Operational Excellence on the plant floor and in the control room:

*A disciplined approach to understanding the opportunities to maximise the performance of your assets through the use of instrumentation and control.*
Outline

- On average, instrumentation and control will be between 1 and 2% of the total project cost (Automation Research Corporation, 2012)

- I&C Optimization contributes over 5-10% of the plant’s throughput and over 2% of its recovery

- Their importance continues to increase with current trends in the industry

- Use examples from mineral processing plants across the world to illustrate the impact of I&C Optimisation on energy efficiency in comminution
Our company

- Focused in Plant Intelligence for the Mining/Mineral Processing Industry
- HQ in Toronto Canada
- Currently with operations in Canada, Mexico and Chile, South Africa
- Founded by Engineers with extensive experience in technology solutions for the Metals and Mining industry.
Comminution consumes up to 80% of plant’s energy requirements!

Flotation recovers valuable minerals from ore.

Efficient flotation operation has a **direct impact** on specific power consumption per unit of metal produced.
The Challenge – the Opportunity

- Variable Ore Types
- Complex Processes
- Fewer Experienced Operators
- Competitive Market
- Dispersed Operations
How do we deal with the challenges?

Today

- Geometallurgy
- Technology
- Instrumentation and control
What is next?

We can design considering variability

We can install more robust and cost effective equipment

We know it can handle the ore **but** how to we manage the process?
Operators

Operators are often compared to commercial pilots. They both:

- Are responsible for safe operation, with potentially huge ramifications of mistakes
- Rely on engineers for robust, reliable design
- Rely on maintenance personnel to keep equipment operational

And are both the Last Line of Defense – for any problem

How similar is the cockpit to an operator console?
Operators

- A commercial airplane cockpit can have over 100 controls
- An operator can have over 300 controls (loops, motors)

So, an operator’s job is actually equivalent to a single pilot operating three planes at the same time!
The Potential

![Graph showing potential control improve over time](image)

- **Safety Margin**
- **PV**
- **Old Setpoint**
- **New Setpoint**
- **Constraint**
- **Poor Control**
- **Improved Control**

*Opportunity*
Where is the Opportunity?

June 25, 2013

[Graph showing data with timelines and labels for Pressure, Power, and Mill Feed/Water Addition]
Where is the Opportunity?

SAG Mill #1 Control (Noon-Midnight)

Tonnage
Bearin Pressure

0 100 200 300 400 500 600

27-Aug-14 12:00:00 27-Aug-14 13:12:00 27-Aug-14 14:24:00 27-Aug-14 15:36:00 27-Aug-14 16:48:00 27-Aug-14 18:00:00 27-Aug-14 19:12:00 27-Aug-14 20:24:00 27-Aug-14 21:36:00 27-Aug-14 22:48:00 28-Aug-14 00:00:00

4150 4100 4050 4000 3950 3900 3850 3800 3750 3700 3650

Portage Technologies
How can WE Capitalise on the Opportunity

- Recognise that each site and each mineral is unique.
- Create a **site** best operating practise, leveraging global benchmarking which is customised to reflect the reality on the ground.
- Automate the best practise.
Our Philosophy

A plant can only Manage what is Measured and can only Optimise what is Controlled.
The Progressive Control Hierarchy

- Process
Stockpile

Dust Control

PT FT

Dust Control

Expert Coarse/Fine Ratio

SAG Pressure

APC 01

IT 01

LIT 01

Feed Size Target

SAG Power/Amps

FEEDER'S Size Classification

Total Feed Size Dist.

FEEDER'S Size Classification

APC 01

Fuzzy

Optimized

Base line

Rock Size Camera

Belt Scale Element

Level Transmitter

Multiplier

Weight Controller

Advanced Process Control

To SAG Mill

SE 4105

41-509

Feeder-01

SE 4106

41-510

Feeder-02

SE 4107

41-511

Feeder-03

XA 01

XA 02

XA 03

XA 04

APC 02

MPC

REL_1

REL_2

REL_3

WT 4103

IT 4103A

IT 4103B

SP (From APC-02)
Results and Discussion
Managing Change in Ore Type
Cyclones define the circulating load in the comminution circuit and ensure that liberated material is passed downstream.

Inefficient operation leads to lost recovery, grade, capacity and reduced throughput.

