Asset Management and Data Analytics

June 26, 2018
Today’s Agenda

1. Asset Management Drivers and Trends

2. Typical Asset Risk Assessment

3. Data Analytics Continuum

4. Machine Learning and Asset Failure Prediction
Asset Management Does Not Have to Be Complex

“Delivering a specified level of service to customers and regulators at an optimal life cycle cost with an acceptable level of risk.”

Businesslike Management of Assets
Asset Management Drivers and Trends
## Typical Asset Management Drivers

<table>
<thead>
<tr>
<th>External Forces</th>
<th>Asset Age &amp; Condition</th>
<th>Service Levels</th>
<th>Cost Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Regulatory compliance</td>
<td>• Aging and deteriorating infrastructure</td>
<td>• Demand for improved service levels and reliability</td>
<td>• Drive to do “more with less” through optimized decisions, effectiveness and efficiency</td>
</tr>
<tr>
<td>• Growth and demand</td>
<td>• Solid justification for capital investments and O&amp;M programs</td>
<td>• Prevention of critical asset failures</td>
<td>• Move toward a “businesslike” culture</td>
</tr>
<tr>
<td>• Pressures from the public and elected officials</td>
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Current Industry Asset Management Trends

**Focus on capital planning, business case development and project justification** – ensures funding goes to the most critical projects and creates transparency

**Ongoing CMMS procurement, implementation, enhancement and upgrades** – large utilities aligning with top tier and medium/small utilities with mid-tier vendors with GIS integration

**Large organizations embracing asset management as an organizational model** – medium/small utilities focusing more on practices and processes within existing structure

**Focus on business intelligence/analytics is growing rapidly** – all industry organizations are focusing on intelligent water systems
Asset and Risk Management Strategy

- Know what assets you own
- Understand their criticality and condition
- Understand their serviceability, remaining life, and economic value
- Understand asset performance and failure history
- Identify largest risks and the likelihood and consequence of failure
- Have a documented life-cycle strategy for all major assets – linked to asset performance and service level goals
Typical Asset Risk Assessment
Asset Risk – How is it Defined?

Risk is defined as the quantification of the likelihood of failure (condition) times the quantification of the consequence of such failure (criticality), factoring in any required adjustments for redundancy or risk mitigation.
Condition Assessment – Evaluates Probability of Failure

**Physical Condition**: current state of repair and operation
- Visual inspection of facility assets
- Evaluate general condition of major process equipment and infrastructure & major electrical equipment
- Discipline-specific review (mechanical, electrical, structural, HVAC assessments)
- Building envelope evaluation

**Performance Condition**: current and future requirements
- Work order history
- Discussions with O&M staff

\[
\text{Condition} = (\text{Physical} \times W1) + (\text{Performance} \times W2)
\]
Consequence of Failure – Evaluates Asset Criticality

• Expected system-wide consequence of failure associated with failure of an asset

• Evaluation Criteria:
  • Safety / Security
  • Level of Service
  • Financial Efficiency
  • Regulatory compliance
  • O&M
  • Resilience

• One set of criteria for all vertical (facility) assets

\[ \text{CoF} = \sum (C1 \times W1) + (C2 \times W2) + (C3 \times W3) + (C4 \times W4) + \ldots \]
Risk Assessment – *Prioritizes Assets for R&R*

**Asset Risk Matrix**

<table>
<thead>
<tr>
<th>Risk Rating</th>
<th>Probability of Failure (PoF)</th>
<th>Criticality</th>
<th>Risk Category</th>
<th>Risk Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Very Good</td>
<td>0.03%</td>
<td>0.06%</td>
<td>Low</td>
<td>0.09%</td>
</tr>
<tr>
<td>2 Good</td>
<td>0.22%</td>
<td>0.44%</td>
<td>Medium</td>
<td>0.46%</td>
</tr>
<tr>
<td>3 Fair</td>
<td>1.09%</td>
<td>2.18%</td>
<td>High</td>
<td>2.28%</td>
</tr>
<tr>
<td>4 Poor</td>
<td>8.91%</td>
<td>17.82%</td>
<td>High</td>
<td>18.73%</td>
</tr>
<tr>
<td>5 Very Poor</td>
<td>40.14%</td>
<td>80.28%</td>
<td>High</td>
<td>80.38%</td>
</tr>
</tbody>
</table>

**50-Year Projected Renewal Needs**

- Low Risk
- Medium Risk
- High Risk
- Current Budget

**Remaining Life as % of Expected life**

- Condition Grade
- Remaining Life
Preventive Maintenance Has Evolved Over Time…

- Run to Failure
- Calendar
- Usage
- Condition
- RCM
...But It Is Still Not As Effective As It Should Be

80% equipment fails in spite of calendar maintenance

63% scheduled maintenance is unnecessary

The problem is here

process-induced

The spend is here

wear-and-tear
Risk-Based Inspection & Maintenance Optimization

Benefits:
- Better estimate of EUL
- Avoid critical failures
- Optimize inventory and resources

