



Advances in LW Automation

Eric K. Anderson - General Manager

Robert Colaw - LW Maint. Coordinator

Kyle Faykus - Automation Engineer



Where is Tunnel Ridge?

Alliance Resource Partners, L.P. Coal Operations



1. HAMILTON COMPLEX
Mine No. 1
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Longwall & Continuous Miner
Coal Type: High Sulfur
Transportation: Railroad, Truck, & Barge

2. RIVER VIEW COMPLEX
River View Mine
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Continuous Miner
Coal Type: High Sulfur
Transportation: Barge

3. DOTIKI COMPLEX
Dotiki Mine
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Continuous Miner
Coal Type: High Sulfur
Transportation: Railroad, Truck, & Barge

4. GIBSON COMPLEX
a. Gibson South Mine
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Continuous Miner
Coal Type: Medium Sulfur
Transportation: Railroad, Truck, & Barge

b. Gibson North Mine (Idled)
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Continuous Miner
Coal Type: Medium Sulfur
Transportation: Railroad, Truck, & Barge

5. WARRIOR COMPLEX
Warrior Mine
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Continuous Miner
Coal Type: High Sulfur
Transportation: Railroad, Truck, & Barge

6. PATTIKI RESERVES
Mining Type: Underground
Mining Access: Shaft
Mining Method: Continuous Miner
Coal Type: High Sulfur
Transportation: Railroad & Barge

7. HENDERSON/UNION RESERVES
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Continuous Miner
Coal Type: High Sulfur
Transportation: Railroad & Barge

8. SEBREE RESERVES
Onton Mine (Idled)
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Continuous Miner
Coal Type: High Sulfur
Transportation: Barge & Truck

9. HOPKINS RESERVES
Mining Type: Underground & Surface
Mining Access: Slope, Shaft & Pit
Mining Method: Cont. Miner & Truck/Shovel
Coal Type: High Sulfur
Transportation: Railroad, Truck, & Barge

10. MC MINING COMPLEX
Excel No. 4 Mine
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Continuous Miner
Coal Type: Low Sulfur
Transportation: Railroad, Truck, & Barge

11. TUNNEL RIDGE COMPLEX
Tunnel Ridge Mine
Mining Type: Underground
Mining Access: Slope & Shaft
Mining Method: Longwall & Continuous Miner
Coal Type: High Sulfur
Transportation: Railroad & Barge

12. METTIKI COMPLEX
Mountain View Mine
Mining Type: Underground
Mining Access: Slope
Mining Method: Longwall & Continuous Miner
Coal Type: Medium Sulfur - Metallurgical
Transportation: Railroad & Truck

13. MOUNT VERNON TRANSFER TERMINAL
Rail or Truck to Ohio River Barge Transloading Facility

○ CURRENT OPERATIONS
△ TRANSFER TERMINAL
□ RESERVES



Tunnel Ridge Operations Summary

- 9400 Acres of Coal
 - Ohio County, WV and Washington County, PA
- 25+ Year Reserve Life
- 1 Longwall, 3 CM Development Units
- Mining Heights – 78-92”
- Production – 6.6 Million Tons – 2016, 7.0 Million Tons Estimated for 2017
- 426 Current Employees
- Prep Plant – 2000 TPH, Heavy Media
- River Loadout – 5000 TPH Capacity, MP82.3 Ohio River



Tunnel Ridge Longwall Overview

- Standard Width = 1200'
- Typical Length = 15,000'-20,000'
- High Voltage Longwall Face
- BiDi Mining Method
- Utilizing Remote Mining Operations.



Tunnel Ridge Longwall Equipment

- JOY 7LS-1A Shearer
- PSS 1020-ton, 2-leg Shields 1.75m
- JOY BSL, CMT, and AFC Drives (3x1200hp)
- LWA Panline, 48mm Thiele chain
- CAT PMC-R Shield Electrics
- Line Power Power System
- Kamat Emulsion Pumps
- Alliance Longwall Command Centers.



