Predictive Maintenance and Quality

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“ALL SYSTEMS WILL FAIL, THE ONLY QUESTION IS WHEN, AND HOW FREQUENTLY”
Asset intensive companies are required to solve complex operational and process issues

<table>
<thead>
<tr>
<th>Asset Performance</th>
<th>Process Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Lack of visibility into asset health</td>
<td>▪ Competing maintenance, financial, and operational requirements</td>
</tr>
<tr>
<td>▪ Inability to accurately forecast asset downtime and costs</td>
<td>▪ Lack of visibility of indicators across organizational silos</td>
</tr>
<tr>
<td>▪ High costs of unscheduled maintenance</td>
<td>▪ Inability to leverage analytical insights for process optimization</td>
</tr>
</tbody>
</table>
Predictive Maintenance and Quality

What if you could predict the failure of an asset to prevent costly unexpected downtime?

What if, you could determine which components require service and which ones don’t?

What if, you could predict parts life based on operation to optimise inventory levels at the various service centers?

What if you could quickly mine the thousands of maintenance logs to determine the most effective repair procedures and maintenance cycles?

You could...
- Improve operational efficiency
- Prevent equipment downtime
- Extend the life of an asset
- Reduce unscheduled maintenance
- Improve diagnosis and prognosis capabilities
- Determine best repair strategies
- Exceed customer expectation
The challenge of infrastructure, people and applications

- Manage and maintain an aging infrastructure by:
  - Extending asset life and maximizing return on assets while
  - Meeting financial and operational compliance requirements and mitigating risk.
  - Enabling Predictive Maintenance to reduce asset downtime and extend useful life.

- Control the “brain drain” among employees facing retirement by:
  - Capturing the knowledge and critical skills of long-time employees with proven workflow, enforced best practices
  - Optimizing processes and allowing a shrinking workforce
  - To work more efficiently and cost effectively.

- Consolidate operational applications by:
  - Supporting work and asset management for all lines of business—transmission, distribution and generation for electric, water, wastewater and natural gas.
  - Allowing a single system to manage all types of assets including production, facilities, transportation and IT.
  - Providing a lower total cost of ownership, one version of the truth and best practices enforced with standard software at all sites.
Predictive Maintenance key to Asset and Process Performance

Maintenance Maturity Model

Managing costs while improving reliability and safety

- **Reactive Maintenance** (machine fails, then fix)
- **Preventive Maintenance** (based on manufacturers’ schedules, time, or operational observations)
- **Condition-based Maintenance** (based on monitoring to assess condition of assets)
- **Predictive Maintenance** (based on models of evolution of the condition of assets)

Predictive Maintenance uses analytics to model foreseeable evolutions of the characteristics of individual assets.

Source: Gartner
Predictive Maintenance and Quality delivers significant value, where both the impact of failure and the probability of failure are high.

Severity Factors
• Health and safety issues
• Asset damage / Repair costs
• Loss of revenue
• Customer satisfaction issues

Likelihood Failure will be Forseen

<table>
<thead>
<tr>
<th>Failure Severity</th>
<th>Remote</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Very High</th>
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<tbody>
<tr>
<td>Severe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Slight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Impact</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Greatest need for Predictive Asset Optimization
Lower need for Predictive Maintenance and Quality
CASE STUDIES
A Middle Eastern Energy Provider increases grid reliability

20% Cost Reduction by avoiding the expensive process of reinitiating a power station after an outage

$80,000 Savings on petrol combustion costs by preventing the malfunction of a turbine component

Increased efficiency of preventive maintenance schedules, costs and resources, resulting in fewer outages and higher customer satisfaction

Business Problem: The company’s research institute is charged with improving the safety and reliability of power generation and transmission while fueling innovation. That includes planning for disruptive events such as solar storms as well as making improvements in transmission efficiency, incorporating new sources of renewable energy into the grid and analyzing growing volumes of data from an increasingly smart grid.

Solution: This energy provider uses powerful predictive analysis to understand when and why outages occur so it can take steps to prevent them
A Major Hydro Company increases grid reliability

**Increases**
grid reliability by detecting signs of failure in the near-real time stream of data

**Meeting regulatory requirements**
for expanded use of wind and solar power

**Lays the groundwork**
for a smarter energy grid, using advanced analytics to predict and prevent failures while adapting to rising demand and a shifting energy mix

**Solution Components**
• Information Management
• ILOG
• Business Analytics
• Rational Software
• Smarter Cities and Financial Operations
• WebSphere

Business Problem: The company’s research institute is charged with improving the safety and reliability of power generation and transmission while fueling innovation. That includes planning for disruptive events such as solar storms as well as making incremental improvements in transmission efficiency, incorporating new sources of renewable energy into the grid and analyzing growing volumes of data from an increasingly smart grid.

