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ERTMS systems performance challenges & the case for a combined approach to analytics, diagnostics & troubleshooting

White Paper: ERTMS systems performance challenges & the case for a combined approach to analytics, diagnostics & troubleshooting

The Benefits of Digital Rail

In Europe and around the world, rail organisations are looking to Digital Rail to help them increase capacity, run faster, safer trains more efficiently, and reduce costs.

On 10 May 2018, Mark Carne, Chief Executive of Network Rail, said

> *"Transforming our railway into the digital age offers the chance to deliver huge benefits for our passengers and the freight that this country depends on…*
>
> *New digital signalling offers a cost-effective alternative that supplies significant benefits for rail users: More capacity, speed and reliability…*
>
> *Over half of Britain's analogue signalling systems with lineside traffic lights controlling trains will be replaced within the next 15 years, with the aim to see 70 per cent of journeys benefit from digital railway technology."*

But what do we mean by Digital Rail? For passengers, they may see it as the ability to use mobile devices continuously on-board or the provision of apps to find and book tickets, for example. For anyone responsible for or involved in rail network operational performance, Digital Rail is synonymous with ERTMS (the European Rail Traffic Management System), the systems that underpin train control and traffic management.

The ERTMS Environment & Challenges

This paper looks to examine three key challenges faced by those responsible for ERTMS systems performance and operations and proposes 'what good looks like' to mitigate them.

The ERTMS environment consists of three parts:

- GSM–R for rail telecommunication
- European Train Control System (ETCS) for signalling
- European Train Management Layer (ETML) for passenger and fleet management

Delivering Digital Railway's benefits, such as greater capacity and lower costs, relies on the smooth and continuous operation of GSM-R telecommunications, and the ETCS signalling networks and interlocking systems, that make up ERTMS.

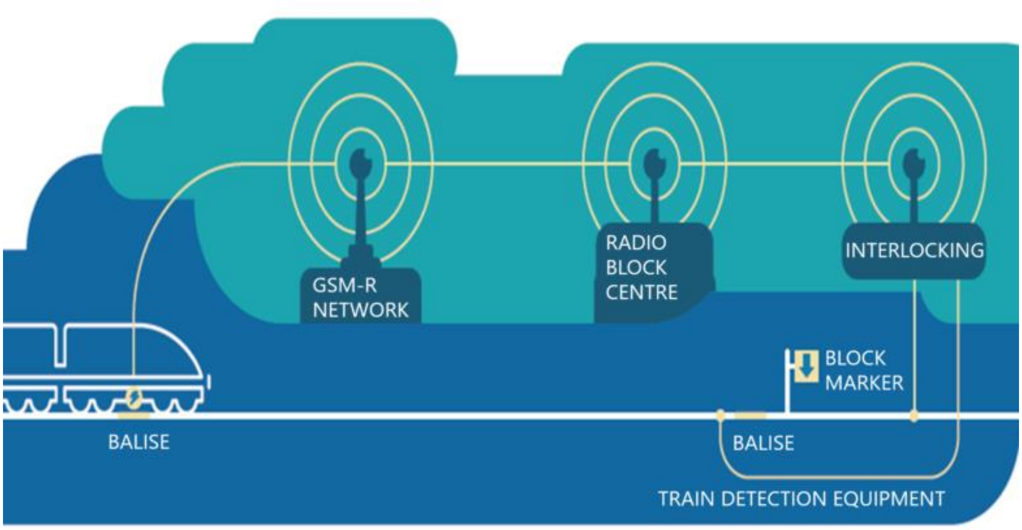
Under full Level 2 ETCS, train movement authorities and other signal aspects are monitored continually by the radio block centre using trackside-derived information and transmitted to the vehicle continuously via GSM-R together with speed information and route data. Apart from a few indicator panels, it is therefore possible to dispense with trackside signalling. However, the train detection and the train integrity supervision still remain in place at the trackside and balises are used as passive positioning beacons or "electronic milestones".

