

AUTOMAIN



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**D6.1 - Demonstration of in-service
inspection (by a freight locomotive)**

Objectives of WP6.1

- The aim of WP6.1, and hence Demonstrator Scenario 1, was to develop an autonomous in-service track inspection system.
- The system should be demonstrated by Deutsche Bahn on a European Freight Route 1 (Betuwelijn) between Rotterdam and Cologne.

An in-service monitoring system

- The monitoring system should provide track alignment and track defect information.
- These data should be displayed using an MMI.
- Output should include a maintenance assessment, based on failure prediction algorithms.
- An optimised maintenance date and plan will be displayed by the software in the MMI.

Project development

Considering the narrow timeframe of the 2 months test period installing measurement tooling in only one train creates much risk , E.G. unavailability. Therefore we organised a parallel demonstrator using a slightly different approach for comparison. An in-service track monitoring system using a passenger train on the Brighton to London mixed traffic line (GB), which was developed by the University of Birmingham.

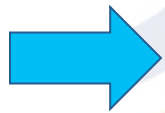
Monitoring versus inspection

Monitoring	Inspection
Orientated on the fault ▪ <u>fault detection</u>: a system is able to detect a fault which is happening ▪ <u>fault diagnosis</u>: a system is able to diagnose the fault ▪ <u>fault prediction</u>: the system is able to predict a fault a certain amount of time before it will happen	Oriented on safety ▪ identify the assets that do not meet the standards ▪ carry out inspections specified in inspection standards ▪ carry out the inspections in a way that satisfies the inspection requirements (e.g. precision of measurement)
Monitoring supports efficient maintenance	Inspection ensures safety

In-service monitoring (DB)

Inspection intervals are related to safety issues

- Short inspection intervals on high speed lines
- Long inspection intervals on high loaded freight lines with low maximum speed
- High deterioration on freight lines
- Less accuracy of maintenance planning



In-service track monitoring using a freight locomotive

“Continuous” track monitoring:

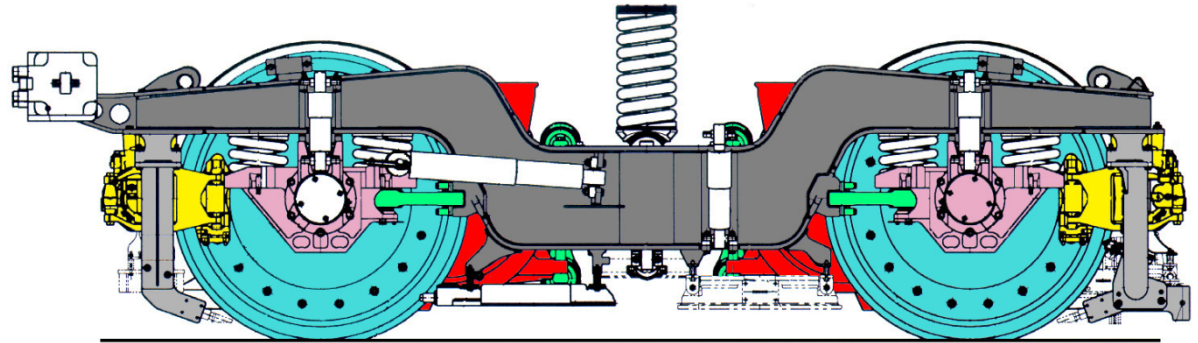
- Allows measurements and prediction of track deterioration
- Point on weak points in the infrastructure
- Supports planning of maintenance activities
- Does not replace inspection which is necessary for safety reasons

In-service monitoring (DB)

Some important issues to be solved

- High requirements regarding installation of mechanical and electronic devices in in-service locomotive with powered wheels
⇒ special system design, approved components, maintenance plans, cable management and approval

The installation in a powered bogie increases the risk of mechanical (gear) and electro-magnetic disturbances



In-service monitoring (DB)

In-service track monitoring using a freight locomotive

Selected route and freight train

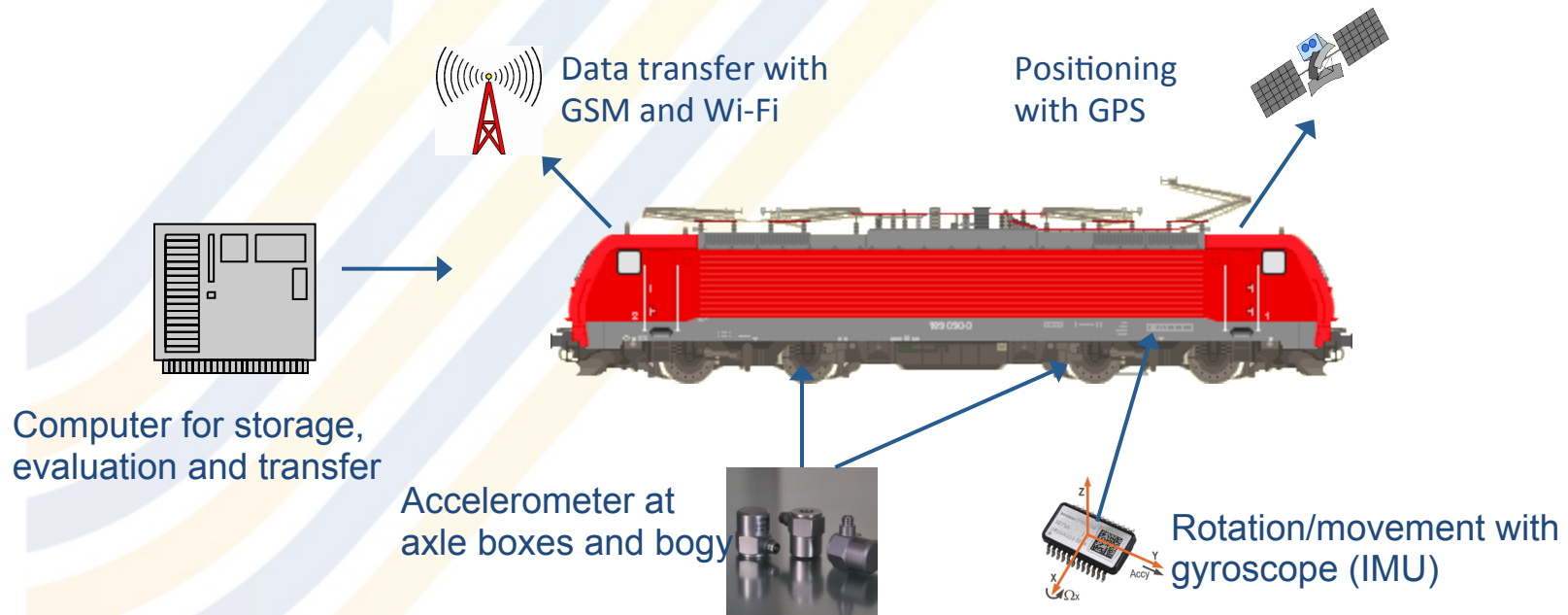
- Freight route from Rotterdam to Dillingen/ Saar (Dillinger mill)
- Heavy ore-train with 5400t
- Double traction with BR 189
- Six-axle cars capable for 25t axle load
- Cars and locomotives with automatic coupling
- Selected locomotive runs only on one route
- Partly old track with old buildings
- Track along the rivers Rhine and Moselle



