Railway Metrics and Dynamics

INTELLIGENT RAIL SUMMIT ’23
DATA-DRIVEN MONITORING & MAINTENANCE

Towards continuous railway monitoring - insights from Trafikverket

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Digitization and management of rolling stock and infrastructure, Railway.

Business Concept/Purpose:

To sell information about maintenance status and safety status of the rolling stock and infrastructure from the same basic sensors in railways.

- -Real-time monitoring of railway infrastructure, rolling stock and goods/passengers.
- -Anticipate and indicate trends/errors before they occur and cause major problems
- -Optimize maintenance.
- -TMS. train/production statistics, the train consist.

Continuous monitoring for enchanced safety and efficiency

A SYSTEM OF SYSTEMS

RMD

MAINTENANCE + ECM

INFRASTRUCTURE MANAGER (IM)

RAILWAY UNDERTAKING (RU)

DASHBOARD

Train Consist

Train Position

Common Interface (RNE)

Train delay, departure, arrival

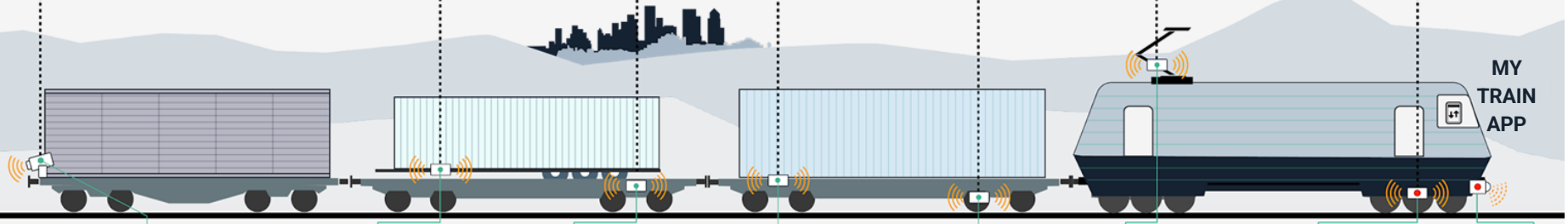
Train Consist

BI - Business Intelligence

SERVER

COLLECT – ANALYZE – REPORT

Dashboard
TMS
Infrastructure
Rolling stock,
Waggon location etc
Driver behaviour energy index
Ride Index