> *When something goes wrong with any of these three systems, the result can be frustrating and expensive for passengers and rail organisations alike. For example, according to the data of a tier 1 railway operator in Europe, every minute late beyond the agreed tolerance level, corresponds to a 6000 € fee.*

These are just a few of the errors that can occur:

- GSM-R coverage, handover, interference, transmission errors, congestion, authentication failures and equipment malfunctions
- ETCS signalling, MSC-RBC communication errors, RBC- EVC protocol stack issues, software bugs in RBC firmware, RBC-RBC interoperability problems,
- Interlocking misreading, mis-alignments, switch issues, track occupation issues
- EVC malfunctioning, wrong identification, drivers' mistakes

With such a diverse range of potential issues, finding the root cause of a problem can be both time consuming and frustrating for signalling and telecoms engineers, and expensive for the train operators or infrastructure providers when it comes to unplanned maintenance and penalty payments. In addition, as a GSM-R network is used considerably less than a typical mobile network, it is impractical to rely on statistical data to measure quality of service.



Challenge 1 - "The ERTMS environment is complex"

The ERTMS environment is highly complex and its constituent parts - the GSM-R telecoms, signalling and interlocking systems - are very different technologies, which are typically managed by different departments within the rail organisation.

However, for Digital Rail to succeed, these systems must work perfectly together 24/7, as well as adhere to stringent ERTMS operability requirements.

The tests required to meet the ERTMS radiopath standards are extensive. Two examples are shown below:

Test	KPI	Referenced Standard
Short repetitive voice calls	• Connection establishment delay • Connection establishment failure	ERTMS–Class 1
Data connection in circuit switch mode	• Maximum break during HO • Network registration delay • Transfer delay • Connection loss rate • Transmission interference	ERTMS–Class 1 SUBSET-093 UIC 0-2475

Whilst much work can be done to use simulations and lab environments for testing, the individuality and complexity of these systems means it is impossible to test everything until it is in the field – especially when National signalling solutions are being used (often referred to as Hybrid Digital).

However, the lab tests can only go so far. For example, the interoperability test described in UIC 0-2475, Subsets -110, -111 and -112 relates to the laboratory testing of the actual Train EVC or Onboard Unit (OBU) against the actual trackside implementation Subset and cannot be exhaustively defined when it comes to make the equipment working in the real environment. Therefore, whilst lab testing is very important, it does not necessarily prevent interoperability issues, such as the deadlock in ETCS protocol that recently happened to one of the major railway European operators.

The impact of errors

When something goes wrong with the GSM-R, signalling or interlocking and the train does not receive its next 'movement authority', it cannot proceed. This can result in frustrating delays, a poor passenger experience and incur penalties - all of which are compounded if more trains further up the line are then also delayed.