In-service monitoring (DB)

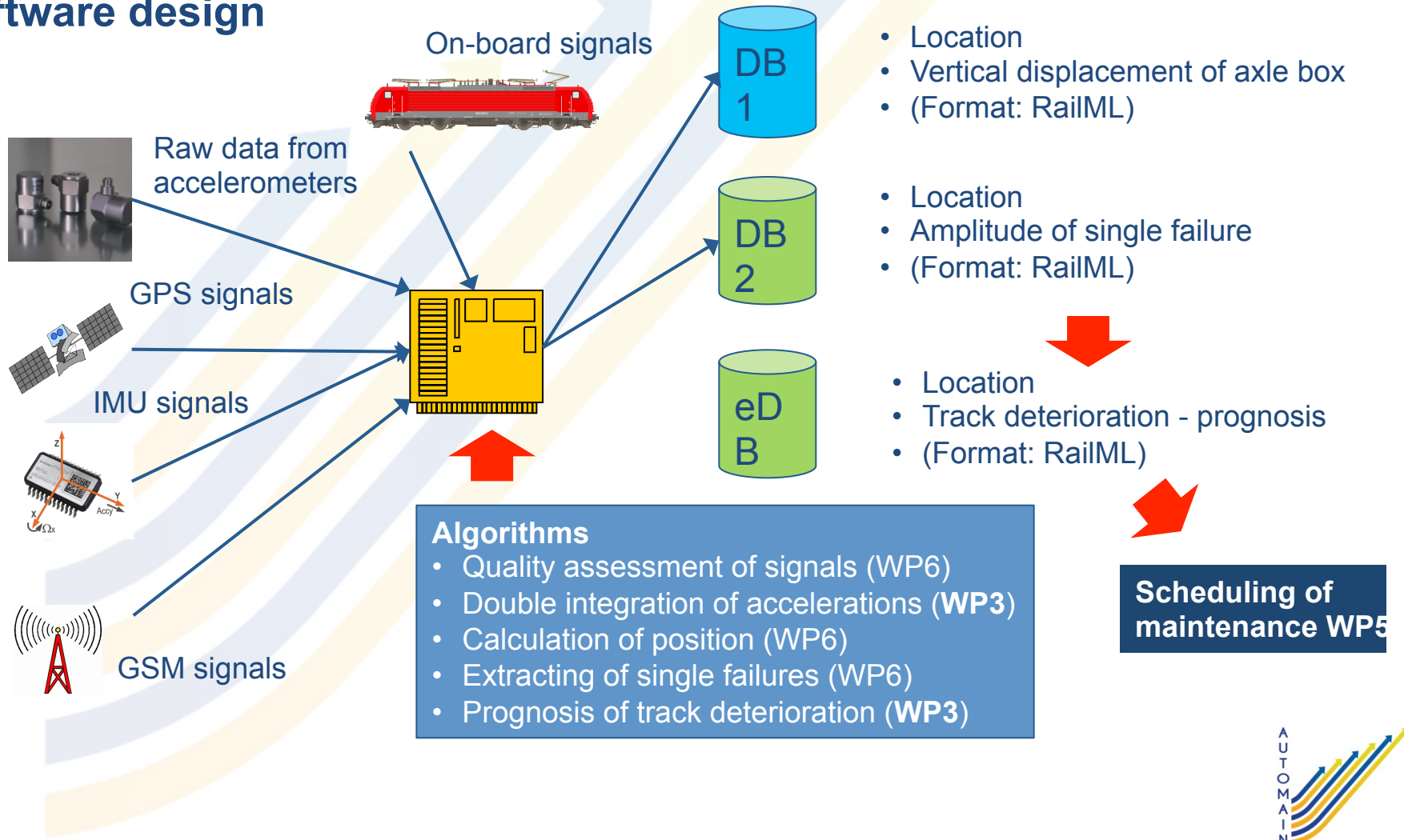
In-service track monitoring using a freight locomotive

System design



In-service monitoring (DB)

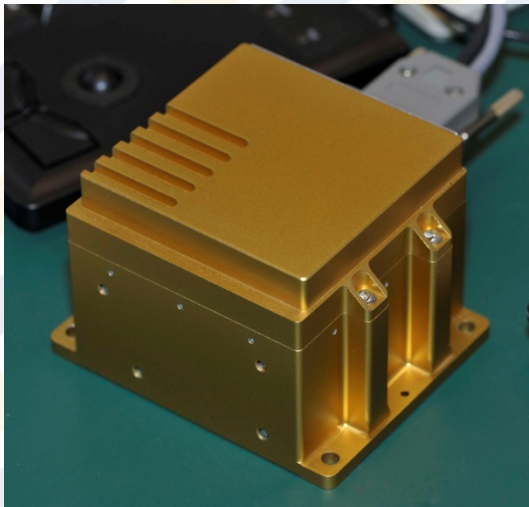
Software design



In-service monitoring (DB)

Equipment

High precision inertial measurement unit provides information used for determining of measurement position



Dust and water proofed connections will ensure long-term usability of system

In-service monitoring (DB)

19" rack includes all IT equipment

- This rack will be installed in the machine room of locomotive
- It contains among others
 - Measurement computer
 - Optoelectronic decoupling system
 - Amplifier for accelerometers
 - GPS receiver and GSM modem
 - Power supply
 - Monitor
 - ...

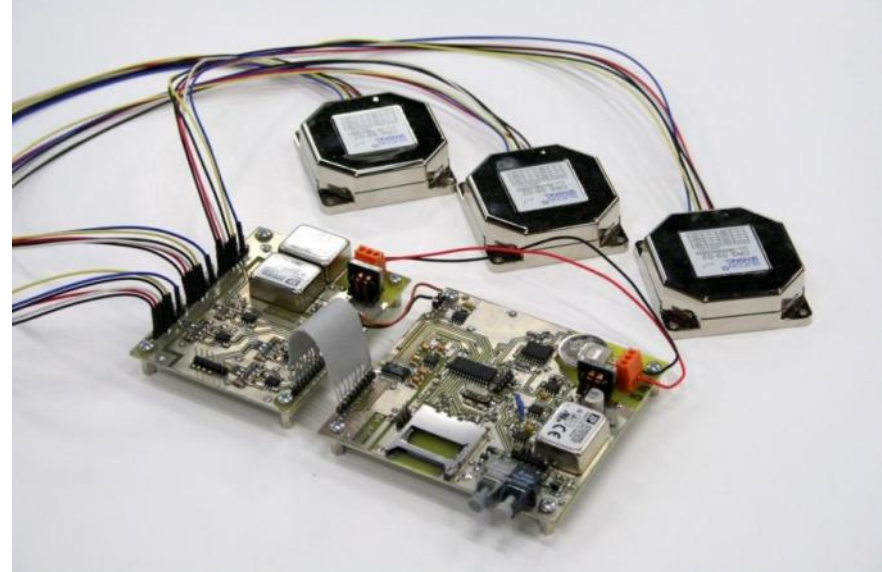
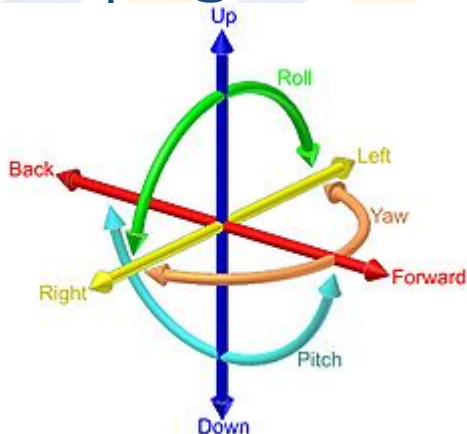


