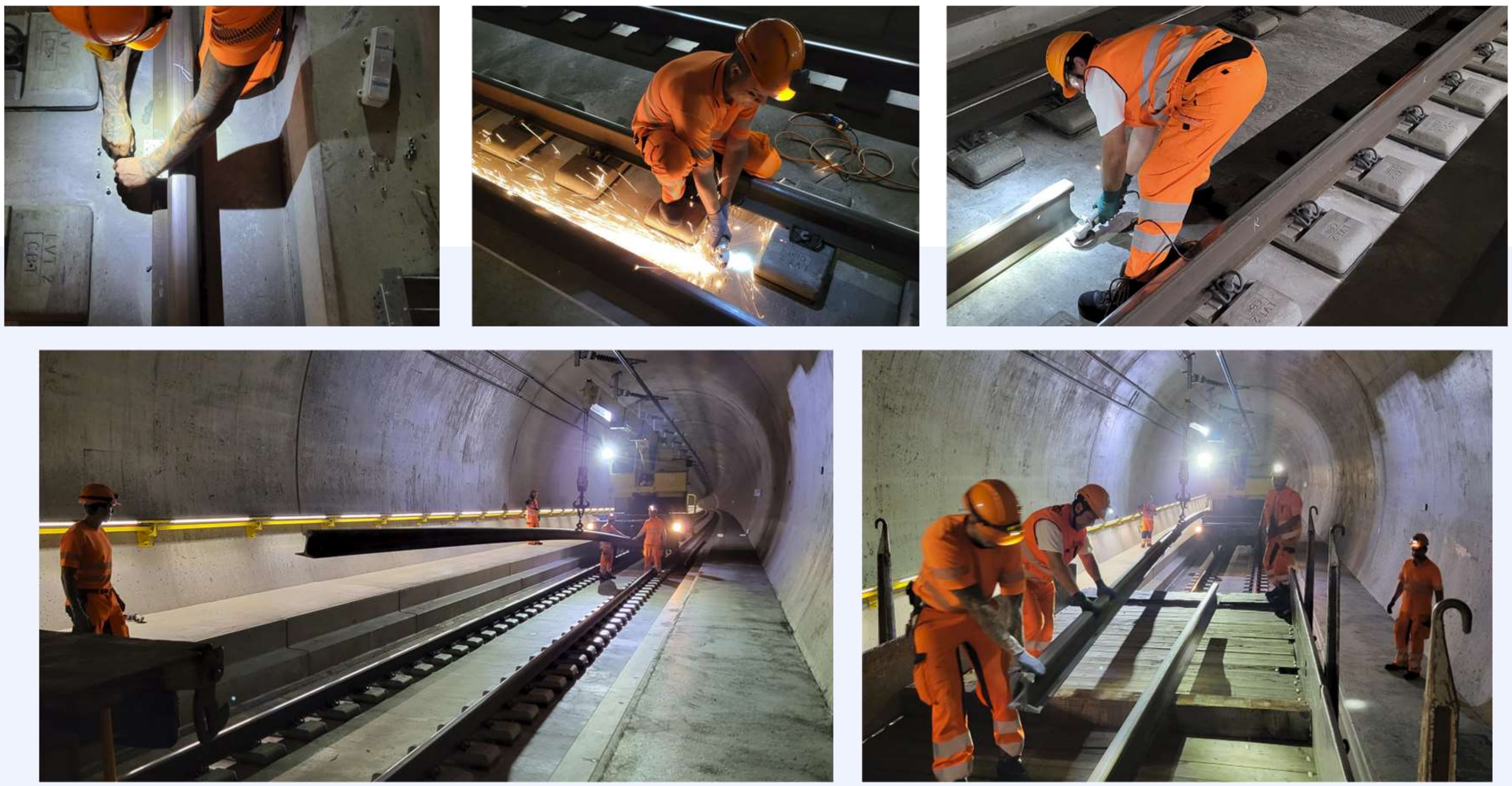


Figure 24 – Some highlights of the test site removal
(Photo: M. Corradini, 05.08.2024)