MY TRAIN APP

RAILWAY CAMERA

KINGPIN LOCK SENSOR
VERIFY CARGO LOCKED

WEIGHT SENSOR
CARGO WEIGHT

PERFORMANCE MONITORING UNIT (PMU)
WHEEL FLAT DETECTION
TRUCK HUNTING
TRACK FAULTS,
DERAILMENT, ROUGH LOADING

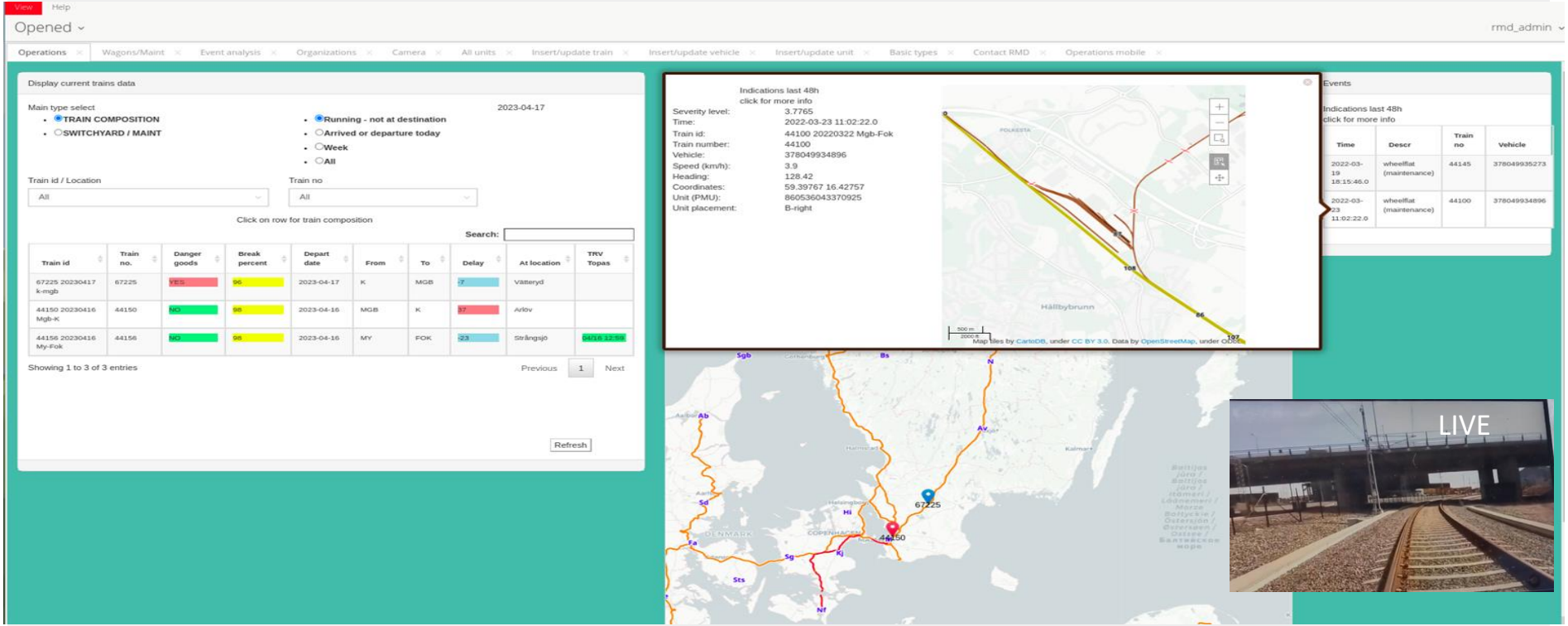
WHEEL SENSOR
WHEEL PROFILE

PANTOGRAPH SENSOR
VERIFY PANTOGRAPH AND CATENARY CONDITION

PERFORMANCE MONITORING UNIT (PMU)
WHEEL FLAT DETECTION
TRUCK HUNTING
TRACK FAULTS etc.
DTFI

FRONT SENSOR

Dashboard


View
Help
Opened
rmd_admin
Operations
Wagons/Maint
Event analysis
Organizations
Camera
All units
Insert/update train
Insert/update vehicle
Insert/update unit
Basic types
Contact RMD
Operations mobile
Display current trains data
Main type select
TRAIN COMPOSITION
SWITCHYARD / MAINT
2023-04-17
Running - not at destination
Arrived or departure today
Week
All
Train id / Location
Train no
All
All
Click on row for train composition
Search:
Train id
Train no.
Danger goods
Break percent
Depart date
From
To
Delay
At location
TRV Topas
67225 20230417 k-mgb
67225
YES
96
2023-04-17
K
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-7
Vätteryd
44150 20230416 Mgb-K
44150
NO
98
2023-04-16
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K
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Arlöv
44156 20230416 My-Fok
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NO
98
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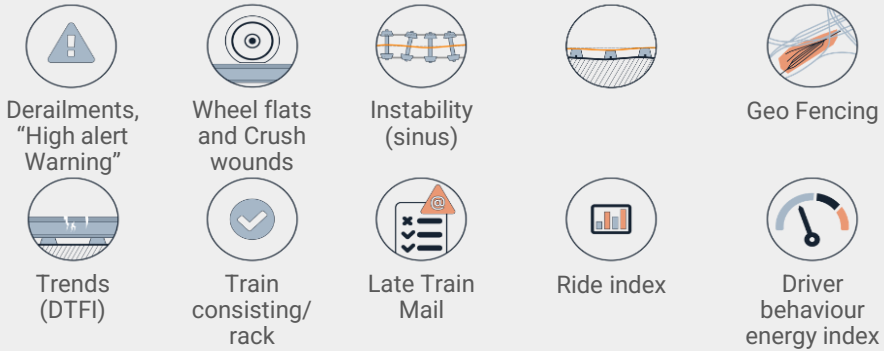
MY
FOK
-23
Strångsjö
04/16 12:58
Showing 1 to 3 of 3 entries
Previous
1
Next
Refresh
Indications last 48h
click for more info
Severity level: 3.7765
Time: 2022-03-23 11:02:22.0
Train id: 44100 20220322 Mgb-Fok
Train number: 44100
Vehicle: 378049934896
Speed (km/h): 3.9
Heading: 128.42
Coordinates: 59.39767 16.42757
Unit (PMU): 860536043370925
Unit placement: B-right
Hällbybrunn
Map tiles by CartoDB, under CC BY 3.0. Data by OpenStreetMap, under ODbL
Events
Indications last 48h
click for more info
Time
Descr
Train no
Vehicle
2022-03-19 18:15:46.0
wheelflat (maintenance)
44145
378049935273
2022-03-23 11:02:22.0
wheelflat (maintenance)
44100
378049934896
67225
44150
LIVE

