

Challenge #1: Debug our train tracks!

<http://hackzurich.siemens.cool>



SIEMENS

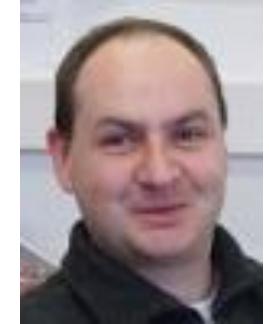
Siemens – a Company of Skilled Engineers

Siemens

- ❖ One of the biggest software companies worldwide
- ❖ Founded 174 years ago
- ❖ ~ 300'000 employees
- ❖ € 57 billion revenue (2020)
- ❖ Diverse portfolio
 - ❖ Mobility
 - ❖ Smart infrastructure
 - ❖ Digital industry
 - ❖ Health care
 - ❖ Power generation (wind, renewables, gas)

Engineers

- ❖ Daniel Helfer
 - ❖ Software engineer R&D
 - ❖ Expert for train control systems
- ❖ Christoph Walser
 - ❖ Project manager R&D
 - ❖ Expert on train management dispatching systems



Agenda

- 
- 1. Siemens and workshop hosts 
 - 2. What is our challenge about?
 - 3. Railway technology primer: what you need to know
 - 4. Data provided for challenge
 - 5. How to get the data
 - 6. Q&A

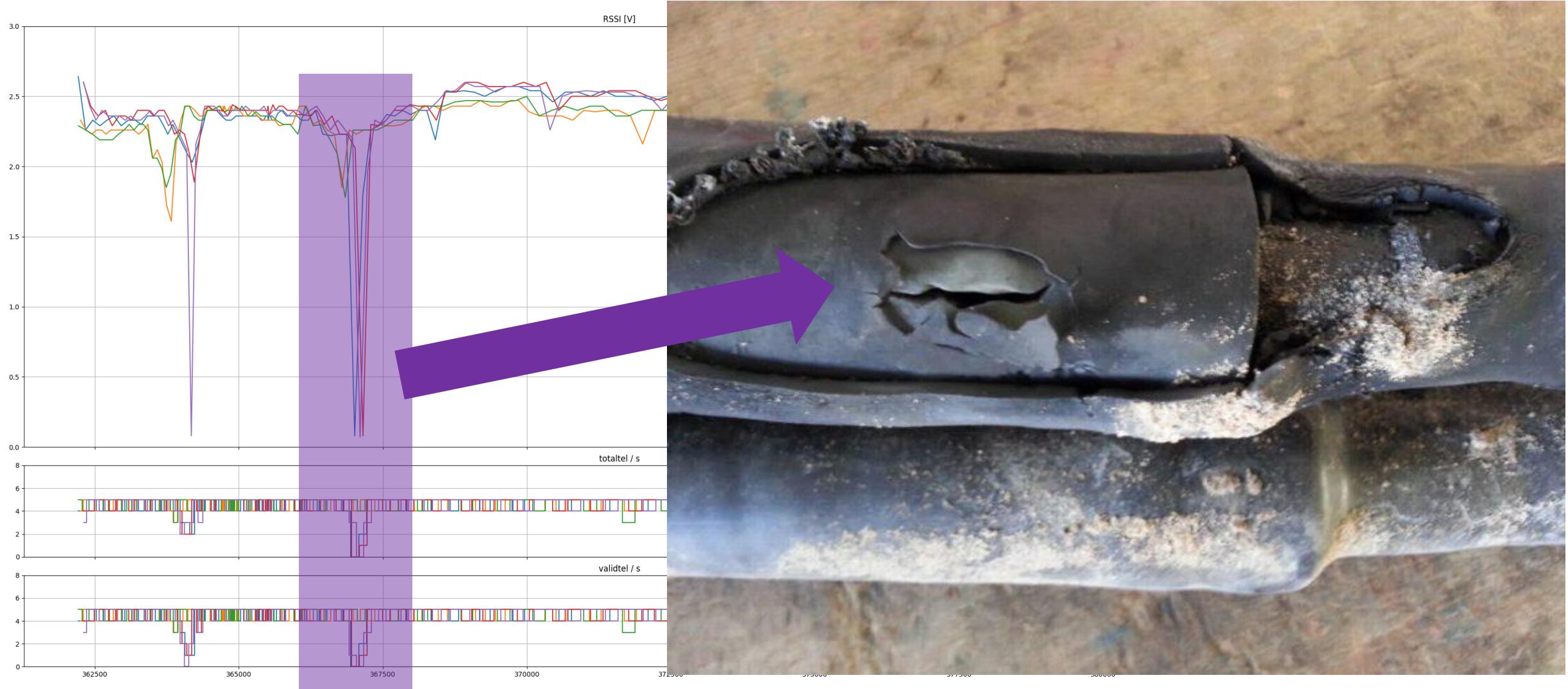
What is our challenge about?



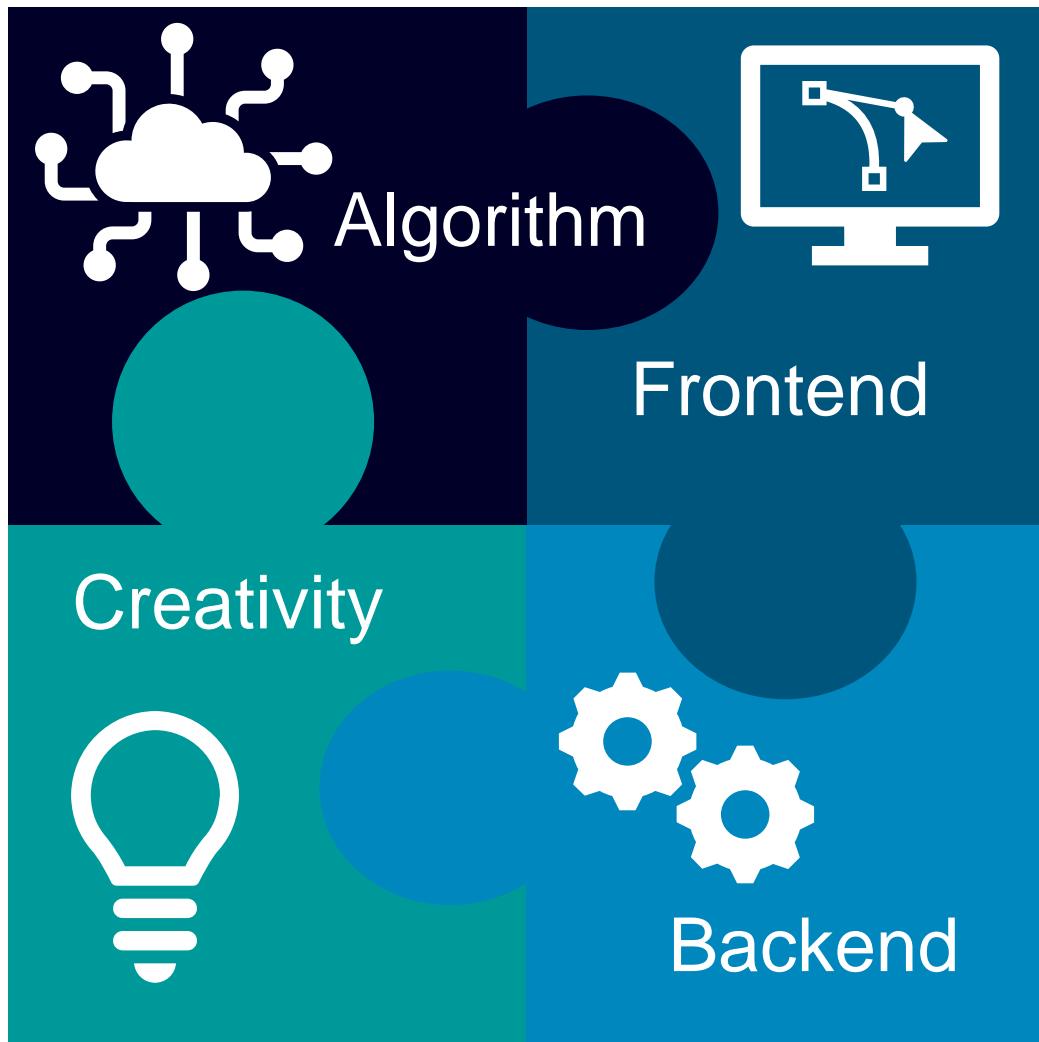
What is our challenge about?



What is our challenge about?



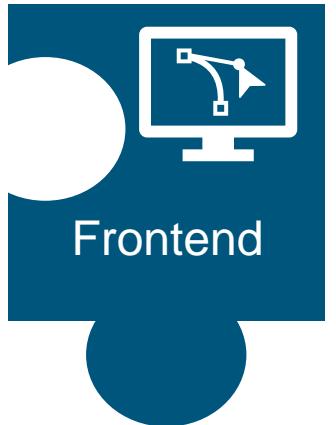
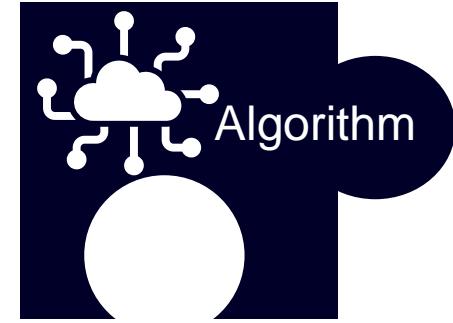
What is our challenge about?



What is our challenge about?

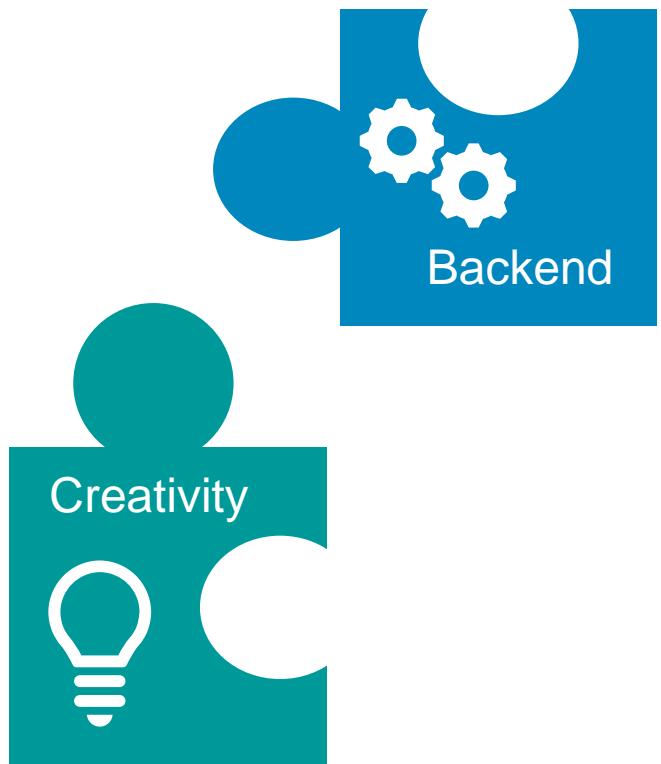
- ❖ Develop an algorithm to detect, predict and categorize failures based on communication metadata provided by us.
 - ❖ Anomaly detection is possible with advanced statistics, artificial intelligence, and other principles
 - ❖ Predict the time of failure and the failure category

- ❖ Create a frontend that visualizes the data. Ideas for the frontend:
 - ❖ Show failures localized on some sort of a map
 - ❖ Have a slider to go back and forth in time
 - ❖ Show additional data on failure locations: pictures, Google Street View, Google/OSM maps, ...