Figure 25 - 06.08.2024, 06.00 a.m. – At the end of the outage, the full speed was released.

h. Measurements recorded during the test period

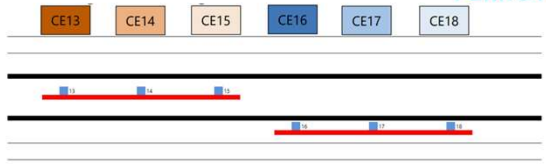
- In principle, **no significant displacements of the free rail sections were detected**;
- The defined limit values of 5, 10 and 15 mm were not exceeded with the exception of individual measurement errors. All displacements were less than 1.5 mm, i.e. less than 30% of the first alarm level;
- The Z direction showed the greatest scatter for all sensors;
- A stronger scattering of the measurement results in the Z-direction of the two sensors CE16 and CE18 was visualised in the raw data. A statement about the dependence of the position of the sensor on the rail section cannot be made from the measurement data;
- A connection with temperature changes was not recognised.

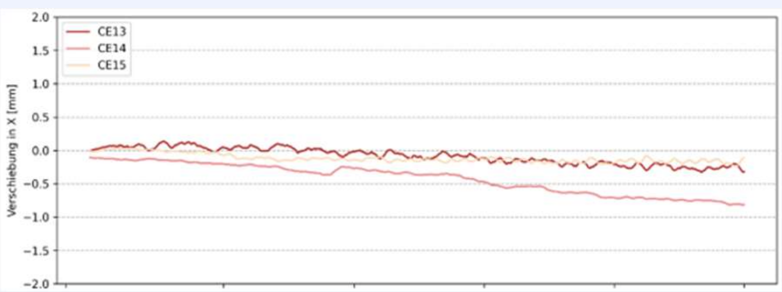
Figure 26 - Km 335+272, track 7000 (west tube),
Photo: M. Corradini, 18.06.2024

g. Trend of displacements recorded during the test period

a) Sensors between the rails

- All averaged displacements were less than one millimetre during the measurement period. This shows that no significant displacements of the free rail sections were measured. Several sensors show trends of absolute displacement.
- The monitoring of the free rail section between the two rails showed a slight displacement of approximately 0.4 mm in the X direction. No displacements were visible in the Y direction via the three measuring sensors;
- Two sensors have had a slightly greater height difference between the sensor and the receiver.