Solution: Working with an integrated analytics and optimization platform from IBM, this company is applying advanced predictive analytics and high-performance computing to solve the most pressing energy challenges facing the industry including the prevention of failures and the reduction in the length of outages
An iron & steel manufacturer predicts equipment malfunctions & product defects

$2 Million
Reduction of costs for every 0.1% improvement in production efficiency

Improved steel and iron production efficiency
by reducing the incidence of production shutdowns related to equipment failure and product defects

Boost skills transfer
by embedding process knowledge into equipment and process optimization algorithms

Business Problem: The optimisation of plant production is the key to profitability. Some of the main parameters include throughput, product quality, machine availability and efficiency. Small flaws, such as temperature imbalances in a furnace or the wrong tension setting on a steel roller, can lead to defective products, customer dissatisfaction and costly delays. The company wanted to spot emerging equipment and product-quality problems early.

Solution: The IBM solution analyzes large volumes of production control data to seek patterns in equipment operations, product quality, failure patterns and the like.

Solution Components
- IBM SPSS Statistics
- IBM SPSS Modeler
PREDICTIVE MAINTENANCE AND QUALITY
PMQ analyzes data from multiple sources and provides recommended actions, enabling informed decisions.

1. Collect and integrate data: Structured and unstructured, streaming and at rest.
2. Generate predictive and statistical models.
3. Optimise decisions.
4. Display alerts and recommend actions.
5. Act upon insights.

- Predictive Maintenance and Quality:
  - Data agnostic
  - User-friendly model creation
  - Interactive dashboards
  - Enables faster decisions

- Asset performance
- Process integration
Predictive analytics workflow

External data → Predictive analytics → Analytical footprint for failures, breakdowns and threatening situations → Event Detection
Model performance on Gas Escape History

<table>
<thead>
<tr>
<th>Prediction</th>
<th>GAS_ESCAPE_FLAG</th>
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<th>YES</th>
<th>Total</th>
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<tr>
<td></td>
<td>NO</td>
<td>188689</td>
<td>109191</td>
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<td></td>
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<td>Total</td>
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<td>193868</td>
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<td>Row %</td>
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<td></td>
<td>Column %</td>
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<td>100</td>
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</table>

Risk of Reported Escape

83% of previous gas escapes captured by model

<table>
<thead>
<tr>
<th>Prediction</th>
<th>SLA_FAILED</th>
<th>Not Violated</th>
<th>Violated</th>
<th>Total</th>
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<tbody>
<tr>
<td>Not Violated</td>
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<td>28005</td>
<td>4118</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Column %</td>
<td>99.932</td>
<td>89.289</td>
<td>99.428</td>
</tr>
<tr>
<td>Violated</td>
<td>Count</td>
<td>19</td>
<td>494</td>
<td>513</td>
</tr>
<tr>
<td></td>
<td>Row %</td>
<td>3.704</td>
<td>96.296</td>
<td>100</td>
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<td></td>
<td>Column %</td>
<td>0.068</td>
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<tr>
<td>Total</td>
<td>Count</td>
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<td>4612</td>
<td>32636</td>
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<td></td>
<td>Row %</td>
<td>85.868</td>
<td>14.132</td>
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</tr>
<tr>
<td></td>
<td>Column %</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Risk of Violation

96% of previous violations captured by model
Example Model Results

Rule 11 for 1

if HOUR > 18 and HOUR <=20 and PROP_METER_POINTS_ABOVE_MEDIAN <= 0.540 and TOTAL_SUPPLY > 705,216 then "GAS ESCAPE"

Predictor Importance
Target: GAS_ESCAPE_FLAG

Least Important  Most Important
Predictive analytics workflow

1. **External data**
2. **Real time data**
3. **Production Operations**
4. **Predictive analytics**
5. **Analytical footprint for failures, breakdowns and threatening situations**
6. **Event Detection**
7. **Business rules engine, Standard operating procedures**
8. **Enterprise Asset Management – Work Order**
9. **End user reports, dashboards, drill downs**
10. **Act upon insight**
With a proven architecture