For such an impactful unit, cyclones have historically been under-instrumented.
PCD mounts on the OF and UF

Detects Roping and Plugging

- Within 5 seconds of the incident
- Manual switch within 45 seconds
- Auto switch within 10 seconds
- Versus typical response of 10 – 20 minutes

Next version working on detecting wear

Typical plugging or roping event sends between 15 and 30 m$^3$ of coarse to flotation!
Cyclone 3- Roping

No spike observed in sensor reading
Cyclone 2-1

Plugged cyclone

Cyclone 2-2

Plugged cyclone
Cyclone feed pumpboxes frequently run using “traditional” level control where pump speed is adjusted to keep level in the box at a fixed level. Ultimately leads to a continuous variability in cyclone feed flow, pressure, and cut-point. PARC PPC Control strategy was leveraged to use the pumpbox as a source of absorbing variance rather than passing it on.
Results
Results

- 7% increase in throughput
- Grind Variability reduced by 80%
SAG Vibration

- Sensors are mounted on the bearings AND in three rings ON the SAG shell
  - Inlet
  - Middle
  - Discharge

- More direct measurement than sound
  - Loading
  - Pooling
  - Steel Charge?
Trunnion Bearing Sensor vs. Process Data
Load Detection (Loading Mill) – 90 second lead

Load change detected
Discharge Pressure @ 12:49:27

Load change detected
Vibration @ 12:48:43
Progressive Control Solution
Developing a Strategy

Measure

Manage

Optimise
Advanced Regulatory Control.

- Create a model of the process using the process.
- Invert the model to build a controller.
- FMPC
- PFS
- PPC
Progressive Control System
Multidimensional Integration

SAG mill operation with progressive control integration
Results - Energy Savings

The example below shows the energy savings observed at a BC Copper Mine after Advanced Control Implementation:

<table>
<thead>
<tr>
<th>Project Gains</th>
<th>Mean Before</th>
<th>Mean After</th>
<th>Change</th>
<th>Δ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughput t/h</td>
<td>1,440</td>
<td>1,499</td>
<td>59</td>
<td>4.1%</td>
</tr>
<tr>
<td>Recovery (%)</td>
<td>83.26</td>
<td>84.15</td>
<td>0.89</td>
<td>1.1%</td>
</tr>
<tr>
<td>kWh/t</td>
<td>8.75</td>
<td>8.33</td>
<td>-0.42</td>
<td>-4.8%</td>
</tr>
<tr>
<td>kWh/lb Cu</td>
<td>1.37</td>
<td>1.29</td>
<td>-0.08</td>
<td>-5.8%</td>
</tr>
</tbody>
</table>

6.8 Million kWh energy savings annually (equivalent to 4,700 tonnes of CO₂ emissions reduction)

$340,000/year savings in energy (at 5 cents per kWh)

$9.3 Million/year added revenue from increased throughput and Copper Recovery
## Results - Energy Savings

### Benefits of Advanced Control at a plant in Mexico:

<table>
<thead>
<tr>
<th>Period</th>
<th>Visit</th>
<th>Dates</th>
<th>Average Throughput (t/h)</th>
<th>Average SAG Power (kW)</th>
<th>Average BM Power (kW)</th>
<th>Average SAG + BM Power (kW)</th>
<th>Power Consumption (kWh/t)</th>
<th>SAG Power Consumption (kWh/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>First Visit</td>
<td>4-Mar to 23-Mar</td>
<td>272.7</td>
<td>3326</td>
<td></td>
<td>7642</td>
<td>12.2</td>
<td></td>
</tr>
<tr>
<td>Period 3</td>
<td>Towards the end of the visit</td>
<td>24-Sep to 29-Sep</td>
<td>286.3</td>
<td>3400</td>
<td>4491</td>
<td>7890</td>
<td>27.6</td>
<td>11.9</td>
</tr>
<tr>
<td>Δ Period 3 - Before</td>
<td></td>
<td></td>
<td></td>
<td>▲ 5.0%</td>
<td>▼ -4.3%</td>
<td></td>
<td>▼ -8.8%</td>
<td></td>
</tr>
</tbody>
</table>
Summary

- Variability is our reality and our challenge.
- We can only Manage what we Measure and can only Optimise what we Control.
- Data
- People
- Technology as the facilitator
- 5-10% throughput, 1-3% recovery
- 6-8% reduction in specific energy consumption