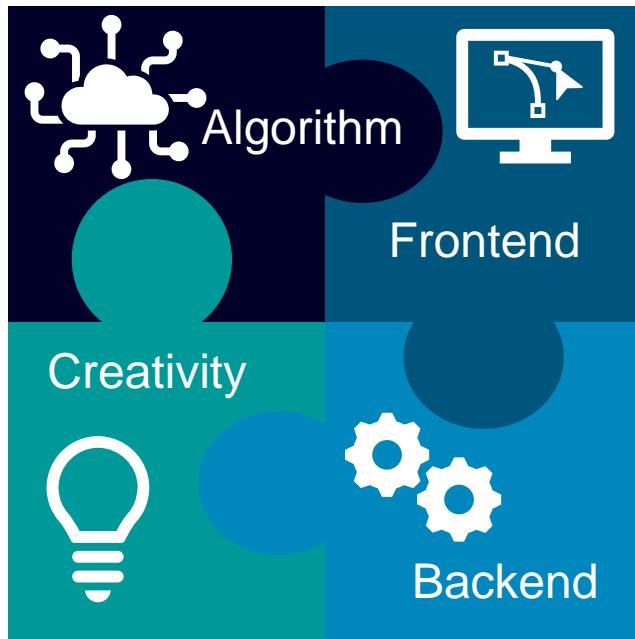


What is our challenge about?

- ❖ A backend to store raw and analyzed data would also be nice (but is not a must)...
- ❖ Discuss your ideas with us at our booth or on Slack – we are open for your creativity!



What is our challenge about?



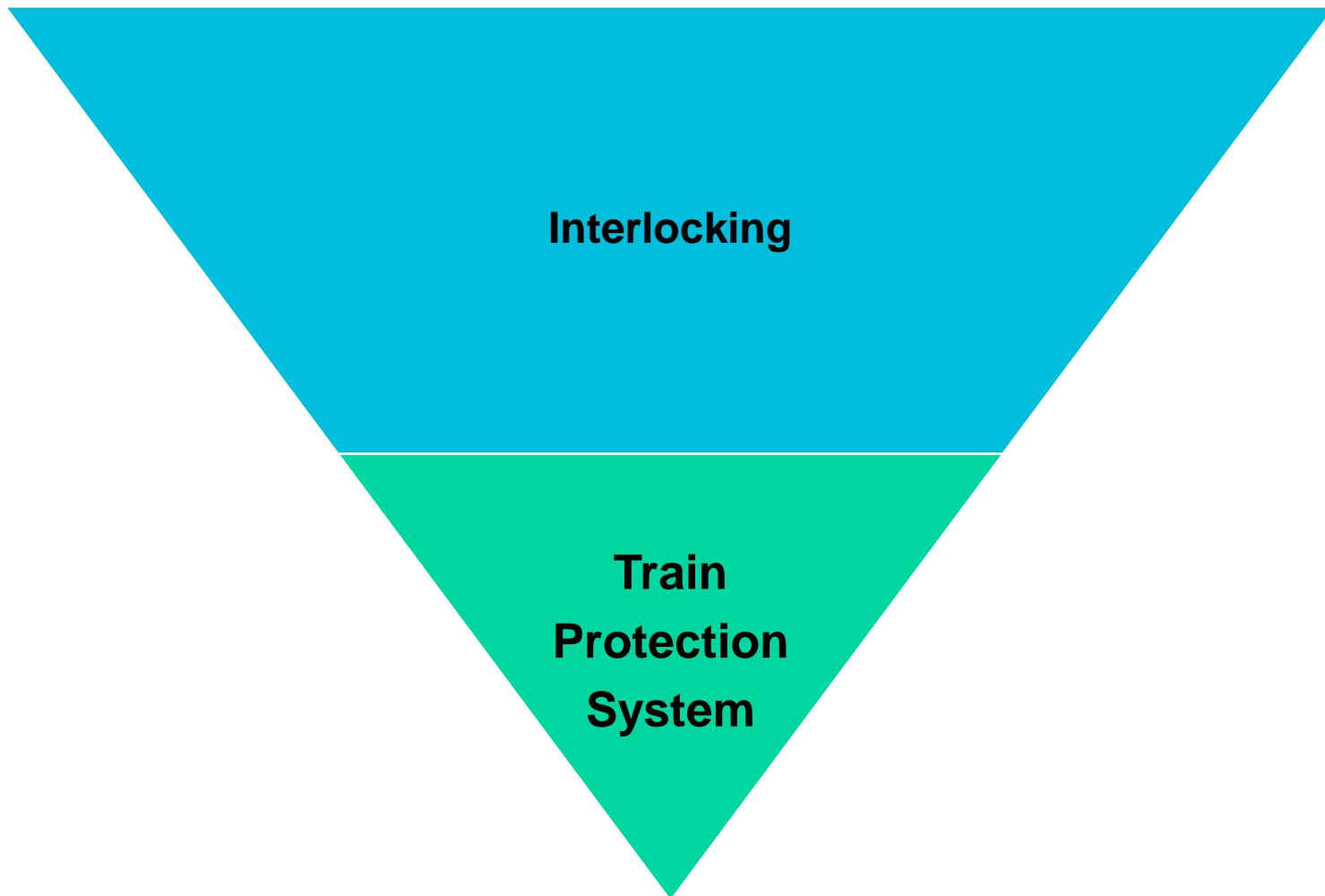
Use the technology of your choice.
We like opensource software with permissive licenses ☺

Railway technology primer: What you need to know

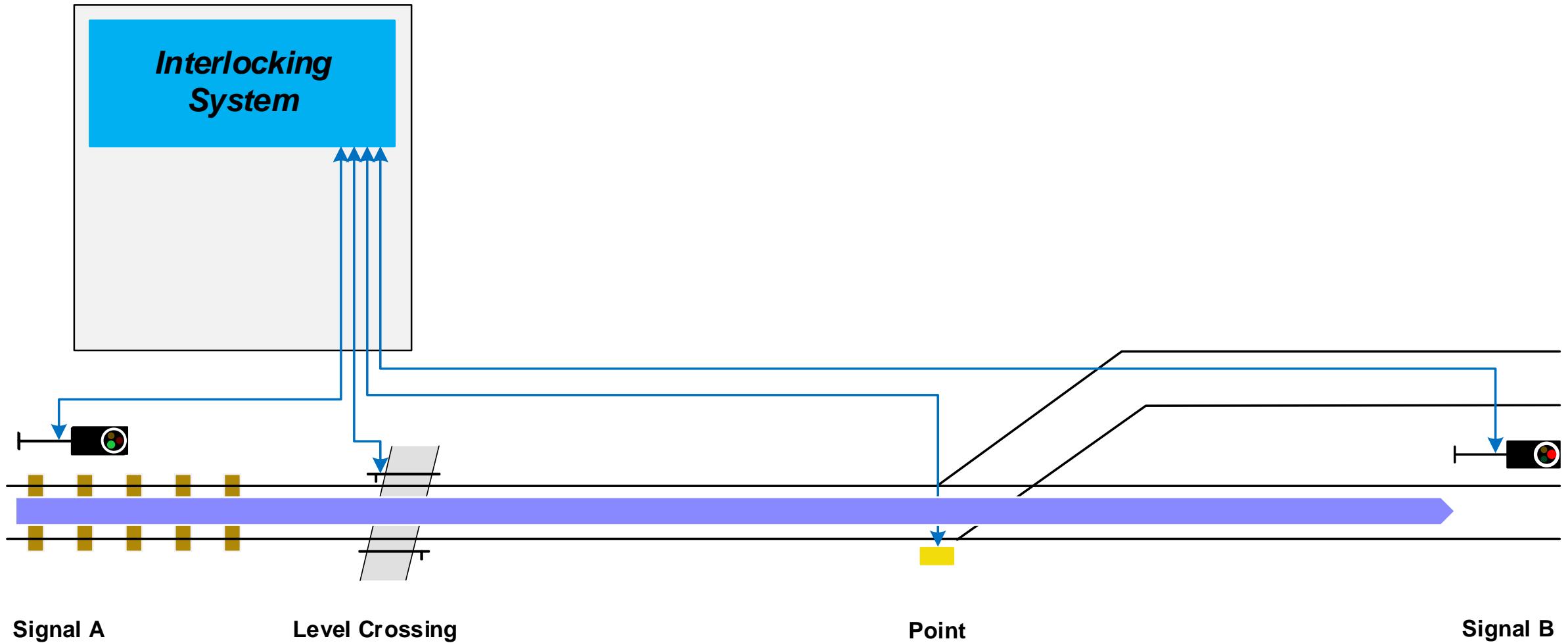
Have you ever asked yourself what is needed so that your train brings you safely to your destination?



