Diagnostics for High Performance Rolling Stock

Remote diagnostics system for improved performance

Although the original objective for using the Trimble® R2M diagnostic system was to improve fleet performance, as the project progressed it has also delivered much wider benefits in areas such as fleet safety, driver performance, timetabling data, infrastructure, and energy analysis.

Solution

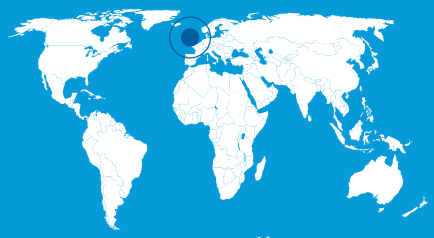
Trimble R2M System

Real-time remote diagnostics

Find out more at rail.trimble.com

overview

The Greater Anglia Rail company has significantly improved the performance, reliability, and customer environment of its intercity trains by developing and fitting the Trimble R2M remote diagnostic system to its Class 90 locomotives and Driving Van Trailers (DVTs).



Location
Norwich to London,
United Kingdom

CHALLENGE

Seeing that remote diagnostics could result in performance improvements this initiative was the first in the UK rail industry where a comprehensive real-time data, transmission, and analysis system was "retrofitted" to a complete fleet of existing trains. Delivering real-time information to the Anglia Integrated Control Centre (Operations Control), and to the rest of the Greater Anglia fleet maintenance and operations team, the implementation has improved performance on mainline services from Norwich to London.

The flagship Norwich to London intercity services were suffering from unsatisfactory performance with the Class 90s and DVTs achieving a moving annual average Miles per Casualty (MPC)[1] rate of around 4000. An action plan was developed and implemented, including many "traditional" modifications and technical improvements. However to take a 20 year old loco without the advantages of modern EMU Train Control and Monitoring Systems (TCMS) to an exceptional level of performance was going to take more than a suite of modifications. It was recognized at this point that it was not simply the MPC rate that was important.

The other significant reason why the aging fleet contributed so many delay minutes (and caused so many Public Performance Measure (PPM)[2] failures) was the fact that recovery of a failed set was so hard and had a disproportionate impact on performance. As a result, it was necessary to reduce both the number of failures and the impact of any failures that did occur. So a project was conceived to provide better fault diagnosis and performance data, by monitoring in real time what was actually happening to the vehicles involved. Where the project differed from other remote condition monitoring projects was that it was really aiming for genuine "real time" measurement, rather than only getting data hours or even weeks later—this is one of the key reasons why Trimble's remote diagnostic system was selected.

SOLUTION

The solution is a number of "train-borne" components that have been designed together to take regular readings from the train. The number and choice of channels was steered by the maintenance depot's knowledge on what needs to be monitored to prevent failures and also, just as importantly, what needs to be monitored to help take the right decision quickly when things do go wrong. The analogy used is that the system is designed to take little bits of data on a very frequent basis, so it is checking on a vehicle's "vital signs" constantly. The initiative therefore used low cost, low bandwidth GPRS to transmit data, to ensure that all information is sent as soon as it can be. The data-taking elements use industry-wide protocols that are widely available to allow for future uses. The integration into the train has been achieved in a simple maintainable way. The system even has its own on-board battery backup to ensure that in the event of a train battery fault it is still transmitting and communicating that fact to the control.

The Trimble system takes the raw data transmitted and processes and translates that data into vital, usable, and relevant pieces of information. To achieve this aim it was crucial to know not just what was happening to a train technically, but also where the train was at any given time and how it might be reached and repaired, i.e. both the fleet/technical issues and the operating circumstances were important. Therefore key interfaces were developed with the fleet allocation and asset management systems, which meant that the Operations Control could see which train service (by headcode and time) had a fault, as well as which vehicle.

The Trimble system also takes information to prompt and put forward recommended actions for fleet or operational staff to implement, to help both identify and rectify a given train fault. By immediately putting forward possible problems and potential repair options, the system saves the time the employee might take to assess the options available and enables a consistency of approach to each problem—regardless of which employees are on duty.

Greater Anglia staff are also presented with a series of recommended actions to recover (while in service) from the fault. Shortly into the project Greater Anglia also launched a very successful energy efficiency program. To support this strategy an energy meter was added to the scope of the project to measure and improve energy consumption for the full intercity fleet.

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The benefits of the system are manifested in a number of ways. The primary benefits are in fleet performance, which was the original catalyst for the project, with the Moving Annual Average (MAA)[3] MPC rising from 10000 to 16000 since Trimble was installed and the delay minutes per period MAA falling from 2500 to 1500. However, the impact of the project has been felt in many other areas, including safety, driver performance, timetable planning, and energy efficiency.

The Trimble R2M system has improved fleet performance in four key ways—through the prevention of faults, better diagnosis of problems, quicker repair and recovery of failed trains and by facilitating continuous improvements.

Preventative (before the train enters service). The data from the system is used to identify failures that will occur if they are not addressed. Indicators can include an adverse trend in an analogue signal or incorrect sequences of digital signals, which may highlight air system problems, brake problems, voltage problems, cab heating, and air conditioning issues or other possible failure modes, which can then be tackled before they cause delays.

Repair and recovery (getting the train home). The data sent back to Operations Control and fleet support and maintenance technicians is invaluable in enabling real-time informed and focused decisions to be taken to minimize the impact of a technical failure. Depending on the nature and location of the problem this information can help prevent any impact on timetabled services or reduce the impact of a problem with a train in-service.