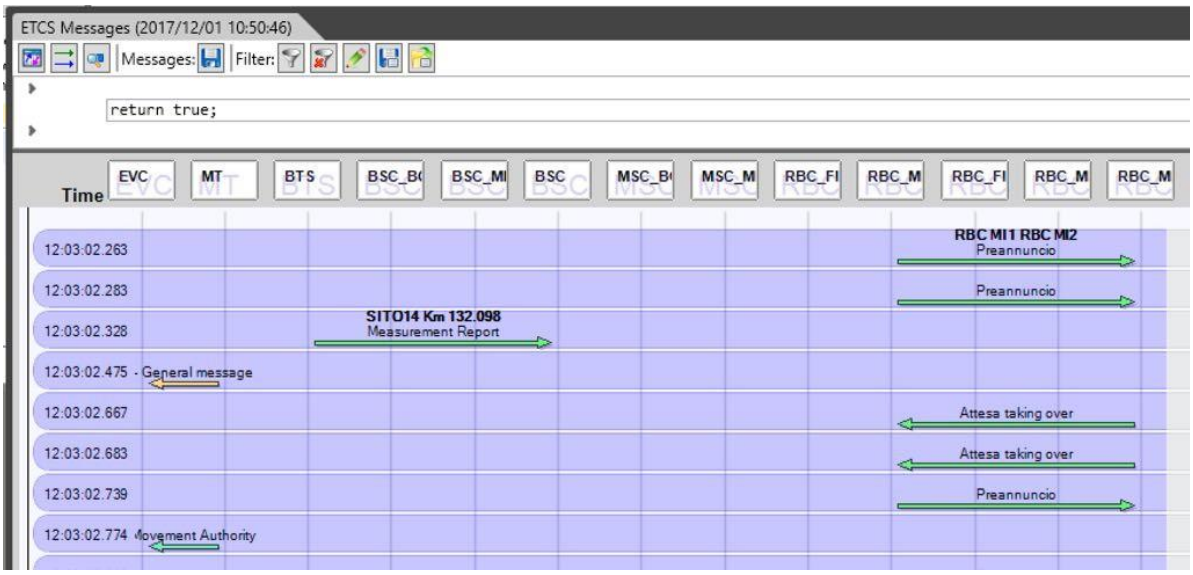
> *"In one case, the entire high-speed line was paralyzed for more than 10 minutes because of a protocol error.*
>
> *A message sent by the OBU (sequence number 129) got lost. This meant that the Radio Block Centre (RBC) did not send back any acknowledgement as it had not received the message. The OBU then neither solicited an acknowledgment nor retransmitted the message. Both the RBC and OBU simply kept the communication alive using standard messages such as the 24-General Message and the 146 – Acknowledgement. It was not crystal clear if the message was sent by the OBU because there was no evidence on the RBC logs and the OBU was not monitored."*

Checking the performance for each of these systems is challenging, as there is so much data from to manage and synchronise, in order to try to identify the issue.

What does good look like?

Such a complex environment requires vast numbers of data packets to be sent between the train and the signalling and interlocking in real-time. In an ideal world, this data would be collected and presented in such a way that it provides a complete picture of each train run.

If all the data from the GSM-R, signalling and interlocking could be collected, synchronised and displayed in a single place, it would provide a significantly simplified view of the train run and diagnostics, without losing any of the detail. As a result, it would provide complete visibility of ERTMS systems performance from start to finish.



Cases like this are hard to identify via laboratory testing and therefore cost money in the form of penalties to the railway operator and time to analyse the issue.

Whatever we do, these types of anomalies may still occur. However, once all the ‘players in the game’ are under analysis and can be monitored, we are no longer ‘flying blind’ when it comes to testing and monitoring the live environment.

Challenge 2 – “Data silos make troubleshooting hard work”

Typically, rail telecoms, signalling and interlocking have their own separate combinations of vendors and monitoring tools – sometimes, even on the same line.

Data that is collected and analysed in silos, makes it hard or almost impossible for anyone to see the full picture – which is both frustrating and costly.

> *“There are over 80 individual sequences required just to start a single train ‘mission’ under ERTMS. If just one is missed or is not transmitted correctly, the train cannot proceed.”*

When a train stops, scanning multiple logs to find what went wrong and where, makes troubleshooting very time consuming, even for the most experienced of engineers. It’s even more challenging when the data is missing or unable to be correlated.