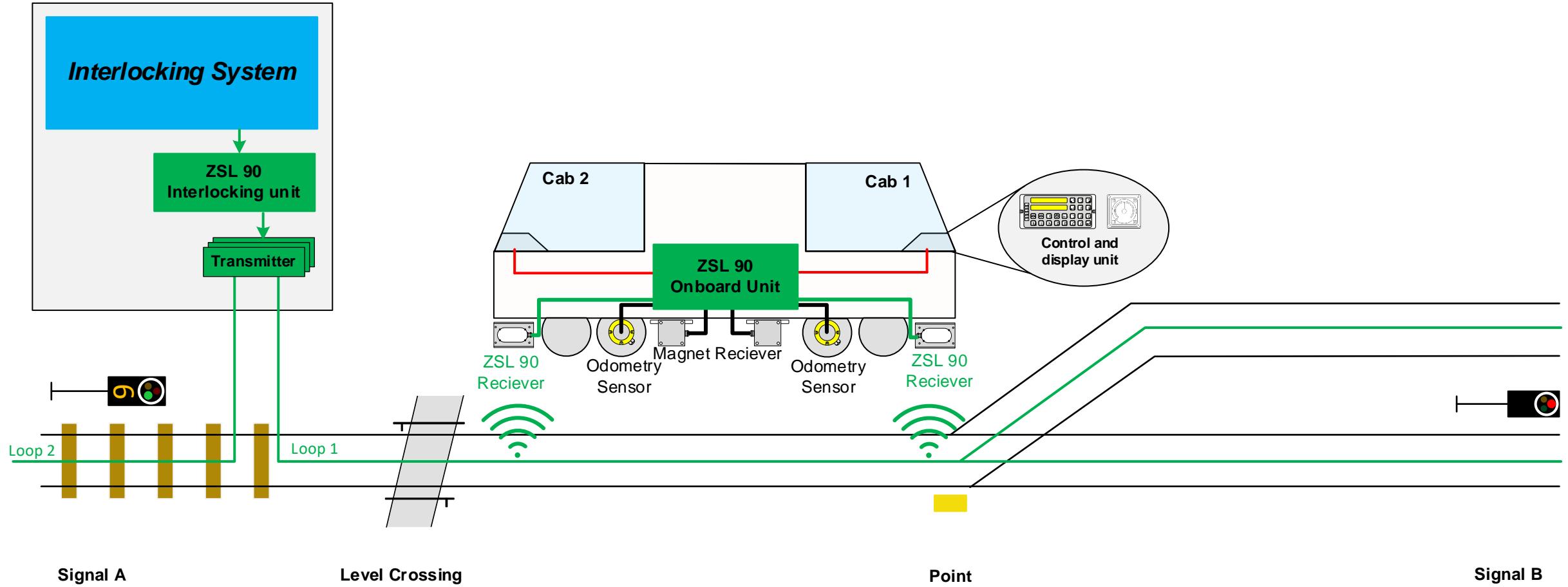
Making train rides safe



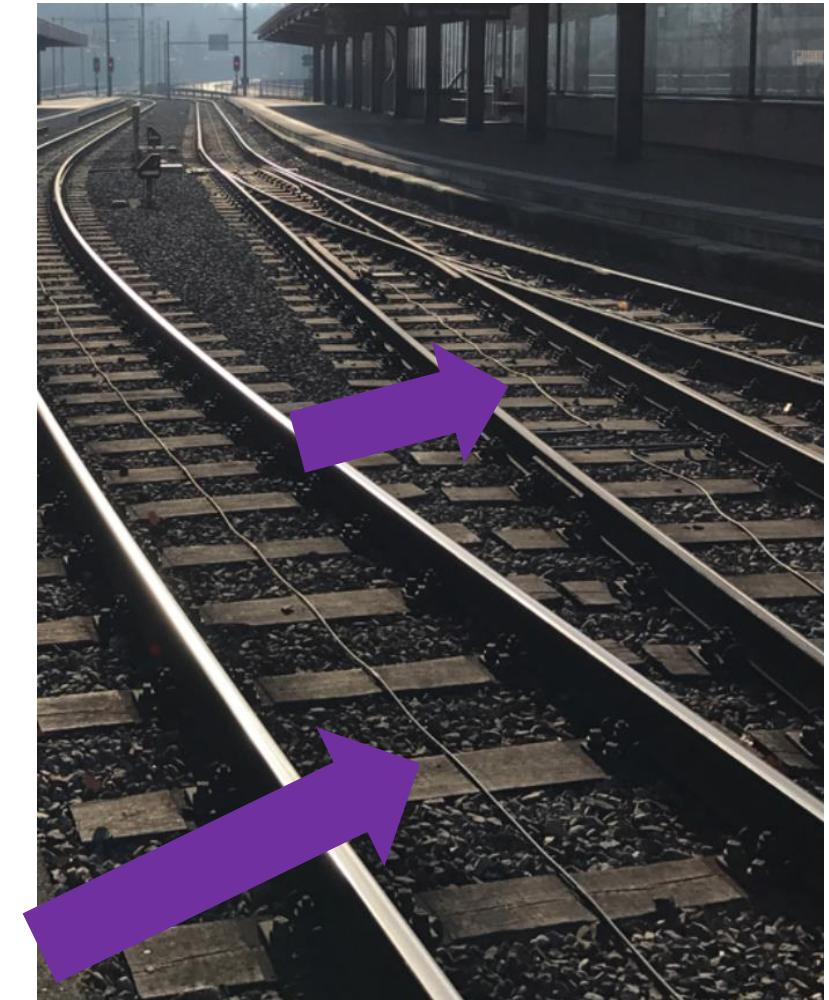
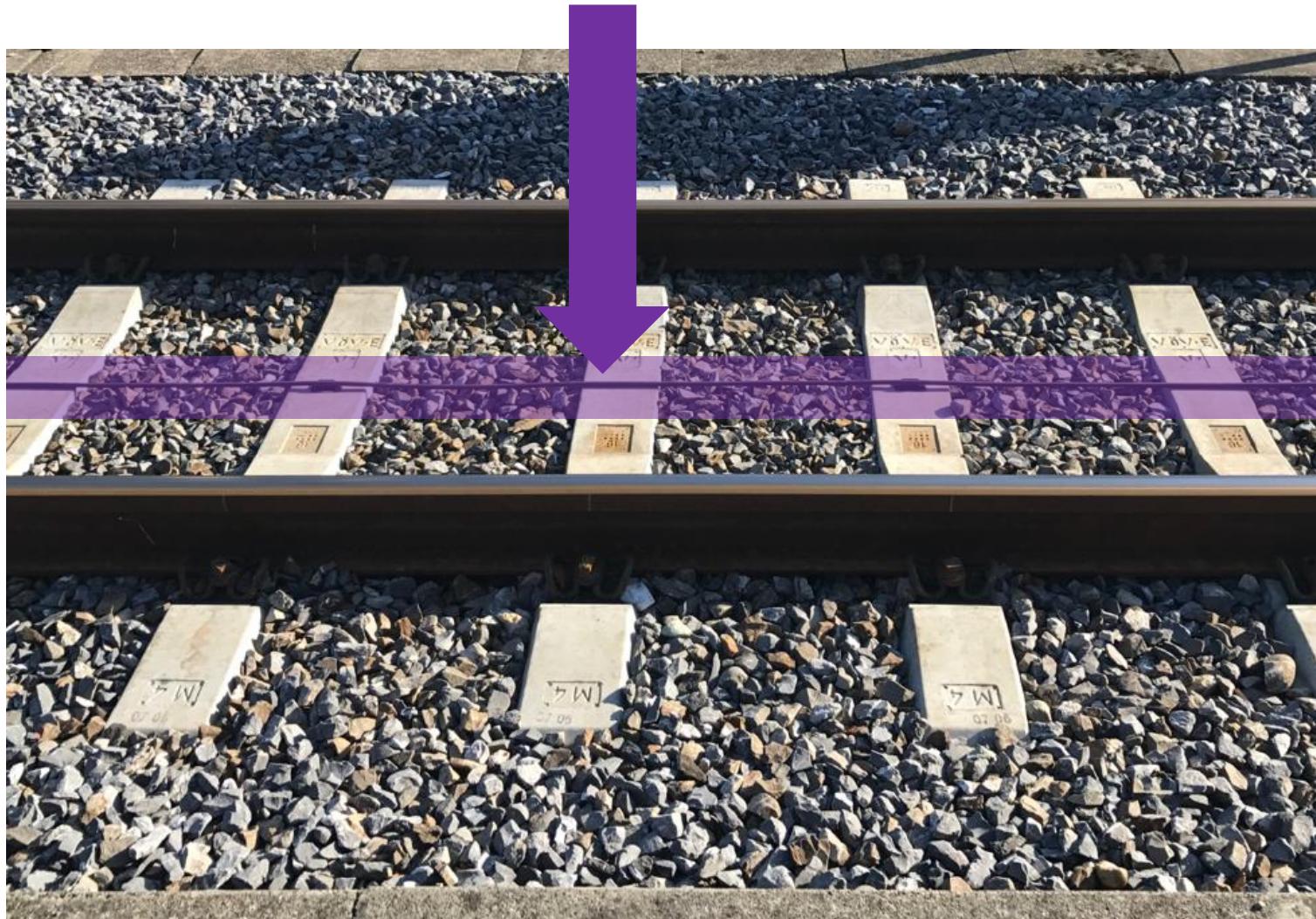
Interlocking system



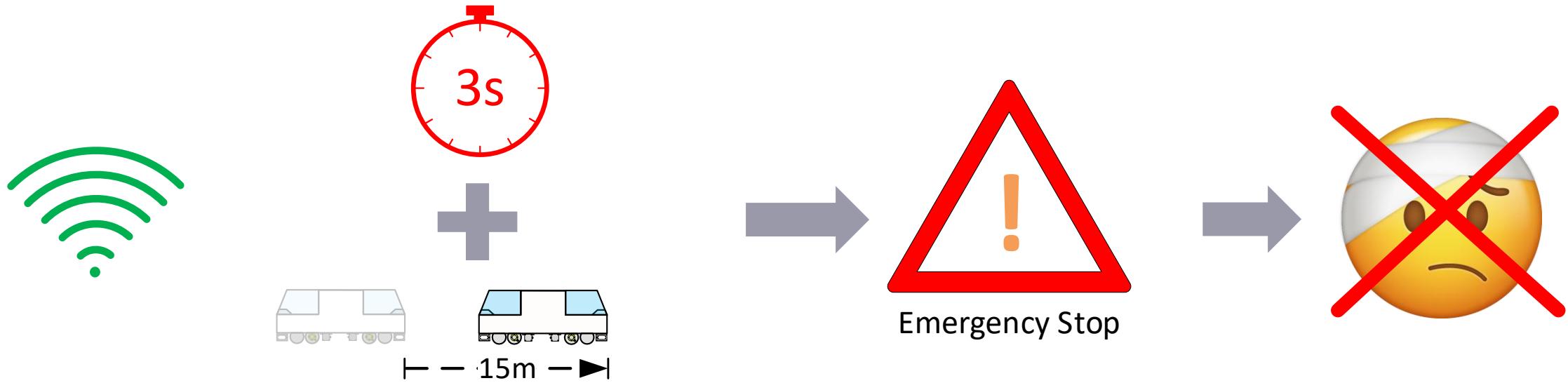
Train protection system 'ZSL 90'



Loop antenna



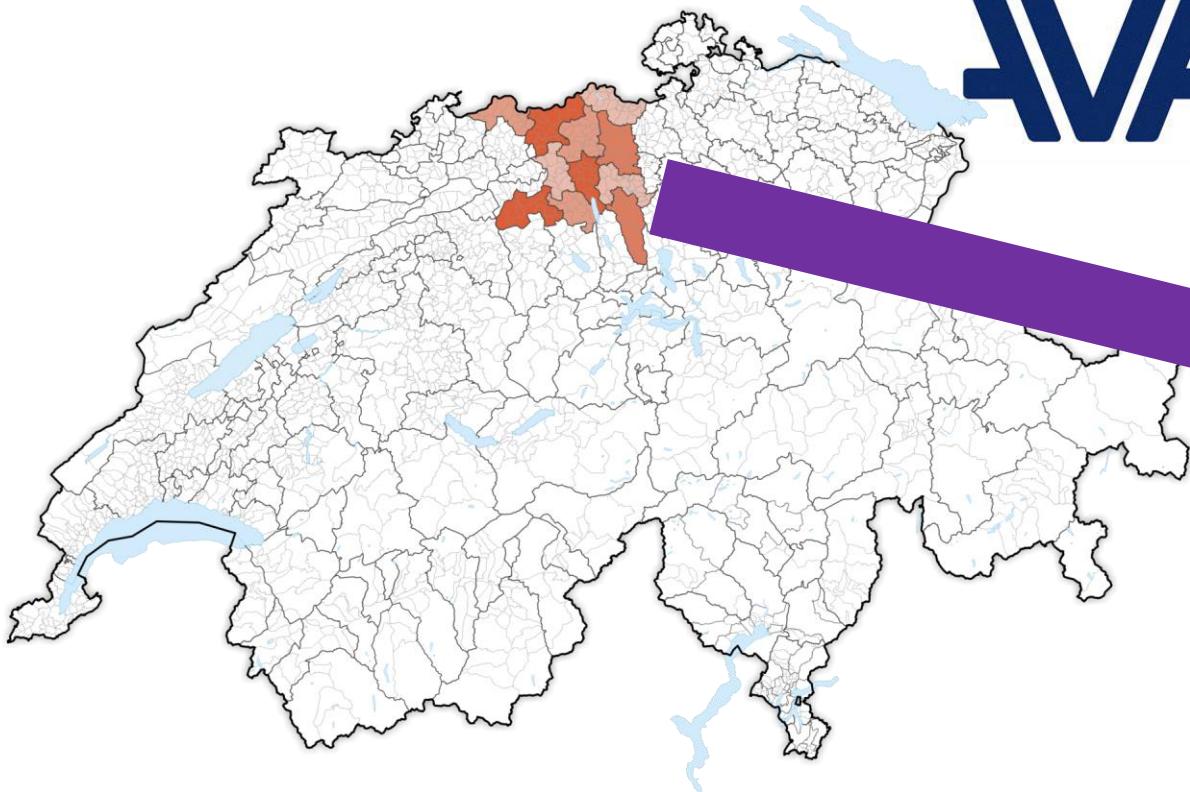
What happens if the loop transmission breaks?



