

Safety on the line

Graham Smith reviews the evolution of intelligent wireless monitoring solutions and how increasingly smart sensors will help those in the rail and construction sector predict and avert potential dangers

Technology has become integral across rail and construction over the last 20 years. Since the turn of the millennium, the industry has come a very long way and the influence of digital technologies has spanned a wide range of areas. Whether companies are looking to improve their bottom lines, streamline processes or make day-to-day life easier, technology has played a pivotal, facilitating role.

Theoretically, the underlying goal of this digital revolution is to improve our lives. For many, that correlates to profits or convenience, but in the rail, construction and mining industries, technological innovations not only make things quicker and easier, but also greatly enhance safety in an environment where this is often the most critical factor.

Intelligent Monitoring Solutions

Among those spearheading this 'safety first' emphasis by being able to identify early signs of structural and geotechnical failure and fatigue are wireless Intelligent Monitoring Solutions (IMS). These



Examples of Senceive FlatMesh triaxial sensor nodes installed to monitor rail track heave/settlement and track bed cant and twist movement

bring together the key technologies of wireless, smart sensors and the gateway to the outside world to offer enhanced prediction and enable instant/rapid decision-making.

Sensors have traditionally been functionally simple devices that convert physical variables into electrical signals or changes in electrical properties. While this is an essential starting point, smart sensors/intelligent sensing needs to add the following properties to perform as Internet of Things (IoT) components:

- Cost effective, to be economically deployed in large numbers
 - Physically small and unobtrusive in any environment where possible
 - Wireless, for versatility
 - Sensor nodes need to be able to talk continuously to each other
 - Self-identification and self-validation
 - Very low power draw, plus smart algorithms, so can survive for years without a battery change
 - Robust, to minimise or eliminate maintenance
 - Self-diagnostic and self-healing
 - Self-calibrating, or accepts commands without lag
 - Able to provide immediate alerts
 - Data pre-processing, to reduce the load on gateways, PLCs, and cloud resources
- Information from multiple sensors can be combined and correlated to draw conclusions about latent problems; for example, Tilt sensors, In-Place Inclonometers or Piezometers combined with still camera images can be used to detect and validate the onset - or actuality - of landslide failure. Smart sensors are built as IoT components that convert the real-world variable that they're measuring into a digital data stream for transmission to a solar powered gateway.

Incorporating IIoT into smaller, easier to deploy, long-life wireless devices can help to monitor assets in rail and construction by utilising a wide range of structural and geotechnical sensors, as well as wireless cameras. Once deployed, engineers receive smart localised 'Big Data' in near real-time, aiding the prediction of asset failure, and importantly, allowing immediate reaction to potential danger.

Minimising risk

Wireless IMS allows surveyors to be proactive, as well as reactive. These systems provide early prediction and minimise risks in dangerous areas while saving time and money - allowing preventative work to be done in order to limit asset failure. If there is any movement on a track, an embankment, or even in a tunnel, these devices will detect

it - and will signal them in near-real time to reduce potentially vital delays in closing lines or conducting repair works.

Looking to the future, AI or machine learning could soon take large volumes of this kind of data and certain asset failure classes; analyse and potentially aid the prediction, or show earlier trends in failures and potentially remove or minimise the need for any human intervention for critical asset decision-making.

While predictability remains a little way off for some asset classes, and needs all the necessary safety protocols in place, the more enlightened organisations with their data scientists have been working on this for years and it will almost certainly be part of day to day operations in the not too distant future.

Flexible IMS Monitoring

There are many critical success factors that make for instant and effective intelligent sensing. For rapid decision-making to function, it does require particular high-performing wireless platform infrastructures to be in place and will not work with star, LoRa or point-to-point wireless systems.

Barnehurst is a prime example of how IMS can be extremely useful in detecting slippages and risks on earthworks. However, the value of IMS extends beyond geo-technical applications and can be used to detect movement on almost any asset in rail, construction and mining. Overhead line equipment and track bed, as well as bridges and tunnels and buildings, quarries, pits and mines, are other examples of where the technology is proving itself for enhanced safety. Small and robust wireless sensor nodes are now being deployed almost everywhere. They can be connected with multiple sensors and sensor types in remote locations without anyone needing to be worried about the asset - until something happens.

Thankfully, the technology exists that allows us to immediately know what's happening on 'at risk' assets, in remote or busy locations and to accurately measure movement down to a hundredth of a millimetre, with a reporting rate of only a few seconds. With the best platforms, it can afford unprecedented reliability, long battery life, precision and repeatability for a multitude of purposes and environments. This is not the future... it is today.

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Some 200 Senceive triaxial tilt sensors installed on the slope alongside the track, coupled to seven 3G cameras (pictured left) provided early warning of the Barnehurst landslide (right)

ON THE RIGHT TRACK

The proactive approach facilitated by wireless IMS gives engineers the best chance of protecting the public from danger. A prime example was furnished earlier this year following a landslide on Network Rail's Southeastern Bexleyheath line at Barnehurst in Kent.

In the early hours of the morning on Monday February 11th, rail engineers were alerted to the landslide by text and email alerts from sensor nodes and still camera images. They had detected an earthworks failure at around 3:30 a.m., with a tree on the tracks, and the line was swiftly closed. The alerting itself is worthy of note, but it is in the preamble leading up to the failure where the value of IMS shines.

The technology that had been deployed on-site had earlier detected slow and gradual movement. As the movement happened over time, the system also automatically requested further data samples from other nearby nodes to see if the small movements were widespread. It also "told the gateway to stay open" in order to transmit data and minimise any lag to allow immediate decision making.

These smart characteristics combined to provide a picture of the situation at any point in time. With all alerts and alarms from sensors and images being remotely sent to the engineers as trigger points were breached, it provided an early indication of the potential for failure. When it did finally collapse, everyone was ready and engineers could act immediately to close the line. While cancelling early morning trains was an inconvenience to commuters on the day, engineers on-site did a sterling job in preventing potential danger to the public. Following a week of repairs, the line was operating as normal.

While IMS played an important role in providing rapid and enhanced data, the final decision-making still needed human intervention. However, Network Rail and other third-party monitoring engineers had a richer, more complete, and perhaps most importantly, immediate picture of the unfolding situation at any point in time.