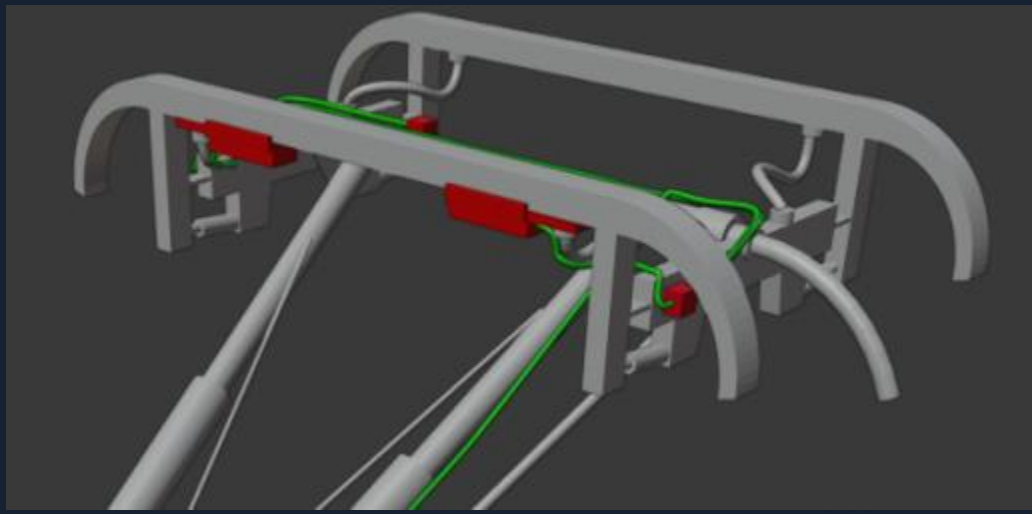
RMD Solutions: The Performance Monitoring Unit (PMU)

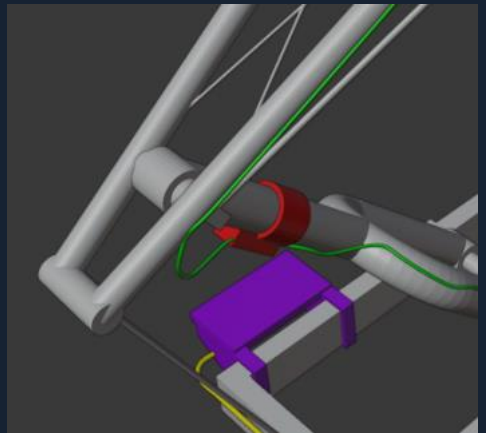
- Multiple ways of mounting the PMU on wagon frame or boogie
- Super-efficient energy management (up to 6 years non-stop battery use, solar power optional)
- PMU's communicate with the cloud (2G to 5G)
- Measures accelerations (vibrations) in three directions, GPS position and speed
- Continuous or event triggered measurements
- Can connect to external sensors as temp. moisture, etc



Pantograph sensor system

- Under development
- A PMU based system with external sensors
  - Connected to PMU with wiring
    - Communication via CAN-bus
      - GSM/5G etc.
  - Two accelerometers (per head)
  - Angle sensor





