Norfolk Southern Railway and TIBCO

FRED EHLERS

Mr. Ehlers (holding Trailblazer award, with TIBCO CEO Murray Rode) joined Norfolk Southern in 1985 as a management trainee. Formerly vice president of Network and Service Management, now vice president of Information Technology, his experience also includes railroad operations. He is a frequent speaker on IT and industry concerns and a member of the Board of Directors of Railinc Corporation, an IT service provider. He is a graduate of Harvard Business School's Advanced Management Program and holds a Bachelor's degree in Materials and Logistics Management from Michigan State University's Eli Broad Graduate School of Management and an MBA from Queens University of Charlotte.

ROBERT MILLER

Mr. Miller joined Norfolk Southern (NS) in 1998 and in has been the Manager of Enterprise Architecture since 2002. He has 41 years of experience in IT, with 25 years of experience developing software for large enterprise applications. In 2012, he assumed the management of a TIBCO competency center for NS where he manages the application development and systems engineering of the company's ESB and CEP platform. Education: Indiana University Fort Wayne, Indiana University Bloomington.

Norfolk Southern is one of 10 North American Class 1 railroads, which have revenues of $250 million or greater. Its traditional business was transport of bulk commodities, raw materials, and heavy finished goods. Pivoting to capitalize on significant growth in consumer goods shipped via containers (intermodal), the company would also face strong competition from trucking as well as highly service-sensitive customers. Two company leaders describe the technology journey to digital business to enable lower costs, excellent customer service, real-time visibility, forthcoming benefits from the railroad IoT and predictive analytics, and a 2016 TIBCO Trailblazer award.

TECHNOLOGY INITIATIVES

Ehlers begins, "As the backdrop to our digital drivers, it's really important to understand that Norfolk Southern, any railroad, is very asset-intensive. We have a lot of expensive assets that we have to manage, monitor, and carefully steward for efficiency. The other thing is that our business is going through tremendous change, and with that change, that growth, comes demand from our customers to know where their product is and that it's going to get to its destination on time.

"These are the drivers that are helping us define our technology strategy:

- Markets are increasingly service sensitive and time critical. We no longer measure delivery in days, but in hours and minutes.
- Customer supply chains require a highly accurate, constant stream of data. Customers want constant updates on arrival times and any information on plan deviations.
- While this is great business, it is also generally lower margin, so we need a strategy that efficiently provides a high level of service.

"This isn't revolutionary, but the pace has shifted our priorities.

"Predating TIBCO, we had a spider web of data flows between our legacy applications. While we tried to keep it as organized as possible, it was not an ideal situation. When we disseminated information outside of our production systems, we used our data warehouse, which was never real time and rarely provided the user with the best possible information.

"Three years ago we embarked on a journey to build a 'transportation event processor' (or TEP) on TIBCO technology, which centralizes operational events from legacy silo applications. We also built asset state models to create a coherent, highly accurate real-time view of the railroad focused on important assets and resources. Everything we build sits on this foundation. And now we are building next-generation operations applications."

The Norfolk Southern team consisted of six TIBCO BusinessWorks™ developers, three TIBCO BusinessEvents® developers, and three infrastructure support staff. The ambitious project is about to pay off with revolutionary applications as described in this case study.

NORFOLK SOUTHERN ASSETS

- 20,000 route miles in 22 states and the District of Columbia
- 2,600 trains and 170,000 railcars in daily operation
- 4,200 locomotives
- 10 major classification yards
- 350 small to medium yards
- 42 intermodal terminals
- 28 automotive terminals

TOOLS AND TECHNOLOGIES

- Apache® Cassandra® big data sources
- API gateway technology
- Database technology
- IBM WebSphere MQ messaging middleware
- Jenkins integration technology
- Master data distribution services (Master Data Management technology to come)
- TIBCO ActiveMatrix BusinessWorks™ integration platform/enterprise service bus
- TIBCO ActiveSpaces® in-memory data grid
- TIBCO BusinessEvents® streaming analytics
- TIBCO Enterprise Message Service™ messaging middleware
- TIBCO Spotfire® data analytics

GOALS

Says Mr. Miller, "Our technology objectives in support of the business were to modernize our key systems. We wanted a common view of the core data around the assets: railcars, locomotives, crews, and the locations where work is done. We needed to bring the data together and create a single version of the truth for those applications. We also wanted to create a platform that made that data easy to access. The plan was to build a near real-time current state of transportation information data service that would:

- Provide automated business monitoring and issue notifications
- Enable root-case analysis and collaboration
- Enable automated or managed resolution
- Improve data quality (accuracy and timeliness) for operational and master data
- Create a central event model to understand, manage, and optimize operations, which was the fundamental technology requirement

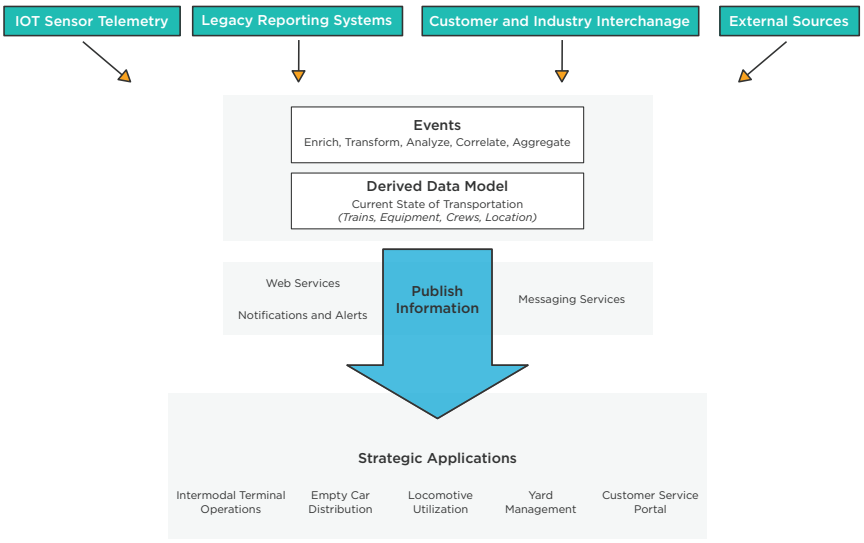
CAPABILITIES

"To promote a single version of the truth across applications, data would be controlled by business rules," continues Miller. "We would capture business telemetry from across the enterprise and provide value-added services that would clean, transform, aggregate, correlate, and publish. We needed to utilize streaming analytics to maintain asset data on states and location and to generate alerts, alarms, and triggers. And we needed to provide information to applications in near real time and transform data to the format needed by each application."

INTEGRATION PLATFORM

Miller explains, "TIBCO technology is used to implement three patterns of application integration:

- Data consistency, ensuring that independent applications get the facts in a consistent manner and from a single authoritative source
- Multistep processes, enabling independent applications to exchange event data and implement processes
- Composite applications, supporting software assembly of business functions that have heterogeneous component parts



DATA TYPES AND FORMATS

CICS, COBOL, FTP, HTTP, Java, REST, SOAP, XML

APPLICATION/DATA INTEGRATION

- AccessNS customer service portal
- Customer and industry interchange data
- Empty car distribution
- Intermodal terminal operations
- IoT telemetry data from wayside scanners, automotive and railcar GPS tracking
- Legacy reporting systems (train arrival/departure times, train consist, signaling systems, route details, ETAs)
- Locomotive data (GPS, operational, mechanical health)
- Operating locations (customers, crews, stations, trackside, yards)
- National Weather Service
- State of Transportation application
- Truckers' mobile communications app
- Yard management

"Capturing data about transportation events across the network is accomplished through an enterprise shared services integration approach," says Miller. "Data published by locomotives, wayside sensors, line of business applications, customer and industry data interchanges, and external sources are captured by the integration gateway deployed on the TIBCO BusinessWorks platform. Once captured, the events are transformed from their original application format to a canonical data format that abstracts the data from the specific application that produced it and represents a more generic business entity: trains, railcars, locomotives, crew members. These events are published as TIBCO Enterprise Message Service topics."