In-service monitoring (DB)

- Successful **test run in laboratory** with all sensors connected to the measurement computer
- Approval from EBA (authority for railway safety)
- Successful **installation of measurement technique** in 189 - 041
- Measurement runs started at the 15th of November
- Defect at air entrance container stops locomotive
- First validated results weren't possible in the AUTOMAIN project time-frame. Tests however will be continued until the end of the year.
- Results will be available for those interested

In-service monitoring (UK)

- Low cost (~12k£) bogie mounted measurement unit
- Location from tachometer and GPS (pitch rate gyro and map matching)
- Inertial measurement unit
 - Tri-axis, 10 g accelerometer @ 8kHz
 - 3x Single axis, 100 deg / sec gyroscope @ 8kHz



In-service monitoring (UK)

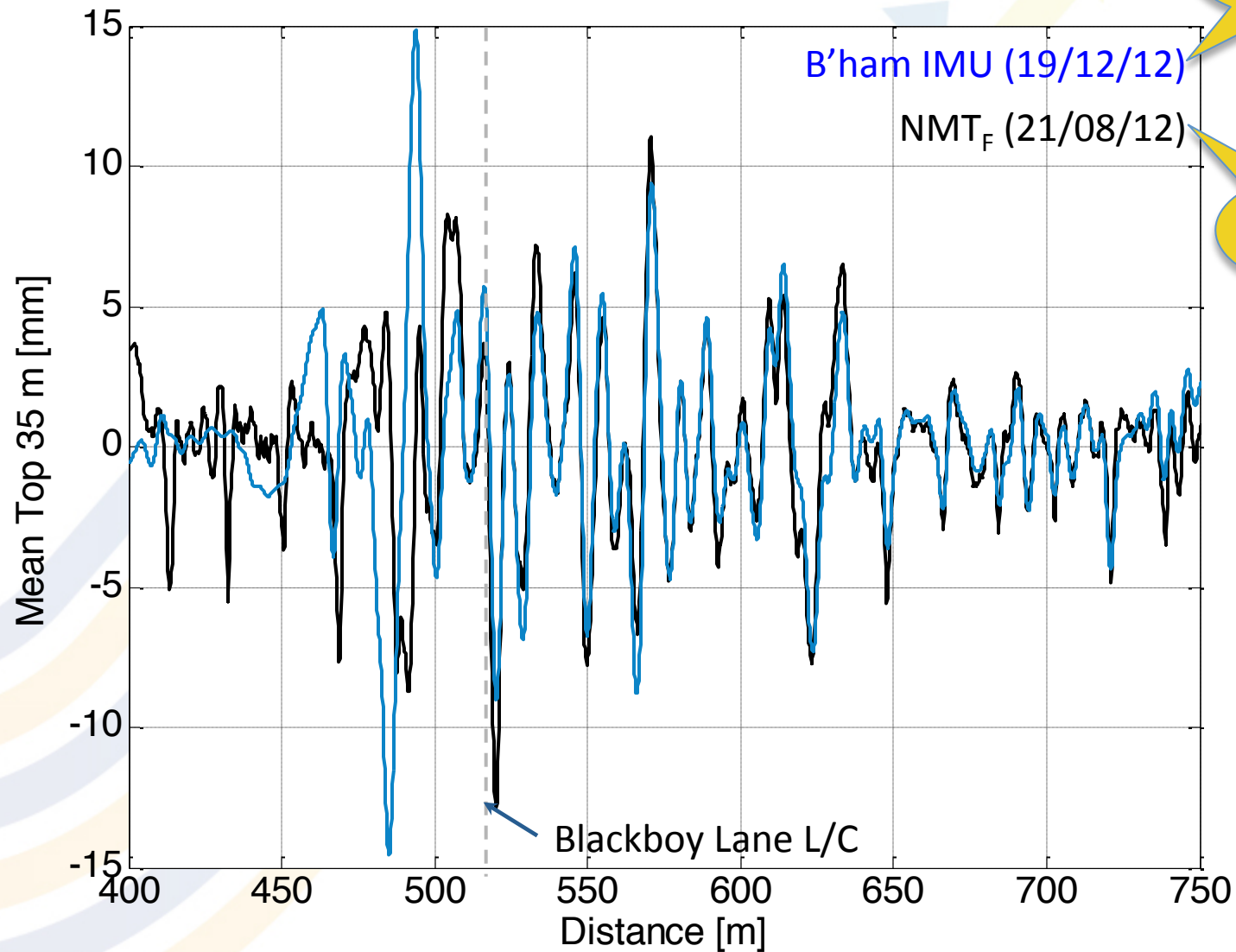


Proof of concept UK

- Daily measurements by one passenger train set on a part of the network (next page)
- Reliability of input data analysis
- Benchmark with inspection train data
- Data mining
- Development of wear prediction algorithms
- MMI for failure recognition

