Expanding the scope of condition monitoring tools

Swedish company Railway Metrics & Dynamics has developed a low-power monitoring unit initially aimed at addressing rolling stock faults such as wheel flats. Now, as CEO Jan Lindqvist explains, the company is exploring how infrastructure can be monitored more effectively as well.

Condition monitoring technology may not be glamorous, but it has undoubtedly brought huge amounts of hype to the rail sector over the past decade and more, because the potential benefits of fully exploiting the 'Internet of Things' revolution are very significant indeed.

The rail freight community in particular could be a big winner. There have been long-standing aspirations from across the sector for advanced sensors and battery units to address a slew of commercial challenges, from trimming overheads to mitigating safety risks and finally matching the customer service provision offered by road haulage. Yet it is equally fair to argue that for all the hope of the past 15 to 20 years, widespread adoption of IoT has remained stubbornly elusive, and the 'system level' improvement in railway performance which advocates are pushing for has yet to come to fruition.

Reflecting on his two decades in the freight business, Railway Metrics & Dynamics CEO Jan Lindqvist acknowledges that 'back in 2010, batteries were too expensive and lacking in performance', which made it hard to fit monitoring sensors to rolling stock in a commercially viable way. At that time, Lindqvist was leading Rush Rail, a small open access operator in Sweden named after his favourite prog rock band. 'Wheelsets were a constant problem', he recalls. 'Clearly a serious wheel or brake defect can cause derailments and other serious accidents, but even wheelflats cause delays and add huge costs to your operation. We wanted to find technology to help the address the issues.'

The RMD Performance Monitoring Unit mounted on an intermodal wagon.

Specifically, Lindqvist wanted a sensor that could help track the rolling dynamics of wheels and monitor specific vibration wavelengths. This search led him to join entrepreneur Howard McCall, Jack Long and Helmuth Kristen in setting up RMD in Sweden in 2011. The following year it launched its core product, a sensor which the company terms a Performance Monitoring Unit. 'The next two to three years made this kind of technology much cheaper and more effective', he explains. 'The cost of an accelerometer has declined dramatically over the past 15 years.'

Deploying PMU

RMD spent five years honing the PMU sensor, registering patents for the design in 2018 covering France, Germany, the UK, Sweden, Australia and the USA. The same year, the sensor went into series production and has subsequently been deployed by the Swedish business unit of Mercitalia subsidiary TX Logistik.

Key to the sensor's design is a 'fit and forget' approach to deployment. The unit can sit in various positions on a wagon or bogie frame for wheelset monitoring, or be mounted on a pantograph. In each case, strong magnets are used to fix it in place. Each PMU has two accelerometers and one GPS tracker, plus a battery. The battery life is two years, but in practice Lindqvist says that this can equate to up to six years of operation. RMD is now offering optional solar power as well.

Key to the long life of the device is its 'sleep mode', where a bare minimum of vibration data is recorded in the background until an anomaly is detected. PMUs have microcontrollers installed which feature a CPU with integrated working memory and program memory, all mounted on a single silicon chip. At that point, the PMU 'wakes up' to record a wider series of variables. Similarly, data transfer to and from the cloud is carefully managed to ensure that as far as possible, only datasets requiring action or investigation are transmitted. 'The PMU is designed to optimise the power consumption while also making sure that it is in a position to notice anything that could be wrong.'

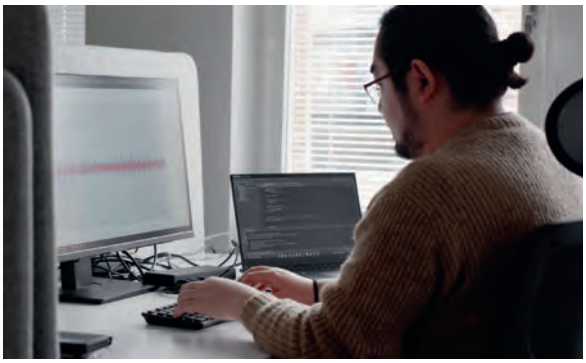
Lindqvist explains that the sensors pick up accelerations in three dimensions with help from a gyroscope. Every vibration pattern is unique, reflecting parameters such as the distance between bogies and the number of wagons in a train. Extensive data collection can thus be undertaken from each individual vehicle, and the acceleration data is correlated using GPS.

Data transfer is undertaken via a 2G to 5G telecoms network, while a wagon-mounted PMU can be equipped with long range radio. In total, Lindqvist estimates that there are currently around 200 PMUs in use supporting live operations.

Towards a platform approach

Since 2016, RMD has been working to develop what the company terms a 'platform', offering a suite of complementary services based around the PMU technology. However, Lindqvist is quick to assert that this development work is ongoing and 'we don't have a whole system yet'. Nevertheless, RMD is targeting a range of potential end users from across the sector, from fleet owners to railway undertakings, Entities in Charge of Maintenance and, in its most recent work, infrastructure managers.

A suite of tools has been developed to augment the capability of the PMU.



These cover pantograph monitoring, a rear view camera, and sensors for wheel condition, weight and kingpin locks — these last two are still in the testing phase, Lindqvist says, and are being developed in response to market demand for better tracking of wagon condition as trains are on the move. A particular focus in Scandinavia is on the stability of intermodal shipments in the wake of the fatal January 2019 accident on the Storebælt fixed link in Denmark, when a passenger train hit a semitrailer dislodged from a passing freight service.

