Norfolk Southern Railway

Analytics for Better Safety

Overview

Northfolk Southern must adopt a comprehensive approach to reduce the number of incidents in their railway operations.

Motivation

1. It is essential to ensure the **safety** of the **employees and customers** who use Norfolk Southern's services
2. Reduce **financial losses** and **damage to the company's reputation** resulting from incidents
3. **Comply** with regulatory requirements and **avoid penalties**
4. Create a **positive image** for the company, highlighting its commitment to safety and innovation in railway operations

Data Maturity Stage

Stage 3 - Analytical Aspirations

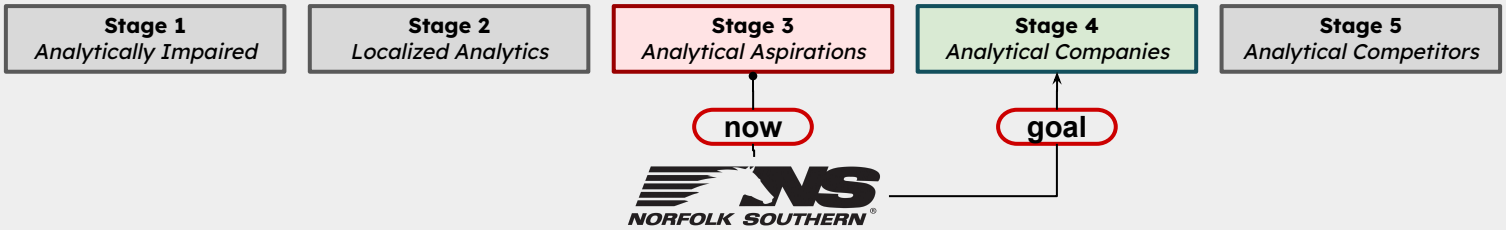
Business analytics journey:

- Early 1990s with departmental reporting
- Evolved into data warehousing and analytical applications
- Resulted in the use of analytics to support business decisions

They have been building centralized data repositories and enterprise-wide data approach for periodic maintenance. However, **the number of sensors and data collected from them are not enough to provide earlier warnings of potential safety issues**.

Despite the continuous efforts to build an analytical organization, Norfolk Southern still **needs to improve on real-time analytics and robust analytical capabilities for better safety and become competitive**.

Data Maturity Stage



DELTA model of analytical capabilities	Stage 1: Analytically impaired	Stage 2: Localized analytics	Stage 3: Analytical aspiration	Stage 4: Analytical companies	Stage 5: Analytical competitors
Data	Inconsistent, poor quality, and unstandardized data	Data useable, but in functional or process silos	Organization beginning to create a centralized data repository	Integrated, accurate, common data in central repositories data still mainly an IT matter	The relentless search for new data and metrics
Enterprise	No enterprise perspective on data or analytics: poorly integrated systems	Islands of data, technology, and expertise	Early stages of an enterprise-wide approach	Key data, technology, and analysts managed from an ernterprise perspective	Key analytical resources focused on enterprise priorities
Leadership	Little awareness or no interests in analytics	Local leaders emerge but have little connection	Leaders beginning to recognize the importance of analytics	Senior leaders develop analytical plans and build analytical capabilities	Strong leaders behave analytically and show passion for analytical competition
Targets	No targeting of opportunities	Disconnected targets that may not be strategically important	Analytical efforts coalescing behind a small set of targets	Analytics centered on a few key business domains with the ambitious outcome	Analytics integral to the company's distinctive capability and strategy
Analysts	Few skills are attached to specific functions	Unconnected pockets of analysts: an unmanaged mix of skills	The influx of analysts in key target areas	Highly capable analysts explicitly recruited, developed, and managed	World-class professional analysts and attention to analytical enthusiasts
Technology	Desktop technology, standard office packages, poorly integrated systems	Individual analytical initiatives, statistical packages, descriptive analytics	Enterprise analytical and predictive plan, tools, and platforms	Enterprise analytic plan and processes, cloud-based big data	Sophisticated, enterprise-wide big data and analytics architecture
Analytical techniques	Mostly ad hoc, simple math, extrapolation trending	Basic statistics, segmentation, database querying, key metrics are leveraged to gain insights	Simple predictive analytics, classification, and clustering; dynamic forecast	Advanced predictive methods deployed to discover insights	Neural networks and deep learning, genetic algorithms, advanced machine learning

DATA

Pre-Innovation

IOT SENSOR COLLECTION POINTS:

Train

- Speed
- Engine heat
- Battery Failures
- Fuel consumption
- High stress & wear
- Cooling water leaks

Track

- Cracks
- Flooding
- Switches
- Vibration
- Rail joints
- Landslides
- Crossing clearance
- High stress & wear