Evolution of

Test: Monitoring data is less precise but follows the inspection data pattern



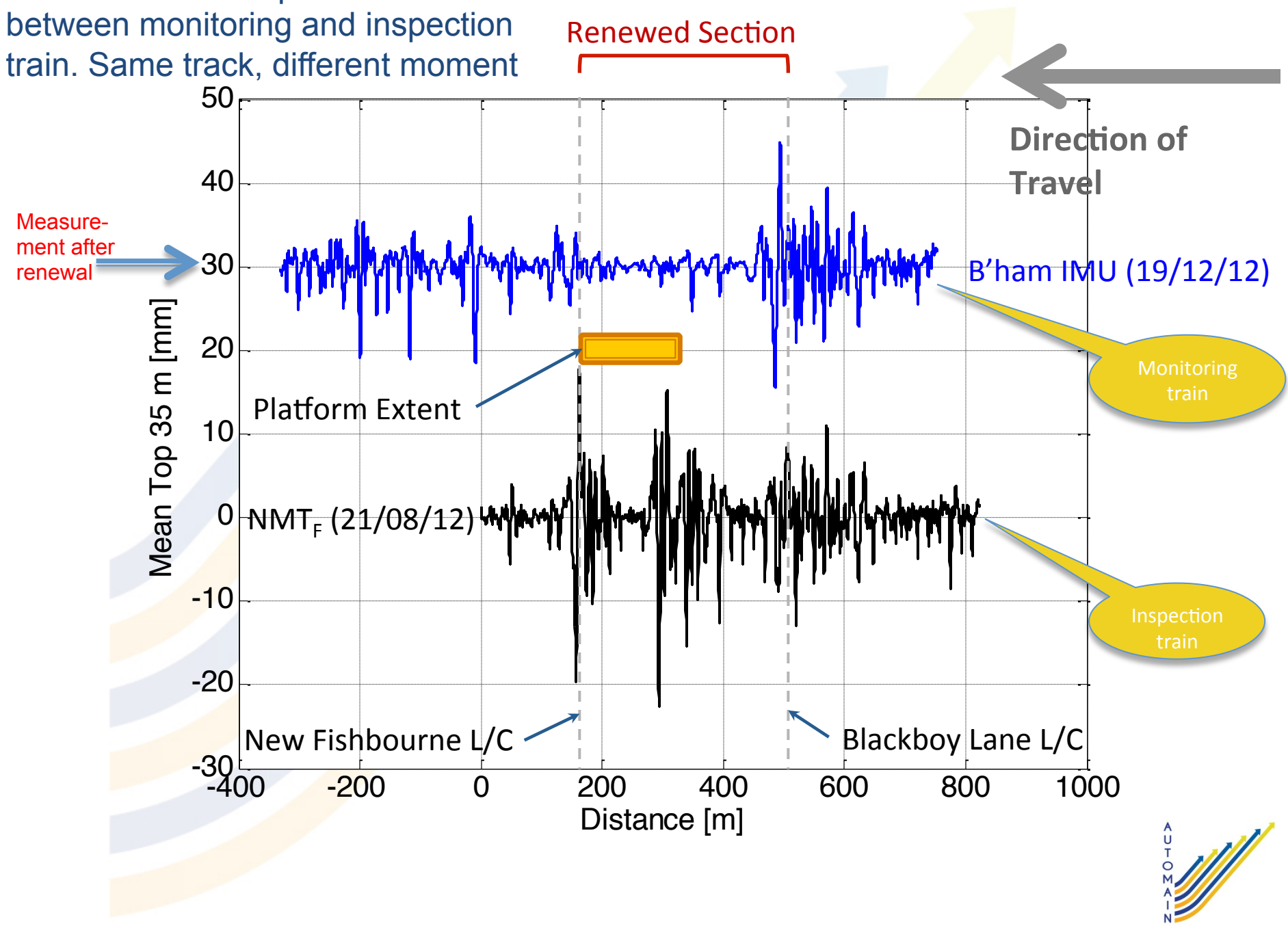
Monitoring train

Inspection train

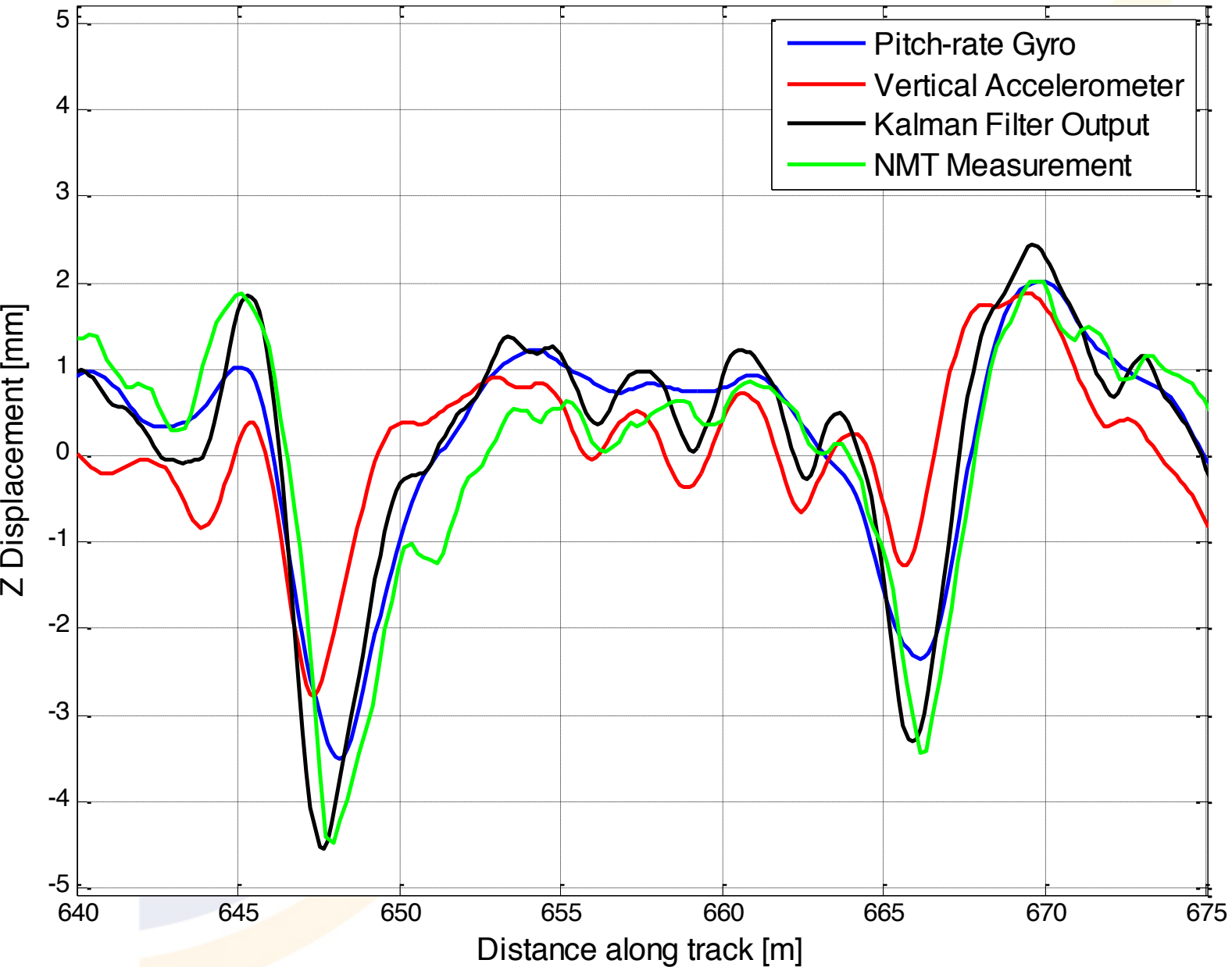
Example: section Fishbourne, Sussex



Measurement comparison
between monitoring and inspection
train. Same track, different moment