Data provided for the challenge



Where do we have the data from?



Aargau
Verkehr



Source: Tschubby, CC BY-SA 3.0, via Wikimedia Commons

Data sets provided

rssi.csv

- RSSI readings, telegram statistics, and train positions
- Column DateTime as Key

velocity.csv

- Velocity/speed of train
- Column DateTime as Key

disruptions.csv

- Occurred disruptions
- Column DateTime as Key

events.csv

- Occurred events
- Column DateTime as Key

Mapping_Events_Disruptions.csv

- Mapping table for all possible events/disruptions
- Translations German/English

How to use the provided data: Received signal data

rssi.csv

- **Ax_RSSI**



- Received signal strength indicator (RSSI)
- Recorded signal strength by the receiver on the train
- The recorded RSSI signal lies within the range [0.0 V ... 3.0 V]

Value Range [V]	Rating
[2.0 – 2.9]	Excellent
[1.6 – 2.0]	Good
[1.2 – 1.6]	Fair
[0.9 – 1.2]	Weak

- **Ax_TotalTel**

- Total number of telegrams received since system start

- **Ax_ValidTel**

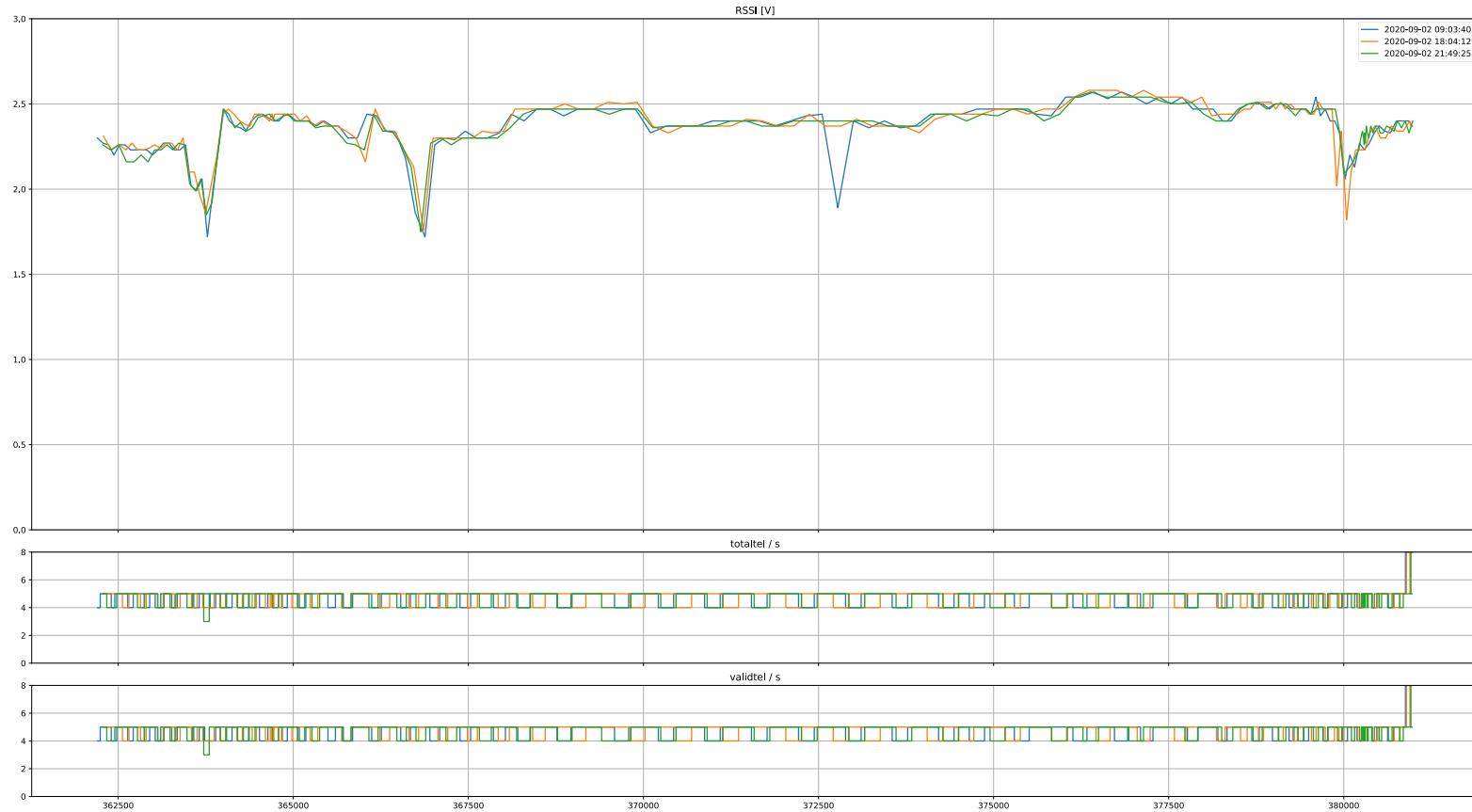
- Number of telegrams with valid CRC received since system start

As data is tracked once per second, the delta between two sample points can be used as a second quality indicator at the sample point.

Ax_, x=1,2 stands for receiver (antenna) number

Deep dive into signal data

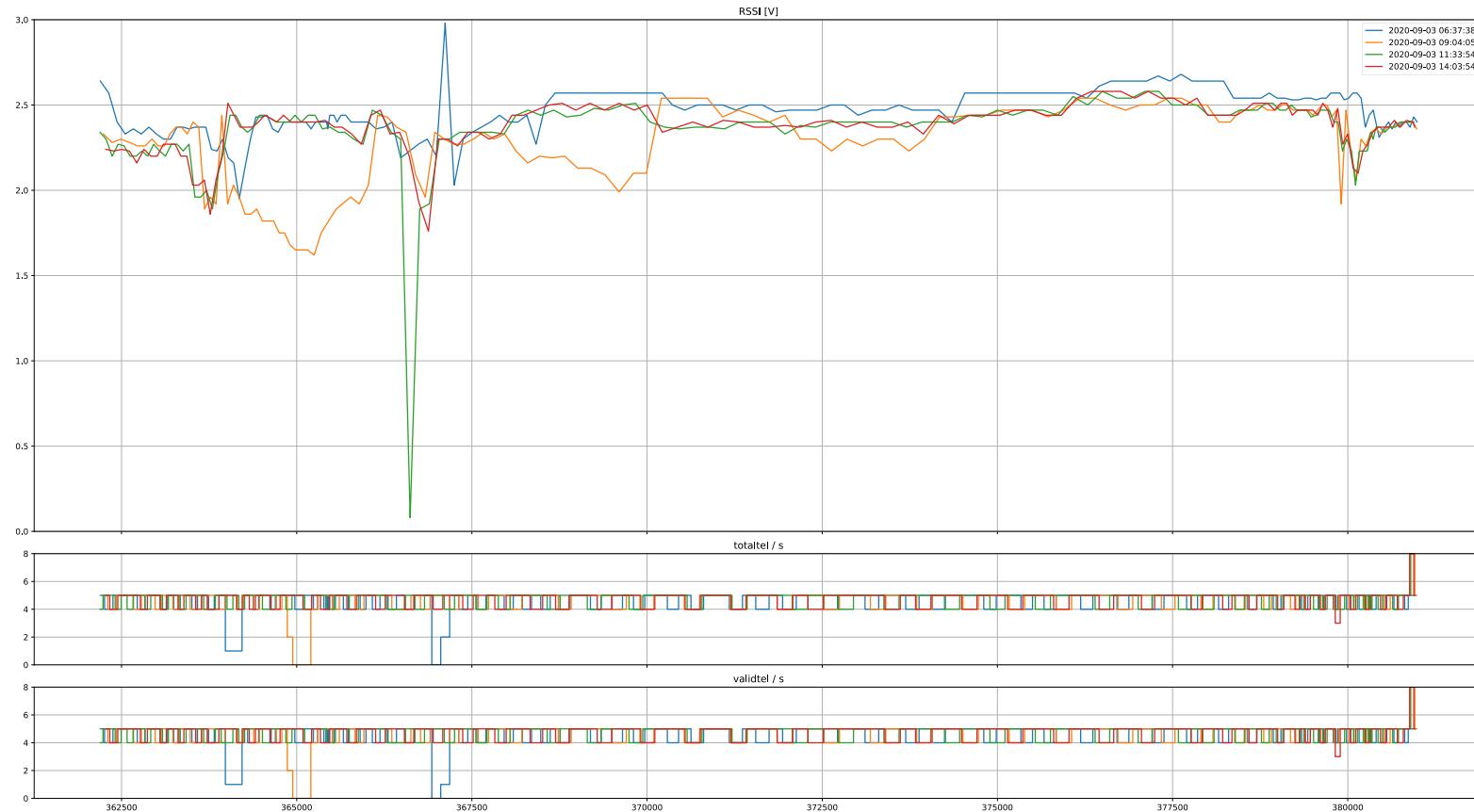
rssi.csv



- RSSI, TotalTel and ValidTel plotted against the position on x-axis
- Every track path has a characteristic repeating RSSI profile
- The number of telegrams per second typically varies between 4 and 6 telegrams