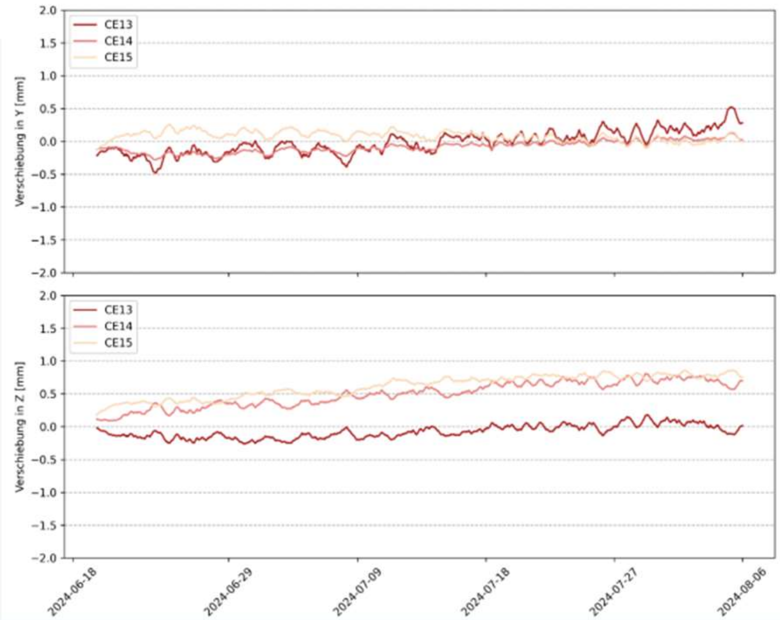
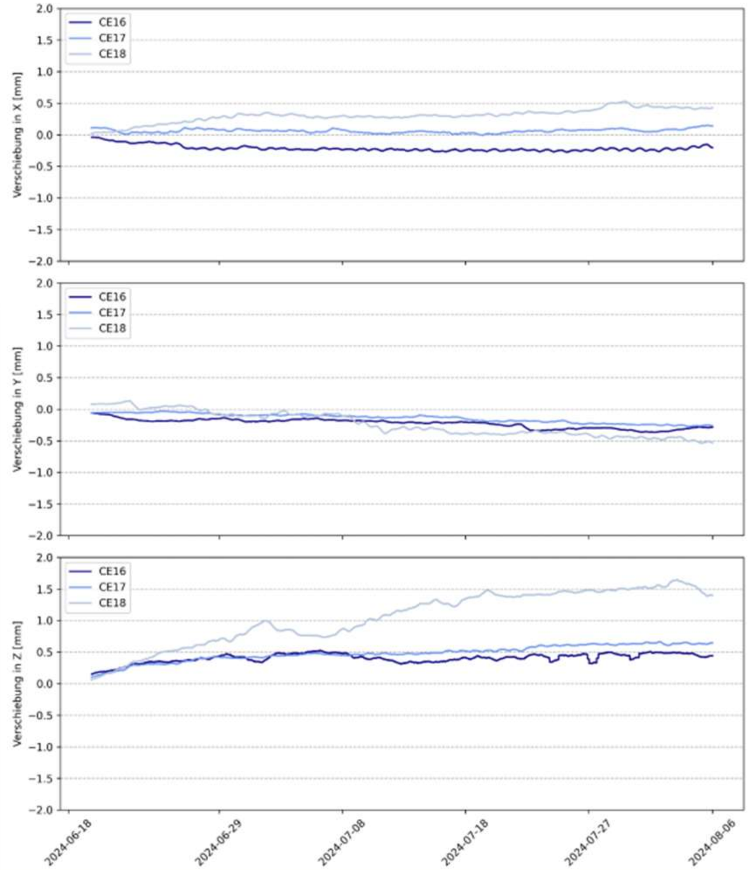
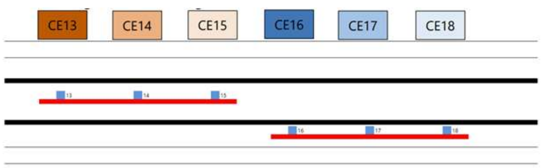


Figure 27 – Displacements of the sensors C13-C15 (Source: Trigonet)

b) Sensors next to the rails





- The trend lines showed hardly any shifts in the position of the free rail section next to the tracks during the entire measurement period;
- The height difference between the sensor and the receiver maximised during the measurement period;
- Sensor CE18 measured the largest changes during the monitoring period;
- Minor deviations in the measurements could have been caused by the slight accumulation of iron dust on the magnetic transmitter. The measured displacements do not indicate a displacement of components of the measuring system. At best, the base plate with the adhesive may have become slightly loose in the height of the sensors, which could also be the cause of the change in height.

Figure 28 - Displacements of the sensors C16-C18 (Source: Trigonet)

h. Comparison of measured displacements & rail traffic

- The measured movements showed such low values that no significant correlation could be established with the passage of the trains. The movements were analysed in random samples with the train passages;
- The comparison did not reveal anything significant;
- It was viewed in detail on 24 July 2024. It is possible to recognise that the days 24.07 - (26.07 - 27.07) and 30.07 differed from the usual ones. This can be seen from the graph, which refers to the "z", which had three downward peaks:

