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Real Mining. Real People. Real Difference.

Longwall Automation: Ambition Across the Years and the Hemispheres

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ANGLO AMERICAN COAL

&

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JOY GLOBAL INC.

LONGWALL USA 2015
Pittsburgh, PA

In the beginning…There was R.O.L.F

R.O.L.F: Remotely Operated Longwall Face

- Proof of concept in 1959
- UK National Coal Board attempt to “Realize the Dream” of Longwall Automation
- Media reports technology triumph
- Royal commissioning ceremony

ROLF was unsuccessful due to availability and maturity of technology

55+ years later… We are yet to “Realize the Dream”

Technology improved, but individual focused development resulted:

- Powered Roof Support (PRS) electronic controls
- Shearer technology
  - Data communication on power cable
  - Automated cutting and tramming
- Armored Face Conveyor (AFC) control
  - Motor load sharing
  - Chain tension management

Safety, productivity and cost have improved,
but fully automated face is still a vision

A new field offers insight: Process Control Engineering

It sounds difficult …But Its not:

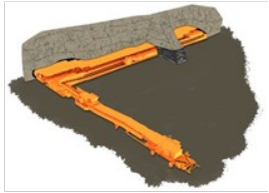
- Generate a detailed PROCESS MAP (Example Bi-Directional Cutting)
- Do a GAP ANALYSIS … What can be done versus need to be done
- Make a plan of how to “Fill the Gaps” (Technology or Policy)
- Development of “Known” solutions
- Research tasks where reliable solution are not available
- Implement solutions based on Cost/Benefit, Complexity and Risk
- Evaluate performance
- Continue efforts until success is achieved

The best solutions are simple and reliable

LONGWALL MINE OF THE FUTURE AUTOMATION JOURNEY PLAN

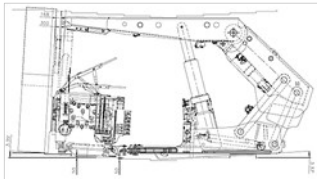
Moranbah North

Grosvenor



2014
UNI-DI Operation
Simple Automation

UNI-DI Cutting
FaceBoss ASA & RS20s
Face alignment
850mm web depth
Smart Services



2015
BI-DI Operation
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Smart Services
850 web depth
BI-DI Cutting
Integrated Automation
Automated Face Straightening
Collision avoidant configuration

5 Operators on the Face
Face Operation

2016
Remote Monitoring and
Advanced Automation

Smart Services
BI-DI from ROC
1000mm web depth
Improved Face illumination
Improved Dust Control
Shearer & Area cameras
High Speed Digital Communications

2 Operators on the Face plus MG personnel for
Remote Monitoring and Operation from MG roadway

2017
Remote Operation with
Fully Automated System

Smart Services
AFC/BSL VFD Control or 11kV?
Enhanced cameras

2018
Remote Supervision
Semi Autonomous Operation

Smart Services
Spatial Awareness
Seam Positioning
Remote Mining

0 Operators on the Face
Remote Operation and
Supervision from MG
roadway

ROM Coal (MNM & Grosvenor)