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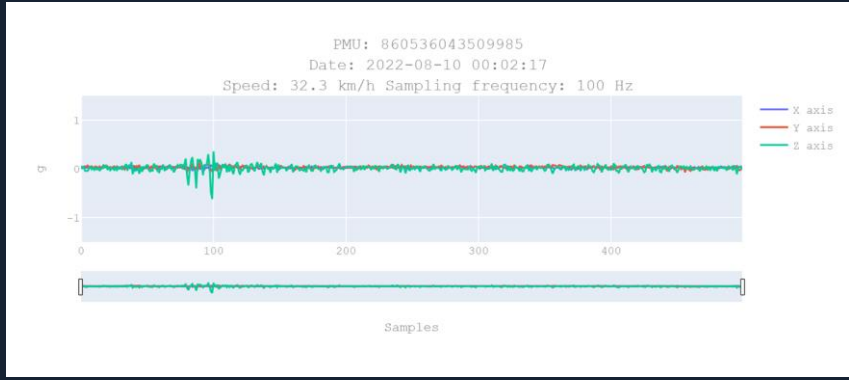
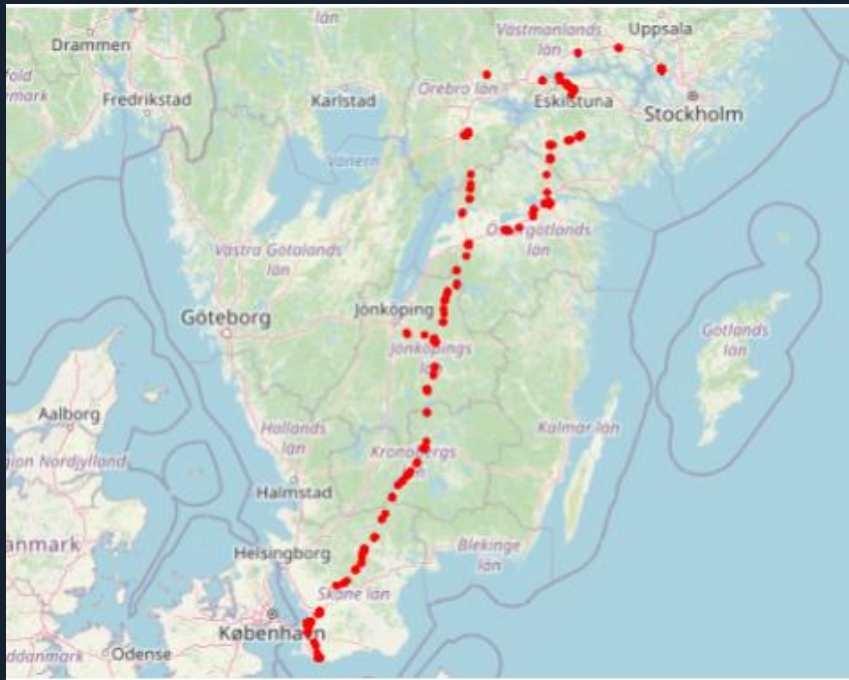
Vehicle monitoring

Continuous monitoring for increased safety and efficiency

- Each measurement contains of:
- Vehicle response symptom (accelerations)
- Position
- Speed
- RMD developed its own tool for reviewing data

- The data can be post-processed to highlight the errors
- Filtration
- Statistics analysis
- Visualization, dashboard, My train app





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Railway Metrics and Dynamics

Innovation project with Swedish Transport Administration

MAJ Project = Monitoring the Infrastructure using Railway vehicle's

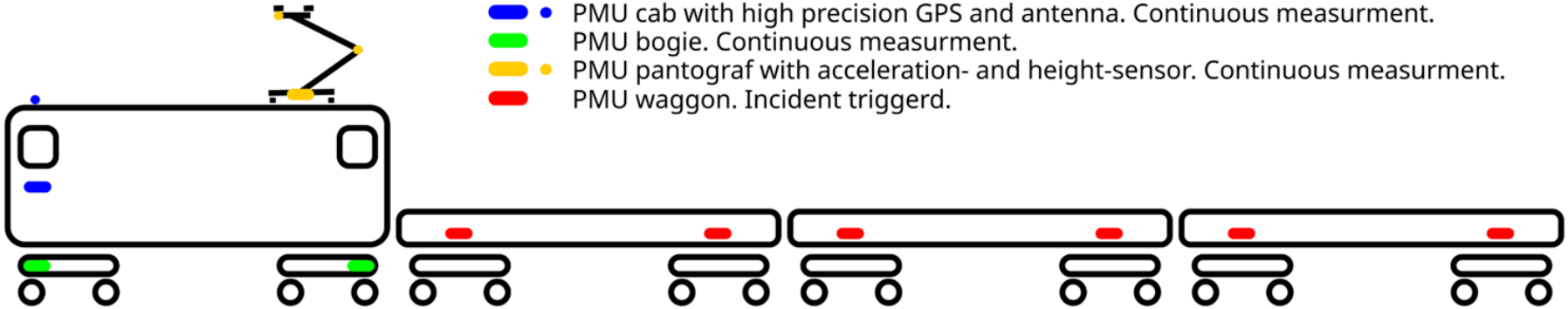
- In short - to monitor railway infrastructure
  - Track and catenary system
- Instrumenting vehicles with PMUs to
  - Measure track and detect track irregularities
  - Measure overhead lines to detect anomalies
- Analyze the data to provide status for the railway infrastructure
  - Decision support – maintenance actions
  - Show changes over time to infrastructure, trends