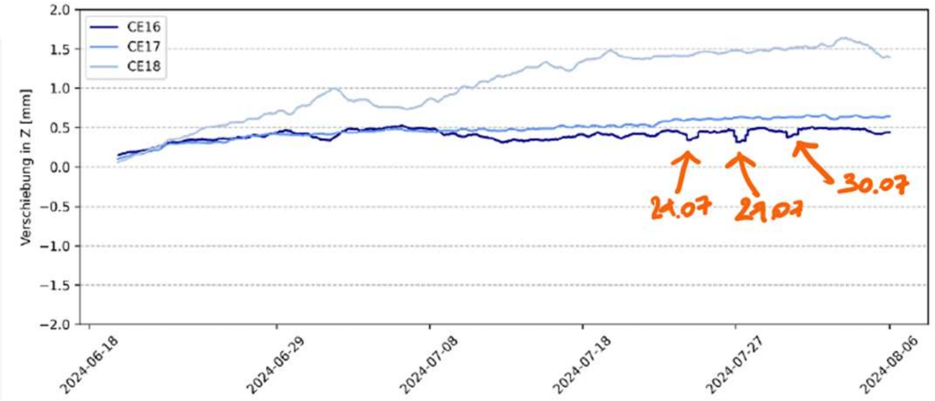


Figure 29 - Displacements of the sensors C16-C18, in the z-axis (Source: Trigonet)

- On the four dates, there were particularly heavy, consecutive and narrow passages (but also on other dates, e.g. on 21 June and 22 June, without anything special being observed).

i. An analysis of a significant day: 24.07.2024

- Sensor C13 - Movement in Y-axis;
- **719 measurements** and **142 trains**;
- 11 passes > of 1,000 tonnes for a total of approx. 16,500 tonnes.

Figure 30 - Graph of the displacements detected by sensor C-13, in direction Y, on 24 hours of the day 24.7.2024 (CIPM2020)

24.07.2024	01:35	01:45	VEZB	CAMO	7011	932	40022	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1324
24.07.2024	02:00	02:11	VEZB	CAMO	7011	932	45022	Ferngüterzug	GüterZ WLV international	1539
24.07.2024	02:04	02:14	VEZB	CAMO	7011	932	69688	Ferngüterzug	GanzZ	1622
24.07.2024	02:13	02:22	VEZB	CAMO	7011	932	97488	Leermaterialzüge des Personenverkehrs	Versuchs- und MessZ (ReiseZ)	168
24.07.2024	02:21	02:30	VEZB	CAMO	7011	932	68160	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1664
24.07.2024	02:25	02:35	VEZB	CAMO	7011	932	41014	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1612
24.07.2024	03:23	03:33	VEZB	CAMO	7011	932	60202	Ferngüterzug	FerngüterZ	1031
24.07.2024	03:26	03:36	VEZB	CAMO	7011	932	41084	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1768
24.07.2024	03:29	03:39	VEZB	CAMO	7011	932	45012	Ferngüterzug	GüterZ WLV international	1381
24.07.2024	04:55	05:05	VEZB	CAMO	7011	932	40320	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1479
24.07.2024	05:00	05:10	VEZB	CAMO	7011	932	40030	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1726
24.07.2024	05:05	05:13	VEZB	CAMO	7011	932	38100	Lokzug	Lokzug	84
24.07.2024	05:09	05:18	VEZB	CAMO	7011	932	42070	Ferngüterzug	GüterZ des komb Verkehrs (UKV)	1348

Figure 31 – Data of some of the passenger and freight trains that passed through the site test on the 24.7 (Source: SBB, Fahrplan und Betrieb)

- The passage of trains was represented with a factor of 0.25.
- It is not possible to recognise a correlation between these data.

