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Advanced Rail Weather Information: Weather Monitoring and Prediction for the Rail Sector

Since 1998, Vaisala has been working to introduce a range of rail weather solutions. These solutions have been derived from work in the highways sector where, for over 20 years, operational benefits have been achieved by linking data from road weather stations with localized, site and application specific forecasts.

Until recently, the rail sector largely ignored such enhanced solutions. However, in many ways railways can be more susceptible to the effects of the weather, with it causing significant disruption at all times of the year due to extremes of temperature, wind and precipitation.

The main parts of the rail infrastructure affected include the track and switch points, conductor (power) rails and overhead wires/catenary systems. A range of solutions is now available to help manage the effects of weather on the rail network. Some examples implemented in the United Kingdom are discussed here.

Overhead wire icing and high winds

Ice on the overhead wire causes trains to lose power and in extreme cases leads to the overhead wire / catenary system being brought down. Arcing caused by the presence of ice also leads to excessive wear to the train-mounted pantograph conductors. In addition, high wind gusts can cause dangerous movement of exposed overhead wires, leading to loss of power to the train and de-wirements.

In 1998, Vaisala was approached by Railtrack LNE (now Network Rail) in the United Kingdom to help solve similar

Line	Section	Temp (°C)	Humidity (%)	Wind Speed (m/s)	Wind Dir
4.68	LSNOMW	-1.81	100	1.6	SSW
4.1	Great Wymondley			2.4	WSW
	Hitchin			1.2	WNW
6.7	Everton			4.5	WSW
10.2	LSNOMW	-0.82	100	6.1	SSW
1.3	London Le Grange			7.4	W
3.2	Leeds Park			5.1	SW
8.9	London			6.0	W

Vaisala Rail Weather system user interface.



A Vaisala Overhead Wire Ice Weather Station.

problems which were jeopardizing the reliable operation of the rail network.

The Railtrack LNE wind management strategy was based around text and/or general wide area hazard (Yes/No) type forecasts. However, the effects of wind can be highly localized and influenced by local terrain/topography so making wind gusts difficult to forecast. This often led to train speed restrictions being introduced too frequently, which in turn resulted in unnecessary delays. Alternatively, it was possible for localized wind events to occur which had not been forecast, leading to expensive and disruptive de-wirements.

The solution developed by Vaisala provided the means for train speed restrictions to be introduced only in areas affected by high winds, thus reducing delays and costs, while also minimizing infrastructure damage under high wind conditions.

The Vaisala Wind Alarm system is based around a network of strategically located wind weather stations reporting real-time wind gust alarms to the Vaisala Rail Alarm server in the Network Rail Control Room in York, England. A total of 22 wind weather stations have been in use since 2000, along

the East Coast Main Line (ECML) between London and Scotland. Each wind weather station controls a particular line section, and wind related train speed restrictions are now limited to line sections where high wind gusts have been reported.

Ice monitoring and prediction for the overhead contact wire

Ice events are best managed through the provision of accurate site-specific forecasts detailing the timing of the events. Such warnings then allow users to plan preventative measures, such as applying heating to the wire, or running scraper trains to break-off any ice/frost before the passing of main service trains.

Experience in the highways sector suggested that it would be possible to both measure and forecast ice accretion, which could then help in the forward-planning of maintenance operations.

As part of a project with Network Rail, Vaisala developed and verified the performance of a new non-contact overhead wire sensor which reports overhead wire temperature and state (ice, frost, snow, wet, moist, dry). Vaisala also developed and verified a short range overhead wire ice NowCast model, with data

from the new non-contact sensor being used to initialize the model.

If ice, frost or snow is forecast for the following 3-hour period, a message is passed to the Vaisala Rail Alarm server and an alarm generated. These alarms are used to trigger warning notices which are relayed to maintenance crews and train operators, in addition to scheduling scraper trains as necessary.

More recently, working with Network Rail and some interna-

tional forecasting agencies, it has been demonstrated that the forecast period can be extended and overhead wire forecast models can now give rail operators reliable 24-hour advance warning of overhead wire temperature and state.

The Vaisala Overhead Wire Ice Weather Station comprises: a non-contact overhead wire sensor, an air temperature and relative humidity sensor, wind speed, direction and gust sensors, and a present weather detector. ➤

Solutions to Help Manage the Effects of Weather on the Rail Network

Monitoring of

- High wind gusts
- Heavy snowfall
- Heavy rainfall

Monitoring and prediction of

- Overhead wire icing
- Conductor rail icing
- Hot rails

"...using the Vaisala Rail Weather System has helped us reduce the amount of weather related train delays... so reducing the impact on our passengers"

- Trevor Marshall, Network Rail Weather Strategy Coordinator

Following the success of the non-contact sensor and forecast model development, 5 Overhead Wire Ice Weather Stations were installed alongside the ECML wind system. This Overhead Wire Ice Monitoring and Prediction System has been in operation since 2000.

Precipitation warnings and track-side visual monitoring

Rail networks can be susceptible to heavy rain and snowfall. The Vaisala Rail Weather System can also report precipitation type and amount using the Vaisala Present Weather Detector.

This element of the system can warn users about heavy rain and snowfall events at remote locations. The information provided facilitates the proactive management of areas at risk of wash-outs/landslips, and the targeting or planning of snow clearance operations. Web-based Weather-Cams can also be provided as an "eye on the ground" at remote locations.