TRAFIKVERKET
SWEDISH TRANSPORT ADMINISTRATION

RMD
Railway Metrics and Dynamics

Part of system of systems

Continuous monitoring of Rail Infrastructure for Trafikverket
MAJ-project



RMD

Simulation vehicle and infra.

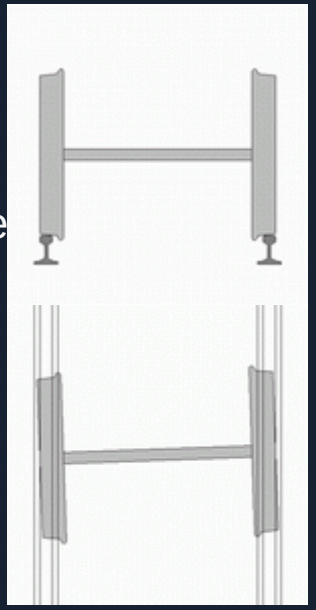
Vehicle response varies depending on fault type, vehicle type, speed, etc.

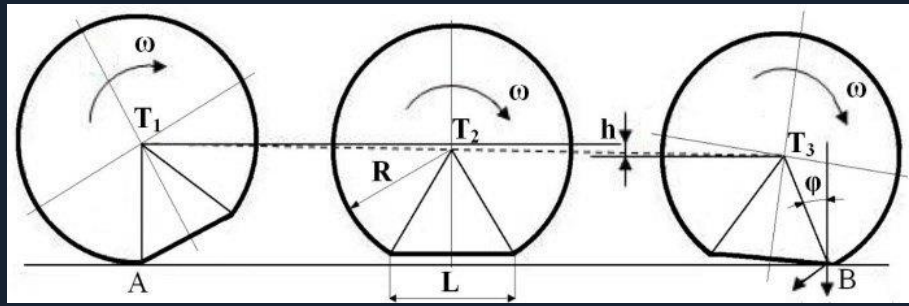
Simulations allow us to control all parameters

- Characteristics of the vehicle (weight, speed)
- Track (appearance, geometry)

