The Impact of Technology in Mining

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Agenda

• Mining Business Drivers
• Core Technologies
• Mining Technology Today
• The Value of Automation
• The Future
Impact of Technology on Key Mining Issues

1. Safety & Sustainability
2. Productivity / Asset Utilization
3. Remote Regions
4. Shift to Underground
5. Technology Integration
6. Energy Costs
7. Financial Performance
8. People – Skilled Resources
9. Demand for Innovation
10. Infrastructure (rail, ports, etc.)

Technology can impact many of these issues
Key Core Technologies

• Positioning Systems
  – GPS/Glonass
  – Inertial systems (Gyroscopes/Accelerometers)
  – LADAR
• Radio Communications
  – Broadband (802.11, 802.16)
• Detection
  – RFID, Radar and LADAR
• On-board computing
• Off-board software
WHEREVER THERE'S MINING
Object Detection

• Backup Cameras

Initial proximity alert systems were comprised of simple backup camera systems to show operator what was behind the vehicle.
Integrated Detection Systems

- The integration of onboard computers, radars and cameras provide the in-cab operator with a wider field of coverage and automated alarm generation.

- Integrated GPS Proximity Systems that allow machines and other vehicles to know each others location.
Longwall Safety - Proximity
Remote Control Dozer

- Reduces risk to operator
  - Stockpile Dozing
  - Cleaning up after a slide
  - Dozing material into tailings dam
  - UG – removing the operator from hazardous environment
  - Ripping
Machine Control and Guidance

- Loaders/Dozers/Drills & Draglines
- Utilizes High Precision GPS
  - Centimeter accuracy
- Provides operator with design in cab
  - Ore types and waste
  - Mined out area
  - Elevation of machine
  - Hole pattern
  - Spoil Pile management
- Real-time productivity updates
- Reduces dilution
- Results in smoother pit floors
- 25%+ Increase in dozer productivity
- Safety
  - Avoidance zones, Geo fences
Fleet Management Systems

- “Conductor” at the Mine
- Truck Assignment
- Automatic Reporting
  - Cycle times
  - Locations
  - Delays
  - Operators
- Safety
  - pre-operation check list
  - mayday capability
  - Messaging
  - Machine Awareness
- Significant productivity improvements
  - 10 –15% typical increase in productivity
  - 5%+ Payload Increase via Payload Management focus
  - 3%+ End shift/beginning shift production increase
Autonomy ...
Key components of an Autonomous Mining Machine

- **Drive by wire**
  - Ability to control machine digitally
- **Detect objects**
  - Rock, vehicle
- **Position**
  - Where am I?
  - What is my heading?
  - What is my speed?
- **Machine Health**
  - What is not right? Engine, Tire, Transmission
- **Safety**
  - Where are the other machines relative to me?
  - Where are the light vehicles?
- **Navigation**
  - Where do I need to go?
  - What is my path?
Value of Autonomy - Underground

- **Safety**
  - People removed from machine

- **Productivity and Utilization**
  - Machine can be controlled from surface
  - Improved machine utilization
  - Machine can be worked during shift change
  - Can start earlier after a blast
  - FASTER -- Runs in 2\textsuperscript{nd} gear vs. 1\textsuperscript{st} gear

- **Maintenance**
  - Less machine damage
Longwall Automation

- **PMC – Programmable Mining Controls**
  - Enhanced control of drives, roof supports and plow or shearsers

- **Plow System**
  - No plow operator required at longwall during automatic operation

- **Shearer – Focus on more semi-autonomous mode**
  - Operator as more of an observer
    - Less noise & dust
  - Dome Cameras – reduce need to walk the face
Prototype of Dome-Camera (Shield): FLP Housing
Value of Autonomous Drilling

- **Safety**
  - Operator not on machine
  - Driving over highwall

- **Consistency**
  - Hole location
  - Consistent hole elevation vs. hole depth

- **Increased productivity**
  - Automated control of drilling process
  - More consistent operation with new operators
Value Autonomous Haulage

- **Safety**
  - Barriers for people
  - Less climbing on and off machines
  - Consistent operation

- **Sustainability**
  - Less environmental footprint at mine

- **Increased productivity and utilization**
  - Virtual shift change
  - Truck does no take breaks

- **Ability to re-engineer mining processes**
Implementing Autonomy

- Autonomy is a lot more than removing the operator
- Provides an opportunity to significantly change processes
- Requires focus on Culture change management i.e. People
- Multi-year process to implement with many stakeholders
  - Mining company employees
  - Government Safety Authorities
  - Community
Conclusion

- Mining Technology has been evolving for over 20 years

- Significant step changes are occurring
  - Safety, Productivity and Utilization

- Semi Autonomous / Autonomy is a reality if not requirement
  - Underground LHD’s, Surface Trucks and Drills

- What's next …
Caterpillar and NASA partnership in developing multiple use technologies for use with Cat customers and NASA’s SEV (Space Exploration Vehicles).
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