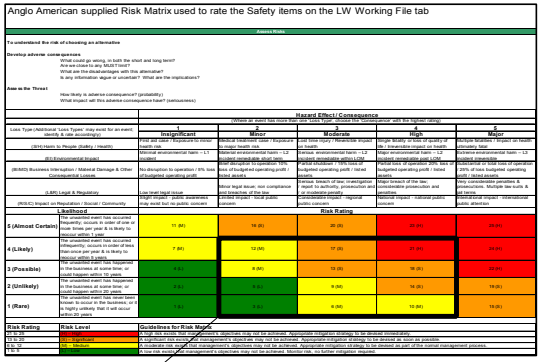
167%

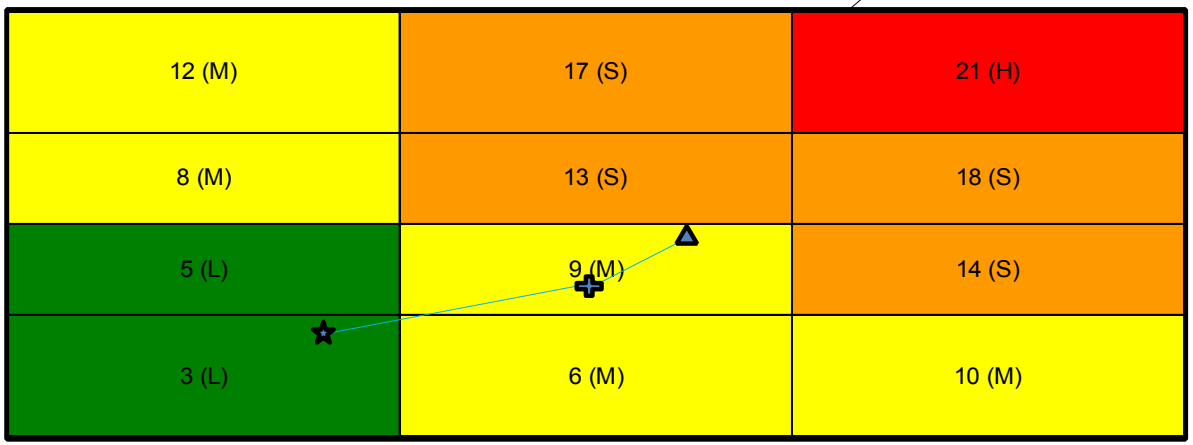
100%

Focused on safety, Reducing risk

Impact of 103 Safety Items Identified
Grosvenor Peer Review Process

- Original 1750t MNM Equipment Matrix Rating
- Grosvenor Equipment Matrix Rating
- Grosvenor Equipment Operated via ROC Matrix Rating


Anglo American supplied Risk Matrix used to rate the Safety items on the LW Working File tab



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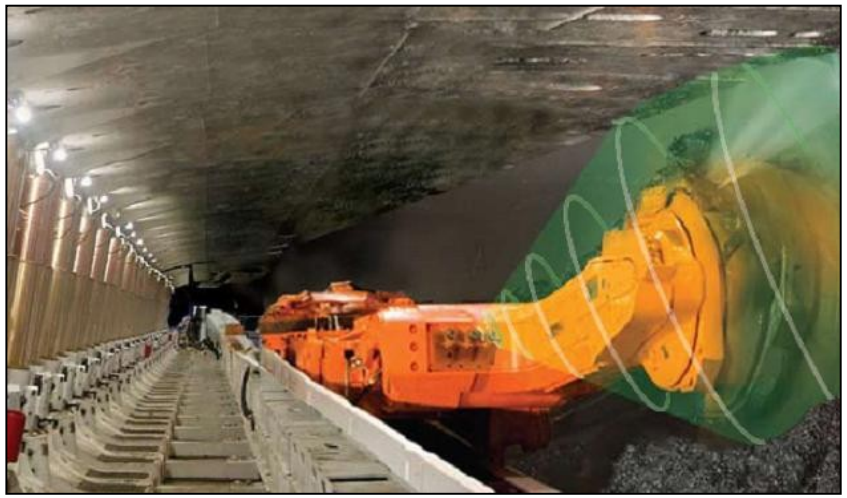
Partnership Journey: Remote Operation Center

What is Longwall Automation?

Definition of Automation:

- Equipment repetitively performing consistent sequences of required tasks without human intervention.

The Vision



Autonomous Operation

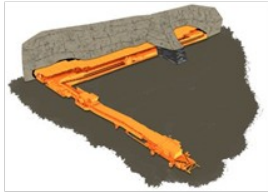
The Reality

Remote Operation

Longwall Mine Of The Future Journey Plan

Benchmark Performance with Drive to Zero Harm

Moranbah North — **Grosvenor**



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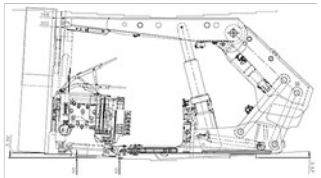

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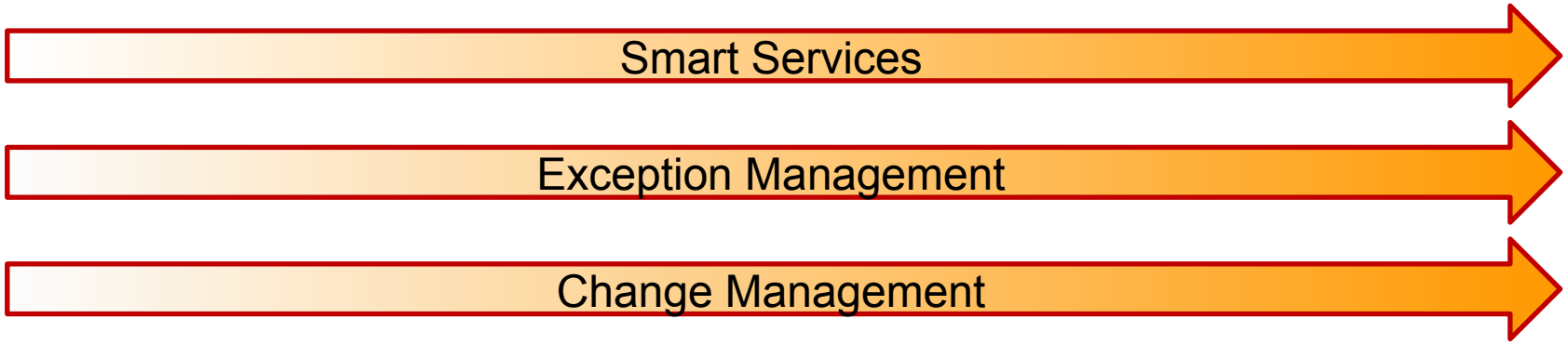
Migration to Remote Operation – Journey Plan

