Standardization of maintenance data for benchmarking and asset performance analytics

**Topic:** Data Collection & Storage

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Who are we and what do we do

Software for industrial applications such as APM

Asset Answers aggregates work history data from many industrial facilities around the world by asset type, manufacturers, and many other characteristics.
Metrics and Rollups

**Cost**
- Ratio of Planned vs. Unplanned Work
  - Avg. Corrective Work Cost
  - Corrective Work Cost %
  - Proactive Work Cost %
  - Reactive Work Cost %
  - Corrective Work Count %
  - Proactive Work Count %
  - Reactive Work Count %

**Reliability**
- Frequency of repair and failure events
  - MTBF
  - MTBR
  - MTTR
  - Failure Rate

**Availability**
- Availability, downtime, and maintenance effectiveness
  - PM Effectiveness
  - Mechanical Availability
  - Mechanical Unavailability
  - Mechanical Downtime

Align with SMRP (Society of Maintenance & Reliability Professionals) best practices
Standard data model needed to aggregate maintenance data

Customer data – Maintenance records from CMMS/EAM

Data model requires:
- Standard structure
- Standard codes
- Standard method of expressing maintenance procedures

Desired asset performance analytics such as reliability metrics

Challenge: EVERYONE uses the CMMS/EAM differently

Standard data model and codes are straightforward, but in order to aggregate data we learned we needed a standard definition of different maintenance processes in order to consistently aggregate data.
Standardization Woes – Example 1

Example of non-standardization of codes across one company with multiple sites.
Standardization 1 Woes – Resolved

VIBRATION

Vibration

Leaks Externally

Leaking

LEAKING

Mapped to Standard

Vibration

Leaking
Standardization Woes – Example 2

Example of non-standardization of different levels of the functional location hierarchy.
Standardization 2 Woes – Resolved
Event Type Definitions

Asset Answers standard event type definitions used for extracting CMMS/EAM data. Often, companies can have 20+ codes, or combinations of different codes which map to these 4 event types. The event type definitions are derived specifically for estimating common performance metrics and align with SMRP.

<table>
<thead>
<tr>
<th>Event Types</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair</td>
<td>Work required to restore an asset’s intended function.</td>
</tr>
<tr>
<td>PM/PdM</td>
<td>Preventive or predictive work</td>
</tr>
<tr>
<td></td>
<td>• Preventive: time-based</td>
</tr>
<tr>
<td></td>
<td>• Predictive: condition-based monitoring.</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Capital projects and non-maintenance related activities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Corrective</td>
</tr>
<tr>
<td>Proactive</td>
</tr>
<tr>
<td>Reactive</td>
</tr>
</tbody>
</table>
Work types needed for different performance metrics can have overlapping definitions, which we define and standardize.

For example, SMRP defines "proactive work" as either preventative work, predictive work, or corrective work identified from preventative or predictive work orders. The proactive work metric is used to measure & monitor the amount of work done to prevent failure or identify defects that could lead to failures.
Event Timing Visualization

Breakdown Failure Encountered
Notification created
In Service
Corrective / Reactive Repair
Corrective / Proactive Repair

TBF
TBR
TTR
Downtime
PM PdM
PM PdM
PM PdM
Degradation Encountered by PM
Notification created
Notification created

Timeline

Standardizing time elements across different company’s CMMS/EAM
### Key information often present in unstructured fields

#### Failure Mode information in unstructured field:

<table>
<thead>
<tr>
<th>Free Text Work Order Description</th>
<th>Failure Mode</th>
<th>What I want to see:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need to re-grout base to reduce long time vibration problem</td>
<td>Unknown</td>
<td>Vibration</td>
</tr>
<tr>
<td>Clear blocked piping/pump</td>
<td>Unknown</td>
<td>Plugged/Choked</td>
</tr>
<tr>
<td>The stuffing box was replaced not long ago because of a water leak in the drive head, the leak is back</td>
<td>Unknown</td>
<td>Leakage</td>
</tr>
</tbody>
</table>

#### Data Quality Problem: Incorrectly coded work orders

<table>
<thead>
<tr>
<th>Free Text Work Order Description</th>
<th>Event Type</th>
<th>What I want to see:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair leaking safety valve</td>
<td>PM</td>
<td>Repair</td>
</tr>
<tr>
<td>Daily Inspection of Analyzers</td>
<td>Repair</td>
<td>PM</td>
</tr>
</tbody>
</table>

#### Recording when a failure occurred:

<table>
<thead>
<tr>
<th>Free Text Work Order Description</th>
<th>Breakdown?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER PUMP FAILURE. Water pump has failed and has leaked all the coolant out through the tattle hole</td>
<td>FALSE</td>
</tr>
<tr>
<td>Sump level sensor has failed. Cannot run plant without this sensor.</td>
<td>FALSE</td>
</tr>
<tr>
<td>Compressor lube box oil seal has failed. Requires seal replacement ASAP</td>
<td>FALSE</td>
</tr>
</tbody>
</table>
Supporting slides
Maintenance management work process

APM software here to analyze maintenance data for asset performance improvements
Comparison of reliability estimates - before and after

**Before:** inability to calculate Mean Time Before Failure (MTBF)

**After NLP applied to maintenance data:** Benchmarking comparison of MTBF is possible

<table>
<thead>
<tr>
<th>Work description</th>
<th>BEFORE: Breakdown indicator</th>
<th>AFTER: Is A Failure?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal is leaking badly</td>
<td>FALSE</td>
<td>True</td>
</tr>
<tr>
<td>Block valve is broken</td>
<td>FALSE</td>
<td>True</td>
</tr>
<tr>
<td>open and inoperable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00120-Pump 1 Work Request</td>
<td>FALSE</td>
<td>False</td>
</tr>
<tr>
<td>Check impeller size</td>
<td>FALSE</td>
<td>False</td>
</tr>
</tbody>
</table>

**Comparison of MTBF (days):**

- **Company 1:** 470 days
- **Company 2:** 314 days

Example of using NLP approaches to characterize failures