The Internet of Trains

Analysing sensor data helps Siemens keep operators on track by reducing train failures

CASE STUDY / TRANSPORTATION

"We are heading towards next-generation maintenance", says Gerhard Kress, Director of Mobility Data Services at Siemens. "It is a whole new business model. Instead of selling our customers a train, we sell them its performance over a certain period of time." And with guarantee periods of up to 20 years, this business model is as attractive to Siemens' customers as it is risky for the company itself.

From reactive to predictive maintenance

Train operators the world over are expected to work miracles, i.e. never to be late. So, with acute service and availability targets to meet, an efficient maintenance program is important. And data-enabled functionality is a must for Siemens.

Reactive maintenance (after an incident) and routine, preventive maintenance with its visual inspections and scheduled exchange of components, are no longer enough. We've moved on to more cost-effective, condition-based, predictive maintenance.

The actual condition of components is measured via the transfer and remote monitoring of diagnostic sensor data; data which is also used to analyse patterns and trends. This helps predict when a component is likely to fail, so it can be repaired before anything untoward happens.

To ensure the commercial sustainability of this approach, Siemens needs to use and re-use existing data, creating a kind of 'Internet of Trains'. Towards this end, they're analysing sensor data in near real time, which means they can react very quickly, ensuring that customer transport services aren't interrupted. "It is really difficult to define every issue before it impacts operations using only data from the trains", Kress explains. However, recent success stories prove that everything is possible.

Predicting failures in time

For instance, Spanish train operator RENFE uses Siemens' high-speed train, Velaro E, key components of which are continually monitored by Siemens. A train developing abnormal patterns is dispatched for an inspection service to prevent failure on the track. Which helps keep RENFE services incredibly reliable – only one of 2,300 journeys has been noticeably delayed (by 5 minutes – passengers are reimbursed fully, if a delay is over 15 minutes). And it allows the train to compete with flights on routes between Madrid – Barcelona, and others.

And in the UK, Siemens conducted a pilot project with a large European train operator on one of its regional routes.

The project analysed a relatively small data set of one million sensor-log readings, taken in five-minute intervals over the course of a year. Analysts measured variables such as component temperature and pressure from 300 different sensors. This data was overlaid with many thousands of corresponding reports of failures and fixes. Then the team combined data sources, defined the most relevant engine problems, and divided the data into appropriate sections.

They used the Teradata Aster Discovery Platform's exceptional range of analytic tools to evaluate the combined data from different perspectives. It highlighted variables that helped to predict engine problems and identify failed elements that triggered the malfunction of other components. Siemens then applied the Aster nPath function to categorise the different sensors attributing normal, high, and low values, then tracking changes. These changes revealed which sensor pattern was likely to result in engine failure. For example, on a number of occasions Siemens found that when the engine temperature dropped from mid to low then rose to mid value again, an engine failed three days later.

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During the validation process, comparing results from the test data to the total data set showed a high degree of accuracy, proving that sensor-data analysis makes it possible not only to predict engine failures, but to react in time to prevent them.

Predictive modelling improves both top and bottom line:

- Increased up-time through significant reduction of un-planned downtime.
- Extension/flexibility of maintenance intervals because we understand the risk.
- Reduced labour costs: quicker root-cause analysis, improved first-time-fix rate, etc.
- More mileage / fewer cars, improved utilisation of assets.
- Enhanced plan-ability, with streamlined SCM.
- Maintenance can be performed at the least-costly location.
- Provide Up-time guarantees, performance-based contracting.
- Increased service contract capture rate; recurring revenues - higher percentage of total service revenue.
- Service as key differentiator.

Service as key differentiator

"It is all about increasing up-time and avoiding unplanned downtime. If we predict incidents early enough we, and our customers, can react accordingly", explains Kress. "Our customers get more mileage from fewer trains. Predictive maintenance enables them to use their assets better while, at the same time, reducing costs. Additionally, data analytics can speed up root-cause analyses, reducing labour time."

Siemens expect predictive maintenance to evolve into next-generation maintenance, and a whole new business model. "We are able to provide completely new services with up-time guarantees, risk-sharing models, and performance-based contracts for mobility systems", says Kress. He's convinced that the Internet of Things will revolutionise the railway industry. And alongside automation, excellent service will be a key differentiator, with customers buying the operation of the vehicle rather than the vehicle itself. For example:

- **Rhein Ruhr Express:** Delivered an almost 100-strong regional train fleet, plus 32 years of full maintenance at a fixed price, with performance penalties.
- **Thameslink:** Performance-based maintenance contract requiring nearly-run-time analysis of diagnosis and process data.
- **Metro Riad:** availability targets (40 seconds arrival-departure per train) can only be reached with data-enabled services.
- **ICx:** high-performance KPIs form part of the delivery contract.

Focus on digitalisation

Siemens AG has head offices in Munich and Berlin, Germany, and an annual revenue of 75 billion Euros (93 billion US Dollars). The digitalisation of products and services plays a major part in the work of all nine divisions of the engineering giant.

> "Digitalisation is one of our focus areas. We realise that a digital twin to our physical goods is extremely important to give better value to our customers."
>
> – Gerhard Kress, Director of Mobility Data Services at Siemens.

The company produces a variety of trains and infrastructure components such as automation and power systems, railway signaling, and control systems. The mobility division offers solutions for urban / inter-urban mobility and logistics (local and long-distance railway traffic is another key business sector).

On the data front, Siemens Corporate Technology deploy their own version of the Teradata Unified Data Architecture (UDA) including a Data Warehouse, an Aster Discovery Platform, and an appliance for Hadoop. Consequently, depending on the analytical project, Siemens are able to combine and analyse different types of data on whichever is the most suitable platform.

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