The simulations are calibrated with

- Measured data





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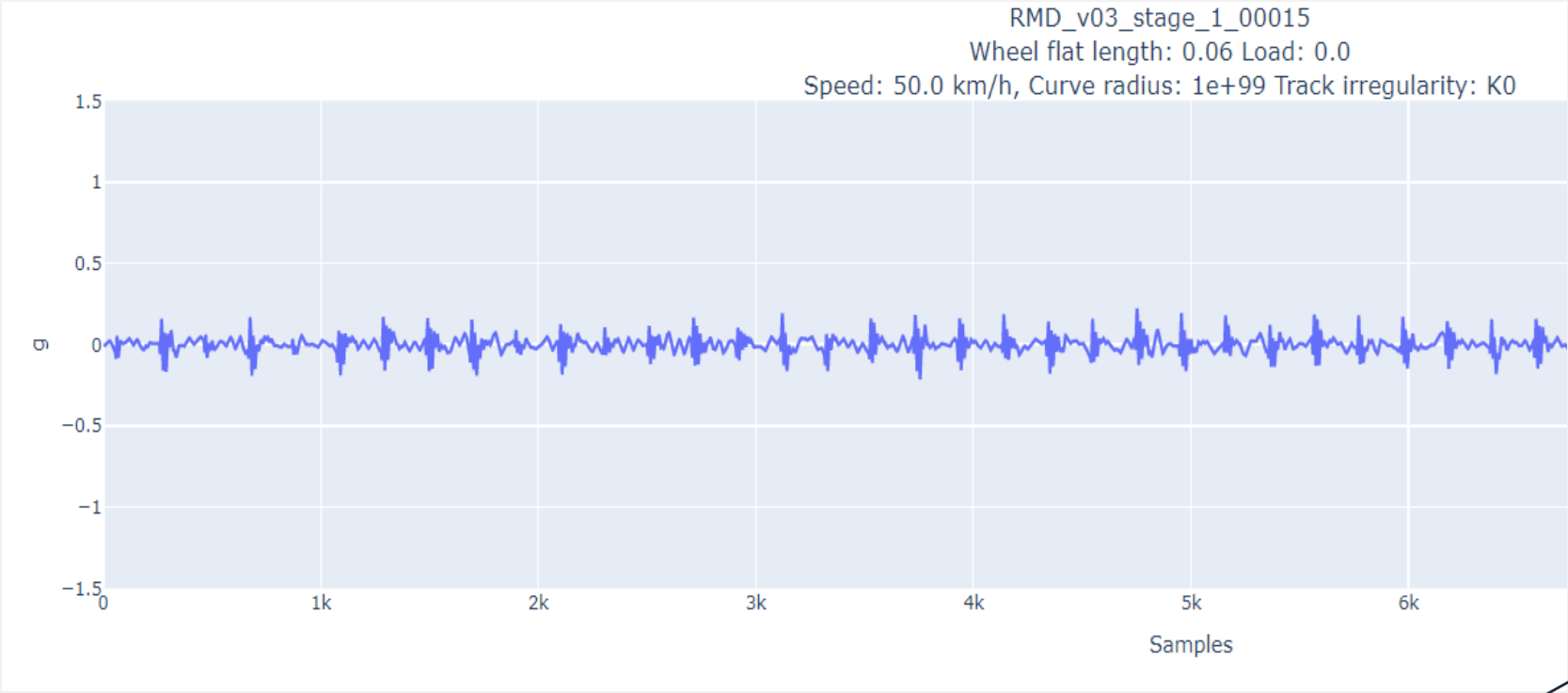
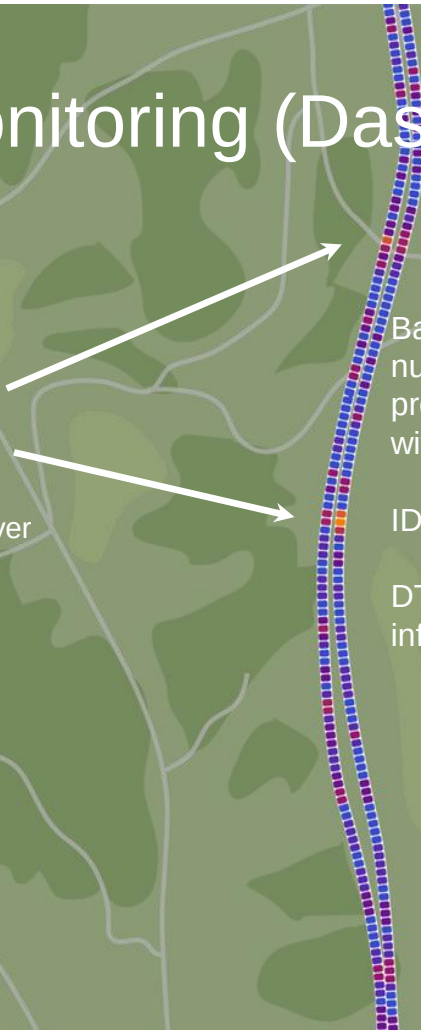
Example simulated wheel flats 6 cm, 50 km/h



Infrastructure monitoring (Dashboard)

- Easy overview through heat maps
- Analysis of railway sections over time
  - Trends over time
  - Compare geographic stamps over time
- Stopping errors
- Damage that requires action



Based on the measured acc, we create Index numbers, DynamicTrackForceIndex (DTFI), which provides information about the track fault's interaction with the vehicles.

IDTFI is speed and vehicle type independent.

DTFI can, through different filtering, provide information about different types of infra faults.

What causes degradation?

