

Health monitoring of wheel profile

Automatic wheel profile measurement equipment

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Health monitoring of wheel profile

1 Background/Introduction

2 Wheel profile monitoring system

3 How to find the system?

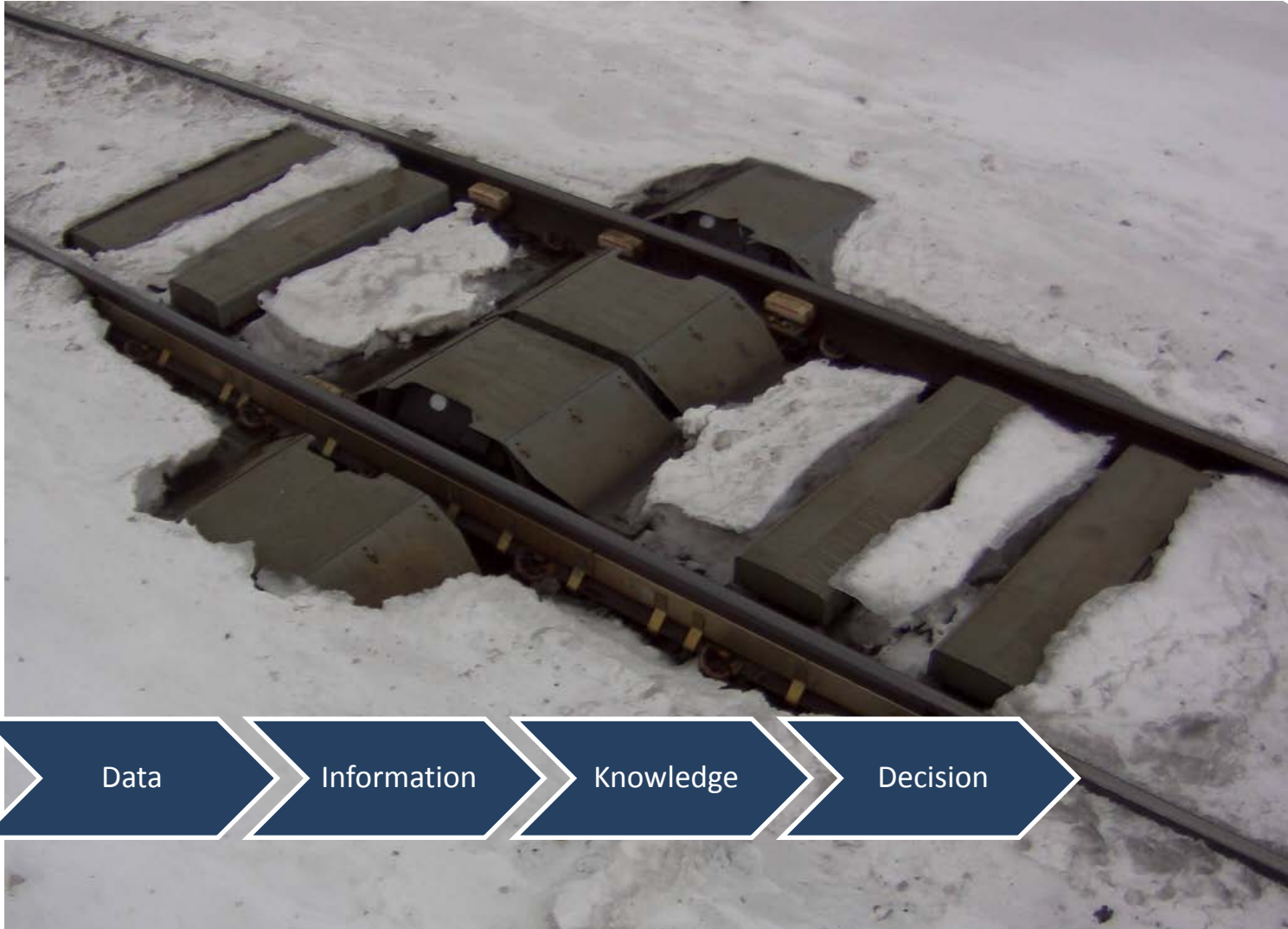
4 Installation and validation

5 Discussion and questions

Health monitoring of wheel profile from the IM side

Wheel profile monitoring system (WPMS)