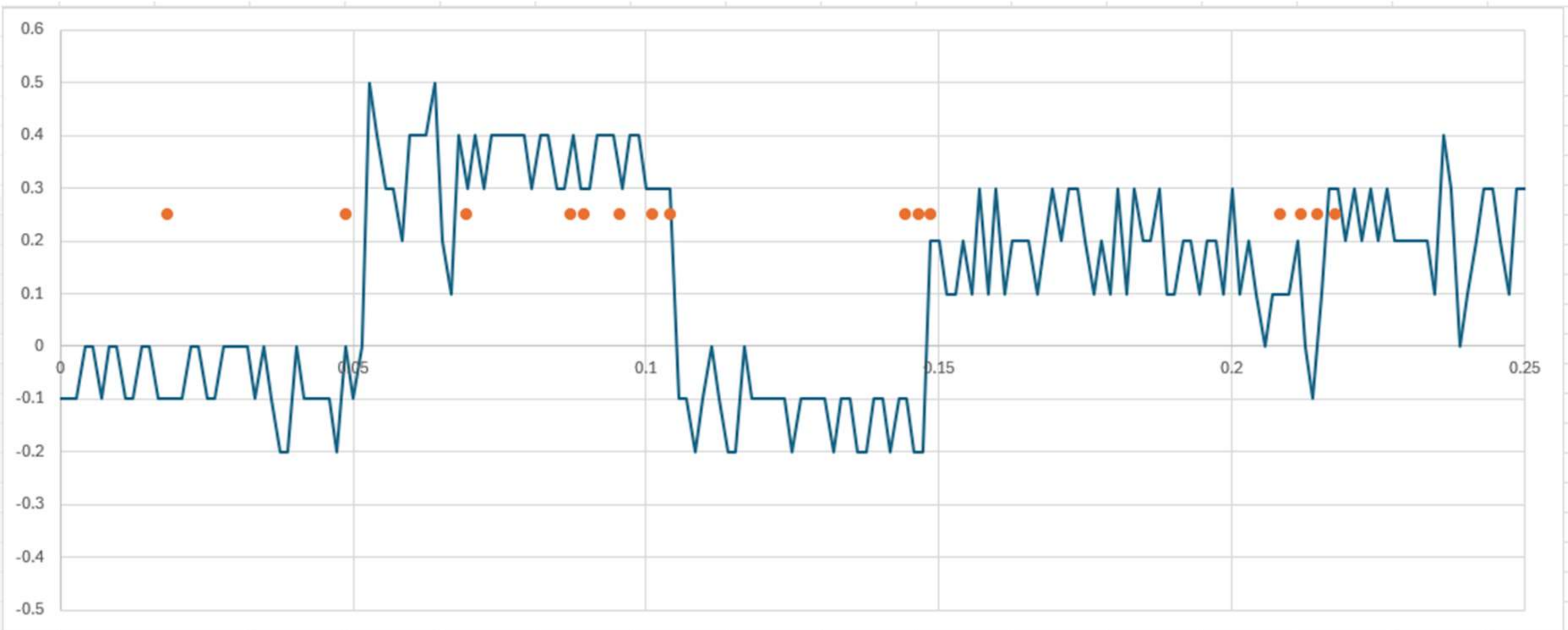


Figure 32 - Close-up of the detail of the displacements recorded by sensor C-13
in the first 6 hours of 24.7, in direction Y (CIPM2020)

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I. Concluding remarks on the test

Although the vibrations from the trains and thus the spatial displacements were hardly perceptible (anyway), and taking into account the high detection accuracy, other accompanying factors had a greater influence on the displacement recorded by the sensors due to the structure of the overall system and the variability of the environmental conditions.

For example, played a role the following effects :

- the deformability of the superstructure;
- the air pressure caused by the trains passing over the sensors;
- the shrinkage/dilatation of the adhesive used to fix the sensors as a function of the air temperature;
- other minor cause.

➢ **the test proved that 18m of freely laid rails do not move**

m. Upcoming activities

Slab-track superstructure (tunnel):

- Development of the railway safety risk analysis (K250);
- Integration of these improvements in the work process for the update of the instruction I-22211 of SBB CFF SBB
  - forecast start of validity: 2026

Ballast superstructure (outside the tunnel):

- Benchmarking with other Railway Infrastructure Managers;
- K250 processing;
- Integration in I-22211.