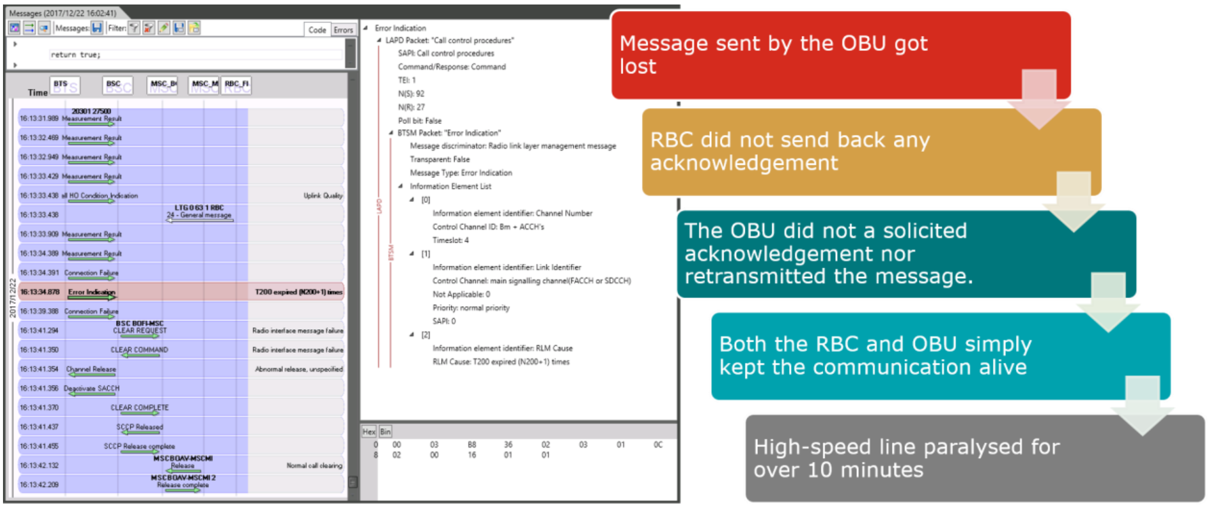
If there are penalties to be paid as a consequence of the delay and it is difficult to pinpoint the cause, it can be even more difficult to refute any potentially unjust charges.

What does good look like?

When a failure occurs, engineers may well have to conduct manual searches of the data logs to try and pinpoint the error. In an ideal world, ‘good’ would see many or most of these manual searches replaced by automated alerts, making it easier to see what went wrong, when and where.

If it were possible to see each sequence of events synchronised as tables, charts and maps, it would be much easier to pinpoint any GSM-R, signalling or interlocking failures much more quickly.

That means the team can dedicate more of their time and expertise to identifying the ‘why’ and fixing the problem.



"Combining all the data in one place enables engineers to find issues in minutes or hours, not days"

Challenge 3 – "Budget constraints and KPIs mean we can't rely on a 'fix on failure' approach"

Unplanned maintenance increases costs and often means frustrating changes to engineering work schedules.

When ERTMS systems are in place and operational across a wide part of the rail network or single line, it is imperative that everything runs smoothly.

Asset management comprises all systems, methods, procedures and tools to optimise costs, performance and risks for the complete rail infrastructure life cycle. The aim is for the stakeholders to jointly to find the best 'value for money'. Finding a balance between the requirements and the overall (lifecycle) cost can be done by applying risk management and consequently linking activities to the companies' objectives.

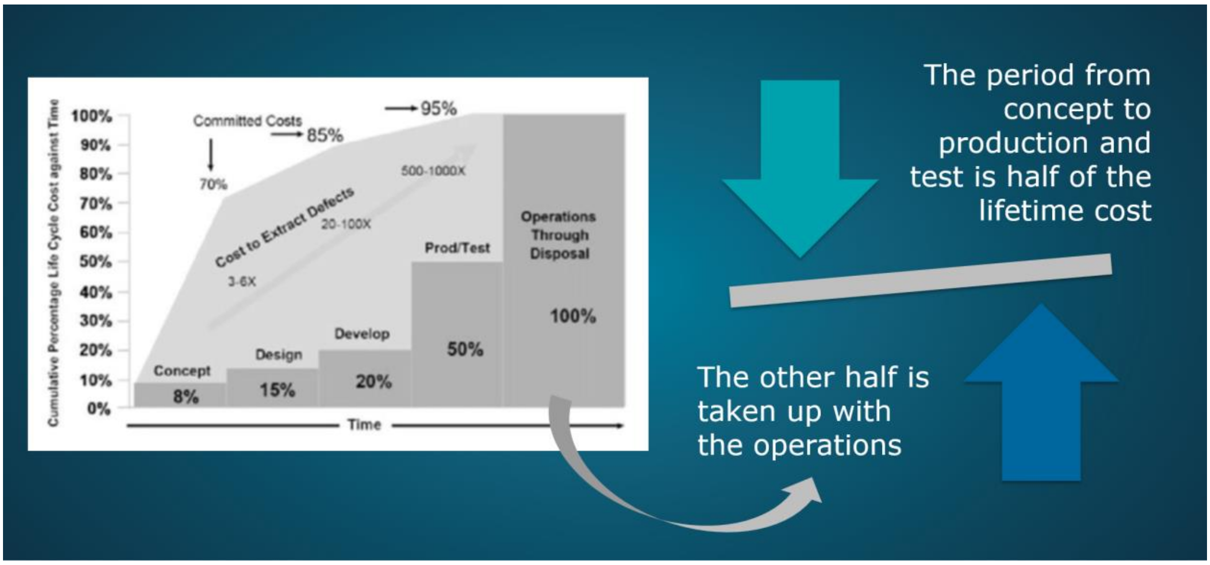
"50% of the spend to maintain the asset is in the operational phase"