Detect



Predict



Malmbanan

- Iron Ore Line, only European Heavy Haul line
- Operation for over 100 years
- Constructed for an axle load of 14 tonnes
- Upgraded to axel load of 30 tonnes
- Length of iron ore train is 750 m, the number of wagons is 68 and the gross train weight is 8,520 tonnes ^[1]
- Mixed traffic which has a large range of vehicle

Capacity

- Predicted growth of 136% to 2050 ^[2]
- Due to the expansion of the mining
- To support this demand for increased capacity, the asset manager must think in new ways and add more **intelligence** to the infrastructure, e.g. through automatic asset monitoring.

Asset condition

- “[Effective] asset management and the use of intelligent infrastructure are key factors in delivering the railway of the future.” ^[3]
- The rail-wheel contact is an important factor for which the wheel and rail profiles play a significant role.

Measurement of wheel profiles

- Traditionally the wheel profile is measured manually using the MiniProf equipment.
- Time-consuming task and there is a need to increase the inspection frequency
- Track wheel deterioration and remove bad wagons from service.
- The condition of the wagon wheel (profile) is one of the most important aspects in this procedure.

Gain with monitoring the wheels

- The operator can benefit from this by using the information to **optimize** the wagon maintenance intervals and reduce the risk of failing wagons **causing delays** in the delivery chain [4]
- The infrastructure manager can use the information from an automated wheel profile monitoring system for management purposes, for reducing **maintenance costs** or even for **preventing failures** of and damage to the track [5,6,7]
- Information on the wheel profile can also give knowledge of the **rail degradation** process and therefore increase the maintenance quality [8]

Status today

- Automatic measurement of the wheel profile is still an area where **little research** has been conducted in Sweden.
- There are still uncertainties regarding the **availability** and **robustness** of automated WPMS installed in areas with an extreme climate
- There is also a need to examine the possibility of reducing the **failure-driven capacity** consumption on a line by analysing the information from an automated wayside WPMS.

2 Wheel profile monitoring system

Condition monitoring in the Swedish network

Driftsatta detektorer

Version 100329

- Driftledningscentral
- Servo/SATT [Varmgång/Tjuvbroms]
- FUES I [Varmgång/Tjuvbroms]
- FUES II [Varmgång/Tjuvbroms]
- MULTIRAIL WheelScan [Hjulskada/Vågning]
- Salient [Hjulskada]
- KIKA [Stromavtagardetektor]
- BUBO [Upplyftdetektor]
- Frontec [Varmgång/Tjuvbroms]

To inspect the rolling stock there are wayside detector stations for the detection of hot boxes, hot/cold wheels, damaged wheels, overloaded cars, unbalanced loads, contact wire lift, and pantograph and wheel-rail forces [9]



2 Wheel profile monitoring system

- The WPMS consists of four separate units
- These boxes contain a laser, a high-speed camera



