Automation in the Mining Industry

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Definition: Automation

- Discipline to program & manipulate equipment
- Instrumentation, sensors, final-control-elements, control systems, network communication

Http://ssabh188.blogspot.com
Definition: Robot

A machine to make our lives easier

http://www.physiologytoday.com
Integrated Systems which emulate and enhance the human ability to:

- **Perceive**
  - **PERCEPTION** includes...
  - Sensor systems and recognition

- **Reason**
  - **REASONING** includes...
  - Artificial Intelligence Knowledge Systems

- **Act**
  - **ACTION** includes...
  - Control Systems Actuators

... and this includes the Human-Machine Interfaces required to operate these systems
Automatic Operation

Safeguarded and Monitored Tele-operation

Human Initiative

Mount Keith Mine
Automation in the Mining Industry

- Drilling operations
- Driverless haulage trucks
- Semi-automatic load haul dump truck (LHD)
  - onboard video systems front and back
- Environmental monitoring systems
  - Ground water monitoring
  - Waste water flow
  - ARD (acid rock drainage)
  - Temperatures
  - Ventilation
Mining Automation Application

Andina Mine (underground copper mine in Chile)

- Tele-robotic LHDs
- Improved safety
- One operator runs multiple vehicles
- Operator located outside mine

LHDs example: Caterpillar R2900G Load Haul Dump vehicle.
Autonomous Haulage Trucks

- Removal of workers from potential dangers
- Reduction of Green-House Gasses (GHGs)
- Reduced Maintenance Costs
- Improved Productivity
Autonomous Haulage Trucks

2005 – Komatsu: Codelco
Komatsu: Rio Tinto
Autonomous Haulage Trucks

2007 – Caterpillar: BHP-Billiton

- Expand the Mt. Keith open pit
- Fully-automate the Olympic Dam open-pit
History

2010 – Opportunity of new projects

- Drilling

2009 – Caterpillar: BHP-Billiton

- Hauling
- Digging

Komatsu’s FrontRunner (AHT)

Autonomous-capable Reedrill drill rigs

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History

First Approach (Moon-Shot)

Autonomy
Tele-autonomy

Robot Initiative
History

New approach – Baby Steps

1 – Manual
2 – Computer Cruise Control
3 – Tele Remote
4 – Tele Remote
5 – Sensors for Safety
6 – Sensors for Safety
7 – Fully Autonomous
Autonomous Haulage System Elements
Autonomous Truck Sub-systems

- Communication Equipment
- Breaker Controller
- Acceleration Controller
- Radar Sensor
- Vehicle Speed Controller
- Obstacle Detector
- Front Wheel Steering Angle Sensor
Key Performance Indicators (KPIs)
Key Performance Indicators (KPIs)
Balanced Scorecard

- FINANCIAL
- CUSTOMER
- ENVIRONMENT/COMMUNITY
- INTERNAL
- EMPLOYEE SATISFACTION
- LEARNING AND GROWTH
Key Performance Indicators (KPIs)

- KPIs give “before” & “after” pictures
- KPI’s assist with decision-making
- Goals are easier to measure/monitor
Implementation

Manual

Robotic

KPI (core)

0  % AHT  100

KPI (core)

?
Implementation Challenges

Challenges:
- Management decisions and strategies
- Workplace changes
- Cultural barriers and union beliefs

Possible Solutions:
- Long–term vision and commitment
- Provide training to avoid sabotage
- Regular and consistent communication
- Avoid Labour Replacement as an objective
Ethical Considerations of Automation

- If an automated machine kills a person, who is responsible?
  
The manufacture? CEO? Mine Supervisor?

- Ensure legal and insurance systems are engaged in developing laws governing automated machines.
Simulate how variability of driver performance together with driver replacement by sensors and control affect mine performance
Simulation of AHT

- Deterministic / Probabilistic Simulation
- Focus on Production

Vale INCO - Brazil
Modelling Approach

- Shovel/ Manual Truck model
- Shovel/Autonomous Truck model
Simulation of Manual Trucks

Road Condition  Tire wear  Fuel System

Control System

Limited to Driver’s Performance
Simulation of AHT (sub-systems)

- Sensors
- Telecom
- Control Systems
- Fuel System
- Tire Wear

- Localization
- Centralized System
- Navigation
- Intervehicle Location
- Obstacle Avoidance
- Human Presence

Design of an Autonomous Haulage System
Driver Performance

Max. Speed
Acceleration/Deceleration
Steering and Direction

Cycle Time
Fuel Consumption
Tire Wear
Road Wear
The model will output Benchmarking KPIs:

- Productivity
- Safety
- Breakdowns
- Cycle times
- Maintenance and labour costs
Key Performance Indicators - Targets

- **AHS** +30% Manual
- **AHS** -7% Manual
- **AHS** -10% Manual
- **AHS** +8% Manual
- **AHS** -12% Manual

Investment cost per truck
Truck haulage speeds
Fuel consumption
Mechanical Availability
Tire Wear
Key Performance Indicators - Targets

- AHS: +5%
- Manual: Increased Productivity (+12%)
- Manual: Maintenance costs (-14%)
- Manual: Increased Truck life (+12%)
- Manual: Labour costs (-5%)
- Manual: Increased Production (-40%)
Conclusions

- AHT improves safety, productivity, and maintenance
- The future of AHT in mining looks bright – implementation should be considered a priority to remain competitive and ensure a safe and effective operation
- Simulation bias must be avoided
- Simulation can be used in real time to evaluate changes