If we want to consider the degradation of a single variable and we have enough data stored, we can use trend analysis. That then requires the user's judgment and competence to understand when the degradation of a single issue might jeopardise the systems' end-to-end functionality.

"Spotting trends in degradation normally relies on the user's judgment and competence – and even when mathematical algorithms are used – someone needs to define threshold levels and so on".

If a visual check looks too questionable, mathematical functionalities such as deviation standard, can be put in place to quantify the degradation before that causes a failure (such as GSM-R. signal strength, for example). However, user competence is still needed to define the threshold which triggers the predictive maintenance before the failure.

The third way is pattern recognition using machine learning. This requires a pretty big CPU power and large amount of data, which can make it difficult or impractical. On the other hand, this can be the only approach to find a pattern when more variables are involved or correlated.



Here are five example cases of challenges with asset management.

Case 1 – Interlocking failure

When the interlocking patterns are not properly developed, the train goes into an Emergency Stop. That may happen because of switch failure, ice, faulty sensors, etc. Collecting a consistent amount of data would allow to use the statistics to understand which switches (track points) have more failures and why, we can plan proactive maintenance and prevent unexpected failures.

Case 2 – Balise failure

In an ETCS line, a balise is an electronic beacon or transponder placed between the rails of a railway as part of an automatic train protection. Balises are often set in group of 2-3 units, with two consecutive groups of balises as redundancy measure. When a single balise fails it is not normally a problem because others should be working.

When a balise fails, the ETCS message relays that we have a balise issue but not if it involves a single balise or more than one. If this had been the only balise in the set that was working, its failure now means circulation paralysis. The train cannot trigger or send the position report and cannot reset the odometer error for an emergency stop. Needless to say, this failure would cause big delays to the entire circulation from that line. If we have the right information about which balise is faulty from the OBU data, this would allow us to plan maintenance and set the right level of priority, to not risk blocking the railway line.

Case 3 - Resetting the tachometer

While the train runs, more likely it is to have a measurement error in over-reading or under-reading error in the distance run. Those errors are reset at any balise group, when the train's supposed position is realigned with the real one. When a tachometer is not working well, one of these errors can occur and train's supposed position might fall onto the wrong track circuit. When that happens, the ERTMS system has discordant information. From the interlocking, we see one track circuit occupied but train could be saying that is not 'me'. If that is the case, we still something in the way, so the train must perform an emergency stop and cause delays. Being aware of tachometry over-reading and under-reading errors and proactive monitoring would allow them to be fixed before this kind of issue can occur.

Case 4 - Radio degradation

Nothing lasts forever, including rail telecoms and wayside signalling equipment. When you start seeing a degradation in the radio pattern, you can plan proactive maintenance. For example, you can check radio network coverage in case of BTS failure, so you won't eventually face the block or serious slowdown of train circulation in that area.