3 Selection process

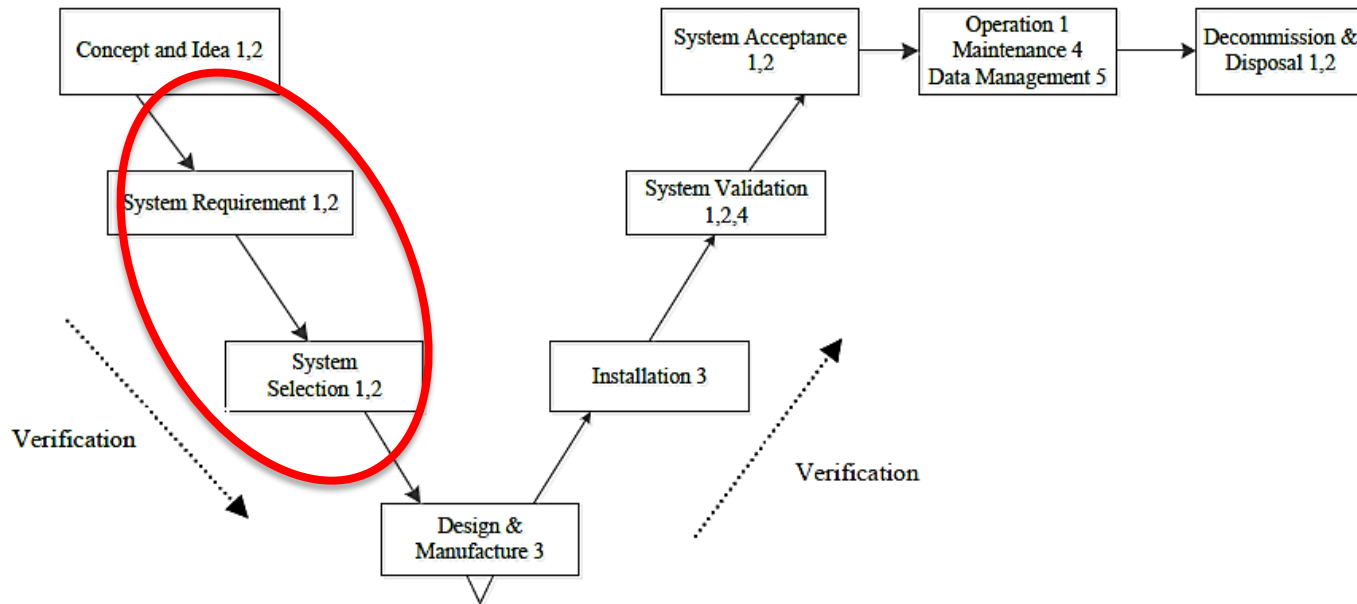
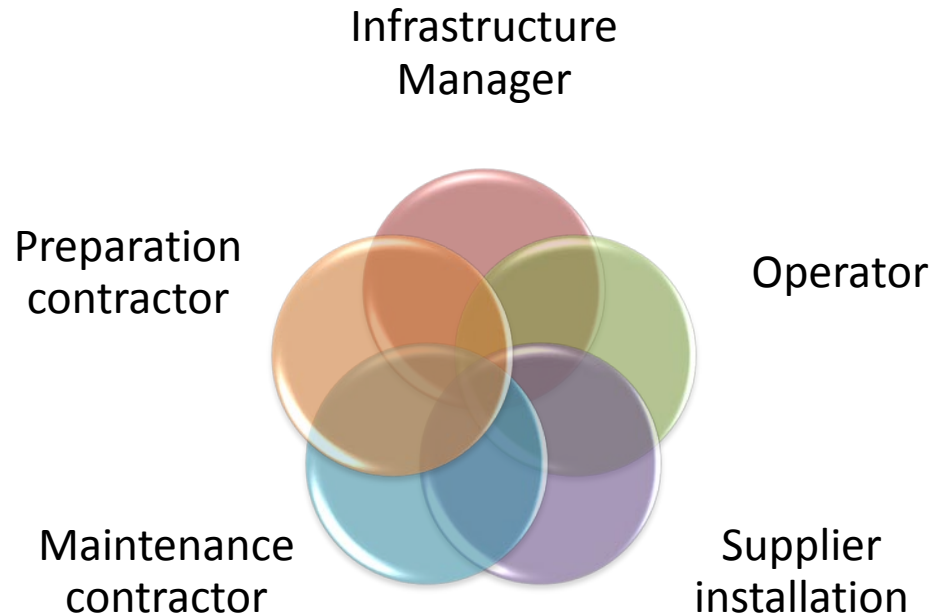


Fig. 3: V representation of the lifecycle of aWPMS (adapted from EN-50126)

1-Infrastructure manager, 2-Train operator, 3-Supplier/Manufacturer, 4-Equipment maintenance company, 5-Data management institution.

3 Selection process

Partners in this project

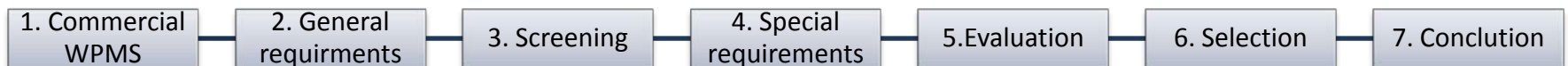


TRAFIKVERKET

3 Selection process

To find the most suitable system

- Collaboration between the infrastructure manager and the main operator
- The selection process has five steps and the work involved in selecting the most appropriate system was to be performed by the infrastructure manager and the operator, together with a railway company consultant.
- The expert group have good experience from the railway sector
- The expert group developed the selection criteria for the special requirements.