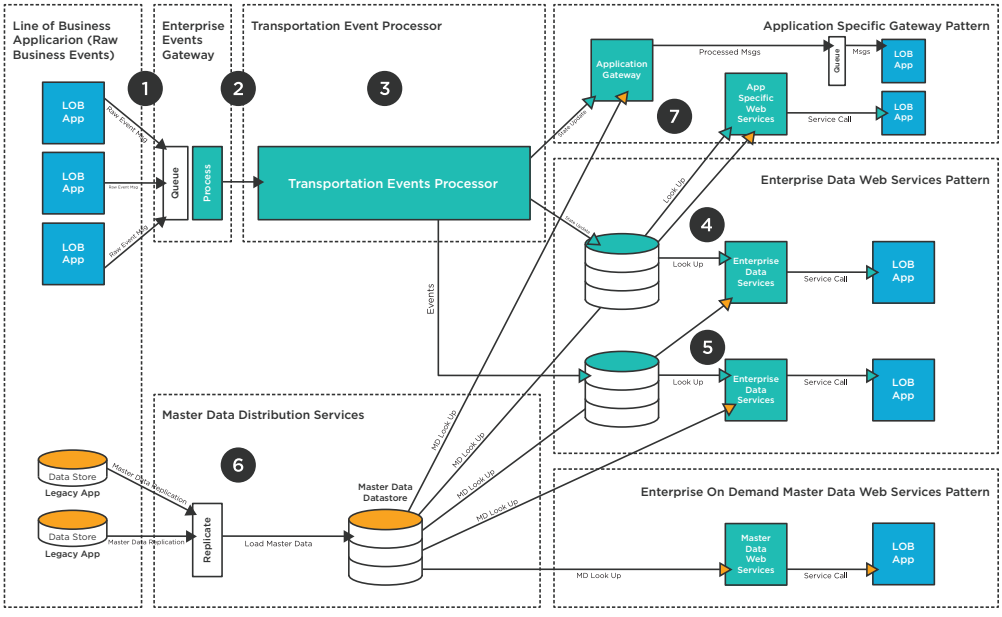
Ehlers says, "Locomotives have become mobile computing platforms and we pull in a wealth of data—from GPS location, to on-board operational information, to mechanical health," says Ehlers. "Our trackside devices are becoming part of the Internet of Things, and we pull in not only information on their state, but the state of the trains rolling by them.

"We pull information from legacy applications indicating train arrival and departures from yards and stations, train consist (rail vehicles making up a train), and precise information from our signaling systems on train location, route detail, and estimated time of arrivals. We pull information from our customer and industry clearing house on traffic coming in and leaving our yards, and the state of our railcars and locomotives as they move on other railroads. We also pull information from external sources like the National Weather Service."

STREAMING ANALYTICS

"The State of Transportation application is implemented on TIBCO BusinessEvents and TIBCO BusinessWorks platforms," explains Miller. "It subscribes to events and maintains a state model for each railcar, locomotive, crew, and train. Operating locations are also maintained for asset tracking. As state and location transitions occur, they are published as updated events that are subscribed to by strategic applications and maintained as a single source of enterprise data across all business domains."

Transportation Event Processor



Logical components of the Norfolk Southern platform. Each step of the integration process is described below.

1. Inputs into the integration platform come from line of business (LOB) applications and an ever increasing number of IoT devices and computing platforms, including on-board locomotive systems, wayside controllers, wayside sensors, data radios, and GPS equipped devices.
2. The inputs come in the form of messages published by these applications that have the proprietary format and transport mechanism native to the publishing application (for example, COBOL). All messages are transformed to a canonical format based on XML and placed on the TIBCO message bus. The canonical format transforms the messages into events about the assets critical to various business functions. For example, a message about a train arrival at a rail yard is transformed into individual events for every locomotive and railcar on that train. The publishing application's platform, programming language, and transport mechanism have been abstracted away and subsequently can be changed, enhanced, or replaced without any disruption to the consumers of this information.
3. The TEP application is a combination of functional components deployed on the TIBCO BusinessEvents and TIBCO BusinessWorks platforms. Based on the events captured, a core set of assets are tracked. The current state of trains, railcars, locomotives, and work locations are all maintained by TIBCO BusinessEvents.
4. As assets are discovered, or as state changes for any asset, the results are recorded in the State of Transportation data store, a combination of relational database tables and TIBCO ActiveSpaces in-memory data grid. A set of enterprise data services are available for informing application consumers of the current state of all active assets.
5. The events are also stored in an event history data store providing short-term history needs for applications. Enterprise data services are available for LOB application consumption.
6. Master data plays a key role in the ability to enhance event data with details about assets and locations. The TEP application maintains an authoritative set of master data for this purpose and also distributes the data to other LOB applications through a set of data services.
7. Some LOB applications have specific requirements that are not covered by the enterprise services. To accommodate those requirements, application specific gateways are implemented on the TIBCO platform. Messaging and on-demand data services follow the same design patterns as the enterprise versions, but allow for application customization.

