Smart Services/PreVail® - Remote Health Management

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Who Are We?
How Big?

**WEIGHT COMPARISON**

747
180,985 kg (399,000 lbs.)*

4100XPC
1,458,000 kg (3,213,500 lbs.)
*188,241 kg (415,000 lbs)
Rated Suspended Load

**SIZE COMPARISON**

P&H 9020C
5,710,728 kg (12,590,000 lbs.)

P&H 9020C
67.67 m (222 ft.) height
125.58 m (412 ft.) long

P&H 4100XPC
21.25 m (69.72 ft.) height
32.1 m (105.31 ft.) long

747
19.41 m (63.68 ft.) height
68.63 m (225.16 ft.) long
Integrating Equipment, Information and Service

World Class Performance

Data ➔ Information ➔ Direction ➔ Results

Smart Services

Knowledge Generation and Continuous Improvement
- Case Management, Escalation and Resolution
- Issue Aggregation w/ Supporting Data
- Sub-System Specific Odometers
- Best Practice

Smart Service Integration
- Work Order Generation
- Supply Chain Optimization
- As Operated Tailored Training
- Machine Inspections

Smart Service Delivery
- OEE
- Real Time All the Time
- World Class Performance Through Strategic Partnerships
- Mastering Lean Mining Methods
Game Changing Service Offering

Continuous Focus on Improving Operations

2010 “PreVail”
- Service Centres – back to OE
- Repairs
- Local Field Service
- Product training
- Parts Warehousing
- Technical Resources
- Asset Revitalizations
- Enabled Machine Wi-Fi Communication
- Data Visualization
- Real-Time Monitoring
- Remote Diagnostics
- Integrated Schematics & Parts Books
- Historical Analysis

2012 “Data to Knowledge”
- Condition Based Equipment Monitoring
- Operator Scorecards
- Monthly Reports/Comparisons
- Cost Avoidance Calculations
- Component Tracking System
- Workflow Engines-Issue Resolution

2013 “Smart Services”
- Global Benchmarking
- Performance Analysis (OEE)
- Integrated Monitoring Centers
- Productivity Analysis & Reporting
- Customer Portal - Visibility
  - Part Locations & Orders
  - Equipment and system performance
- Global network
  - Monitoring all equipment
- Dispatch people and product
- Integration with customer monitoring centers

2016 “Integrated Solutions”
- Smart solutions – global network
- Integrated work orders
  - maintenance
  - parts orders
- Service Life Management

“Core” Joy Global Services

- Global network
- Monitoring all equipment
- Dispatch people and product
- Integration with customer monitoring centers

- Condition Based Equipment Monitoring
- Operator Scorecards
- Monthly Reports/Comparisons
- Cost Avoidance Calculations
- Component Tracking System
- Workflow Engines-Issue Resolution

- Global Benchmarking
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- Global network
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Align to Global Services Network

Smart Services Globally - Lead with Service

Leverage regional centers to support us 24/7 around the globe
PreVail Journey/Architecture/Value Offering
The Journey of PreVail

PreVail as a Product
- Maintenance
  - Maintenance Product for Shovels on the Centurion Platform

PreVail as a Subscription
- Production
  - Custom Dashboards
    - shovel production data
    - Batch based rules
- Underground
  - Underground Maintenance & Prognostics
  - First Continuous Miner

PreVail enabling Smart Service
- Scalability
  - Balance of Fleet
  - 100’s of Expert Rules
  - 100’s of machines
- Expanded Fleet
  - FCT, LWS, Drill, Non-Centurion, JNA machines
  - Expert Rules

Machine Data

Value to the Customer

2009
- 5 Shovels

2010
- 20 Shovels

2011
- 40 Shovels & Miners

2012
- 80 Total Fleet

2013
- 130 Total Fleet

Shovels 20 40 80 Total Fleet 130 Total Fleet
PreVail Architecture

Data Logger
- On board data logger (located in shovel) captures all sensor and event data.
- Data is buffered to ensure no data loss.