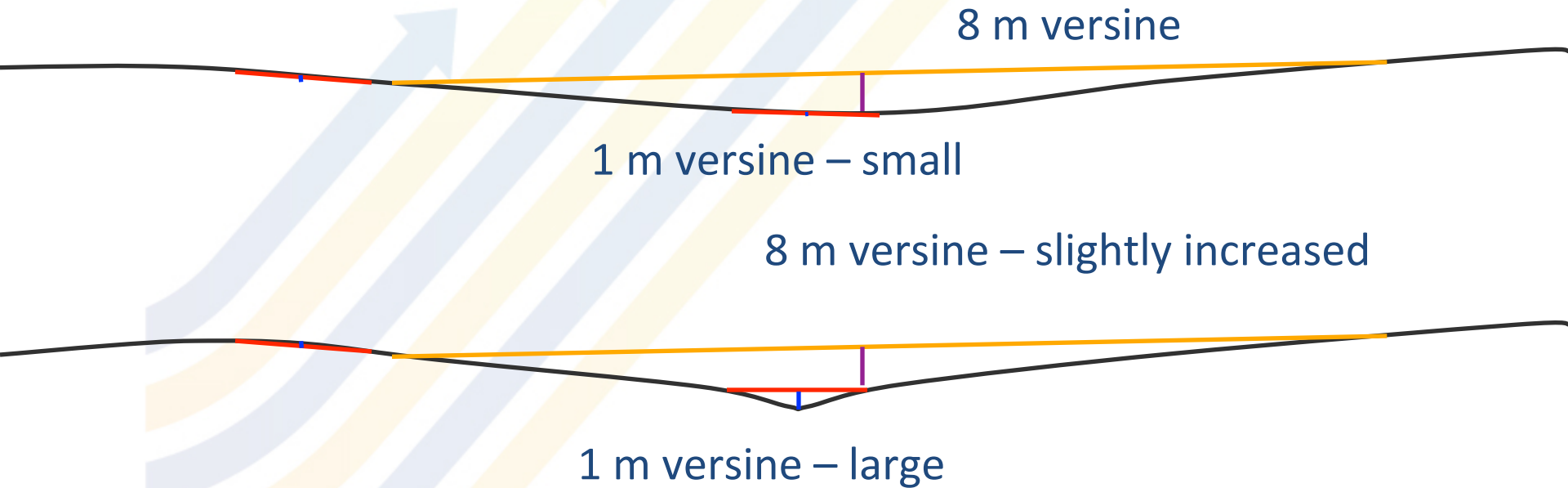


Research for the best usable dataset

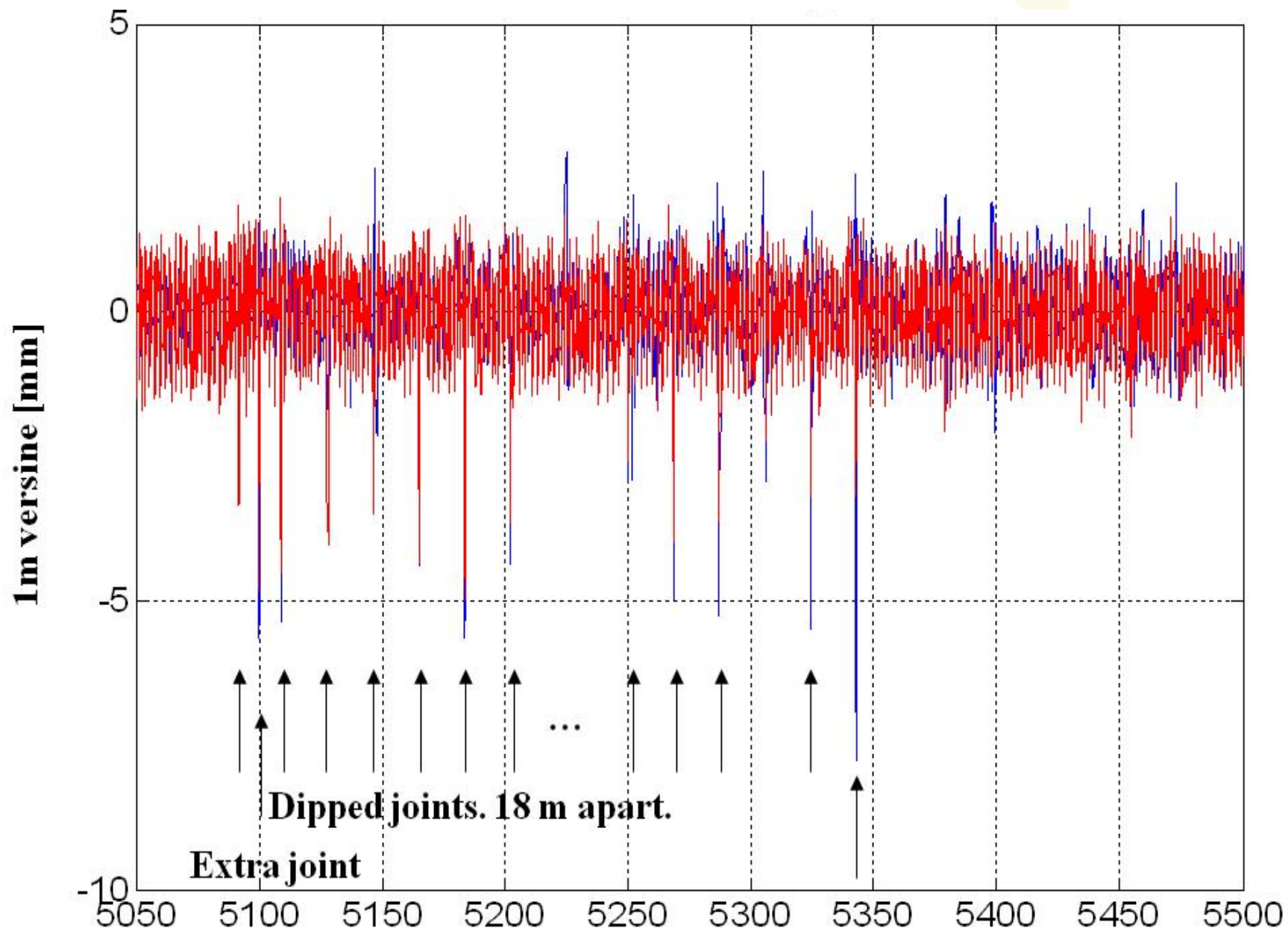


Fault identification and quantification

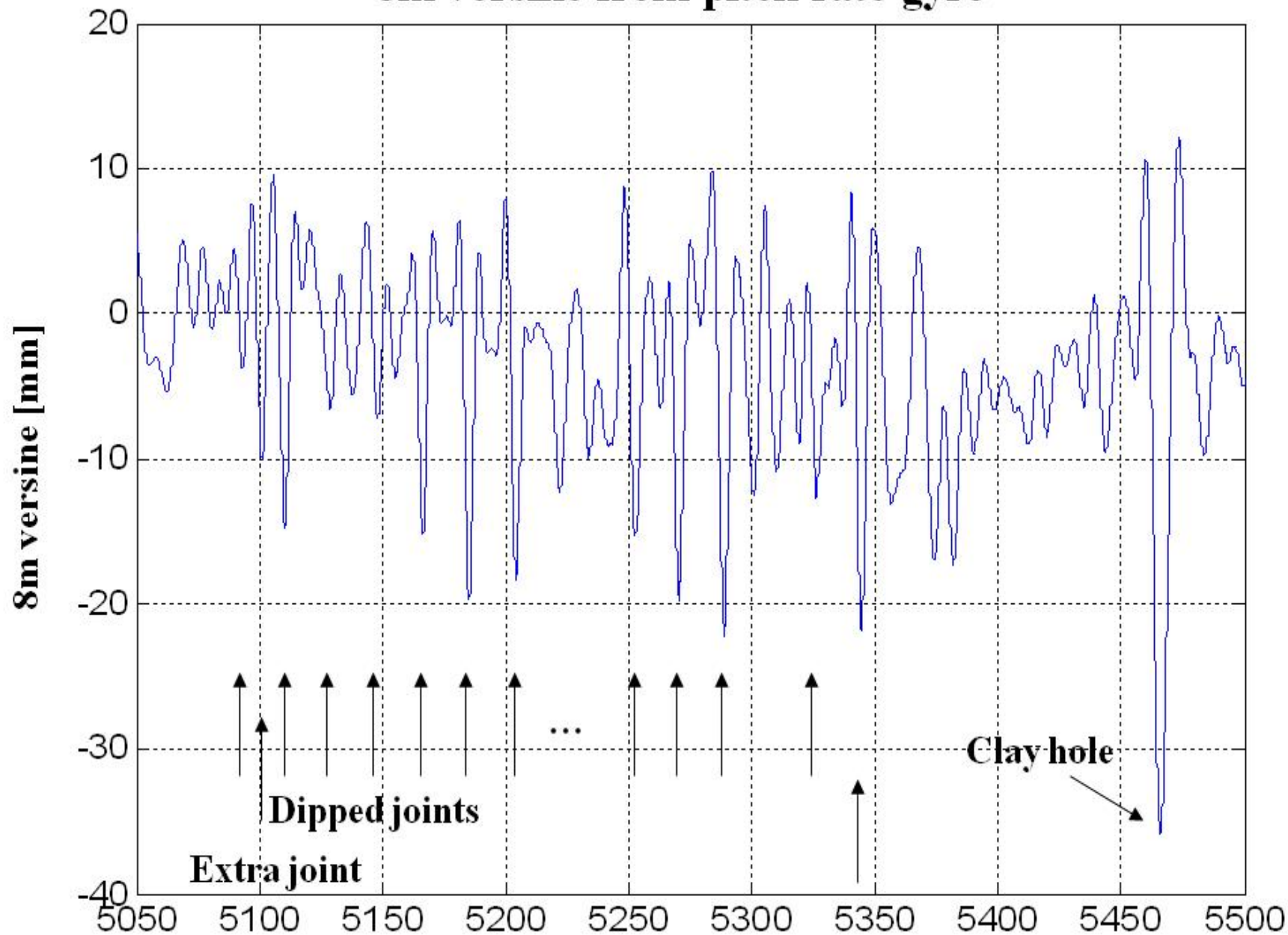
Monitor vertical and lateral trajectories at various wavelengths (versines)