Phases	1: Face Operation	2: Face Monitoring	3: Remote Monitoring	4: Remote Operation
Face Operation	5	3	2	0
Remote Operation	1	1	2	2
Controls & Automation	Base Automation	Advanced product automation and features	Integrated system with Remote Operational Center (ROC) for monitoring	Remote operation from ROC

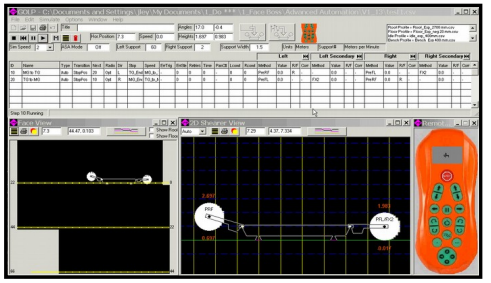


Migration to Remote Operation – Phase 1 & 2 Highlights

Advanced Shearer Automation – Realize Value

- Fully automate run of face cutting sequences & gate end turnarounds
- Consistent operation – cut heights, haulage speeds, cut sequence

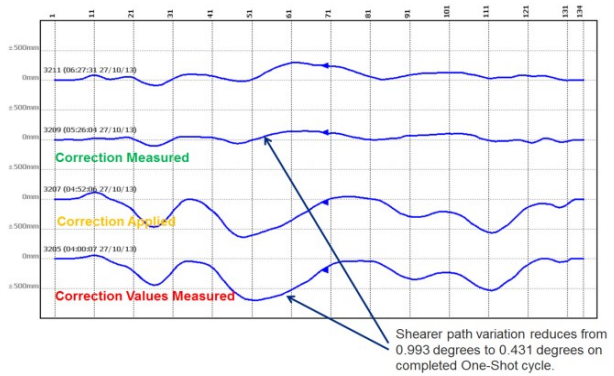
Consistent use of Automation improved productivity – up to 12%

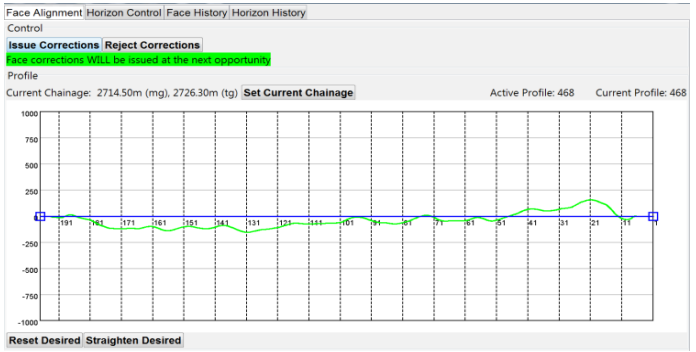


ASA Offline Planning System

Face Alignment – Optimize Productivity, Reduce Downtime

- Implement automated face alignment
  - Reduce pass to pass cycle times



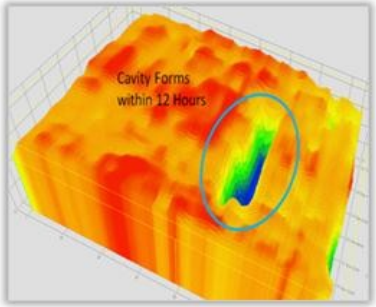


Rate improvement by utilizing Automated vs Manual face alignment – up to 8%

Migration to Remote Operation – Phase 3 & 4 Highlights

Environmental Awareness – Consistent Automation

- System anti-collision
- Cavity detection
- Coal face visualization



Consistent environmental awareness improved stability & hours – up to 9%

Remote Monitoring – Reduced Exposure

- Individual displays for remote system monitoring & operation
- Fully integrated communication

Minimize exposure: Zero Harm

“Realize the Dream” of Remote Operation is attainable

Migrate to Remote Operation from the ROC

General Discussion
Close