Hot rails and conductor rail icing

Weather related problems are also experienced all year round at track level. In 2004, Metronet Rail, responsible for revitalizing two thirds of the London Tube, invested in a Vaisala Rail Temperature System. In January 2005, a Vaisala Conductor Rail Ice System was also installed and commissioned on the same network. With around 70% of the Tube being above ground, managing the network in adverse weather, in particular under extremes of temperature, is a challenge. These two systems are now helping Metronet manage these challenges.

Daytime rail and air temperatures can deviate significantly under clear skies or broken cloud, and this can mean a risk of rail buckling in the summer months.

Historically, manual hourly rail temperature thermome-

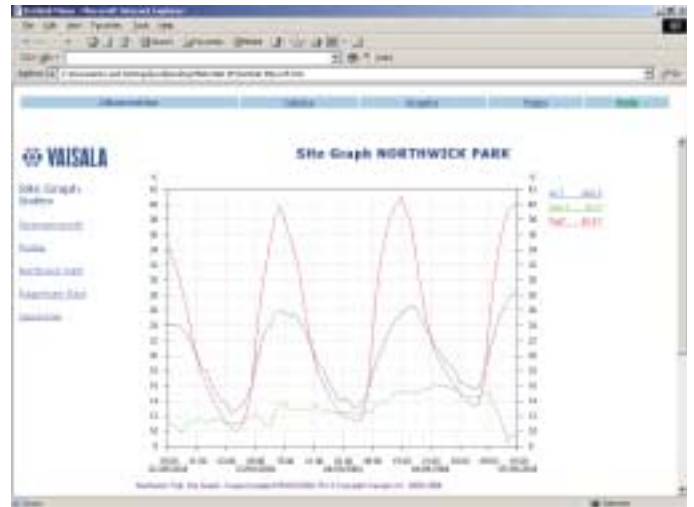
ter checks were made by maintenance staff. Such measurements could be inaccurate and/or inconsistent, as the measurements depended on the operator, or technique adopted. In some cases staff were required to go line-side to take temperature measurements – clearly not an ideal or safe solution.

A Vaisala Rail Temperature System was therefore installed at 10 locations on the District and Metropolitan lines across Central and Greater London. Temperature sensors attached to sections of rail mounted on ballast mounted sleepers next to the line are used to report rail temperature data. Air temperature and relative humidity data are also provided at all locations.

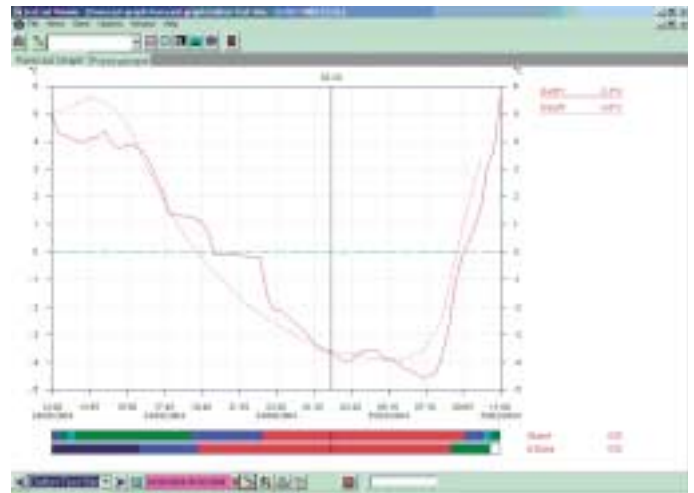
Data are automatically collected every hour all year round by The Vaisala Bureau, and then posted on a dedicated website for Metronet. Along with the normal table and graph views, multiple status maps provide a visual overview of the status of the network, allowing maintenance staff to be mobilized only when required.

With a total of 6 temperature thresholds in summer, maintenance staff can now remotely assess, online, the state of the network and at each threshold act according to their predefined procedures. For example, when rail temperatures are in the 49-53°C range trains are subject to high temperature related speed restrictions. In the winter the system also provides warning when the rail temperatures are less than -7°C to help schedule winter maintenance works.

Ice on the conductor (power) rail can also be a significant problem, causing trains to lose power, leading to service disruption. Some of the hot rail weather stations have been upgraded with the new Vaisala Conductor Rail Ice System. This upgrade uses an innovative technique whereby a sensor embedded within a reference section of conductor rail is used to report



72-hour graph of rail (red), air (blue) and dew point temperature.



24-hour conductor rail forecast and actual data overlay. (Forecast data copyright: PA WeatherCentre)

the temperature and state (ice, frost, snow, wet, moist, dry) of the rail. The network has been classified as having four distinct climatic domains, and one Conductor Rail Ice Weather Station has been located in each of these domains.

Data from the new conductor rail sensor provides a feed into a new 24-hour site-specific forecast model to give Metronet advance warning of the risk of ice on the conductor rail. The site-specific conductor rail forecasts are verified using the Conductor Rail Ice Weather Station data.

The system now provides an additional input into the Metronet decision-making process to introduce sleet (anti-icing) trains and to allow engineering works to run – all aiding the uninterrupted operation of the railway.

In the words of Phil Galligan, Track Delivery Manager for Metronet Rail “...the system provides a better picture of the prospects for the next 24-hours, so if there is a likelihood of ice forming on rails overnight, preemptive action can be taken”. ●

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