Deep dive into signal data: Degradation of loop cable

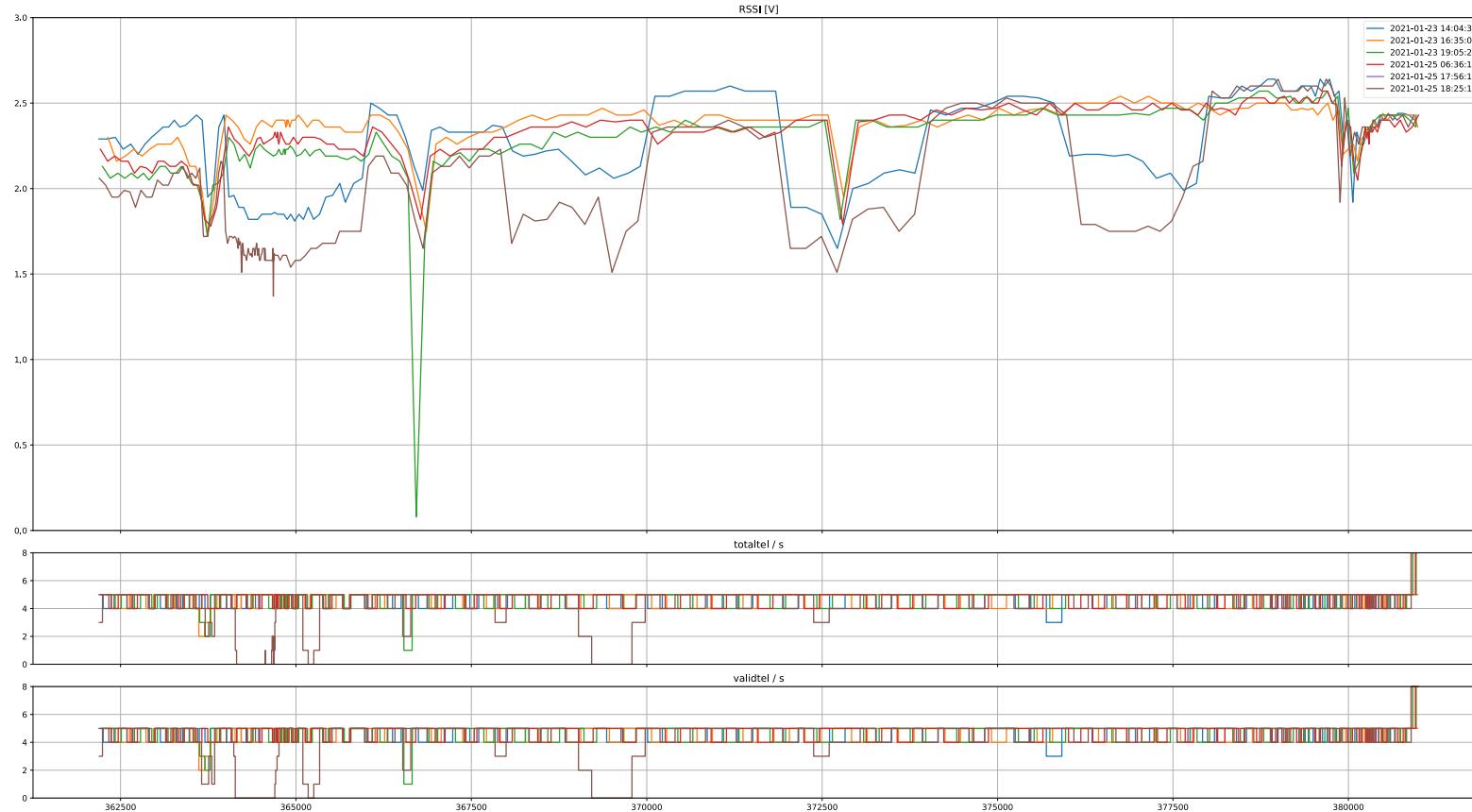
rssi.csv



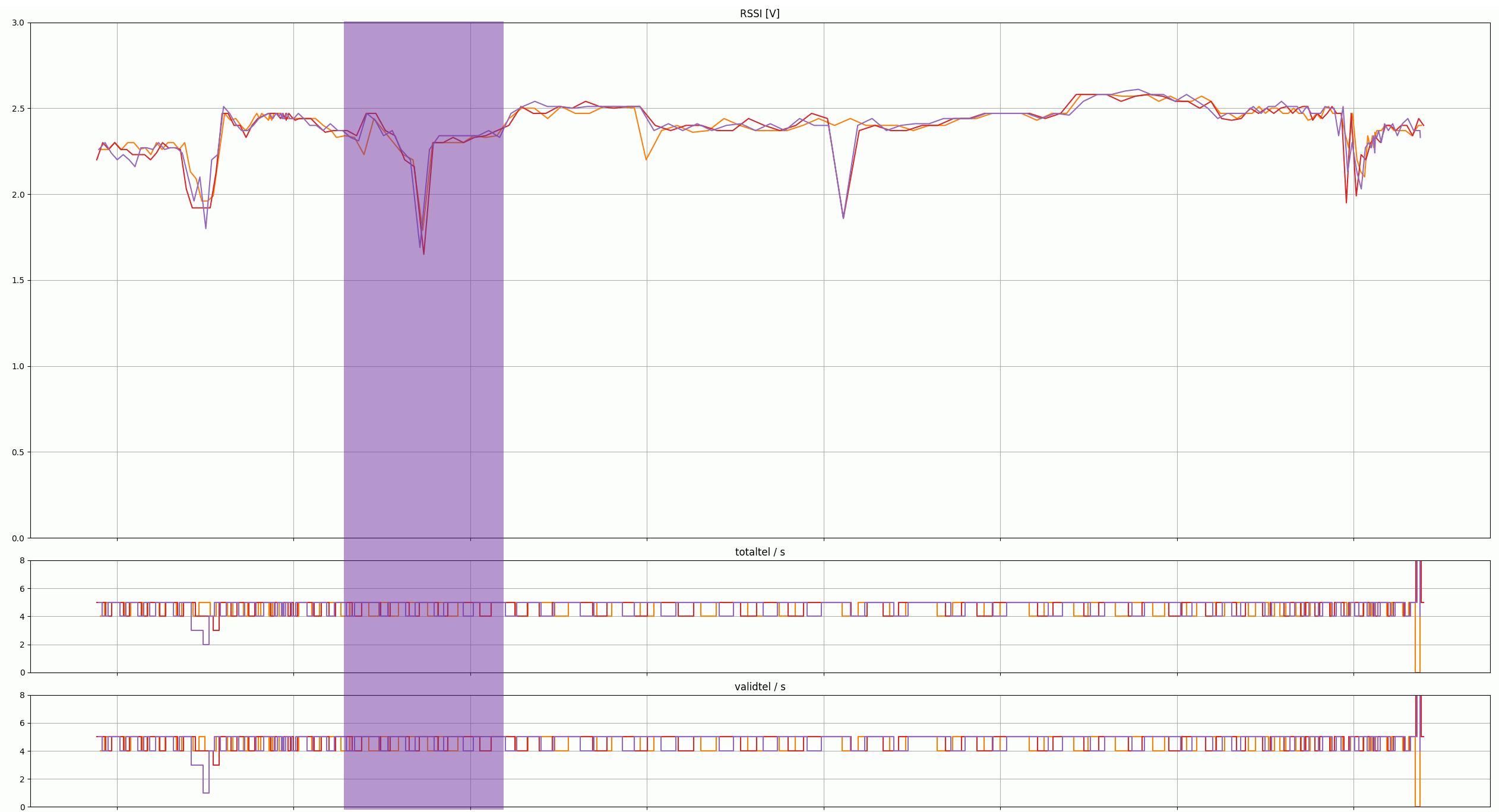
- Deviations of that profile may indicate defect or starting degradation of the loop cable
- If profile deviations and telegram dropout occur at the same time, this indicates a problem at this location
- With the high peak of the blue line to 3.0V and low peak of the green line to ~0V, the receiver indicates signal problems

Deep dive into signal data: Degradation of loop cable

rssi.csv

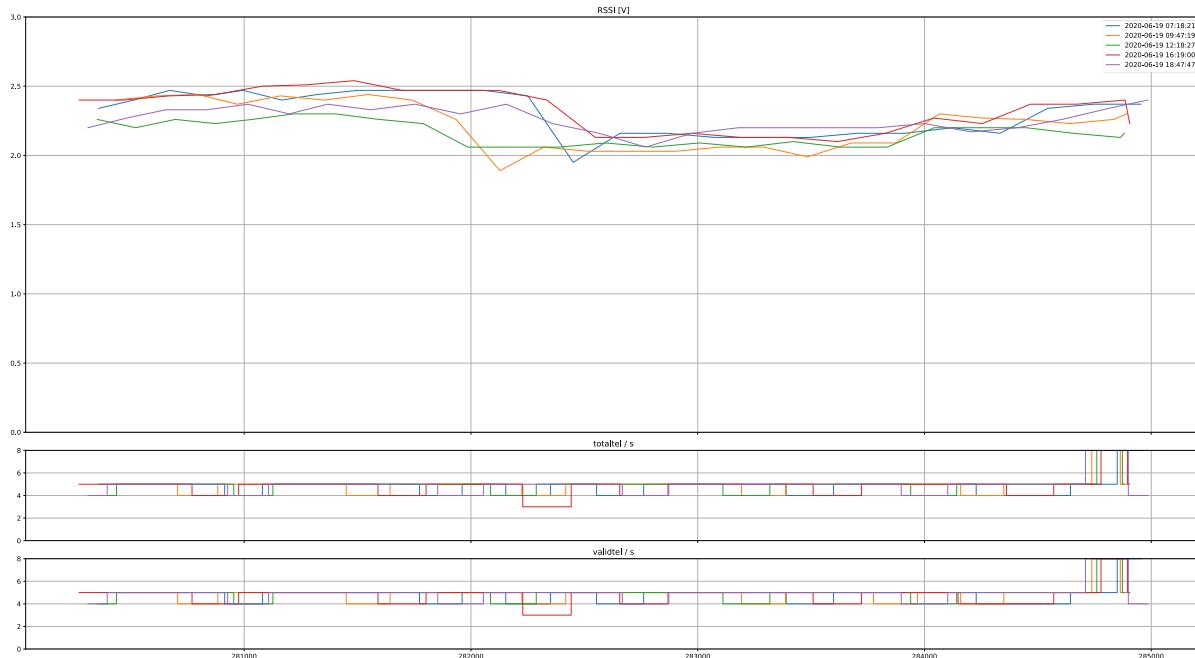


- During heavy snowfall in January '21, degradation of a cable coupling, caused by corrosion, led to massive loss of signal quality
- Location: [36200m – 38100m] (stations Zetzwil – Leimbach)
- Event time:
~January 2021
2021-01-25
- Repair date: 2021-02-01

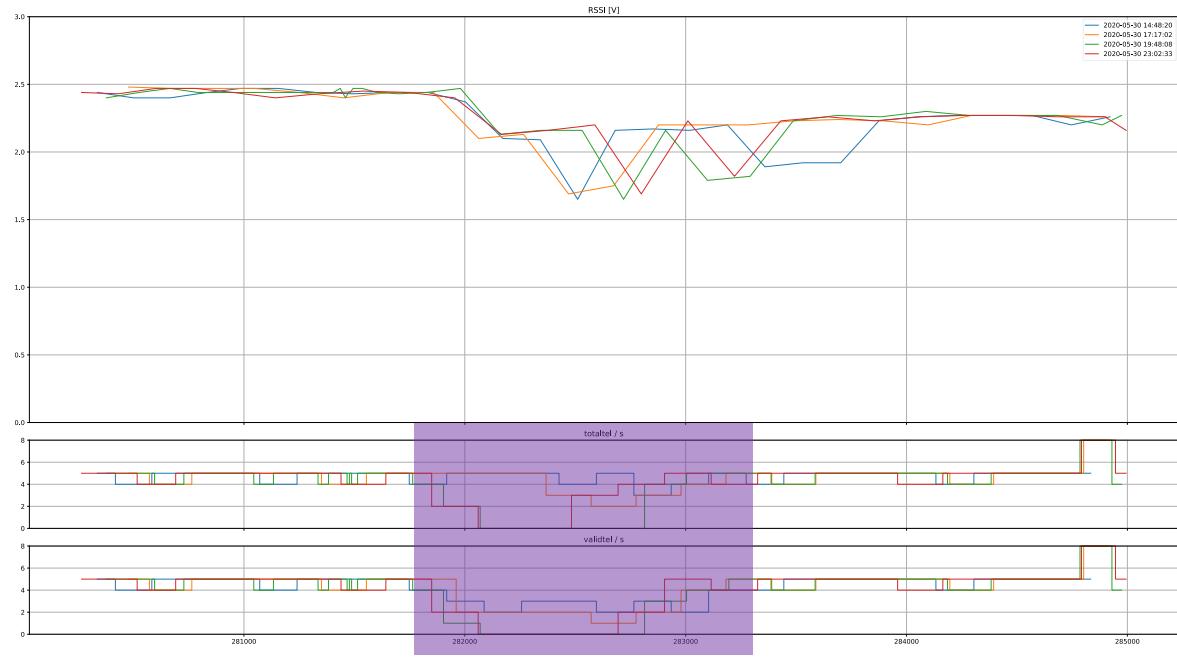


Deep dive into signal data: External interfering transmitter

rssi.csv



- RSSI is still 'good', but both telegram counters drop and additionally the counters diverge.
→ This indicates a bad signal to noise ratio (SNR), possibly caused by an external interfering transmitter.
- The cause for this example was an electric cow fence



- Location:
- [28000m – 28500m]
(near station Bleien-Liebegg)

