Using Operational Data for the Future
Maintenance of the French Rail Infrastructure

Presented by
Stéphane de Paris, Thomas Oriol
Agenda

• SNCF Réseau
• The stakes for Maintenance
• Why the PI System for SNCF Réseau ?
• Use Cases
SNCF Réseau : key figures (1/2)

Characteristics of the French Railway Network*

* The second largest after Germany

Trains travel over

30,000 km of railway lines, including 2,024 km for high-speed travel

+ 800 km of additional track planned in 2017
SNCF Réseau : key figures (2/2)

Along the way there are

- **1,742** tunnels
- **26,733** bridges and viaducts
- **1,142** footbridges over the tracks
- **2,271** signal boxes

On the traditional lines the trains travel at

- **160 km/h** (the international standard)
- **200 km/h** (on a few segments of modernised lines without any level crossings)
- **220 km/h** (for some TGV high-speed segments)

High-speed lines enable them to go up to

- **300 km/h** (on most lines)
- **320 km/h** (on the East high-speed line and on the future Paris-Bordeaux line)
SNCF Réseau : businesses

Engineering & Projects

Guaranteeing access to the network

Maintenance & Works

Traffic Management
SNCF Réseau Maintenance Transformation

**IMPROVE SURVEILLANCE**

- **TRANSFORMATION**
  - REMOTE MONITORING DEPLOYMENT
    - NEW TECHNOLOGIES
      - (sensors, wireless, connected objects,...)
    - EQUIPMENT SURVEILLANCE
      - (static & onboard measurements)
  - LIMIT IMPACTS ON TRAFFIC
  - ANTICIPATE INCIDENTS
  - EVOLUTION OF MAINTENANCE POLICIES

- **LEVERS**
  - REINFORCE NETWORK SUPERVISION
    - Regional Remote Monitoring Centers
  - ASSET MANAGEMENT
    - Define and adjust degradation curves
    - Capitalize on asset knowledge to define new maintenance policies

**TRANSFORMATION**

**LEVERS**
Why the PI System ? 1/2

- **Rediscover our assets** by leveraging 10+ years collected field data
- **Deploy new analyses** and tools, designed and implemented **by and for** the maintenance personnel
- **Open perspective** to (smart) asset management
- **One single place** to easily access field data
Why the PI System ? 2/2

Users & Applications

Field Data Infrastructure

Field Data Sources

PI Tools

Web Portal

Advanced Analytics

PI Server

Scheduled

CMMS

GIS

PI Interfaces

Remote Monitoring Data Concentrators

Weather Stations

IoT Platform IBM Watson
Using Field Data for Maintenance: Before PI System

- Field Data Source
- Maintenance SCADA
- Remote Monitoring Center
- Field Maintenance
Using Field Data for Maintenance: With PI System

PI System ➔ Historical Field Data Analyses ➔ Asset Management

New Tools

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National Deployment to our 4 Regional Divisions

- IDF: Centre de supervision de Paris
- NEN: Centre de supervision de Pagny sur Moselle
- Atlantique: Centre de supervision de Bordeaux
- Sud-Est: Centre de supervision de Lyon
Railway Infrastructure Terminology 1/3

Railroad Equipment

Two-tracks railroad switch, actuated by an electric motor, from a signal box.
Railway Infrastructure Terminology 2/3

Railroad Equipment

Electric switch motor with power sensors (SCAG)
Railway Infrastructure Terminology 3/3

Railroad Equipment

Electric switch motor with power sensors (SCAG)

Point blades with half-open sensor (SKAG)
Railroad Switch #3017
Railroad Switch #3017
Dynamic View of Railroad Switch #3017 in Context

Asset Key Information
Maintenance Dashboard: Assets Condition KPIs at a Glance

**Historical Drill-Down**
Post-Incident Manual Entry: On-Site Feedback into PI Server

List of incident feedback

- Location
- Asset
- Date
- Was traffic impacted?
- Reason
- Picture
Self-Service Access to Switch Motor Curves

Reference & Actual Power Curves - Temperature & Moist - Time to actuate
Startup Generation: Predictive Analytics & Machine Learning

- Corrective Maintenance: Based on running hours or calendar-based performance.
- Preventive Maintenance: Based on measurements, possibly using data related to wear or condition.
- Predictive Maintenance: Extrapolated predictions based on analyses and assessment of data related to wear.

