Improving Data Quality
IN UNDERGROUND MINING OPERATIONS

Neil Ferreira  Product Manager, Fleet Management Systems
MODULAR MINING SYSTEMS, INC.
Underground Production Challenges

- It is always “night shift”
  - Poor operational visibility

Communication is Difficult
- Radio antenna can be miles long

Equipment Tracking is Difficult
- No GPS underground

Unreliable Production Data
- Poor Work Progress Tracking

Restricted Mobility
- Single lane travel ways cause contention

Mining Method Diversity
- Block Cave, Sub-Level, Cut & Fill, Room & Pillar

Performance Analysis & KPI
- You can't measure what you don't capture
Underground Production Challenges

• It is always “night shift”
  • Poor operational visibility
• Communication is difficult
  • Radio antenna can be miles long
• Equipment tracking is difficult
  • No GPS underground
• Production data is unreliable
• Work progress tracking is poor
• Mobility is restricted
  • Single-lane travel ways cause contention
• Mining methods are diverse
  • Block Cave, Sub-level, Cut & Fill, Room & Pillar...
• Performance analysis and KPI tracking are difficult
  • You can’t measure what you don’t capture
Opportunities from Fleet Management Systems

**Fleet Management**
- Production task monitoring
- Equipment time tracking
- Equipment location

**Crew Management**
- Scheduling
- Operator qualifications
- Key Performance Indicators (KPIs)

**Material Movement**
- Material classification
- Material quantity tracking
- Material quality tracking

**Inventory Management**
- Real-time inventory tracking
- Average grade and density
- Survey adjustments

Complete visibility into every aspect of underground operations
Opportunities from Fleet Management Systems

By effectively managing these three key areas, underground operations can improve overall asset utilization, resulting in greater production capacity.

Where is my equipment?
What is the status of equipment and production areas?
How well are equipment and personnel working?
Improving Data Quality

CASE STUDY

Better Production Data, Better Decisions
**Baseline State**

Eight production equipment units

Old hardware – no onboard storage

Limited network coverage

Distributed Antenna System (DAS)

*Manual data adjustments account for 15% of total production (168,881 loads)*

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### December 2014

<table>
<thead>
<tr>
<th></th>
<th>自动加载数量</th>
<th>手动加载调整</th>
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<td>1003</td>
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- **在线加载** | **1,135,770**
- **离线加载** | **58,911**
- **手动加载** | **169,881**
- **总加载** | **1,335,770**
Phase One Milestones

Same eight production equipment units

Hardware upgrade
  Onboard storage capability
Phase One Milestones

Same eight production equipment units

Hardware upgrade
- Onboard storage capability

Mobile application software upgrade
- Automatic haul cycle detection
- Automatic draw order management
- Online and offline scenarios

<table>
<thead>
<tr>
<th>Acciones</th>
<th>Estatus LHD</th>
<th>Estatus PE/PV</th>
<th>Opciones</th>
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<tbody>
<tr>
<td>Draw Point</td>
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<td>C73 Efec: 4,06 Demoras np: 0,97</td>
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<tr>
<td>Planned Loads</td>
<td>48E 15 9 6</td>
<td>56E 15 14 1</td>
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<tr>
<td>Remaining Loads</td>
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<td>57E 15 12 3</td>
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<tr>
<td>Completed Loads</td>
<td>53E 12 2 10</td>
<td>58E 12 0 12</td>
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<tr>
<td>Ingrese Sap</td>
<td>54E 15 2 13</td>
<td>60E 7 0 0</td>
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<td></td>
<td>55E 15 12 3</td>
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<tr>
<td></td>
<td>57E 15 14 1</td>
<td>63E 15 7 8</td>
<td>Bienvenido a DISPATCH</td>
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Hora
Phase One Milestones

Same eight production equipment units

Hardware upgrade
   Onboard storage capability

Mobile application software upgrade
   Automatic haul cycle detection
   Offline draw order management

Results

Manual data adjustments account for only 4% of total production, a 24% reduction in manual load adjustments over 2014
Production Data – 2016 (as of June 30th)

**Phase Two Milestones**

Ten production equipment units
- Eight original and two new units

Communication network:
- Auto-switching DAS/Wi-Fi (Feb 2016)

**Results**

Store & Forward loads decreased by 0.5% due to automatic communication network switching between DAS & Wi-Fi

Marginal improvement on automatic loads recorded (attributed to two additional production units)

<table>
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<th>2014</th>
<th>2015</th>
<th>2016</th>
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<td><strong>Manual Loads</strong></td>
<td>664,141</td>
<td>684,433</td>
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<td><strong>S&amp;F Loads</strong></td>
<td>3,160</td>
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<td>96%</td>
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<td><strong>Automatic Loads</strong></td>
<td>17,132</td>
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<td><strong>Total Loads</strong></td>
<td>684,433</td>
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<td>100%</td>
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</tbody>
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**Availability**

- Online Loads: 664,141
- Offline Loads: 3,160
Overall Improvement

December 2014 Production Data

- Automatic load count
- Manual load adjustment

June 2016 Production Data

- Automatic load count
- Manual load adjustment
Offline data capture and automatic network switching resulted in a reliable production accounting improvement from 85% to 97%.

Production accounting data is used by the Cave Management System to model the cave propagation.
Questions