How to use the data provided: Train position data

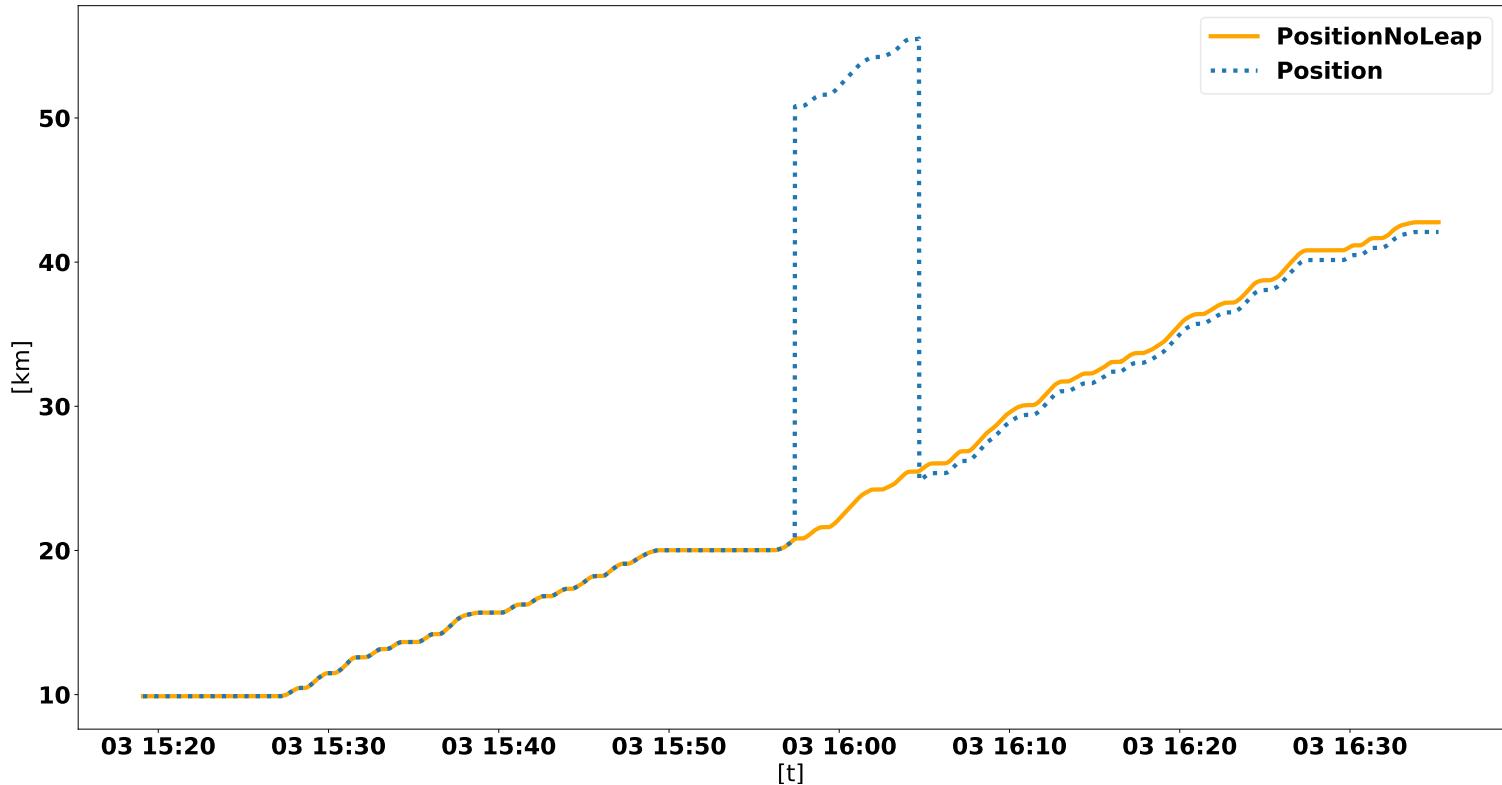
rssi.csv

- **Position**

holds the trains position on an operator specific km scale ranging from ~9 km up to ~43 km and ~52km to ~55km

- **PositionNoLeap**

corrects these positional leaps in column “Position”



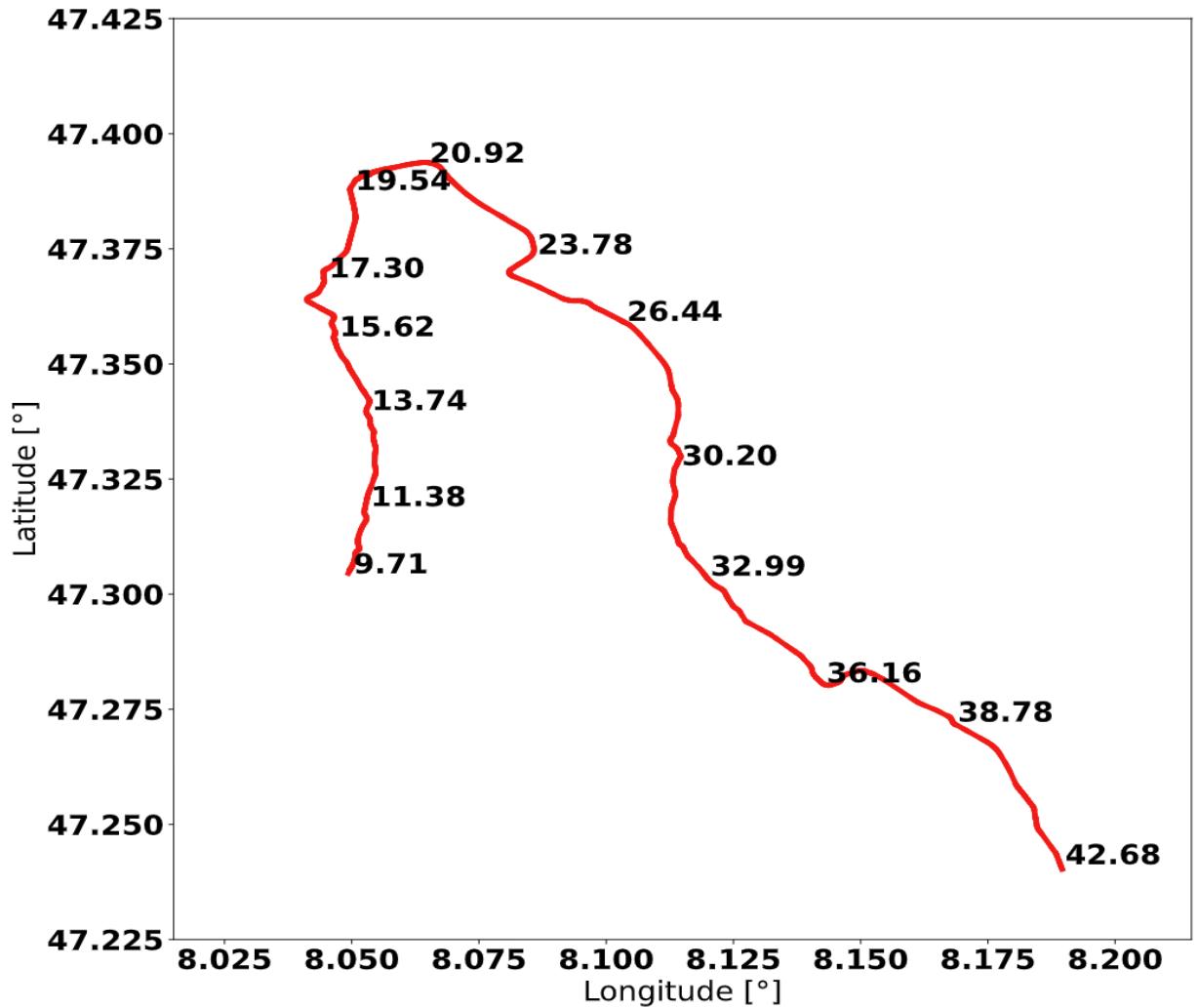
How to use the data provided: Train position data

rssi.csv

- **Latitude, Longitude** represent the corresponding geo-positions

[for the challenge most likely not relevant]

- **Track** holds the trains track number
- **AreaNumber** holds the station number



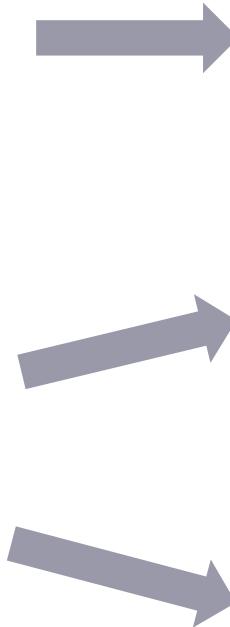
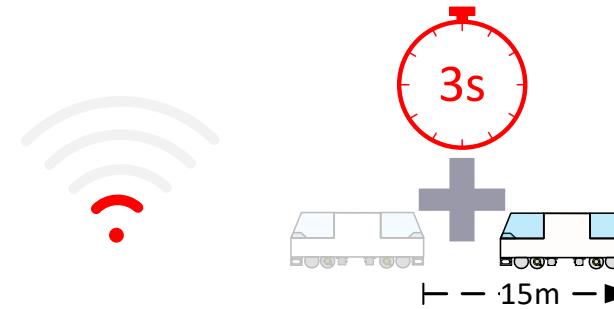
How to use the data provided: Disruption and event data

disruptions.csv

events.csv

The dataset “disruptions” contains all detected disruptions during the period of operation.

Of all the disruptions and events, the following three are primarily of interest:

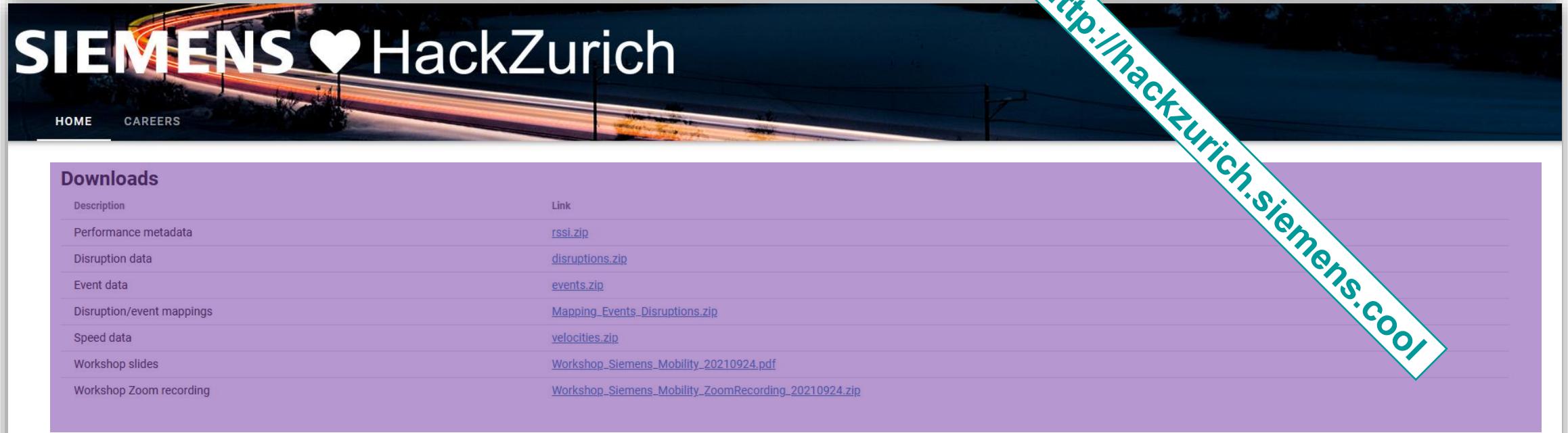


- | | |
|------------------------|--|
| DateTime: | "14.10.2020 06:21:03", |
| DisruptionCode: | "960862258", |
| Description: | "Keine Linienleitertelegramme empfangen"
(no loop telegrams received) |
-
- | | |
|------------------------|--|
| DateTime: | "14.10.2020 06:21:03", |
| DisruptionCode: | "960862267", |
| Description: | "Zwangsbremse wurde aktiviert"
(emergency stop activated) |
-
- | | |
|---------------------|---|
| DateTime: | "14.10.2020 06:21:03", |
| EventCode: | " 1698873074", |
| Description: | "Zwangsbremsung Signal ME_A"
(emergency stop activated) |

How to get the data



How to get the data



The screenshot shows the SIEMENS HackZurich website. At the top, there's a banner with the text "SIEMENS ❤️ HackZurich". Below the banner, there are two navigation links: "HOME" and "CAREERS". The main content area has a purple header titled "Downloads". Under this header, there's a table with two columns: "Description" and "Link". The descriptions include "Performance metadata", "Disruption data", "Event data", "Disruption/event mappings", "Speed data", "Workshop slides", and "Workshop Zoom recording". The corresponding links are "rss1.zip", "disruptions.zip", "events.zip", "Mapping_Events_Disruptions.zip", "velocities.zip", "Workshop_Siemens_Mobility_20210924.pdf", and "Workshop_Siemens_Mobility_ZoomRecording_20210924.zip". A large, diagonal watermark with the URL "http://hackzurich.siemens.cool" is overlaid across the entire screenshot.