OUTCOMES

INTERMODAL TERMINAL OPERATIONS

"Increasing the efficiency of Norfolk Southern's 42 intermodal terminals lets us both reduce contractor costs and increase capacity," explains Ehlers. "The function of an intermodal terminal is basic. We unload inbound trailers and containers from trains, trucks, or ships and load them on the next mode of transportation, the outgoing trains or trucks that take the freight to the final destination.

"Though the function is basic in concept, it is complex in execution. There are many moving parts with inbound and outbound trucks and trains carrying hundreds of containers. Every day it is a different permutation of the 'puzzle.'

"Using TIBCO as our data foundation, we are making intermodal terminals more efficient by providing increased data accuracy and visibility, using a mobile application for real-time communications with truckers, optimizing models feeding the electronic work order system for hostlers (yard engineers) and cranes, and improving planning algorithms for train loading/unloading and yard operations."

EMPTY CAR DISTRIBUTION

"Hauling finished automobiles is good business for Norfolk Southern," says Ehlers. "Unless you live close to the manufacturing facility or inbound port, there is a good chance your automobile was transported by rail.

"In North America, there are 65,000 specialized railcars for hauling finished automobiles and trucks, and at an acquisition cost of $100,000 a piece, they are a very expensive $6.5 billion asset. And they are just an example of a couple dozen different car types. This is why it is so important that we optimize their movement. For the most part they move loads one way—from plant and port to destination, and the empties move in the opposite direction—so triangulation opportunities are very important.

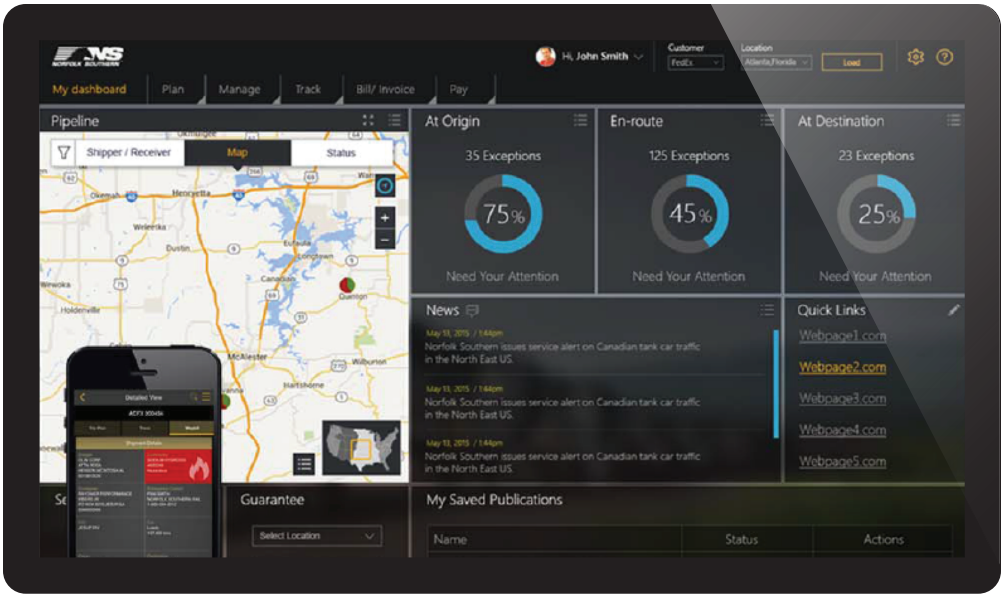
"Like our intermodal terminals, automotive terminals are basic in concept, but complex in operation. Inbound automobiles are delivered daily from plant or ship to a terminal for sorting and dispatch to the various destinations and then unloaded and moved the 'last mile' to the final destination.

"Again, we use TIBCO as the data foundation to support this application, providing detailed location information to optimize the loading and dispatching of cars. It's helping increase asset turns and fully utilize capacity so we can avoid railcar rental fees and defer capital expenditures. We have a detailed tracking model for all railcars and projections for supply and demand. We are optimizing assignments of railcars to customers so we get the right car at the right time. And we are managing customer loading and unloading times to make the best use of scarce assets."

Railcars state and location.