Why Automation?

- Health & Safety
 - MSHA Respirable Dust Regulation – February 2016
 - Reduce Manpower Exposure
- Operational Efficiency
 - Reduced Operator Fatigue
 - Increased Efficiency & System Utilization
 - Increased Tons per Man Hour.



Shield Electrics

- Caterpillar PMC-R
 - Installed May 2015
 - Immediate Results in Functionality, Troubleshooting, Automation.



CAT PMC-R Integrated Lighting

- Yellow Light w/ Audible Warning
 - Conveyor Start Pre-Warning
 - Conveyor Overload Warning
 - AFC Load Percentage Visible



CAT PMC-R Integrated Lighting

- Red Light w/ Audible Warning
 - Warning of Automated (Blinking) and Manual Shield Movement
 - Push Status of Stageloader



CAT PMC-R Integrated Lighting

- Green Light
 - Indication for Locked Out Shield



CAT PMC-R Integrated Lighting

- Blue Light
 - Indication of Status Information Available on PMC-R Screen



CAT PMC-R Shield Electrics

- Full Shearer Initiated Automation
 - Run of Face
 - Gate End Turn-a-Rounds
 - Wedge Cuts
 - Bank Push
 - Batch Advance.

Joy 7LS-1A Features

- Pitch/Roll Sensor, Arm Inclinometers, Haulage Encoders, Cowl Encoders
- Primary Fiber and Secondary Ethernet Communications
- ASA (Advanced Shearer Automation)
 - FX2, Recorded Roof, Recorded Floor, Automated Cowl Positioning, Automated Haulage Speeds
- Upgraded Hydraulic Pumps & Cowl Gearing
- AFC Load Monitoring, Speed Zones.



