Keeping railway operations on track with predictive analytics

Nokia Water Events Prediction for railways

Application note
Abstract

Across the world, railways continue to be integral to local and global economies by transporting goods and people efficiently and safely. Maintaining efficient operations and ensuring safety for railway assets, the environment, and above all, human life are paramount concerns for all railway management professionals. Railway management systems employ new technologies that provide real-time monitoring, but seeing the present is not enough. Railway management needs to see into the future to be able to predict risks before they happen.

This application note summarizes how the Nokia Water Events Prediction application uses its advanced analytics capabilities to create actionable information that helps avert potentially catastrophic railway failures due to water-related events.
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Challenges for railways

Worldwide, railways continue to be integral to local and global economies by transporting goods and people efficiently and safely. Maintaining efficient operations and ensuring safety for railway assets, the environment, and above all, human life are paramount concerns for all railway management professionals.

Water events risk

Railway lines are inherently vulnerable to water events risk. Tracks traverse varied topography with diverse climates and pass through highly populated areas as well as completely remote wilderness.

This has always meant that railway line engineering has focused on mitigating risk because of unique geographic challenges. Railway systems must ensure sustainable network operations, protect infrastructure, optimize route strategies and control assets, all to keep people and goods moving—safely.

The nature of railway lines everywhere means they are exposed to ground hazards where hydrologic erosion (washouts) or high water over the track are primary contributors to derailment. Railway lines are often laid where the gradient requires passing through geomorphologically active ground. Water events affecting railways occur in many ways, such as stream or river courses exceeding their banks, overland flash flooding, ponding, and subsidence and mudflows that are triggered both seasonally and by weather-related events.

Understanding the historic, hydrologic and real-time conditions is essential to rail maintenance and operations. Too often, a washout causes the rail bed to erode due to surface flow water or seepage. A washout can take out the entire railroad right-of-way, leaving twisted tracks hanging precariously undetected until it is too late. Because railways often carry hazardous materials, washout derailments can also trigger fire damage or toxic spills, further risking the loss of life, damage to the environment, litigation and asset loss.

Extreme weather

Ever-increasing extreme weather is exacerbating water event risks, and railway operators are needing to cope with water events occurring in locations where they have not been observed historically. Precipitation is becoming understood as one of the most dominant weather events to cause harmful impact to transportation systems\(^1\). Considering railway infrastructure features, water events can be particularly dangerous. Hydrologic erosion can create landslides, erode river banks, destroy bridges, overload culverts and other supporting structures, or entirely collapse ballast, subgrade and subsoil rail infrastructure layers.

More frequent and intense hurricanes and typhoons and related precipitation and storm surges, record-breaking snow packs followed by spring flooding continue to cause rail washouts and consequent train derailments. These water event failures are happening at alarmingly frequent rates that seem to be increasing alongside extreme weather changes.

Legacy risk management strategies

Historically, risk management strategies have been built on a reactive approach where responses to risk are determined while the risk is present. The inherent methodology of reactive risk management for railway water events can be considered a hindsight tactic with potentially catastrophic results.

\(^1\) Tomorrow’s Railway and Climate Change Adaptation: Final Report, Page 93. RRSB (Rail Safety and Standards Board), June 2016.
Proactive risk management may involve time-intensive trends analysis but cannot handle the real-time information and immense data sets that are growing exponentially.

Innovative applications and advanced analytics capabilities are required to transform railway operations and the passenger experience with a primary benefit being safety. Operational efficiency can also be boosted through better insights into how railway assets are performing, for example by monitoring the track environment for early detection and rectification of issues before they lead to failure and disruption.

Nokia Water Events Prediction solution

Nokia develops advanced analytics applications for asset-intensive industries that focus on operations in context, in motion, in real time with rolling future predictions: collecting and correlating data, predicting asset condition and operation, optimizing and automating networks of people and assets, and visualizing everything in real time. Our applications are developed on an advanced, end-to-end platform. Our machine-learning engine produces cutting-edge analytics that provides high-quality solutions and rapid time-to-value for our customers. This approach to solving business issues gives railway managers the tools to deliver goods and passengers safely and on time.

Nokia Water Events Prediction is a predictive analytics solution that provides actionable data for railway maintenance and risk management/mitigation professionals to determine rail washout failures before they happen and prioritize advance action to be taken.

Water Events Prediction uses advanced predictive analytics to combine past and real-time data and transform it into actionable information on likely future outcomes. An advanced map interface with pre-configured business views filters key attributes without needing to execute queries or create custom reports.

Use cases include using email or SMS alerts that are triggered when the predictive analytics uncover potential rail washout situations. Third-party systems can also be used to distribute alerts if integration with customer workflows is needed.

Advanced analytics

The Nokia Water Events Prediction predictive analytics creates and transforms data sets with an advanced high-powered hydrologic model that models how the water will flow across the land surface. Water event probabilities are determined through advanced analytics modeling, taking into account the detailed characteristics of rail assets that can be impacted. Filtering criteria based on business rules are configured to identify which statistical risks will trigger alerts.

On a continually updating basis, real-time weather data is loaded, and analytics are recalculated. Alerts exceeding defined thresholds (e.g., geography, time interval, or type) are pushed to the user interface and email/SMS (or another system). Alerts are received by operational staff who research conditions to analyze the best course of action to mitigate risk to assets, environment and life for the predicted impact area and assets. An operational decision is determined and resulting action is taken, averting or minimizing the impact of the water event.
Figure 1 shows the analytics data flow.

Figure 1. Nokia Water Events Prediction analytics data flow

Data visualization

Built using the SI Suite platform, Nokia Water Events Prediction is deployed using a scalable server that integrates streaming and operational data while managing analysis and delivering data to its applications (see Figure 2).

Figure 2. SI Suite platform
The Water Events Prediction user interface is presented in a web browser so typical functions are already familiar (e.g., zoom, scroll, multiple open windows). A map window provides extensive custom setting options, including map base type, multi-level favorites and region (see Figure 3).

**Figure 3. Nokia Water Events Prediction user interface**

Pre-configured Business Views (shown at left of Figure 3) are a main access point to data analytics features with check-box selection to display rail properties such as mileposts or watersheds, plus links to dashboards and reports.

Embedded assistance is available through online help, tool tips, and hover text.

The Admin Console provides access to key administrative functions such as setting or changing data sources, configuring security, configuring and managing alerts, and enabling users (see Figure 4). In addition, the Admin Console proactively sends email alerts to personnel.
The System Monitor provides statistics, monitoring, logging and reporting on data, users and system functions (see Figure 5).

Figure 5. Nokia Water Events Prediction System Monitor
Solution benefits

Using predictive analytics, Nokia Water Events Prediction:

- Facilitates better operational awareness to reduce water impacts
- Provides advance prediction of water events locations that allows time for mitigation actions
- Improves passenger/crew safety
- Maintains efficient operations
- Improves profitability.

Conclusion

The Nokia Water Events Prediction application is an advanced, predictive analytics solution targeted at railway washout risk mitigation. The powerful hydrological analytics engine uses geomorphological, meteorological and historical data to predict vulnerabilities in the system. Featuring a flexible alert system with business rules for when, who and how to notify stakeholders if risk is imminent, and a mature intelligence platform, Nokia Water Events Prediction reduces railway risk from water events—improving safety, service and profitability.

For more information about Nokia Software IoT applications, visit nokia.ly/IoTapplications

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