CUSTOMER PORTAL

"We are also overhauling our customer portal, AccessNS, to keep pace with the business environment," continues Ehlers. "This project directly leverages our success with TIBCO. It consolidates multiple streams of data into coherent, real-time information that allows customers to track shipments and receive alerts when a schedule deviates from plan. The information is real time, very detailed, and highly accurate. The portal is tightly integrated with the customer system through APIs."



Norfolk Southern's AccessNS customer portal.

NORFOLK SOUTHERN'S INTERNET OF THINGS

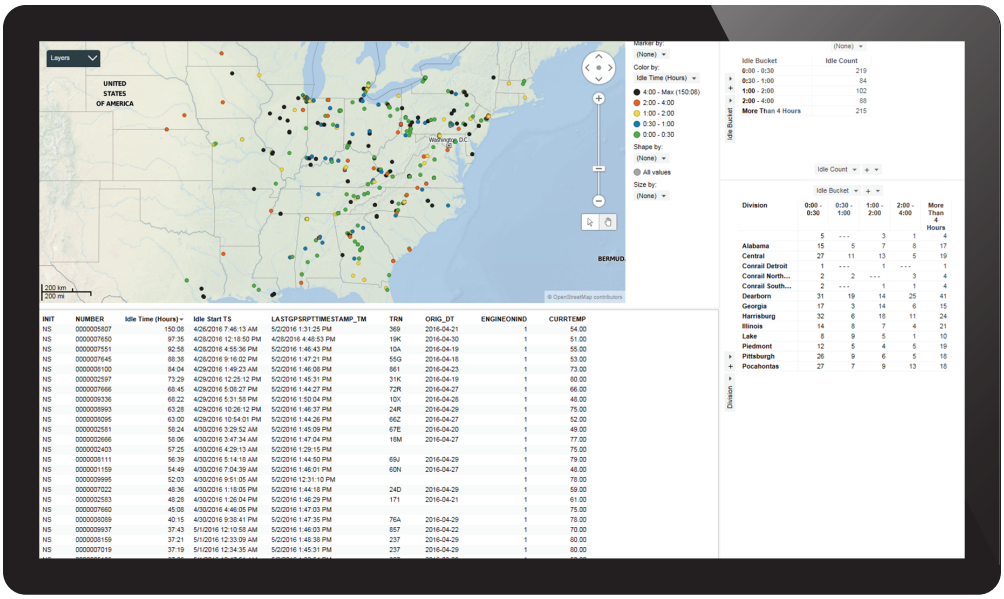
"Leveraging TIBCO and our own Internet of Things, we will expand our state models to signal systems, switches, and trackside defect detectors," says Ehlers. "Not only can we enhance the efficiency and reliability of the railroad, we can also use the information from these devices to monitor their health.

"Bad wheel bearings on freight cars are a great example of what we can detect and trend to alert the crew before we have a catastrophic bearing failure. Besides the obvious safety issues, a failure on a busy section of track can cause significant network issues."

REAL-TIME ANALYTICS

"We are already building visualizations, but we intend to take this further," says Ehlers. "While we have always had robust historic analytics, using TIBCO Spotfire® we can now leverage real-time analytics and better monitor and take action on train delays and service failures as they happen. Obviously, the best service disruption is the one you avoid.

"We can monitor assets like locomotives that are idling and haven't moved in 30 minutes, bring external weather data into the analysis, and change the business rules for locomotive idling."