Looking things from this point of view might help as well in case of extra system interference issue: such as radio problems caused by a third-party. In this case, KPIs related not only to drop and failed calls but to intra-cell handover and handover failure can tell a lot about a radio issue on a specific area. This means you have the chance to analyse and fix them before that becomes a failure on an operational train.

Case 5 - the Radio Block Centre (RBC)

This 'black box' item of equipment is supplied by the signalling vendor and means that a rail operator can't really test it as each signalling vendor has its own standard. Monitoring RBC performance enables an alert to be sent to the right person before it becomes a serious problem. The same can happen with the OBU and radio installed on the train. As soon as you have data indicating that one piece of equipment fails more than the others, you can analyse it properly and fix it before it fails in the field.

It might appear this approach of Value Engineering is just about changing the timing of fixing and maintenance, but it is much more. Firstly, when you can plan a maintenance activity it costs less than when you have to fix something in emergency situation. Secondly, if you can do this in time to prevent a failure in live circulation, it saves money (remember the 6000 € per minute fee cited earlier).

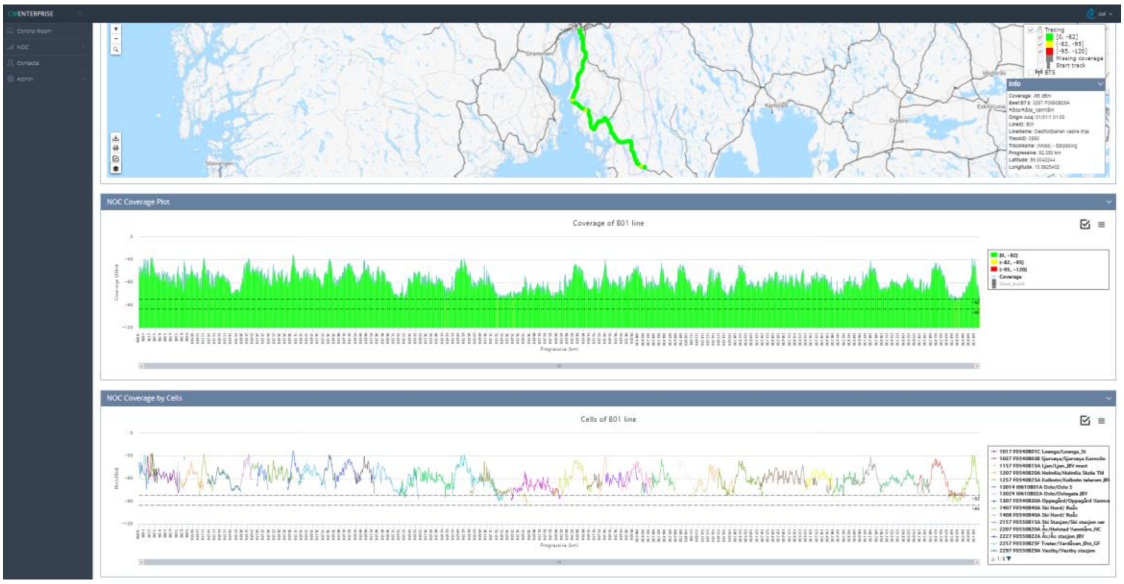
What does good look like?

Using a single analytics platform not only provides greater visibility of real-time systems performance, it would also enable rail telecoms and signalling engineers to build up a comprehensive database of information about their asset performance. This would make it easier to spot degradation trends and faulty equipment, helping them to be better placed to predict and plan maintenance, rather than a costlier 'fix on failure' approach.

> *"A single analytics platform also makes it possible to use the analytics to conduct predictive troubleshooting."*

For example, they could 'switch off' different balises on the analytics platform to simulate failure and then see what happens. This would help them to determine if when a balise fails, whether it needs to be fixed immediately or if the maintenance can be scheduled.