Together, these devices are able to send data to a range of destinations, including RMD's own cloud computers for analysis, to the train driver via an app branded MyTrain, and to a dashboard which can be accessed by an ECM or infrastructure manager. RMD's early deployment of PMUs with TX Logistik has led to the platform being used to automate visual checks on pre-departure train formation and wagon load status, which has reduced the resources required for these activities significantly, Lindqvist reports.

Bridging the skills gap: RMD Chief Executive Jan Lindqvist believes his company has a responsibility to ensure railway domain knowledge is passed down to the next generation of engineers, many of whom have grown up familiar with software-led business processes.

Commercial model

RMD's main revenue stream is the daily fees it levies for the capture and transmission of sensor data, plus an initial installation cost. From its current small installed base largely in the Nordic region, Lindqvist is eyeing a major expansion drive lasting between 18 months and three years that would see PMUs and the related telematics platform rolled out across a number of regions and market segments. To support these growth ambitions, the company floated via an IPO on the Spotlight Stock Market in August last year.

A key driver of growth, Lindqvist says, is likely to be the heavy haul freight market. RMD has already begun early stage trials of using PMUs to provide basic operational data for operators in Mozambique and Botswana. 'Railways in these regions need just the most basic running information that they don't have today', he explains. 'Where is the train? Are there any problems with the wheelsets? If there is a timetable, is the train keeping to it? This kind of thing.' He suggests that better data and analytics could enable heavy haul operators to shave days from a mine-to-port cycle.

Monitoring infrastructure too

The next step for RMD is to assess whether its technology can straddle the divide between the wayside and onboard. In October 2022, the company won an Innovation Procurement tender issued by Trafikverket covering what the infrastructure manager called 'the further development, validation and

RMD is working on sensors designed to enhance the monitoring of freight shipments in transit, including the stability of intermodal containers.

delivery of new information services for automated measurement of the railway infrastructure'; the resulting contract, which runs until June 2024, is worth SKr7·3m.

As part of the ensuing research programme, researchers at the KTH technology institute in Stockholm are to equip a passenger train on the Botniabanan with RMD sensors to augment those already fitted to a fully instrumented bridge on the route. This approach mirrors research being undertaken by MIT in the USA to use mobile phones belonging to car passengers to monitor the structural condition of highway bridges.

'The sensor on the bridge will know when a train is approaching because that train will have a PMU too', Lindqvist says, enabling the interaction between the structure and the train to be captured. This work builds on RMD's existing work using onboard sensors to monitor infrastructure, such the interaction between pantograph and contact wire.

Asked how RMD's proposition differs from other condition monitoring technologies in the market, Lindqvist says that he 'doesn't know of anyone else who can see the whole railway system' including the infrastructure and individual vehicle behaviour from a single measuring device.

Understanding rolling dynamics

Reflecting more broadly on market trends however, Lindqvist feels that the rail sector — at least in Sweden — remains constrained by a gradual loss of corporate knowledge in specific fields. 'There are really only about five people left in Sweden who truly understand wheel-rail dynamics. The knowledge is gone', he suggests, calling the situation 'a scandal'. This 'brain drain' was arguably catalysed by the gradual dismantling of former state railway SJ's research activities as the country's rail sector was liberalised over the past 30 years, but he sees an opportunity now for smaller bespoke players to fill the gap, at least partially.

'The key point about what our company does is that we are not just fitting sensors and harvesting huge amounts of data — we have people around us that truly understand wheel-rail dynamics and can see an anomaly and understand the possible causes. That's railway domain knowledge. We've tried to collect it within our business.'

The problem in the Swedish rail sector, as elsewhere, is that much of this understanding sits with older technicians and academic specialists, who struggle to marry their own knowledge and experience with modern digital and data analytics capabilities. For Lindqvist, companies like RMD have a duty to help transfer this knowledge to a younger generation through the product development process.

To this end, last year RMD opened a Machine Learning Lab in Stockholm to support the further development of its algorithms and software. Looking further ahead, Lindqvist is keen for RMD to explore the adaptation of its platform to make it more well suited for the passenger market, while the company also says that its experiences to date in the rail industry also give it the potential to deploy the IoT platform in other vertical markets in the coming years.

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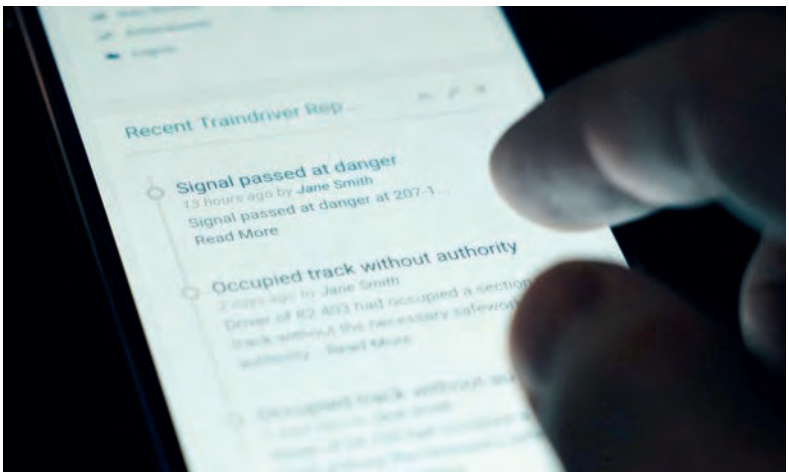
> *Jan Lindqvist, CEO, Railway Metrics & Dynamics*



Below and right: The RMD dashboard is designed to deliver actionable information to operators, infrastructure managers and maintenance companies.