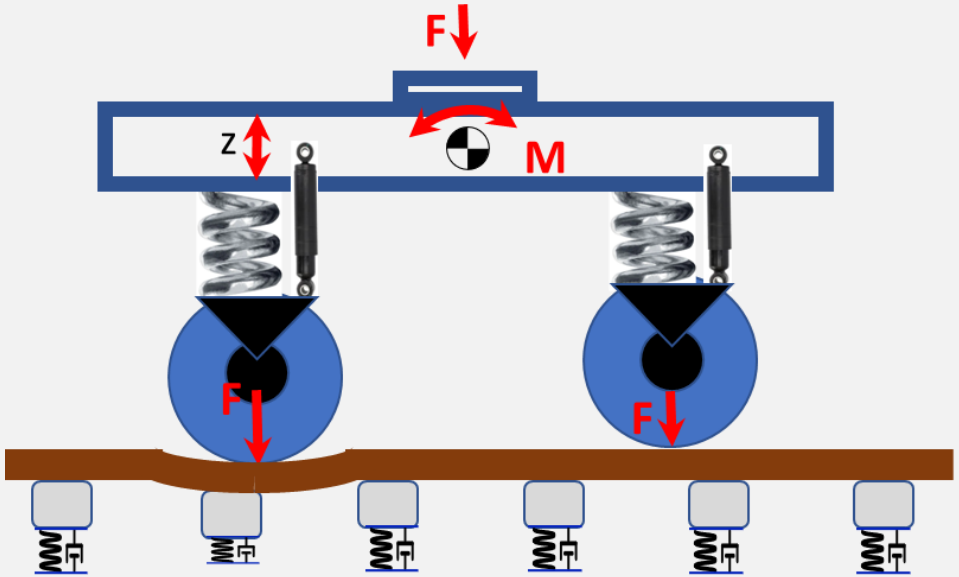
Most of it is due to forces between the wheel and the rail!

The force depends on:

Track geometry.

The mass of wagon and cargo.

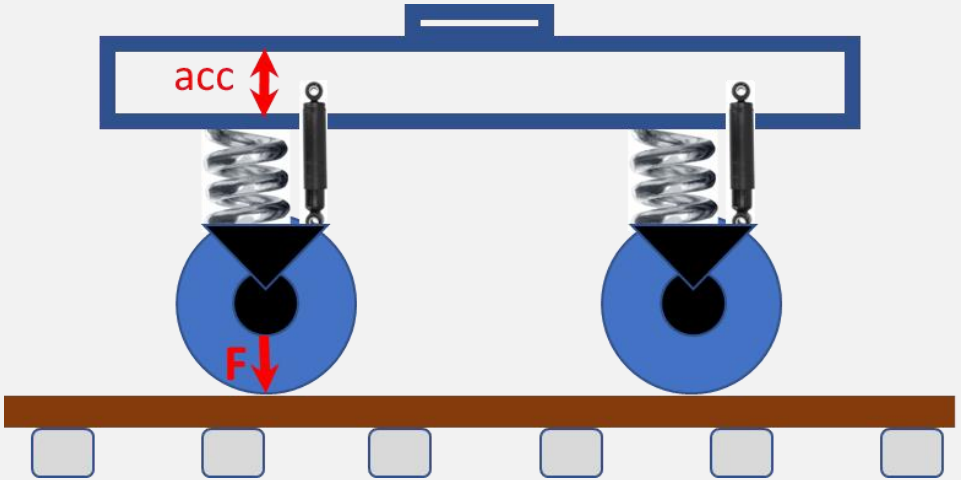
Suspension/damping vehicles and track.

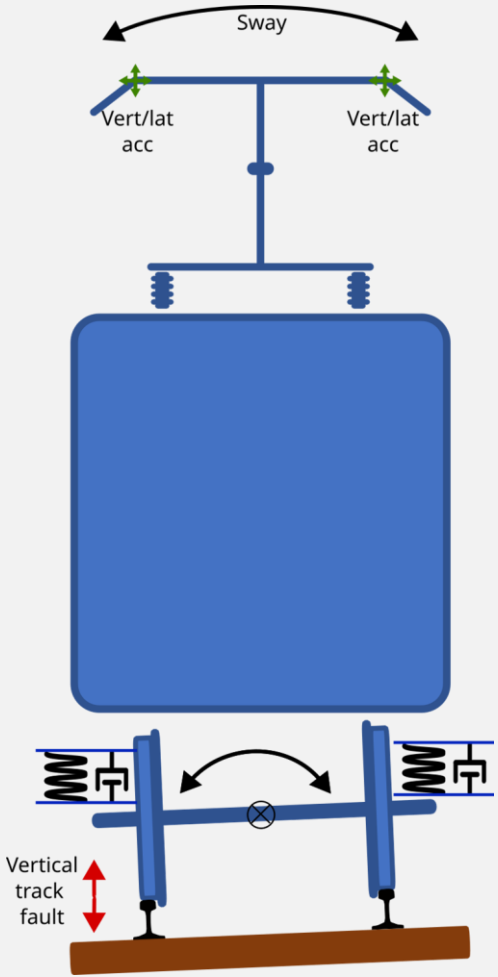


How do we do it?