Post-Innovation

REAL-TIME DATA

Train

- Geospatial data
- Train protection system
- Engineering specifications

Track

- Engineering specifications
- More data sensors to collect data at more frequent length intervals
- Real-time & multi-day forecasts integrated from NOAA or similar sites

ANALYSIS

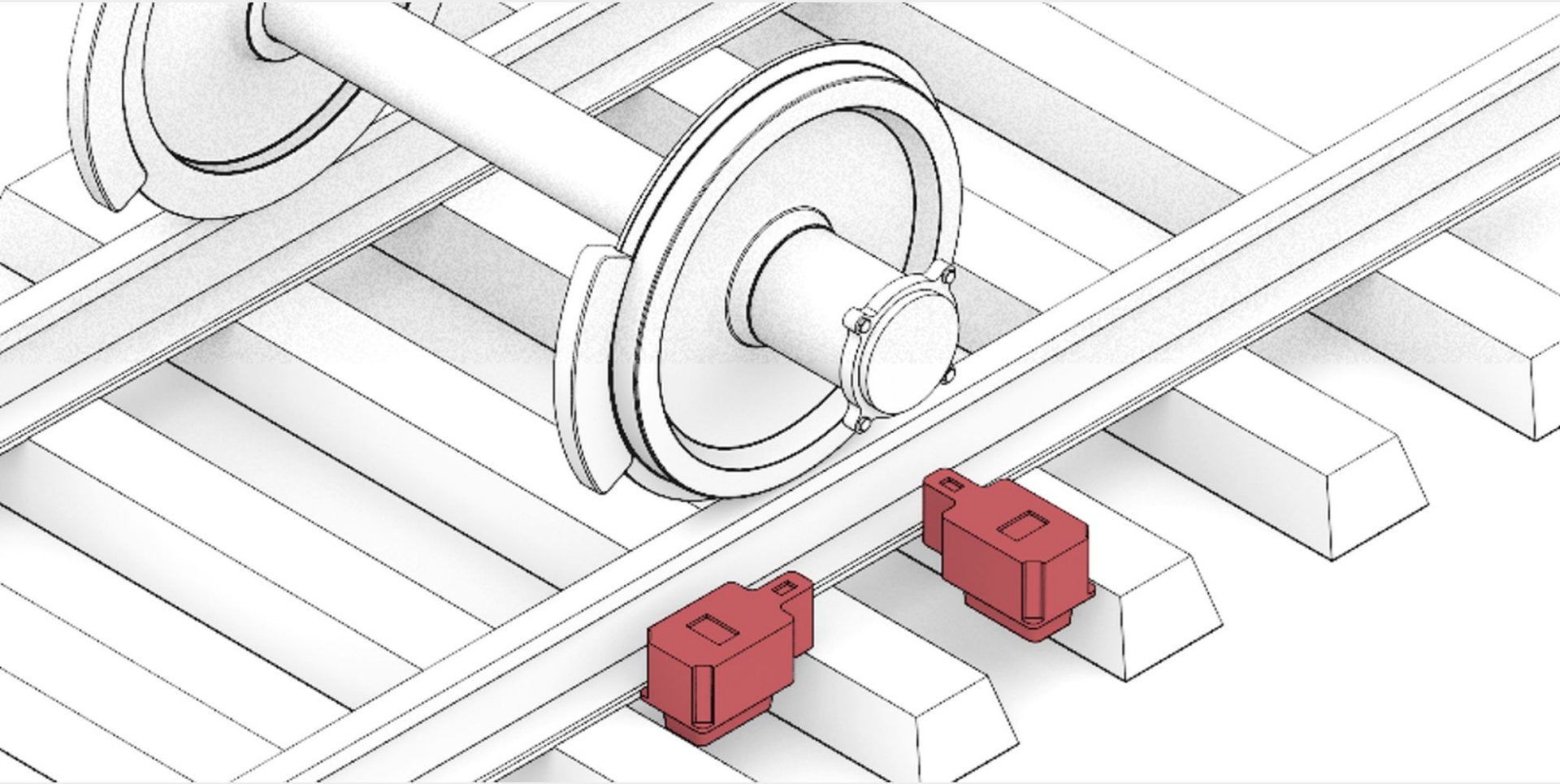
Pre-Innovation

- Digital Twins
- Not real-time data
- Create models of data gathered over time to predict trends in areas that require most maintenance
- ML updates these models with the constant data feeds coming in from IoT sensors

Post-Innovation

REAL-TIME DATA

- **Real -time digital twin**
- **AI**
- **Deep learning**
  - Triggers based on system thresholds
  - Model knows total distance traveled & locomotive life expectancy
  - Contains heat & weight thresholds based on total distance traveled
    - Analyzes data with the safe expected life



QUESTION

Pre-Innovation

Profit-Centric

Cost optimization: How can we?