We look forward to working with you at the HackZurich 2021!

You have questions, ideas for your own project, or just want to chat with us? Reach out on Slack or directly at our booth:

 slack

We are available on Slack and at our booth throughout HackZurich at the following times:

Day	Presence time at booth/slack
Friday	until 01:00 CEST
Saturday	08:00 to 00:00 CEST
Sunday	08:00 to end

Agenda

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1. Siemens and workshop hosts 
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Debug our train tracks together with us!

<http://hackzurich.siemens.cool>



- ❖ Slack channel: #03_ws01_siemens
- ❖ Presence time:
Friday until 01:00 CEST
Saturday 08:00 to 00:00 CEST
Sunday 08:00 to end
- ❖ Talk to us at our booth or over Slack!
- ❖ We are happy to have live meetings with you on:
 - ❖ Slack
 - ❖ MS Teams
 - ❖ Jitsi, Zoom, ...

SIEMENS

| Backup Slides

Further resources

- ❖ **OpenRailwayMap:** <https://www.openrailwaymap.org>
 - ❖ Track data, speed limits along the tracks, signals and trackside equipment
- ❖ **Swiss public transport API:** <https://transport.opendata.ch>
 - ❖ Infrastructure data, timetable data, journey planner, ...
- ❖ **Swiss open government data:** <https://opendata.swiss/en/organization/schweizerische-bundesbahnen-sbb>
 - ❖ Infrastructure/station/rollingstock data, traffic data, ...
- ❖ **Opendata portal Swiss Federal Railways (SBB):** <https://data.sbb.ch>
 - ❖ Infrastructure/station/rollingstock data, traffic data, ...
- ❖ **Railway glossary:** <http://www.joernpachl.de/glossary.htm>
 - ❖ Comprehensive glossary of “railway nerd”-words in English and German

Provided tables

rssi.csv

ID	DateTime	AreaNumber	Track	Position	PositionNoLeap	Latitude	Longitude	A1_TotalTel	A1_ValidTel	A2_RSSI	A2_TotalTel	A2_ValidTel
314524	2020-01-30 06:08:47	25	1	249100	255850	47.363722117377506	8.094060463835786	532709	532400	2.33	531906	531436
314525	2020-01-30 06:08:48	25	1	248966	255716	47.36372636027111	8.093883526040036	532714	532405	2.3	531911	531441
314526	2020-01-30 06:08:49	25	1	248838	255588	47.36373324608145	8.09371465009479	532719	532410	2.36	531916	531446
314527	2020-01-30 06:08:50	25	1	248716	255466	47.36373980911944	8.093553690209477	532724	532415	2.36	531921	531451
314528	2020-01-30 06:08:51	25	1	248600	255350	47.363746049385064	8.093400646384097	532728	532419	2.29	531925	531455
314529	2020-01-30 06:08:52	25	1	248488	255238	47.363763400760185	8.093254875409711	532733	532424	2.29	531930	531460
314530	2020-01-30 06:08:53	24	1	555131	255131	47.36378044714228	8.093115694806587	532738	532429	1.72	531935	531465
314531	2020-01-30 06:08:54	24	1	555027	255027	47.36379701558844	8.092980416463364	532743	532434	2.36	531939	531469
314532	2020-01-30 06:08:55	24	1	554929	254929	47.36381463607289	8.092853650507404	532747	532438	2.33	531944	531474
314533	2020-01-30 06:08:56	24	1	554857	254857	47.36383324113855	8.09276251149845	532752	532443	2.33	531949	531479
314534	2020-01-30 06:08:57	24	1	554771	254771	47.36385546385587	8.092653651015532	532757	532448	2.33	531954	531484
314535	2020-01-30 06:08:58	24	1	554692	254692	47.36387587774736	8.092553651269595	532760	532451	2.36	531958	531488
314536	2020-01-30 06:08:59	24	1	554619	254619	47.36389474121672	8.092461246441072	532765	532456	2.33	531963	531493
314537	2020-01-30 06:09:00	24	1	554553	254553	47.36391357470432	8.092378578386382	532770	532461	2.33	531968	531498
314538	2020-01-30 06:09:01	24	1	554494	254494	47.36393193923963	8.092305430923355	532775	532466	2.36	531973	531503
314539	2020-01-30 06:09:02	24	1	554444	254444	47.363947502405146	8.09224344154791	532780	532471	2.33	531978	531508
314540	2020-01-30 06:09:03	24	1	554403	254403	47.36396116221216	8.092193163640578	532785	532476	2.33	531983	531513
314541	2020-01-30 06:09:04	24	1	554372	254372	47.36397299720171	8.092156077197581	532790	532481	2.33	531988	531518

Provided tables

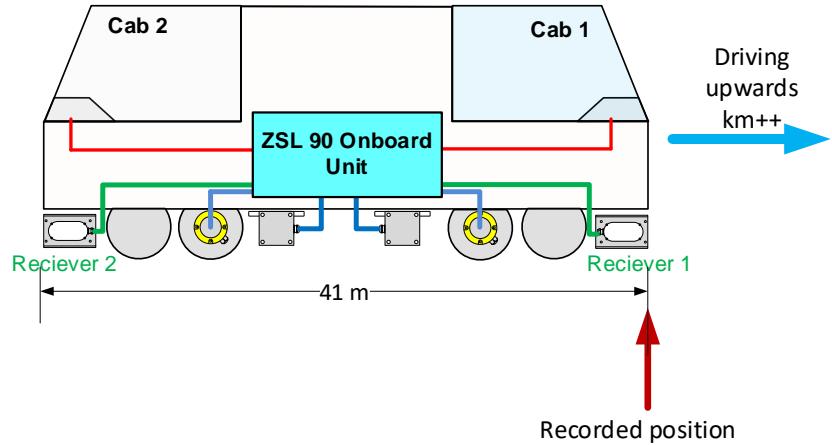
rssi.csv

The **rssi.csv** data table consist of the following columns:

- **ID**: Unique number
- **DateTime**: Timepoint of sample
- **AreaNumber**: Identifier of interlocking block
- **Track**: Track the vehicle is placed on
- **Position**: Position as recorded by vehicle [dm]
- **PositionNoLeap**: Position of vehicle without leap between Buchs and Suhr [dm]
- **Latitude**: Latitude of vehicle at point of sample [°]
- **Longitude**: Longitude of vehicle at point of sample [°]
- **A1_TotalTel**: Total number of telegrams received by antenna 1 since system startup
- **A1_ValidTel**: Number of valid telegrams received by antenna 1 since system startup
- **A2_RSSI**: Received signal strength indication of antenna 2 at point of sample [V]
- **A2_TotalTel**: Total number of telegrams received by antenna 2 since system startup
- **A2_ValidTel**: Number of valid telegrams received by antenna 2 since system startup

How to use the provided data: Consider the movement direction

rssi.csv

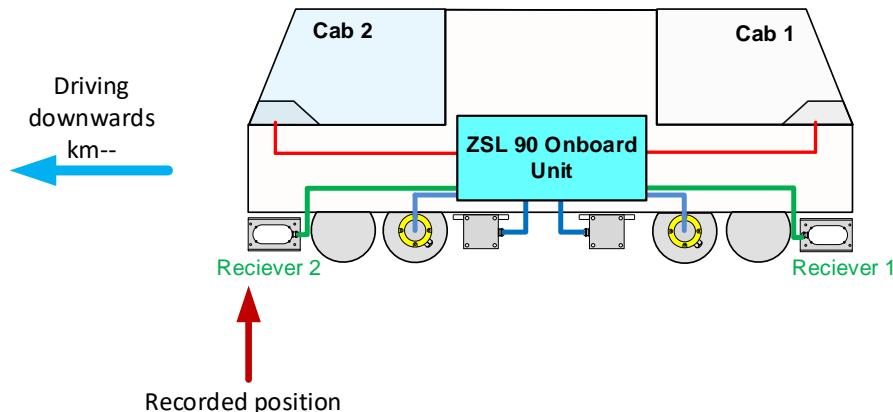


Do not mix upward and downward rides.

The tracked position is always the position of the currently active cab.

Whereas the receiver's positions have an offset depending on the active cab.

The train length is 41m.



Provided tables

disruptions.csv

ID	DateTime	DisruptionCode	Description
2070	2020-09-18 06:49:15	960862258	Keine Linienleitertelegramme empfangen
2071	2020-09-18 16:20:35	960862267	Zwangsbremse wurde aktiviert
2072	2020-09-18 18:25:09	960862258	Keine Linienleitertelegramme empfangen
2073	2020-09-18 19:18:14	960862258	Keine Linienleitertelegramme empfangen
2074	2020-09-18 19:18:14	960862267	Zwangsbremse wurde aktiviert
2075	2020-09-19 04:31:15	960862267	Zwangsbremse wurde aktiviert

events.csv

ID	DateTime	EventCode	Description
12651	2020-09-18 17:07:49	1254663840	Ueberbrueckung: 0 Fuehrerstand 2 besetzt
12652	2020-09-18 17:07:53	977419008	Zugdaten bestaetigt Zuglaenge [dm]: 820 Bremswert [%]: 110 VMaxFzg [km/h]: 80
12653	2020-09-18 17:34:11	1254663843	Ueberbrueckung: 0 Fahrzeug gefuehrt
12654	2020-09-18 18:54:45	1254663840	Ueberbrueckung: 0 Fuehrerstand 2 besetzt
12655	2020-09-18 18:54:47	977419008	Zugdaten bestaetigt Zuglaenge [dm]: 820 Bremswert [%]: 110 VMaxFzg [km/h]: 80
12656	2020-09-18 19:18:14	1698873056	Zwangsbremse Bahnhuebergang BU_83
12657	2020-09-18 19:18:43	559684160	Rueckstellung Zwangsbremse
12658	2020-09-18 19:33:38	1254663843	Ueberbrueckung: 0 Fahrzeug gefuehrt
12659	2020-09-18 19:39:59	1254663840	Ueberbrueckung: 0 Fuehrerstand 2 besetzt