Measures acceleration (acc.), both laterally and vertically on the bogie frame on both sides of the wagon (red arrow), what we call vehicle response.

The correlation between track force and acc. in bogie frame is not 100% due to the wheel axle mass, load bearing spring and damper, but it provides information about track status and trends when it is loaded with a specific vehicle type.





Pantograph sway:

- Track faults can lead to pantograph sway and damage to overhead wire.
- By registering accelerations in both the pantograph top and the vehicle, track position errors can be linked to reduced contact.

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"Measurement" Interaction:

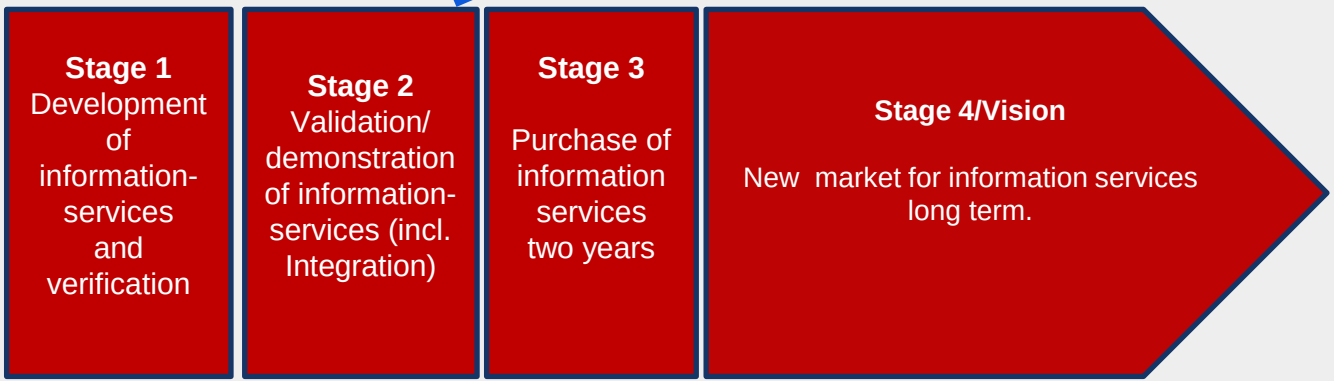
- Rail – Wheels/Bogie

- Contact wire - pantograph

Effect Infrastructure

Effect Rolling stock

Simulation **Machine-Learning**



Imminent
Higher safety
Less down time for the Infra. and the rolling stock.

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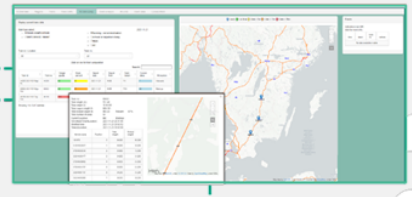

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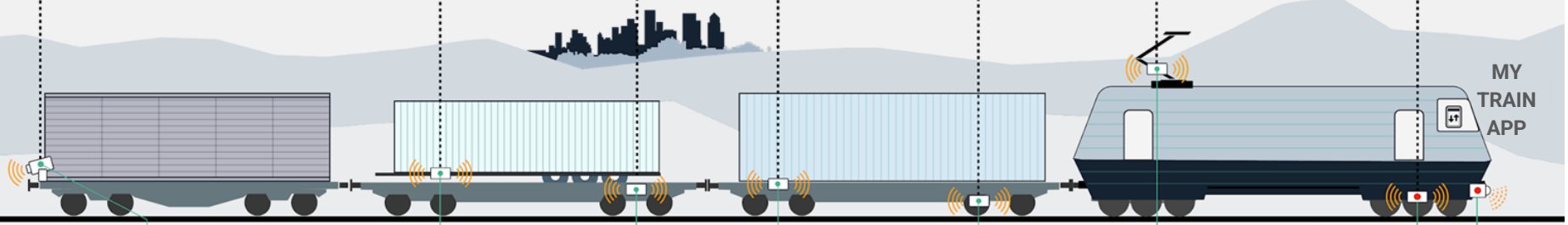

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THANK YOU

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