- Advanced analytics powered by IBM SPSS and Cognos software
- Data integration provided by IBM Integration Bus and IBM InfoSphere® Master Data Management Collaborative Edition software, which feeds a prebuilt, data schema based on IBM DB2® software
- Process integration with automatic work-order generation from Maximo software
- Data models, message flows, reports, dashboards, business rules, adapters and key performance indicators
IBM WebSphere Message Broker – Connecting with Nodes

- Built-in configurable nodes encapsulate transports, technologies, and applications
Predictive Maintenance Application Template

- Decision Areas
  - Use case – Action to Take on Asset
  - Service Group – Resource to Allocate to Action

- Optimization Equation

```
(Prob. of Failure \times Revenue Impact) - (Action Cost + Service engineering group Cost)
```

- Optimization Constraints

<table>
<thead>
<tr>
<th>Constraint Description</th>
<th>Constraint Value Name</th>
<th>Equation</th>
<th>Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>How many actions of this type can be made across all machines</td>
<td>Actions Available</td>
<td>&gt;=</td>
<td>count (Offer)</td>
</tr>
<tr>
<td>Maximum number of actions that can be processed by each service engineering group</td>
<td>Capacity</td>
<td>&gt;=</td>
<td>count (Channel)</td>
</tr>
<tr>
<td>Budget $ available to solve each issue in this optimization window</td>
<td>Issue handling Budget</td>
<td>&gt;=</td>
<td>sum (Action Co...</td>
</tr>
<tr>
<td>Maximum number of actions that should be assigned to each machine</td>
<td>Max. Actions</td>
<td>&gt;=</td>
<td>count (Offer / C...</td>
</tr>
<tr>
<td>Minimum number of actions that must be made for this issue to be solved</td>
<td>Min. Actions</td>
<td>&lt;=</td>
<td>count (Offer)</td>
</tr>
<tr>
<td>Total Hours available from the service engineering groups</td>
<td>Total Budget</td>
<td>&gt;=</td>
<td>sum (Action Co...</td>
</tr>
</tbody>
</table>
Sales Workshop Series

Example Dashboard Reports
ANALYTICS IN ASSET INTENSIVE INDUSTRIES
Analytics is a key enabler in maximizing asset productivity and process efficiency

## Analytics is a key enabler in maximizing asset productivity and process efficiency

**Definition of Maturity Class**

<table>
<thead>
<tr>
<th>Maturity Class</th>
<th>Mean Class Performance</th>
</tr>
</thead>
</table>
| **Best-in-Class:** Top 20% of aggregate performance scorers | 3.5% Unscheduled Asset Downtime  
89% Overall Equipment Effectiveness (OEE)  
+24% Return on Assets (RoA) vs. Corporate Plan  
-13% Reduction in Maintenance Costs |
| **Industry Average:** Middle 50% of aggregate performance scorers | 8.3% Unscheduled Asset Downtime  
83% Overall Equipment Effectiveness (OEE)  
+4% Return on Assets (RoA) vs. Corporate Plan  
-4% Reduction in Maintenance Costs |
| **Laggard:** Bottom 30% of aggregate performance scorers | 16.9% Unscheduled Asset Downtime  
69% Overall Equipment Effectiveness (OEE)  
-7% Return on Assets (RoA) vs. Corporate Plan  
+1% Increase in Maintenance Costs |

Thank You
PREDICTIVE ASSET OPTIMISATION
PAO (current offerings) for IP/C&P

- **PAO Standard**
  - An advanced predictive analytic platform with capabilities for data aggregation, advanced analytics, and visualization on transactional or instrumented data.

- **PAO for Mining**
  - Monitors operations of heavy equipment, and predicts health and performance of equipment using industry-specific data models and analytics.

- **PAO for Oil/Gas (upstream)**
  - Provides performance dashboard related to integrated operations

- **PAO for Refinery (operational forecasting)**

- **PAO for Steel Production**
  - Optimizes energy generation and consumption within a steel production environment

- **PAO Early Warning**
  - Continuous monitoring of product quality for early detection of defects, for incoming subcomponents or final assembly components in a production process
PAO (current offerings) for IP/C&P cont…

- **PAO for Rail Infrastructure**
  - Predicts rail track segment deterioration and failure using industry-specific analytics and data models applied against traditional rail industry data collection methods.

- **PAO for Rail Stock Car**
  - Monitors alarms on rail stock cars and predicts potential failures on the stock care wheels

- **PAO for Energy & Utilities**
  - Monitors alarm and predicts potential failures for power substations

- **PAO for Building Energy Management**
  - Fault detection and diagnostics of mechanical equipment in buildings (HVACs, boilers, chillers, etc.) that reduces energy consumption and improves operational costs