Figure 33 - Wanzwil Tunnel, Track renewal with BOA train
(Photo: M. Corradini, 25 March 2022)

Some considerations

1. True support for the railways and thus an increase in modal split is achieved above all by increasing the extent of the network (a necessary, but not sufficient condition) and possibly by giving it a reticular shape (allowing reasonable and necessary flexibility of operation).

While at the beginning of the 19th century, some 3'800 km/year were being built in Europe, which gave the railway greater accessibility in the territory, from the beginning of the 20th century to today, apart from the high-speed lines that have been built (9'502 km, Year 2022), all the rest of the infrastructure has been upgraded, modernised, but not extended to those areas not yet served by trains.

➔ **this is a paradigm shift that Europe has yet to make**

Figure 34 - In my own small way, I have tried as much as possible to exchange experiences. Here I am in Germany, where I did an internship at DB in 2014 - Project VDE8, Erlangen, VP144
(Photo: M. Corradini, 30.04.2014)

2. Regulations and the widespread application of best practices can serve as a follow-up and supplementary measure to strengthen an existing network. They are not the panacea to the existing gap with the road;
3. The optimisation example shown refers to rail, which, as seen on page 3, is the presumably technically oldest and most interoperable element of the entire current railway system.

   However, similar examples can already be found in many other areas of the railway, including new technologies such as ERTMS; train management; public information; etc.) and not only in the field of infrastructure, but also in the field of trains.

Don't get lost among your thousand ideas

Define the best objective with others

Follow the agreed route

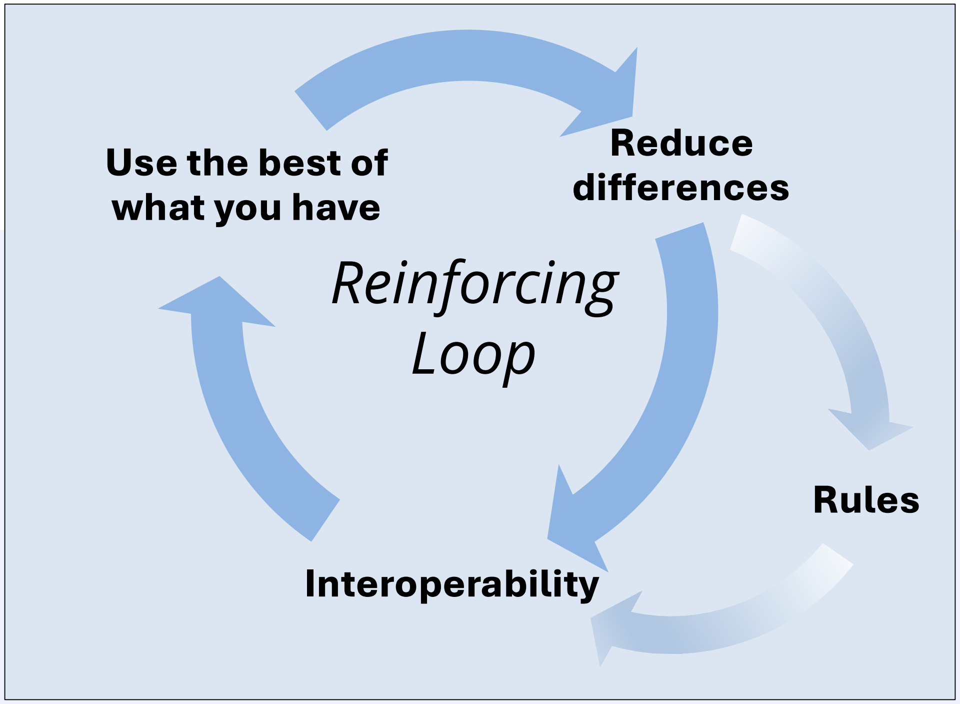
➔ **Knowledge of the railway system and, compared to the past, sovereignty openness (not only technical but, above all, mental) must be vigorously supported by all those involved;**