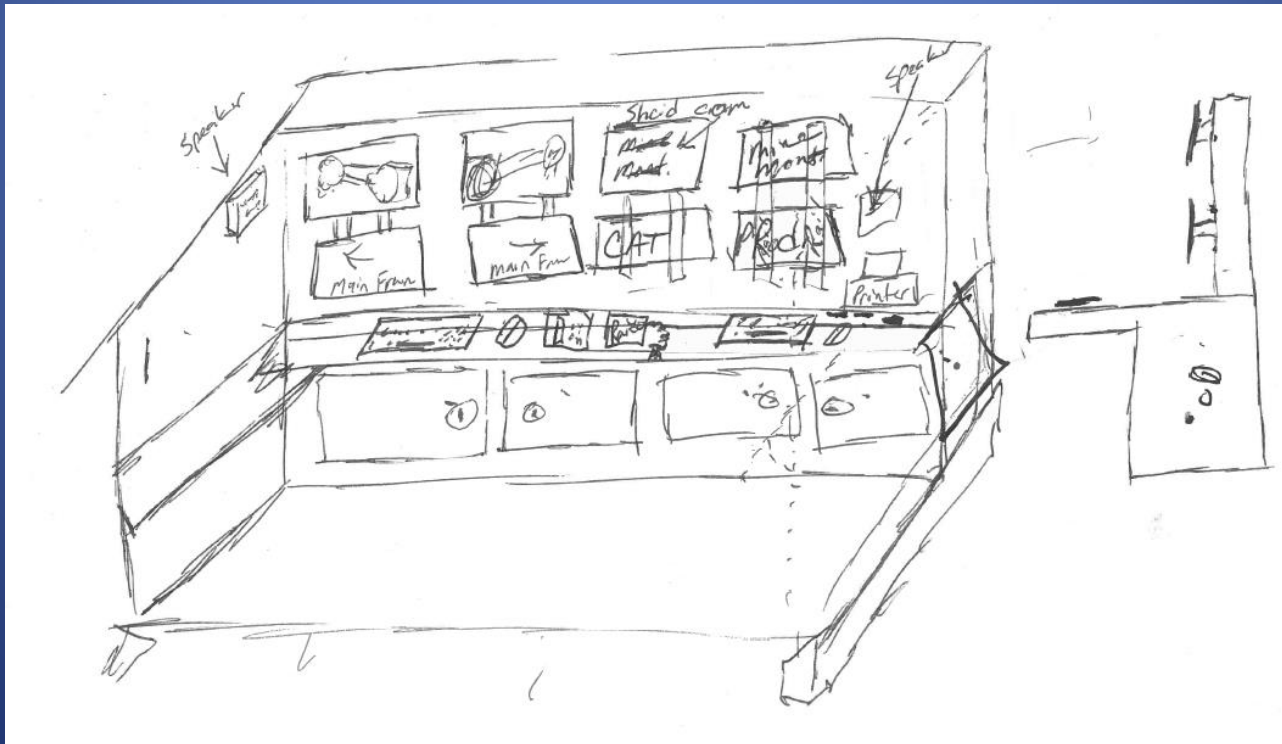
Joy 7LS-1A Features

- Gate End Programmed Stops
 - Fixed Point at HG
 - Variable Point at TG – Based off DCM Position
- Video/Sound
 - Microphone Inside Shearer
 - 8 Cameras, 2 Lights on Shearer
 - In-House Development of Housings, Sprays, and Locations
- Remote Operation.



Longwall Command Center

- Patent Pending Design
- Initial Concept Designed In-House



Longwall Command Center

- Features
 - Positive Pressure, Climate Controlled Enclosure
 - Phone and Radio Communication
 - JOY Display
 - Shear, Drive Information
 - CAT Display
 - Real Time display of Shield Health & Automation
 - Mine Monitor Display
 - Real Time display of Complete Mine Status
 - Camera Display
 - Real Time view of all 12 Cameras & Sound
 - Longwall Graph
 - Real Time 3-D Visual representation of the LW Face
 - Foreman Computer
 - Production & Maintenance Logs/Reports.



Longwall Command Center



Longwall Command Center



Longwall Control Room











JOY Diagnostics

- Remote Monitoring through JOY Citect Software
 - AFC Status
 - TTT Couplings
 - Fill/Drain, Temperatures, Coupling Speeds
 - Solenoid States
 - DCM (Dynamic Chain Management)
 - Real Time Managed Chain Tension, Target/Stroke
 - Solenoid States
 - Alarm History.



JOY Conveyor Screen

Face Conveyor Data

Mode Selector	AFC OVERVIEW	M/G EP	M/G BP	T/G BP	
Auto	Motor Voltage	3930	3930	3903	Volts
AFC Condition HEALTHY	Motor Current	70	71	76	Amps
AFC Run	Motor Power	476	483	513	kW
Normal Run	Coupling Speed	860	1724	1725	rpm
Hard Start	Up To Speed	<div style="width: 100%; height: 10px; background-color: black;"></div>	<div style="width: 100%; height: 10px; background-color: green;"></div>	<div style="width: 100%; height: 10px; background-color: green;"></div>	
Enabled <input type="checkbox"/>	Pitot Tube [CW] [CCW]	<div style="width: 50%; height: 10px; background-color: green;"></div> <div style="width: 50%; height: 10px; background-color: black;"></div>	<div style="width: 50%; height: 10px; background-color: green;"></div> <div style="width: 50%; height: 10px; background-color: black;"></div>	<div style="width: 50%; height: 10px; background-color: green;"></div> <div style="width: 50%; height: 10px; background-color: black;"></div>	
Active <input type="checkbox"/>	Run Command	<div style="width: 100%; height: 10px; background-color: green;"></div>	<div style="width: 100%; height: 10px; background-color: green;"></div>	<div style="width: 100%; height: 10px; background-color: green;"></div>	
Active Control	Loop Temperature	44	41	43	°C
Enabled <input type="checkbox"/>	Imbalance Control	<div style="width: 100%; height: 10px; background-color: green;"></div>	<div style="width: 100%; height: 10px; background-color: green;"></div>	<div style="width: 100%; height: 10px; background-color: gray;"></div>	
	Coupling Inlet Water Flow	-1	0	0	L/Min
	Coupling Inlet Water Pressure	41	32	33	Bar
	Cooling Water Flow	54	66	57	L/Min
	Cooling Water Pressure	36	12	30	Bar
	Pivoting Tensioner	<div style="width: 100%; height: 10px; background-color: gray;"></div>	<div style="width: 100%; height: 10px; background-color: green;"></div>	<div style="width: 100%; height: 10px; background-color: green;"></div>	