3 Selection process

Commercial WPMS

- Suggestions for commercial WPMS could be found in a report by Brickle where twelve systems for this purpose are presented [5]

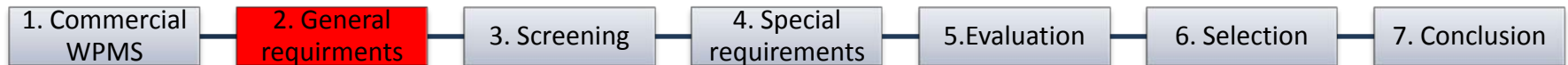
The aim of the report by Brickle et al. was to “identify and evaluate systems that monitor various features and aspects relating to wheel set condition, and to make recommendations for integrating these systems into a comprehensive condition monitoring regime.”.

System	Company
Wheelview*	Beenavision
FactIS WPM	Lynxrail/TTCI
Treadview*	Deltarail
Wheelspec	ImageMap
WheelCheck	Tecnogamma
Argus (Wheel Profile Module)	Hegenscheidt MFD
Model 2000 EVA*	Talgo
Wheel Profile Measurement System	MRX Technologies
Trackside Measurement System*	Mer Mec
Multirail Wheel Profile Diagnostics	Schenck Proces
Laser Measurement System	GHH Radsatz
WheelScan	KLD Labs

3 Selection process

General requirements

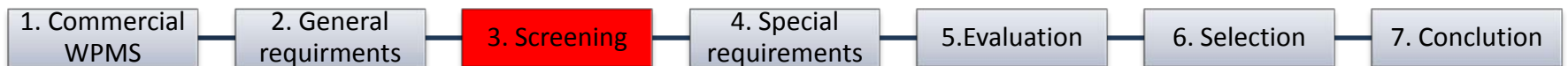
- system features, reporting capabilities, user-friendliness, availability, accuracy, performance, installation, deployment, speed requirements, maintenance and support.



3 Selection process

Screening

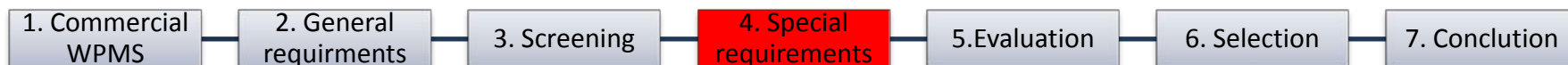
- The screening criterion was that, if a company replied to the questionnaire that we had sent to them, then that company would be considered as a candidate supplier.
- After this screening five suppliers remained.



3 Selection process

Special requirements

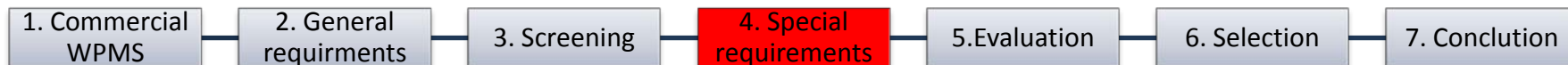
- **Climate:** The climate in northern Sweden is extreme and is characterised by cold winters, large quantities of snow, and snowstorms, but the summer can be fairly warm. The system has to work in extreme conditions, with a temperature range between +30°C and -40°C and with large quantities of snow.
- **Measurement accuracy:** The accuracy must be as high as possible.
- **Photographing speed:** The WPMS has to operate at line speed and photograph wheels moving at speeds in the range of 50-120 km/h, since the traffic speed is in this range.