Inspection Program
- Visual + Performance + Testing

Criticality
- Highest
- Moderate
- Lowest

Maintenance
- Time + Use + Condition
- Time + Use
- Time
Data Analytics Continuum
Data and Key Processes Required to Support Asset Management

**Tracking attributes:** date created, created by, last edit, etc.

**Physical attributes:** make, model, manufacturer, capacity

**Financial attributes:** install date, historic/replacement cost, effective useful life, remaining useful life

**Asset management attributes:** Likelihood of Failure, Consequence of Failure, Operational data (SCADA)
Typical Asset Management Systems and Data Flow
Streamlined Data Analysis and Integration

- LIMS
- CIS
- GIS
- CMMS
- FMIS
- SCADA
- HYDRAULIC MODEL

Data Flow:
- Water Quality Data
- Facility Operational Data
- Capacity & Pressure Information
- Installed and Depreciated Costs

Central Node:
- Customer Complaints
- Collection System Asset Risk, LCC & EUL

Supporting Nodes:
- Asset Risk, LCC & EUL
- R&R PLANNING
- RATE PLANNING
- MANAGEMENT REPORTING & DECISION SUPPORT
It’s Not a Data Gap…It’s a Fact Gap!

Utilities are experiencing a “gap” between the quantity of data they are generating and the resources available to collect, collate, and analyze it.

The amount of information managers are dealing with each day is increasing exponentially, but the resources available to sort, scrub, and analyze the data are decreasing.

- Amount of data generated is growing by 50% each year (IDC)
- Storage costs decreasing: $600 – cost to buy a hard drive that can store all of the world’s music!
What Do We Do with All the Data?

IDG conducted a recent survey of over 200 IT leaders throughout all industries in the U.S.

56% of IT decision makers said that their users report feeling overwhelmed by incoming data and information.

53% said the influx of data has delayed decisions because they didn’t have the right tools to manage it.

Is it only about capturing more and more data, or is it about making more, better, and/or faster decisions?

IDG Enterprise, 2015
Learning from Other U.S. Industries

Survey of 450 Data Scientists and Business Analysts, Executives, IT Application Managers – in a wide range of industries; research sponsored by Cloudera, SAS, SAP, and other vendors
The Data Analytics Continuum

1. Data capture
2. Data validation
3. Data curation (storage, query, transfer)
4. Data integration

5. Data Analytics
6. Business intelligence/decision support
7. Knowledge sharing
8. Performance reporting & visualization

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**Descriptive**
- What happened?
  - Reports

**Diagnostic**
- What’s happening?
  - Dashboards, KPIs, Trend Tools

**Predictive**
- Why is it happening?
  - What process conditions are creating the situation?
  - What other factors are causing the anomaly?

**Prescriptive**
- What will happen?
  - Machine-learning algorithms
  - Cross-functional context applied to process data

- When will it happen?
  - Predict failures with equipment or process problems in the future with considerable lead-time

- What can I do about it?
  - Change the process operation
  - Change the operating plan, maintenance schedule

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**Last Decade**

**Emerging and Future**
Machine Learning and Asset Failure Prediction
Typical Predictive Analytics – Asset Lifecycle Models

- Build a life-cycle model of each asset type
- Calibrate the model with actual failure data
- Highlight statistical deviations and anomalies and make corrections to the models
Predictive Analytics Based on Machine Learning

- **Pattern match**
- **No pattern match**
- **Pattern match**

- Normal
- Abnormal
- Failure Signature
Standard SCADA System

**Primary Sensors / Measurements**
- Flow Rate
- Pressure
- Level
- Temperature
- Analytical parameters (e.g., pH, CL2 residual)

**Secondary Instruments**
- Indicators
- Hand switches
- Programmable controllers
- Computer systems
- Communication networks

**Final Control Elements**
- Valves and gates
- Pumps
- Chemical feeders
- Blowers
- Mixers
- CMMS
Patterns of Failure

Data Pattern

Bearing Failure

Data Pattern

Upstream Cavitation

Data Pattern

Liquid carry-over

Failure₁

Failure₂

Failure₃
Anomaly Identification

Data Pattern
Normal Conditions

Anomaly or new normal?
A Signature Library Can Be Created

Motor
Insulation Breakdown
Stator

Gearbox
Mechanical Wear
Gear

Bearing
Mechanical Wear
Bearing

Equipment Failures
Failure Modes
Trained ML Agents
EAM Failure Codes

Library of Known Failure Signatures
Machine Learning Extends the Prediction Horizon

- Initiate EAM action
- Make process adjustments
- Make inventory adjustments
- Order parts

Finding (subtle) patterns in those data is impossible for humans
Observations

• Machine learning in the water industry is here to stay
• Traditional asset planning and risk management are necessary
• Machine learning and predictive analytics can prolong asset life
• Result = Increased Savings!

(OpEx and CapEx)