This allows some level of fault diagnosis at a defect by defect level and a quantification of degradation

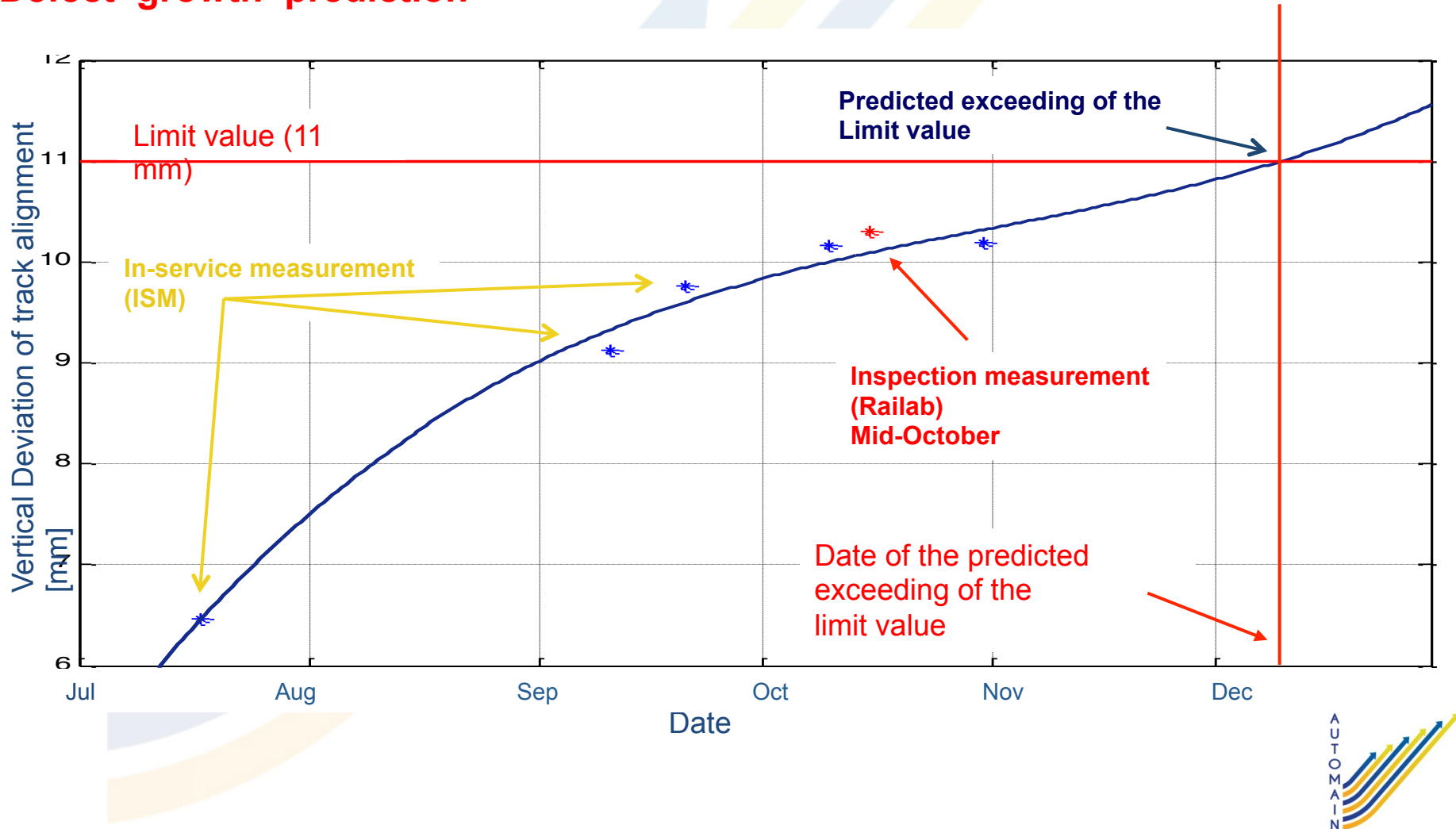


8m versine from pitch rate gyro

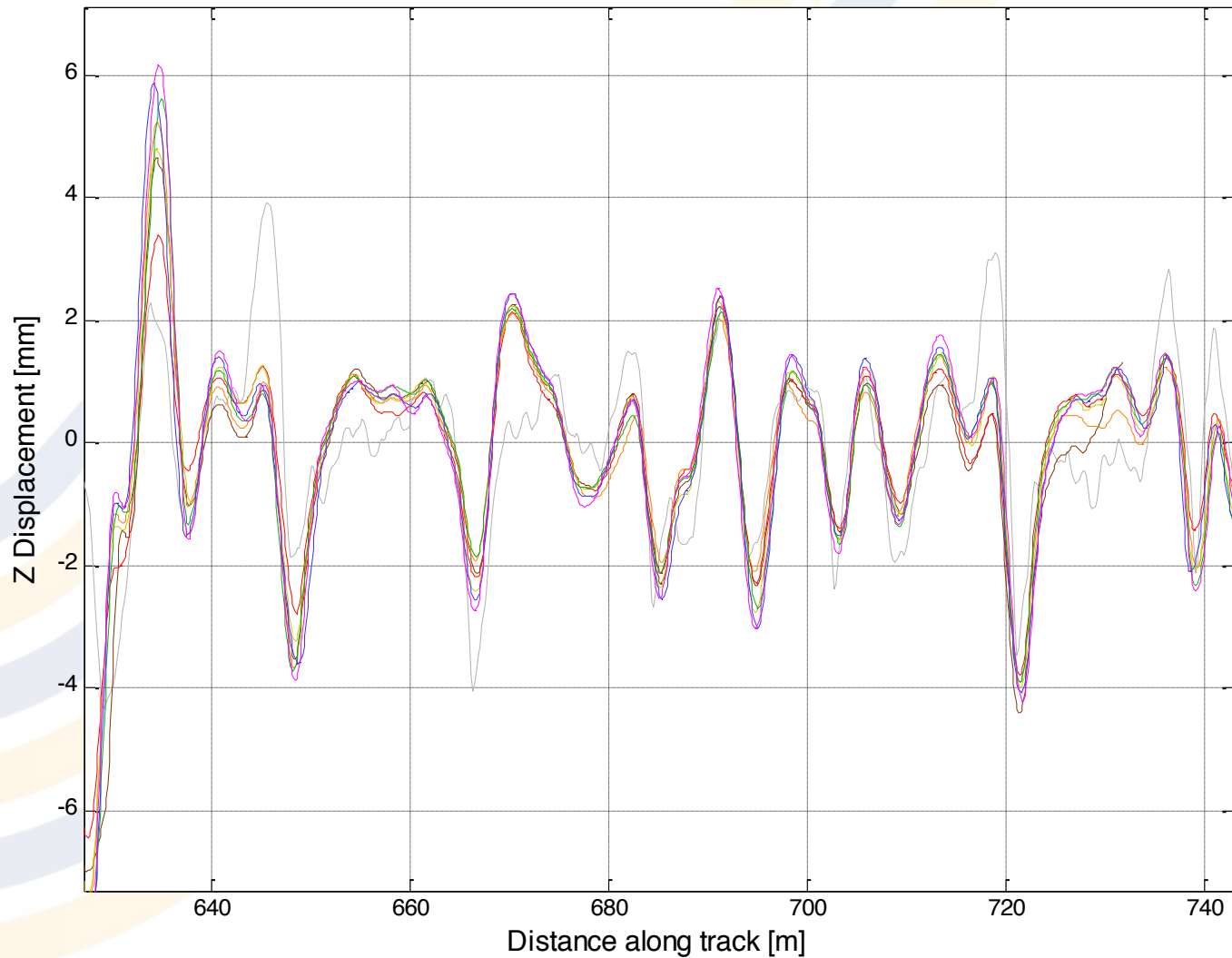


Determining intervention time

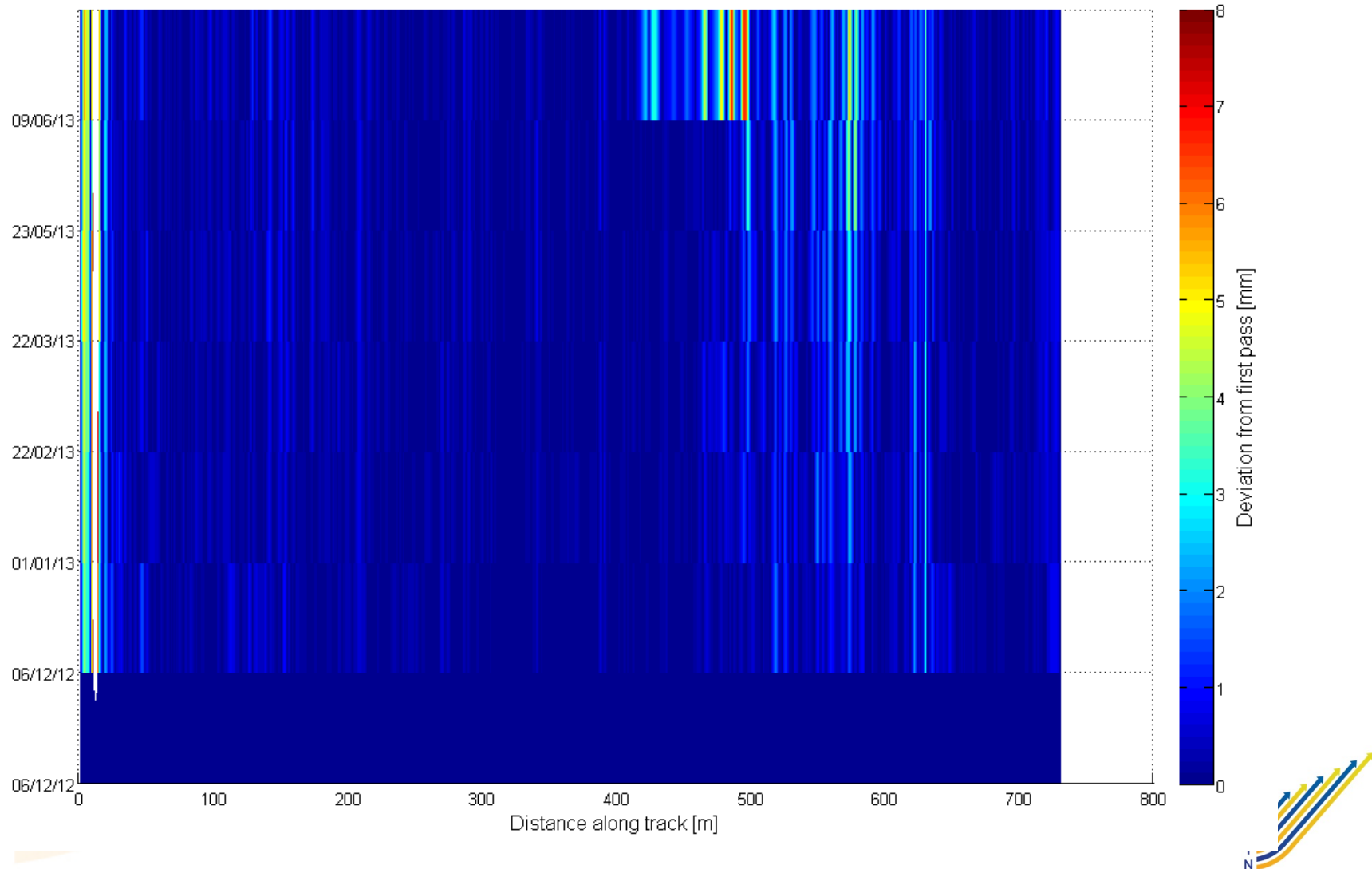
Defect growth prediction



Change in track geometry over time

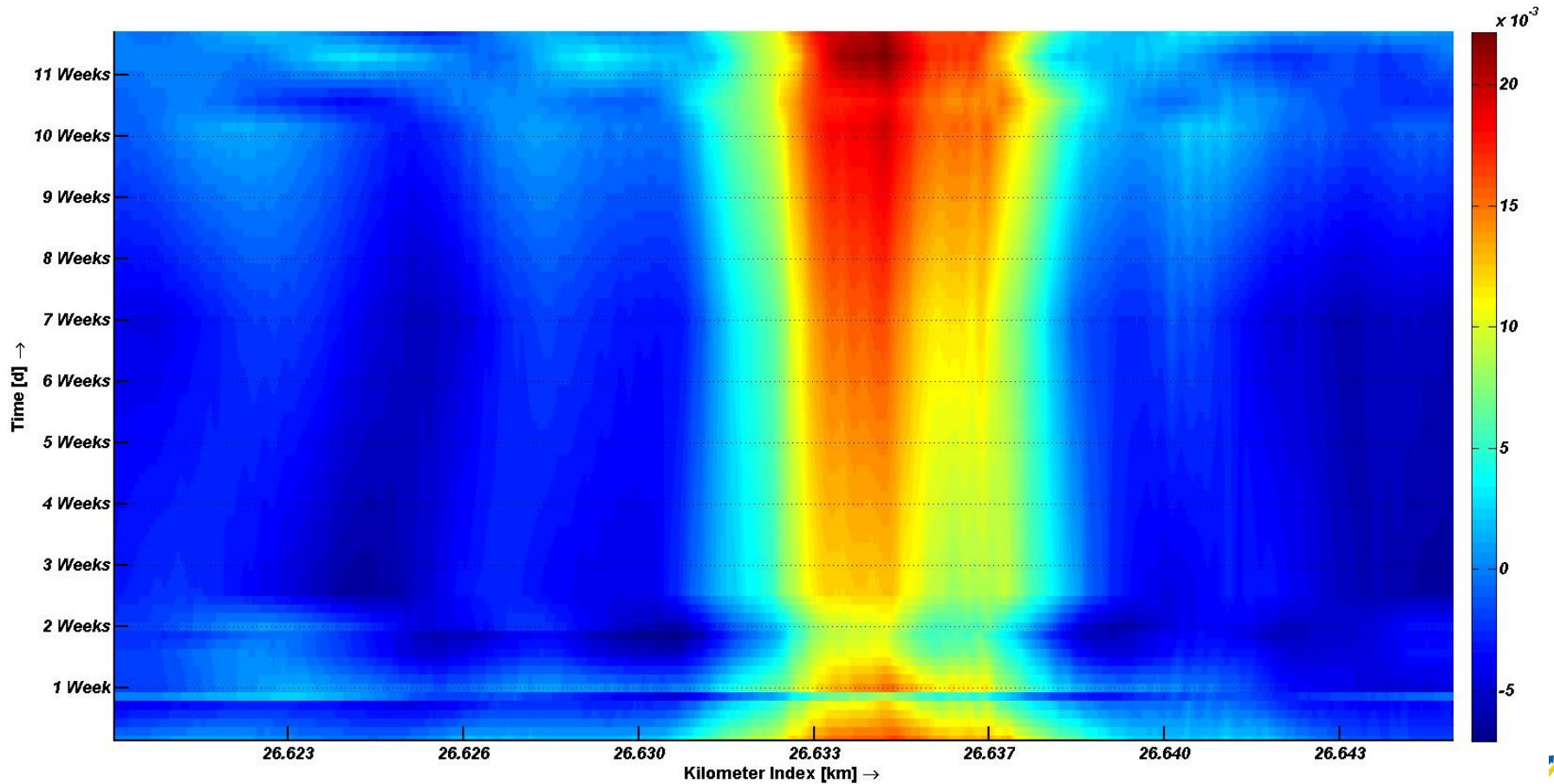


First visualisation of change in geometry



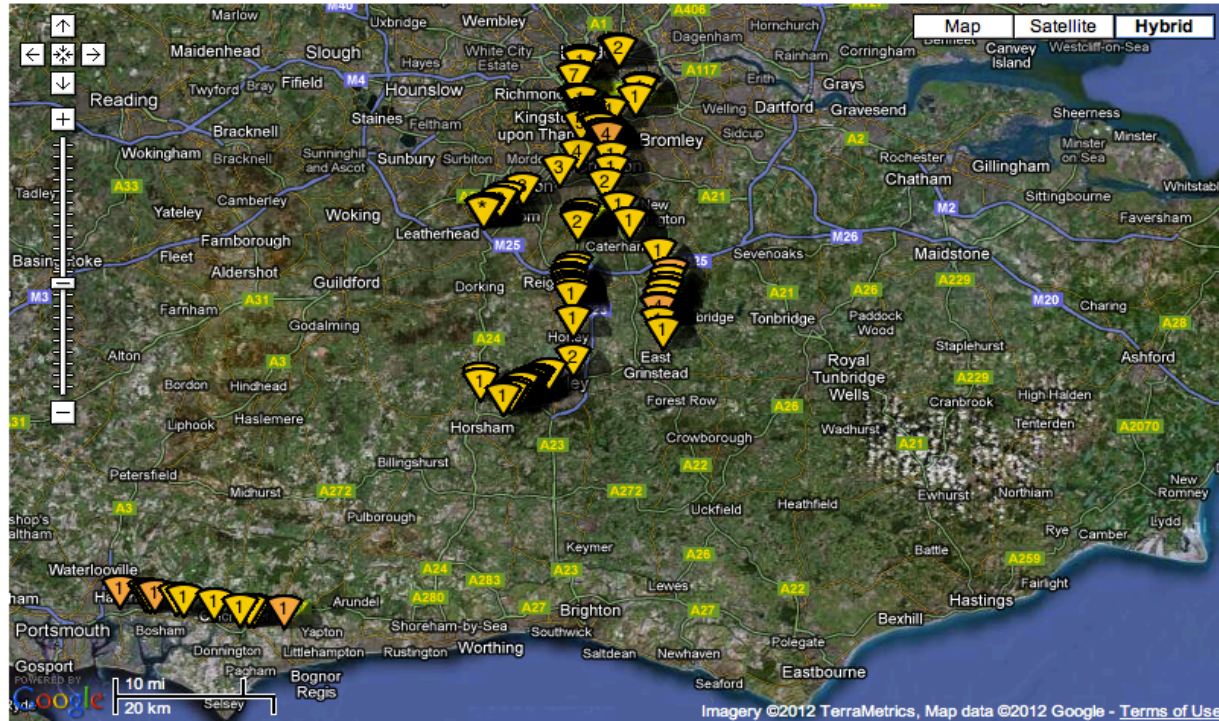
Developed change in track geometry over time

Growth of defects over time



MMI reporting of defect locations

Southern Railways Event Data Viewer



Event Selection

Start Date (Inclusive)

<< < February, 2012 > >>						
Mon	Tue	Wed	Thu	Fri	Sat	Sun
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	1	2	3	4
5	6	7	8	9	10	11

End Date (Exclusive)