3 Selection process

Special requirements

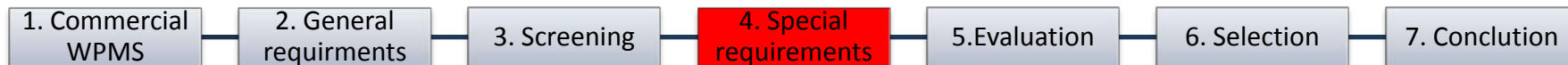
- **Vehicle identification:** Able to interact with the Automatic Vehicle Identification (AVI) system and to match data sent from the tag reader to the WPMS with wheels and wagons.
- **Calibration:** The system must either be easy to calibrate or not need any calibration. It is an advantage if the system emits an alarm, through self-inspection, indicating when it is time for calibration of the equipment.
- **Maintainability:** The system has to be easy to maintain and the time required for maintenance has to be as short as possible. Good maintenance support must be provided, with short delay.
- **Installation:** Disturbance of the traffic cannot be accepted, either for preparation of the site or for installation. The installation has to take place in the empty slots in the timetable.



3 Selection process

Special requirements

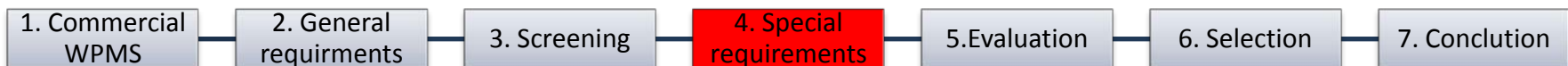
- **Summary:** These main requirements listed above, together with the requirement of commercial availability, had to be met by the WPMS, and a survey was sent to each of the companies. Five suppliers were able to answer the survey, and these five remained in the evaluation (see the summary in Table 2).



3.4 Special requirements

Table 2: Performance of the five wheel profile monitoring systems left after screening.

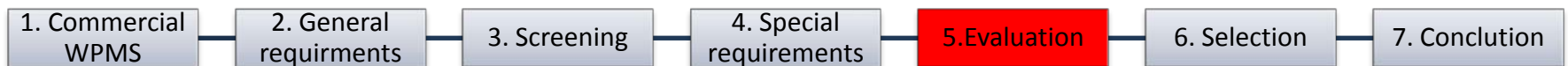
Syst	No. of systems in oper.	Min. speed [km/h]	Max. speed [km/h]	Radial accuracy +/- [mm]	Cold climate oper.	Calibration	Vehicle identification	Maintainability	Estimated installation time, approx. [hours]
A	12	5	120	1.5-2.0	Yes	No	Yes	Yes	No stop
B	12	0	40	0.2-0.5	No	Yes	Yes	Yes	4h stop
C	11	0	30	0.2-0.5	No	Yes	Yes	Yes	10h stop
E	5	0	130	0.25	Yes	Yes	Yes	Yes	No stop
F	7	0	130	0.5	Yes	Yes	Yes	Yes	No stop



3 Selection process

Evaluation

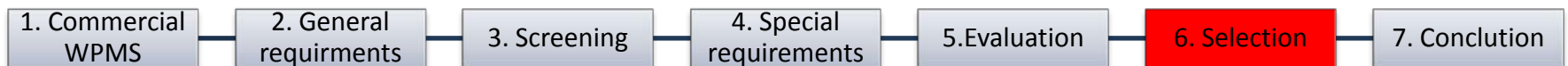
- The evaluation was performed by an expert group comprising personnel from the infrastructure manager and the operator, together with a railway consultant.



3 Selection process

3.6 Selection of a system

- The most important features of the WPMS, as mentioned above, included good speed performance and **climate-resistance** and only three systems possessed these features, namely systems A, E and F.
- After individual meetings with each supplier, one was found to meet our requirements more adequately and system F was selected.