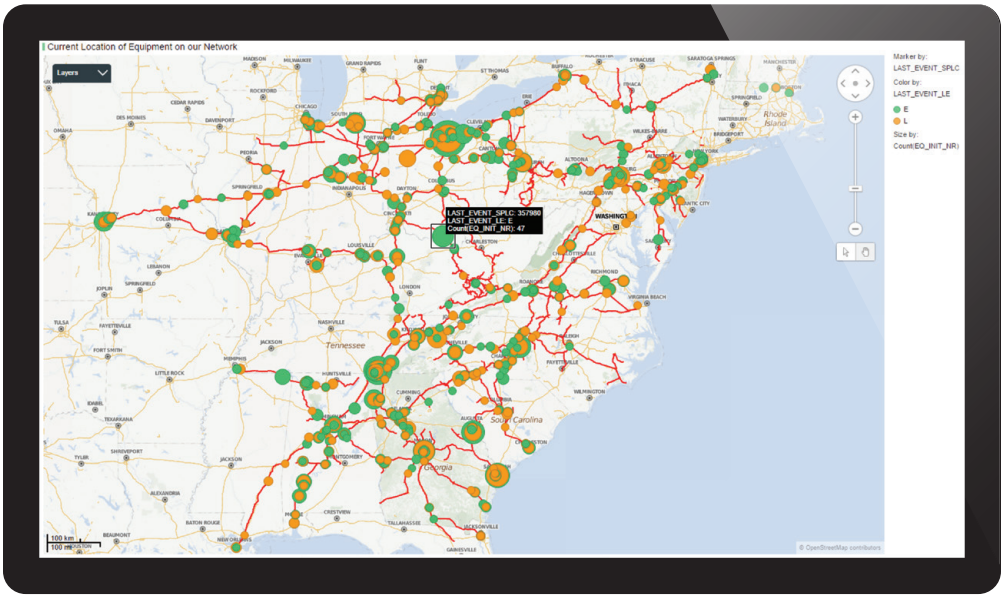


Idling locomotives via Spotfire®.

IMPROVED OPERATIONAL FORECASTING

"Taking network management one step further, we can leverage the TIBCO platform for forecasting future demand against capacity to support better allocation of resources. Yard operations are a great example.

"Think of those 170,000 railcars that we have online at any given time. Using TIBCO to manage all the detailed trip plans for those cars, and then formulating the data on a location or yard basis, we can project into the future where every car will be in 12, 24, 36, 48 hours, and we can set up alerts when and where we will encounter over capacity and under capacity situations. Then we can reroute traffic or move resources to better handle fluctuations."



Railcars' state and location.

TECHNOLOGY ACHIEVEMENTS

AGILITY

- ~25% reduction in time to market

APPLICATION INTEGRATION

- 100% new applications integrated using TIBCO BusinessWorks
- 17 line of business application feeds captured
- 20+ services built for the Transportation Event Processer (TEP)
- 10 master data domains under distribution management
- Master data in use for:
  - Distributing empty railcars
  - Running rail yards
  - Feeding customer portal
  - Supporting preventive maintenance

EVENTS CAPTURED AND GENERATED

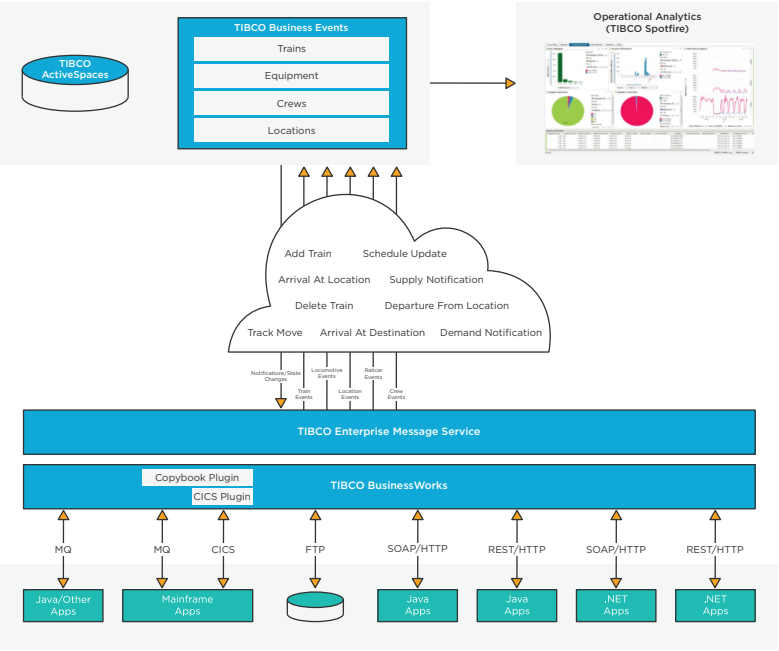
- 3.2M events captured/day from LOB applications
- 60M events generated, including streaming analytics, loading of events into databases for queries, and enhancements published to other LOB applications, including
  - Railcar shipments
  - Railcar health
  - Railcar availability
  - Locomotive utilization
  - Train location

DATA QUALITY IMPROVEMENTS

- Customer
- Equipment
- Location

TECHNOLOGY ACHIEVEMENTS

"Because we have a reusable set of data and services, we can very cost effectively accelerate application delivery. We can eliminate the spider web of messaging between systems and the associated overhead, as well as centralize business rules in one system and avoid duplicating logic in every system that uses enterprise data. We estimate that when fully deployed, we will reduce application development time by 30–40%."



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