Intelligent Monitoring Solutions

Graham Smith, CEO of Senceive looks at utilising wireless technology to enhance rail and construction safety

There is no denying how important technology has become across rail and construction in the last 20 years alone. 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 simply make day-to-day life easier, technology has played a pivotal role in facilitating that.

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 and construction, and indeed mining industries, technological innovations not only make things quicker and easier, but they also greatly enhance safety in an environment where that is often the most critical factor by far.

The themes of The Internet of Things (IoT), Big Data and even more recently, Artificial Intelligence (AI) and Machine Learning, seem to dominate the dialogue around the world of Technology and Innovation. To some in rail and construction, these are certainly not new concepts, but are in fact, simply words to describe the workings and actions of thoughtful scientists and engineers, which to some degree have been in place for years already. In the case of the term IoT, coined around the year 2000, the idea of connecting sensors (things) to the internet or computers, with user friendly visualisation, and being able to analyse data – to enhance decision making – is not something new or novel per se.

Some go further and say that the real tipping point of IoT adoption is when we lose the need to add 'IoT', 'smart' or 'connected' to a product in order to differentiate it. The key is not terminology, but the ability to be able to satisfy ever-

demanding needs of asset owners and users of data. It rather becomes an issue to do with speed, cost, reliability, ease and usability and perhaps within that, most critically, how these come together to be able to make good decisions, both faster and easier with potentially several complex variables to consider in parallel.

In the ultra-safety critical rail and construction environment, that also means not having to put 'boots on the ground' i.e. requiring someone to physically visit a site, and being able to make decisions immediately and most often remotely, to avoid or minimise risk in a potential safety critical situation. Three key enablers of this rapid and improved decision making for rightfully demanding end-users, are improved wireless networking, smart sensors and the interface or gateway to the database/internet.

One key technology theme spearheading this development in safety comes through wireless Intelligent Monitoring Solutions (IMS), which is paramount in enabling instant/rapid decision making and enhancing prediction, to support immediate identification of early signs of structural and geotechnical failure and fatigue. It brings together significant developments in the three key enabling areas of wireless, smart sensors and the gateway to the outside world. Sensors for example, have traditionally been functionally simple devices that convert physical variables into electrical signals or changes in electrical properties.

While this functionality is an essential starting point, smart sensors/intelligent sensing needs to add the following properties to perform as IoT components:

- Cost effective, so they can be economically deployed in large numbers
- Physically small, to 'disappear' unobtrusively into any environment where possible
- Wireless (a wired or powered connection is typically not possible/inappropriate)
- Sensor nodes need to be able talk continuously to each other in a 'mesh'
- Self-identification and self-validation
- Very low power draw plus smart algorithms, so can survive for up to 15 years without a battery change, or manage with energy harvesting
- Robust, likely with no external aerial to minimise or eliminate maintenance
- Self-diagnostic and self-healing
- Self-calibrating, or accepts command commands without lag via wireless or gateway link
- Able to provide immediate or impact triggering of alerts/further data requests across the system
- Data pre-processing, to reduce the load on gateways, PLCs, and cloud resources.

The key is that information from multiple sensors or sensor types can be combined and correlated to infer conclusions about latent problems; for example, Tilt sensors, In Place Inclinometers or Piezometers combined with still camera images can be used to detect and validate from a secondary source, the onset of – or actuality of – landslip failure.

In some cases, two sensor functions are available in one device; in others, the functions are combined in software to create a 'soft' sensor. 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 IoT into smaller, easier to deploy, long-life wireless devices can help to monitor most assets in rail and construction; such as OLE gantries, embankments, rail track and structures – including bridges and tunnels – by utilising a wide range of structural and geotechnical sensors, as well as wireless cameras. Once these devices are deployed, engineers then receive smart localised 'Big Data' in near real-time, aiding the prediction of asset failure, and importantly, allowing immediate reaction to potential danger.

Wireless IMS allows surveyors to be proactive, as well as reactive. These systems can 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 when issues occur.

Technology for safety

Of course, this proactive approach offers a great opportunity to give engineers the best chance at preventing danger to the public when it comes to track and trackside. One particular example of these systems in operation today is from a landslip on the South Eastern Bexleyheath line at Barnehurst in February of this year.

In the early hours of the morning on Monday 11th February, rail engineers were alerted to the landslide by text and email alerts from sensor nodes and still camera images, designed to operate throughout night and day. There were several hundred sensors on-site alongside cameras working simultaneously to identify movement across the 300-metre embankment. They had detected an earthworks failure at around 3:30am, with a tree on the line, and the line was swiftly closed. The alert in itself is worthy of note, but it is in the preamble leading up to the failure where the value of Intelligent Monitoring Solutions and its characteristics shine.

The intelligent wireless monitoring technology that had been deployed on-site had earlier detected slow and gradual movement but only from a limited number of sensor points on the earthworks. These did, at various breach 'alarm level points', and automatically triggering camera images to provide corroboration of significant movement.

However, until the failure, there was little movement of note that was clearly visible to the human eye. To further aid the end user/engineer in a challenging situation, the system also automatically and gradually increased the reporting rate of the nodes without human intervention, down to every minute, as some sensors showed signs of tiny movement. As the gradual movement happened over time, the system also automatically requested further data samples from other wireless nodes in the nearby vicinity, and 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. All these smart characteristics combined to provide a rich picture of the situation at any point in time. With all alerts and alarms from other sensors in the vicinity and images being sent to the engineers remotely as trigger points were breached, it provided 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

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morning trains was a real inconvenience to commuters on that day, rail engineers from Network Rail and the independent monitoring engineer, did a sterling job in preventing potential danger to the public. Following a week of repairs, the line was opened and operating as normal.

It should be noted that whilst the intelligent monitoring system played an important role in providing rapid and enhanced data without human intervention, the final decision making still needed to be taken by human beings. Network Rail and other third-party monitoring engineers, both remotely and on-site staff, however at all times had a richer, more complete and perhaps most importantly, immediate picture of the unfolding situation at any point in time.

Looking to the future, there exists the potential for AI or machine learning to 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. Whilst predictability, remains a little way off for some asset classes – and of course, like driverless cars – 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

It should be noted that there are many critical success factors or enablers in the above to allow instant/fast smart or intelligent sensing to be effective. Indeed, for rapid and immediate decision making to function, it does require particular high performing wireless platform infrastructures to be in place and will for example not work with star, LoRa or point-to-point wireless systems.

Barnehurst is a prime example of how IMS technology can be extremely useful in detecting slippages and risks on earthworks. However, the value of Intelligent Monitoring Solutions extends far beyond geo-technical applications and can be used to detect movement on almost any asset in rail and 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 even today proving integral for enhancing safety. Easy to deploy, highly robust, small wireless sensor nodes are now being deployed almost anywhere. 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 now 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, and with literally decades long battery life with precision and repeatability for a multitude of purposes and environments. This is not the future... it is today.

Graham Smith is the CEO of Senceive, a wireless remote conditioning systems and products provider to the rail, construction and mining sector. It has been supplying the industry, from monitoring companies to contractors for over 15 years. Senceive has multiple platforms to meet the needs of different applications and environments. The company focuses and invests heavily in innovation in products and systems, like IMS, to lead the market globally with technical solutions in helping civil engineers make better, quicker and easier decisions to assets at risk.