➔ **The National Railway Colleges and the UEEIV are essential components of this change.**

Final words

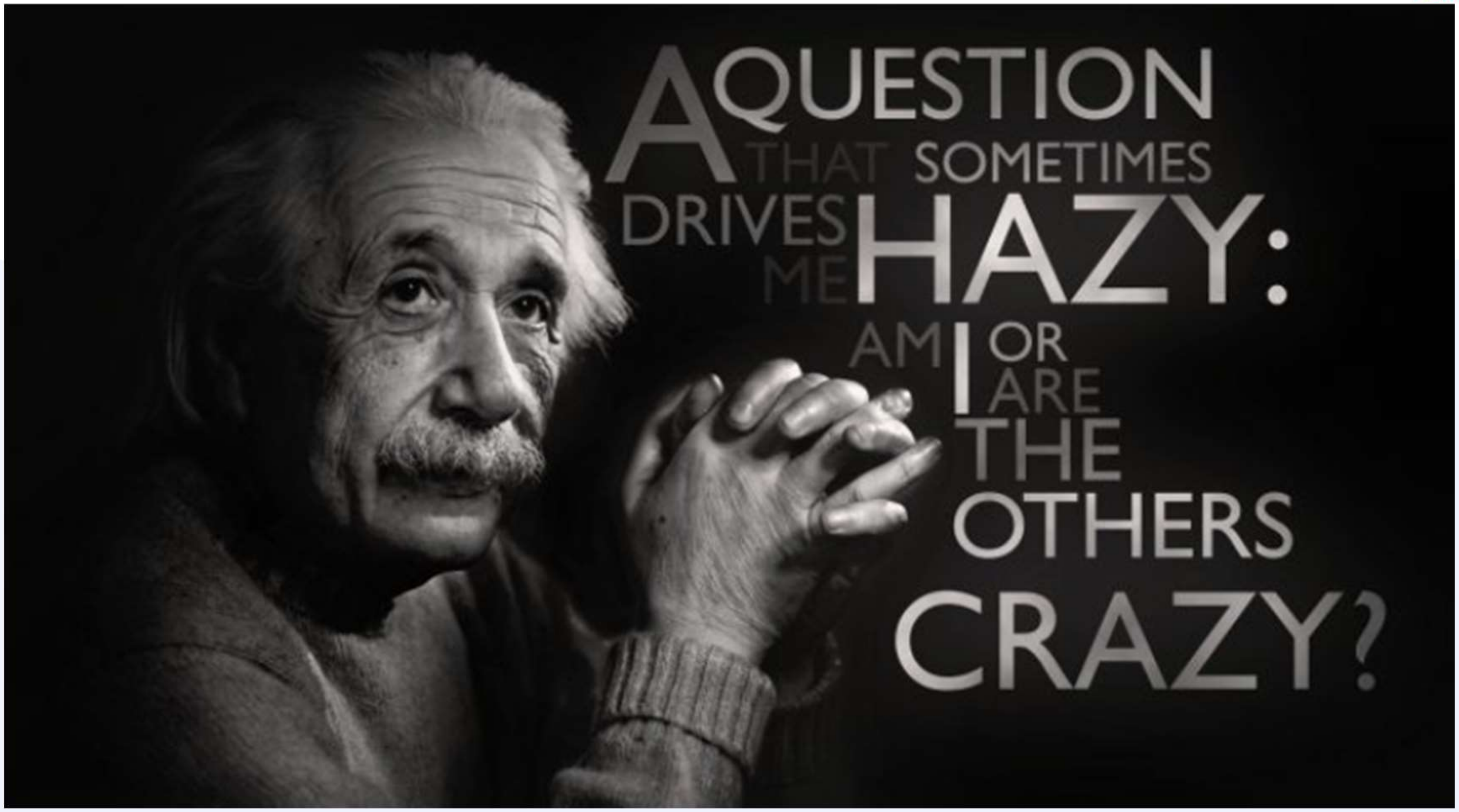
Part 1

- We already have many regulations in a history of at least 30 years
- We need to **better apply what we already know and what we already have**
- We need a **strong central co-ordination** that is able to put the best solutions into system and operation
- We must be **concrete, cohesive, determined, efficient and effective**
- We must act on two main pillars:
  - **choosing the best of technology**
  - **choosing the best of the organisation**