The cornerstone of the PreVail system is access to 24/7 expert diagnostic and consultative support.
PreVail – Value Addition

PreVail’s Value Added

Milwaukee Analysts

Field Technical Resources

Customer Resources

Cost Avoidance / Opportunity Costs

Predictive Modeling

Trend Analysis

KPI Dash Boards

Reporting

Condition Monitoring

RCM Focus

Data Sharing
Power of Data
**Machine’s Behavior – Hoist Over speed Event**

<table>
<thead>
<tr>
<th>Time Stamp</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:29:52.646:</td>
<td>Operator ref went down to 0 RPM, the lowering speed continued to increase</td>
</tr>
<tr>
<td>13:29:54.033:</td>
<td>Armature and Field Currents at current limit</td>
</tr>
<tr>
<td>13:29:54.156:</td>
<td>Load continued to accelerate to -1094 RPM, maximum motion torque failed to hold the dipper &amp; contents</td>
</tr>
<tr>
<td>13:29:55.265</td>
<td>Hoist over speed fault logged, brakes automatically applied</td>
</tr>
<tr>
<td>13:29:57.632:</td>
<td>Dipper fell another 5.7 meters before its motion was halted</td>
</tr>
</tbody>
</table>
Power of Data Trending, Computing, to aid in the explanation of Machine’s behavior down to milliseconds interval….
### Machine Health Analysis - Voltage Feed

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>PreVail Analysis</th>
<th>CBEM Augmentation</th>
<th>Competitive Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mains Voltage Signature-Weak</td>
<td>Trending of mains voltage trips alarms correlation used to detect the possible</td>
<td>A model built on the historical data and has triggered numerous true positive alerts,</td>
<td>• Faster RCA and corrective action leading to shorten the trail cable length and</td>
</tr>
<tr>
<td>power distribution</td>
<td>issue causing downtime</td>
<td>leading one of them into a case study</td>
<td>stabilize the power feed</td>
</tr>
</tbody>
</table>
<pre><code>                                                                                     |                                                                                  |                                                                                    | • Use of Expert domain knowledge and predictive modeling                           |
</code></pre>

**Graphs:**
- **Heavy Spikes in Mains Voltage:**
  - Graph showing voltage spikes with timestamps.
- **Trending of Mains Voltage:**
  - Graph showing the trend of mains voltage over time with alarm correlation.

**Challenges:**
- Power distribution issues causing downtime.

**Analysis:**
- Using historical data to build a model that triggers alerts, leading to a case study.

**Benefits:**
- Faster Root Cause Analysis (RCA) and corrective actions.
- Stabilization of power feed through reduced cable length.
- Expert domain knowledge and predictive modeling.
## Part Malfunction Detection

<table>
<thead>
<tr>
<th>Scenario 3</th>
<th>PreVail Analysis</th>
<th>CBEM Augmentation</th>
<th>Competitive Benefit</th>
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</table>
| AirScrub PlePressure | Trending of the relevant tag and comparative analysis with its behavior on other machines helped identified the issue | A model built on the field investigation, triggered a true positive alert and helped identified a leaky air regulator feeding the manifold | • Leveraged the globally deployed shovel fleet performance to distinguish between normal vs. abnormal behavior  
• Expert domain knowledge used to quickly direct the field reps to take corrective action. |

![Graph showing trends and highlighted anomalies]
Results - Operational Excellence

Capitalized on Operating Practices Refinement Opportunities

CUSTOMER ENGAGEMENT MODEL

SIIR = Swing Impacts Index Ratio, BJIR = Boom Jacks Index Ratio, MSIR = Motor Stalls Index Ratio, Index Ratio = Counts per Operating Hour, CBEM = Condition Based Equipment Monitoring

Maintenance Optimization - Faults Reduction Over Last Two Quarters of 2012

Prescriptive & Predictive Data Analysis – Proactive Data Analysts + CBEM Rules
Machine Knowledge – Access to SMEs & Engineers
Notification/Reporting – 35 FSNs, 48 Weekly Trackers, 12 Monthly Reports
Recommendations/Corrective Action – Closing the Loop with the Mine Site and Field Champions

SIIR = Swing Impacts Index Ratio, BJIR = Boom Jacks Index Ratio, MSIR = Motor Stalls Index Ratio, Index Ratio = Counts per Operating Hour, CBEM = Condition Based Equipment Monitoring
## Results - Productivity Improvements

Completed **180 cases**

Saved **168 Hours**

Rate increase **309 Tonnes per Hour**

Value in Tonnes/Year = 1,85 M Tonnes

1,85 MTons * $150/Ton = **$277 M**

Note: Value calculated on 100Hr’s per week at 1500Tons per Hour
Thank You!