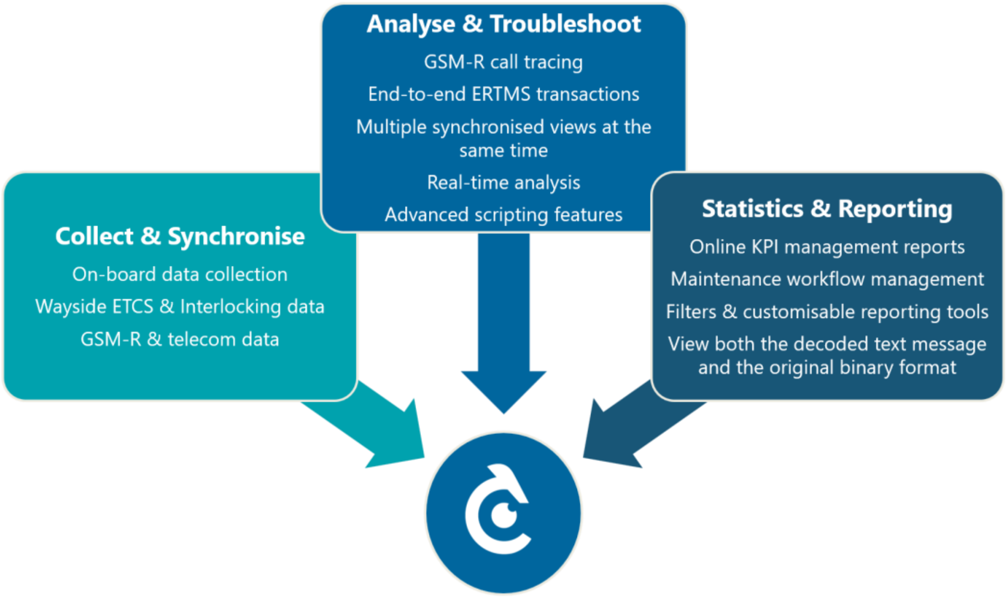
Furthermore, in addition to the continuous on-board monitoring of signalling and communications systems, the ability to monitor other asset components such as track, wheel and brake performance can significantly increase the volume of data being generated on-board, which can impact data storage and impede traditional analysis capabilities.
These provide the potential for systems errors but at the same time, the opportunity for improved knowledge and understanding with regards to asset management, as well as the potential for time and cost savings when it comes to identifying the source of issues and troubleshooting.



A Combined Approach to Analytics & Troubleshooting

NetProbe Analytics from Comest Wireless is a solution that provides complete visibility of GSM-R, signalling & interlocking systems performance on one powerful analytics platform

Data is collected on-board in real-time and combined into a single NetProbe Analytics platform, allowing rail telcoms and signalling engineers to save time & money analysing & troubleshooting ETCS L2 and ERTMS systems performance.



Three benefits it can provide

1. The ability to set up automated alerts and use diagnostic tools reduces the need to rely on manual searches alone
2. All data for each sequence of events is displayed in synchronised tables, charts and maps, so it's much quicker and easier to pinpoint any GSM-R, signalling or interlocking failures.
3. Reports can be customised to enable rail managers and operatives to view relevant KPIs and status updates online at any time.

About Comtest Wireless

Comtest Wireless is an Anglo-Italian company that provides world-class on-board & wayside test and measurement solutions for GSM-R, ERTMS & L2 ETCS systems.

As vendor independent experts, its solutions enable data to be collected and monitored from multiple sources, vendors and types of equipment. This provides a unique, consolidated view across the total network, which saves time & money on conducting telecoms and signalling performance assessments and on failure investigations.

Customers are vendors and operators of GSM-R communication and ERTMS signalling systems. They include rail operators, telecom operators, equipment vendors and government agencies. They also have access to the team at Comtest Wireless, who have extensive and valuable domain expertise and are happy to discuss your requirements, including specifications, installations, data collection, software and reporting customisation and training and support.

If you further information on Signalling, GSM-R or ERTMS test and monitoring solutions, please email contact@comtestwireless.eu, or visit www.comtestwireless.eu.