Part 2

No comment



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About the author:

Marco Corradini has been passionate about railway culture and technology since he was a child.

After graduating with honours from Bologna in Transport Engineering, he worked in Italy at FS Group companies (Italferr and RFI), in Germany (DB International) and in Switzerland (AlpTransit Gotthard and, today, SBB).

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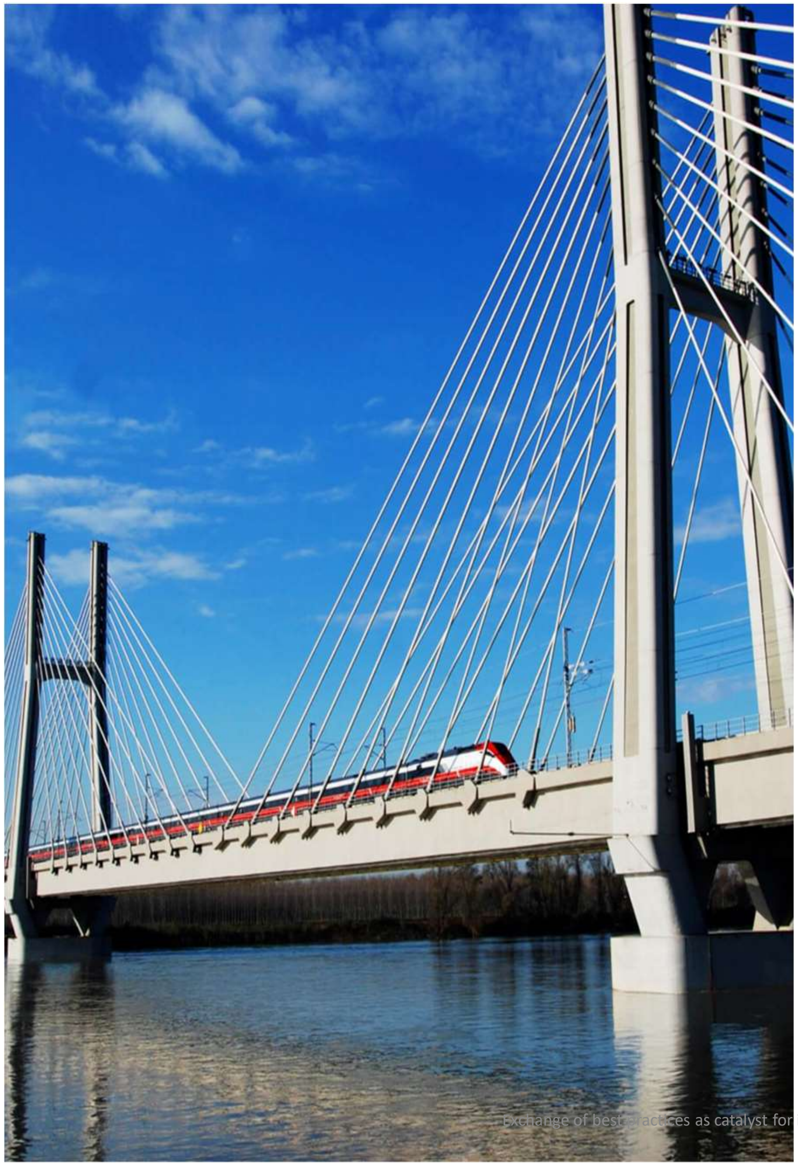

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