Provided tables

velocity.csv

ID	DateTime	CurrentVelocity	AllowedVelocity	EmergencyStopLimit
20587989	2020-02-12 06:53:29	0	45	51
20587990	2020-02-12 06:53:30	0	80	90
20587991	2020-02-12 06:53:31	0	80	90
20587992	2020-02-12 06:53:32	3	80	90
20587993	2020-02-12 06:53:33	5	80	90
20587994	2020-02-12 06:53:34	7	80	90
20587995	2020-02-12 06:53:35	8	80	90
20587996	2020-02-12 06:53:36	10	80	90
20587997	2020-02-12 06:53:37	11	80	90
20587998	2020-02-12 06:53:38	13	80	90
20587999	2020-02-12 06:53:39	14	80	90
20588000	2020-02-12 06:53:40	15	80	90
20588001	2020-02-12 06:53:41	16	80	90
20588002	2020-02-12 06:53:42	18	80	90
20588003	2020-02-12 06:53:43	20	80	90
20588004	2020-02-12 06:53:44	21	80	90
20588005	2020-02-12 06:53:45	23	80	90

The **velocity.csv** data table consist of the following columns :

- **ID:** Unique number
- **DateTime:** Timepoint of sample
- **CurrentVelocity:** current velocity
- **AllowedVelocity:** indicated allowed velocity
- **EmergencyStopLimit:** velocity limit for emergency stop

Provided tables

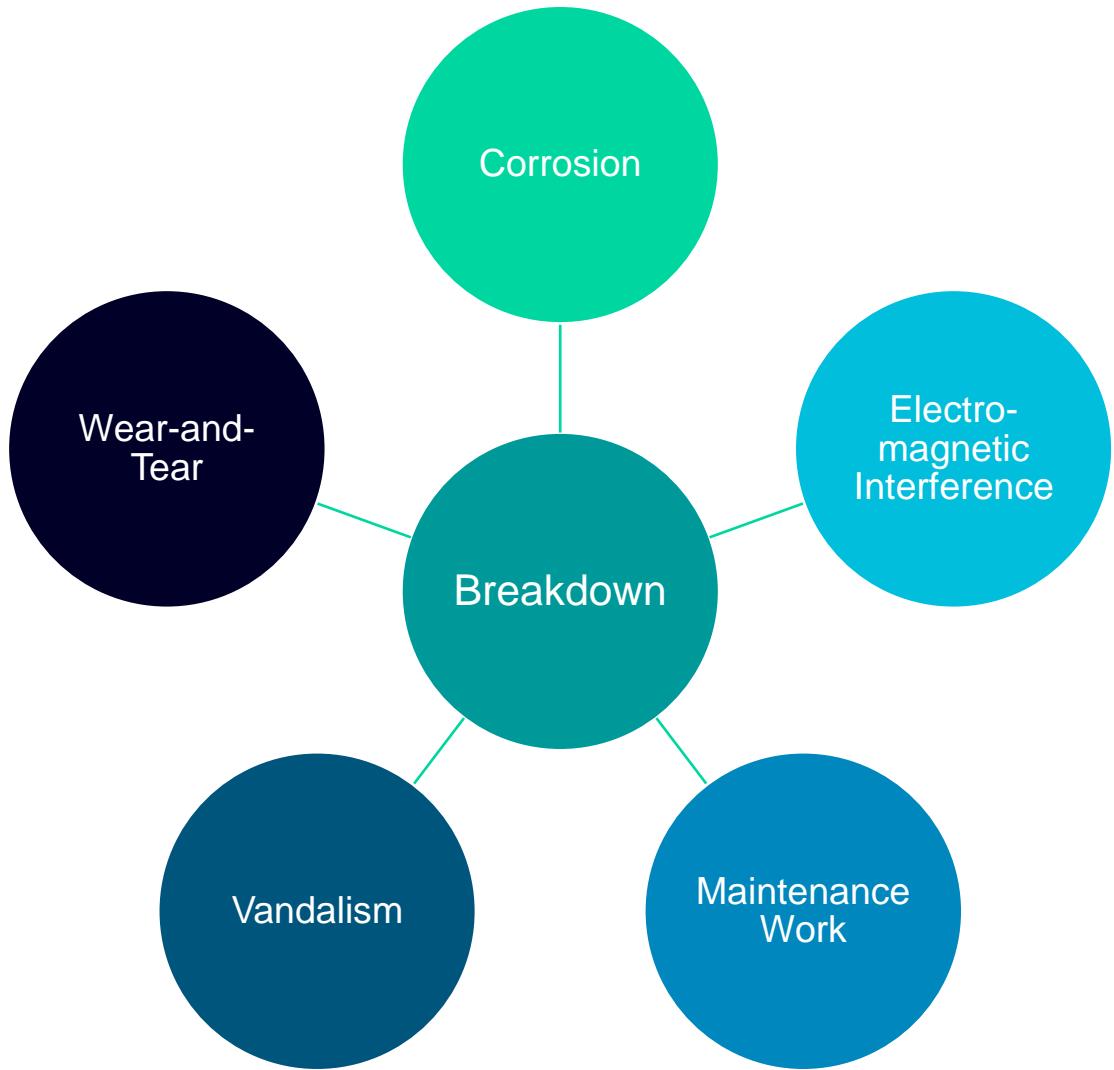
Mapping_Events_Disruptions.csv

ID	EventDisruptionCode	DescriptionGerman	DescriptionEnglish	RelevantForChallenge	Notes
1	960862267	Stoerung: Zwangsbremse wurde aktiviert	Disruption: Emergency brake activated	x	
2	960862267	Zwangsbremse wurde aktiviert	Emergency brake activated	x	
3	960862258	Keine Linienleitertelegramme empfangen	No loop telegrams received	x	
4	960862258	Stoerung: Linienleitertelegramme wurden erwartet jedoch auf beiden Antennen keine empfangen.	Disruption: loop telegrams expected but none received on either antenna	x	
5	960862257	Position unverifiziert (Eichung falsch)	Position not verified (wrong calibration)		
6	960862257	Stoerung: Position unverifiziert (Eichung falsch)	Disruption: Position not verified (wrong calibration)		
7	960862268	Position unbekannt (ZS10)	Position unknown (ZS10)		
8	960862268	Stoerung: ZS10 Modus (Position unbekannt)	Disruption: ZS10 mode (position unknown)		
9	960862244	Hardwarefehler Bediengeräet	Hardware error (operator device)		
10	960862249	Hardwarefehler Verteiler	Hardware error (distribution device)		
11	1238445441	Datei gelöscht	File deleted		
12	559626400	Eichung ausserhalb kleinen Eichfensters Abweichung: {xxxx} dm	Calibration outside of small calibration window Deviation: {xxxx} dm		[dm]: decimeters (1dm=10cm)
13	559665728	Bremstest wurde gestartet.	Brake test started		
14	559665728	Bremstest wurde ausgelöst	Brake test triggered		
15	559684160	Rückstellung der Zwangsbremse.	Emergency brake reset		
16	559684160	Rückstellung Zwangsbremse	Emergency brake reset		

Electric cow fence



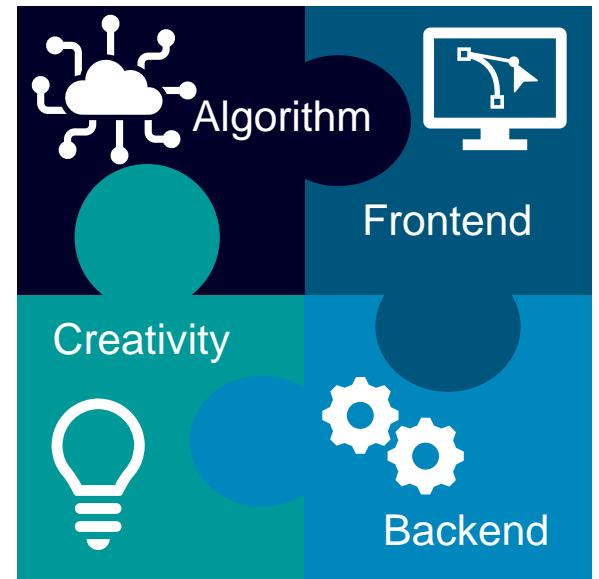
Why can the loop cable break?



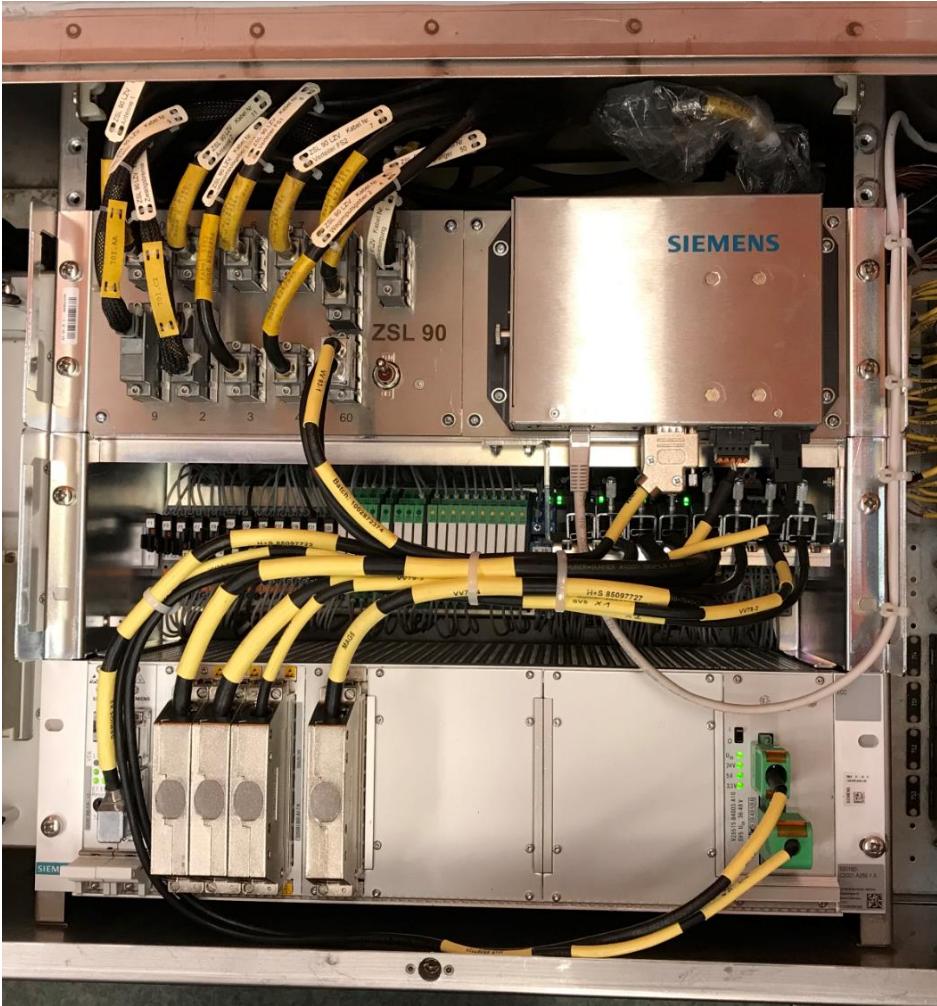
How loop cable defects are detected today

As of today, detection of loop antenna failures is a time-consuming and manual process:

- Analyzing recorded signal strength and packet reception rates
- Visual inspection by walking along the train tracks
- Wait for failure detection from the train protection, which might already be accompanied by an emergency stop.



Onboard Unit ZSL 90



Industrial grade embedded computer

- Intel Atom Plattform
- Debian Linux
- Analytics SW in Java