Condition-Based Maintenance

- SNCF
- OSIsoft
- Dapred
Predictive Maintenance Architecture
Datapred is a Machine Learning Suite Dedicated to Time Series

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Description</th>
<th>Technologies</th>
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<tbody>
<tr>
<td>1970s-1980s</td>
<td>Business reporting</td>
<td>Financial consolidation</td>
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<tr>
<td></td>
<td>&gt; Collecting, centralizing and sorting business data</td>
<td>IBM, JD Edwards, Crystal Reports..</td>
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<tr>
<td>1990s-2000s</td>
<td>Business intelligence</td>
<td>Market segmentation, dynamic reporting</td>
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<tr>
<td></td>
<td>&gt; Finding, quantifying and visualizing relationships in structured business data</td>
<td>Business Objects, Cognos, Hyperion, SAS..</td>
</tr>
<tr>
<td>From mid-2000s</td>
<td>Batch machine learning</td>
<td>Recommendation engines, search engines</td>
</tr>
<tr>
<td></td>
<td>&gt; Same as BI, but with non-parametric models capable of handling big and unstructured data</td>
<td>AWS, Google, Microsoft..</td>
</tr>
<tr>
<td>Today</td>
<td>Sequential machine learning</td>
<td>Sequential predictions, dynamic allocation and anomaly detection</td>
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Quick Refresher on Machine Learning

1. Select an algorithm that can identify patterns in large and diverse data sets
2. Launch the algorithm on your data and let it learn
3. Choose the right balance between accuracy and adaptability
Advanced Analytics Challenge – Curves as Time Series

- Curves are archetypal time series
  - Perfect cases of continuous information
  - A series of curves is also a time series
- Supervised and unsupervised learning
  - 1st challenge → detect anomalies and predict failures based on a library of labels
  - 2nd challenge → use advances in deep learning to unearth « unknown unknowns »
  - The integration of unsupervised learning increases the solution's durability
- Complementary information
  - Machine learning can process raw curves with any kind of complementary data

*Which of these curves is abnormal? 😊*
Datapred’s Solution: Learning Motor Power Curves in Real-Time

1. **Encoder/decoder**
   - **Why**: To identify unusual maneuvers
   - **How**: By learning a neural network to isolate real outliers from statistical noise
   - **What (Output)**: Maneuvers sorted by outlier score

2. **Anomaly detection**
   - **Why**: To detect anomalies in real-time
   - **How**: By classifying maneuvers based on information from the encoder/decoder and tags from the maintenance team
   - **What (Output)**: A comprehensive list of anomalies

3. **Failure prediction**
   - **Why**: To alert maintenance teams before motor failure
   - **How**: By predicting future maneuvers and anomalies with a sequential neural network
   - **What (Output)**: Failure predictions
Anomaly Detection in Practice (1/2) – Monitoring

Encoder/decoder performance
- The 4 « losses » correspond to differences between the denoised and raw curves that can’t be explained by statistical noise
- Together, these 4 losses make up the outlier score

Detected anomalies
- Each anomaly in the maintenance team’s library receives a score
- The highest scores correspond to the bizarre volatility of the curve during the maneuver (failure risk + lubrication problem) and the unusual final burst

Bizarre volatility

Unusual final burst
Anomaly Detection in Practice (2/2) – Alerting

Incident on 24 Oct. 2016

60% chance of motor failure

Alerts and reports

Dubious curves before the incident

Persisting anomalies after the incident
## Potential Extensions of Datapred Machine Learning Suite

<table>
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<th>Temperature</th>
<th>Pressure</th>
<th>Consumption Levels</th>
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<td>Electric Signals</td>
<td>Compositions</td>
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</table>

*Note: The table outlines potential extensions for the Datapred Machine Learning Suite, focusing on temperature, pressure, consumption levels, vibrations, electric signals, and compositions.*
Digital Transformation of Maintenance, for the Benefit of Customers

**COMPANY and GOAL**

Each day, SNCF RÉSEAU enables **15,000 trains** and **5 millions+ passengers** to use the #2 EU railway system.

**CHALLENGE**

Limit impact of maintenance activities on rail traffic

- Further improve assets surveillance
- Anticipate and prevent incidents
- Maintenance policies evolutions

**SOLUTION**

Invest in monitoring and analysis of field data!

- Increase deployment of remote monitoring, innovations (IoT, wireless…)
- PI System lays the foundation for more field data analysis
- New innovative tools

**RESULTS**

Improve visibility on real asset conditions and anticipation (predictive)

- Improve asset knowledge
- Accelerate DATA projects
- Maintenance Teams = Driving Force for Change!
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