4 Installation and validation

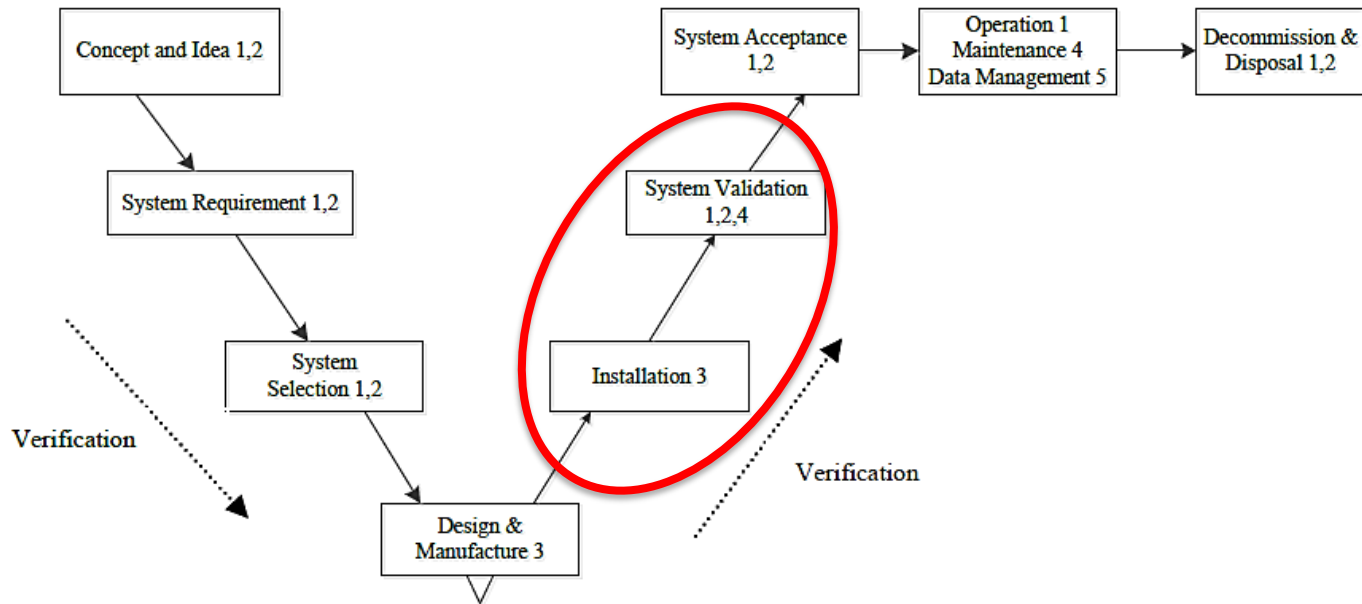


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4 Installation and validation

Preparation and installation of the WPMS

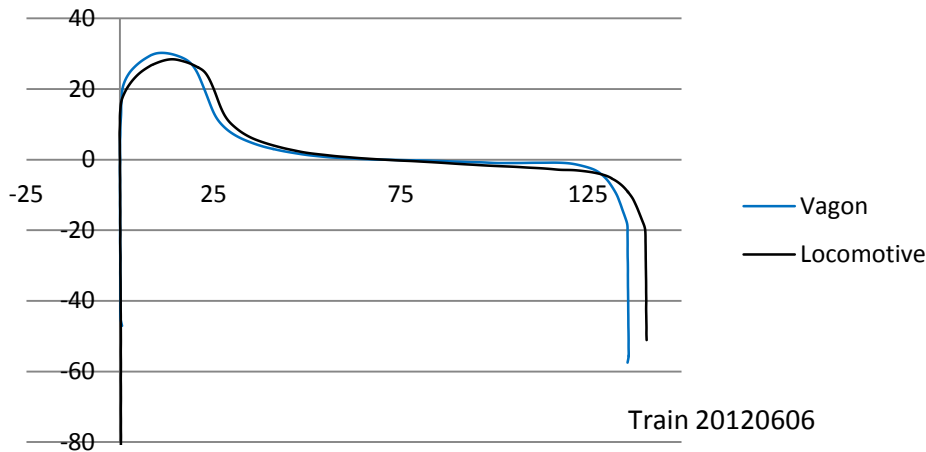
- The installation of the WPMS was carried out in the autumn of 2011, supplier and the IM.
- The Investment Department of Trafikverket was responsible for organising & preparation of the site, and the actual work involved was carried out by contractors.