Diagnosis and rectification (identifying and tackling the underlying fault). The system is focused primarily on performance-related issues, rather than safety-related issues. By monitoring many key channels on a Class 90 and DVT the number of possible failure modes assessed is hugely increased. The other advantages are that the data is readily available, easily accessible and is immediately translated into simply understood directions on dealing with different failure modes, helping technicians diagnose a fault first time.

Continuous improvement (using the data to improve future performance). Helping technical teams understand events and the actions needed to change design or process to avoid future failures.

Overall the project has played a major and essential role in the wider improvements in Intercity fleet performance—accounting for around half of the move from 4000 MPC to 16000 MPC and half of the reduction in delay minutes per period from 3500 to 1500. It also offers the potential to support further improvements to this fleet and others.

The system was not originally adopted to act as a safety system, however, it has aided in safety investigations and indeed spotting potential safety problems. Because the system in effect monitors the results of each driver's actions it has now started to be used for driver performance monitoring and the development of driver training programs The train performance team has access to the data and the system logs the time of every point-to-point station time and every dwell time. This feedback now offers extremely useful input into future rules of the plan and timetable revisions.

A set of controlled trials were run using the system and trying different "styles" of driving to see the effect on energy use. The results were significant circa 8%—showing a considerable difference in energy use due to different driving styles and techniques. The most energy-efficient mode was adopted as the standard mode of operation and the data that the system provides allows the energy use on every individual service operated by Class 90s and DVTs. This data is displayed daily on the drivers notice cases. Because the system is not only recording the energy used, but a lot of the key controls or actions made (e.g. braking, traction demand etc.) further work is being undertaken to look at "automating" the monitoring of the driving style.

In addition, each day, feedback is given to the relevant line managers as to which vehicles have had their lights, heating, and air conditioning turned off when trains are stabled overnight. This simple task generates considerable savings in energy use. Providing managers with specific feedback on compliance with the energy-saving policy makes a big difference in turning a potential saving into a real one on a consistent basis.

Another key measure of the impact of this approach can be seen in the energy usage of the intercity sets, where energy used per mile has fallen from 19.68 in 2008/9 to 18.63 in 2009/10.

Although the original objective for using the Trimble diagnostic system was to improve fleet performance, as the project progressed it has also delivered much wider benefits in areas such as fleet safety, driver performance, timetabling data, infrastructure and energy analysis, thereby becoming a cross-departmental project with more benefits for customers and across the business.

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SPECIFIC EXAMPLES OF BENEFITS TO GREATER ANGLIA

The following tables illustrate a few examples of where the Trimble R2M system has added benefit to the business.

Area	Benefit
Safety	Unplanned short distance train movement occurred at Norwich station until driver applied the emergency brake. The system identified the exact conditions under which the incident occurred (On-Train Monitoring Recorder (OTMR) could not have) and as a result a change to operating procedures has been made to prevent the same sequence of events occurring in future.
Safety	Water in Central Door Locking (CDL) panel discovered. Trimble R2M identified that the CDL signal on the vehicle was operating between stations and therefore doors were being unlocked, helping prompt investigation and rectification.
Safety	The system identified a main governor that failed to operate (wrong side) when main res pressure dropped below 4.5bar. It would not have been identified until its next maintenance schedule 5 weeks later.
Safety	Diagnosis of TDMRT coil defect, defect was intermittent and had cleared by the time the train reached the depot, leaving them with the 'nightmare' diagnosis "Loss of Power NFF". Using R2M it narrowed the fault to one proving string and enabled the depot quickly and swiftly identify the defective item preventing a repeat failure.

Area	Benefit
Maintenance Performance	The Trimble R2M system used in Norwich to monitor 90005 post G exam (loco in Crewe) identified a problem with Automat system prior to loco being sent back to Norwich.
Fleet Performance	Early identification of traction motor locking out on 90003. Traction rolling stock inspector arranged to attend in Norwich.
Fleet Performance	Battery charge fault on 82139 arriving in Liverpool St. At the time the driver had no idea how long since fault occurred and therefore did not know if it was OK to return to Norwich which would normally be a cancellation and Thunderbird rescue. Trimble R2M system (working with Trimble P2M system) determined the failure was a short while before and was then used to monitor battery voltage all the way to Norwich. No cancellation and no failures.
Driver Performance	82136 had the brake test switch left in test position on prep in Norwich. Set unaffected until Liverpool St. Then the brakes would not release. Call from driver to control and use of Trimble R2M system enabled identification of BTS switch in wrong position and avoided the need for a rescue vehicle.

Glossary

Reference: Rail Innovation Awards 2010

1 MPC (Miles Per Casualty) is the average distance between train failures causing delays of more than five minutes.
2 PPM (Public Performance Measure) shows the percentage of trains that arrive at their destination on time.
3 MAA (Moving Annual Average) is the level of reliability and punctuality train companies have to achieve across their whole network and is based on a year's performance figures.

RESULTS

Through the adoption of the Trimble R2M system, Greater Anglia has increased the MPC rates for its intercity fleet by almost 60% and reduced delay minutes for these trains by 40%, whilst also delivering wider benefits in areas such as fleet safety, driver performance, timetabling data, infrastructure and energy analysis, thereby becoming a cross-departmental project, with even more benefits for customers and across the business. The Trimble remote diagnostic system is now being adopted as industry standard best practice.

"Trimble and Greater Anglia have worked together as strategic partners to provide a complete train diagnostic system to our fleet. Using Trimble's R2M diagnostic system we are now able to bring real-time fault information into the control room and provide an intelligent decision and planning support system with GPS to ensure effective and rapid fault recovery."

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