- Increase operational efficiency and reduce costs?
- Optimize our supply chain to reduce costs and increase efficiency?

Revenue optimization:

- Increase revenue from our existing customer base without incurring significant costs?
- Find the most profitable routes we operate, and further maximize their profitability?

Post-Innovation

Community-Centric

Safety and quality optimization: How can we?

- Reduce incidents in our operations?
- Leverage technology and analytics to monitor and improve safety and quality, and identify areas for optimization?
- Invest in infrastructure and equipment upgrades to improve safety, and balance the need for cost-effectiveness and ROI?
- Improve safety protocols and training programs to reduce the number of incidents, while maintaining operational efficiency?
- Ensure compliance with regulatory requirements and proactively address emerging safety and quality issues?

CULTURE

Pre-Innovation

- For over 40 years, NS has prioritized safety, but **management decisions have not consistently reflected this vision**.
- Despite NS' post-pandemic recovery, the workforce decline (reduced by half over the last 10 years, with layoffs in 2021) resulted in **higher workload, employee fatigue, and more human errors** contributing to 60% of the accidents in 2022.
- The increased derailments and concerns for management's punishment also caused **dissatisfaction among employees and lower work morale.**

Post-Innovation

- Management has to **lead by example**
- **Reinforce the safety culture and rebuild morale**. Ensure that safety is a top priority through trainings, encouraging employee involvement, and communications.
- Drive **data-driven decision making at all levels** and functions to increase efficiency without increasing the workforce size.
- Create employee **psychological safety** to encourage raising safety concerns without the fear of punishment.

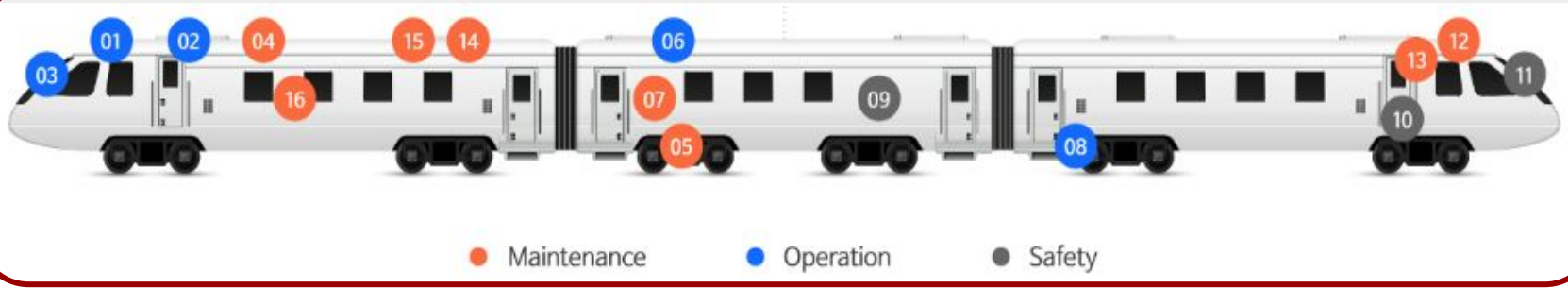
NORFOLK SOUTHERN

Predictive Maintenance Implementation Roadmap (1-Year Plan)

		1 Month	1 Month	3 Months	4 Months	2 Months	1 Month
		Planning	*Data Preparation*	*Project Design*	*Execution*	*Testing*	*Go Live*
Project Manager	- Communicate task status - Create data gov strategy - Maintain project plan	R	C	C	I	I	I
Machine Learning Engineer Lead	- Data quality assessment - Data mapping process - ML design assessment	A	C	A	C	A	R
Machine Learning Architects	- Architecture and methodology - Data quality assessment - Configuration management	I	S	R	S	A	S
Machine Learning Analysts	- Infrastructure support - Data quality assessment - Data execution & testing	I	C	I	R	R	A
Database Administrator	- Initial sizing for staging DB - Life cycle mgmt planning - Schema changes planning	I	R	I	S	I	S

Responsible | **Accountable** | **Consulted** | **Informed** | **Support**

Look & Feel: Data & Visualization



Reference: Busan Urban Railway

01 Temperature and humidity sensor	07 Toilets monitoring	12 Train protection system
02 Low battery detection	08 Water tank level sensorl	13 Pantograph shock sensor
03 Windscreen washer fluid level detection	09 Noise & Air Quality Sensor	14 Air conditioner filter sensor
04 Battery full monitoring	10 Door open/close status monitoring	15 Air conditioning system
05 View monitoring	11 Hatch open detection sensor	16 Electrical transformer monitoring