4 Installation and validation



2 Wheel profile monitoring system

Wheel profiles from wheel measurements equipment



4 Installation and validation

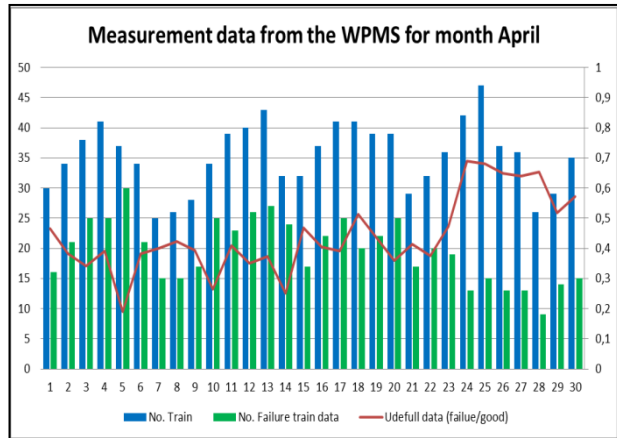
Performance test

The performance test consisted of **two parts**, a test of the *measurement accuracy* of the system and a test of the winter reliability.

The winter performance test was divided into **two blocks**, of which the first concerned the *measurement reliability* and the second the *system reliability*.

4 Installation and validation

Performance test, winter reliability



**Failed sensor
belonging to the
wheel profile
monitoring system
(photo by Dan
Larsson).**

Measurement data from the WPMS for the month of April for the first year.

Problems during the installation and the first winter of operation for the WPMS.

Problem	Component	Reason	Improvement
No connection	Router	Faulty router	New Router
Current turned off	Residual current switch (RCS)	Humidity	Removal of the RCS
Short circuit	Heater	Humidity/cold	Insulating distance
Failed	Axle detector	Ice and snow	Heater

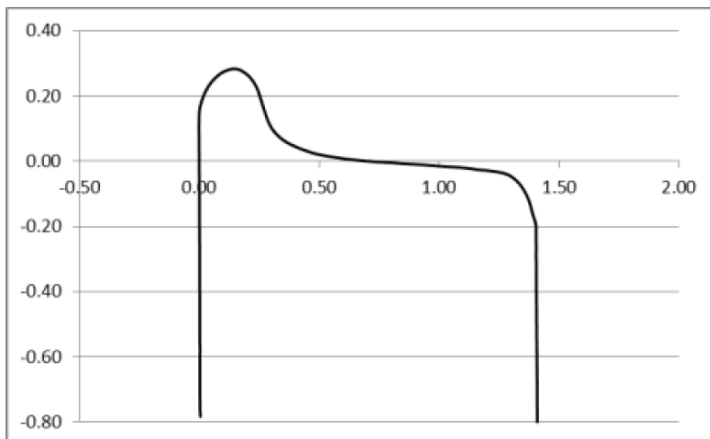
5 Discussion and questions

Outcomes

- Collaboration between IM and rolling stock company give potential to introduce new technologies(share the risk and cost)
- Some running-in problems were reasons for incomplete measurements during the first winter.
- The reliability of the winter performance can be improved

Future work

- How can this equipment be used for extend the live time and minimise the degradation of assets?
- How can this system fit in to already existing monitoring system for IM?
- How can the data be used to the maintenance decisions for the IM?



References

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- [3] B.D. Ollier, Intelligent infrastructure – the business challenge: [Railway Condition Monitoring, 2006. The Institution of Engineering and Technology International Conference on The Centennial Centre, Birmingham, UK, 2006](#), pp. 1-6
- [4] M. Palo, [Condition Monitoring of Railway Vehicles: a Study on Wheel Condition for Heavy Haul Rolling Stock](#), Luleå University of Technology, Luleå, Sweden, 2012
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- [6] D. Barke, W.K. Chiu, Structural health monitoring in the railway industry: a review, Structural Health Monitoring 4 (1) (2005) 81-94
- [7] W. Partington, Wheel impact load monitoring, Proc Instn Civ Engrs Transp 100 (1993) 243–245
- [8] S. Kumar, U. Espling, U. Kumar, A holistic procedure for rail maintenance in Sweden, Proc IMechE Part F: J Rail and Rapid Transit 222 (4) (2008) 331-344
- [9] C. Stenström, Maintenance Performance Measurement of Railway Infrastructure with Focus on the Swedish Network, Luleå University of Technology, Luleå, Sweden, 2012
- [10] U. Juntti, Impact of climate on railway operation - a Swedish case study, in: IHHA 2011, Calgary, Canada, June 19-22, IHHA

Thank you



Condition monitoring of wheel profiles