<< < February, 2012 > >>						
Mon	Tue	Wed	Thu	Fri	Sat	Sun
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13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	1	2	3	4
5	6	7	8	9	10	11

Available Events

Cluster event type	Cluster average severity ↓	Cluster size ↓
Shoe high	moderate	1
Shoe high	moderate	1
Shoe high	moderate	1
Shoe high	moderate	1
Shoe high	moderate	1
Shoe high	moderate	1
Shoe high	moderate	1
Shoe high	moderate	1
Shoe high	moderate	1
Shoe high	moderate	1
Shoe high	moderate	1

Export Event Clusters

To export a summary of the clusters selected (or all available clusters if none selected) please click the button below.

[Export Selected Event Clusters](#)

Laser One



Laser Two



Speed



Qualitative evaluation and conclusions

- The concept of continuous track monitoring has been developed, and the key technical challenges (compared with track inspection) have been addressed.
- New software processes have been developed and have been validated.
- The development of early decision support solutions now exist.

Qualitative evaluation and conclusions

- The TRL level of track monitoring systems has risen to TRL 7 through the 'prototype demonstrations in a railway environment' in Germany and the UK.
- The developed approaches do not require any possession time and deliver additional information for more efficient planning of maintenance activities.

Further work and take-up

- Work will be taken forward by a number of infrastructure managers:
 - German approach (DB)
 - UK approach (University of Birmingham and Network Rail)
- Intention to further develop algorithms to understand the behaviour of track and infrastructure wear by DLR.