SOLENOID INFORMATION Legend

	FILL	DRAIN	WATER
T/G BP	<input type="radio"/> O <input type="radio"/> P	<input type="radio"/> O <input type="radio"/> P	<input type="radio"/> O <input type="radio"/> P
M/G BP	<input type="radio"/> O <input type="radio"/> P	<input type="radio"/> O <input type="radio"/> P	<input type="radio"/> O <input type="radio"/> P
M/G EP	<input type="radio"/> O <input type="radio"/> P	<input type="radio"/> O <input type="radio"/> P	<input type="radio"/> O <input type="radio"/> P

Alarm Reset

Comms Overview

Shearer .@ 63

Conveyor









System Services

Sub Menu

<<

>>

JOY DCM Screen

AFC DCM OVERVIEW

Incoming Pressure	281	Bar						
Dynamic Tension [Set] Actual	[2.5] 3.3	T/Chain						
Dynamic Tension Timer	7	sec						
Position [Target] Actual	[106] 111	mm						
Min/Max Position	0 / 0	mm						
Tailgate Motor Load	76 / 512	A / kW						
Maingate EP Motor Load	72 / 490	A / kW						
Maingate BP Motor Load	73 / 496	A / kW						
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 33%;">Status</th> <th style="width: 33%;">DCM Run</th> <th style="width: 33%;">DCM Selector</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; color: green;">Healthy</td> <td style="text-align: center;">Normal Run</td> <td style="text-align: center; color: green;">Auto</td> </tr> </tbody> </table>			Status	DCM Run	DCM Selector	Healthy	Normal Run	Auto
Status	DCM Run	DCM Selector						
Healthy	Normal Run	Auto						
Cylinder Pressure	5	Bar						
Sag Switch Timer	0	sec						
Sag Switch Count (FS/WS)	0 / 0							

DCM Alarms

No Retract Detected
(Sol energised & ram did not move)

Run Command Signals

Comm


Selected Drives
Average Load (Amps / kW)


71 / 488


Chain Maintenance
Reset

YES

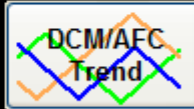
Tension Solenoids

Decrease


Increase




DCM Trend



DCM/AFC Trend

Set Points

Comms Overview

Shearer @ 65

Conveyor

System Services

Sub Menu

<<


>>

Shearer Diagnostics

- Automation Status
 - Remote Operation Screen
 - Pitch and Roll of Machine
 - Drum Pick Height
 - Speed
 - Location (Shield)
 - Left/Right Pump & Cutter Status
 - Remote Configuration
 - ASA Sequence Information.



JOY Remote Operation Screen



Status

Remote Operation


ASA Operator

Automation
Remote Operation

Profiles

Face Parameters

ASA Nominal Pitch




65.0 ft/min
←
42.3 ft/min

Radios

	Left	Right
Local	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Remote	<input type="checkbox"/>	<input checked="" type="checkbox"/>

- Left Pump
- Right Pump
- Left Cutter
- Right Cutter



↑

↓

84 in

52.53

Support #

Pitch ↑

-0.52 Degrees

Prev. Pitch -2.62 Degrees

Roll ↑

0.26 Degrees

Pan Control

OFF

Left Drum

Pitch Correction	Target	Actual	Target	Actual	Target
1	81	79	-1	-0	-0
(in)	Top Picks		Bottom Picks		(in)

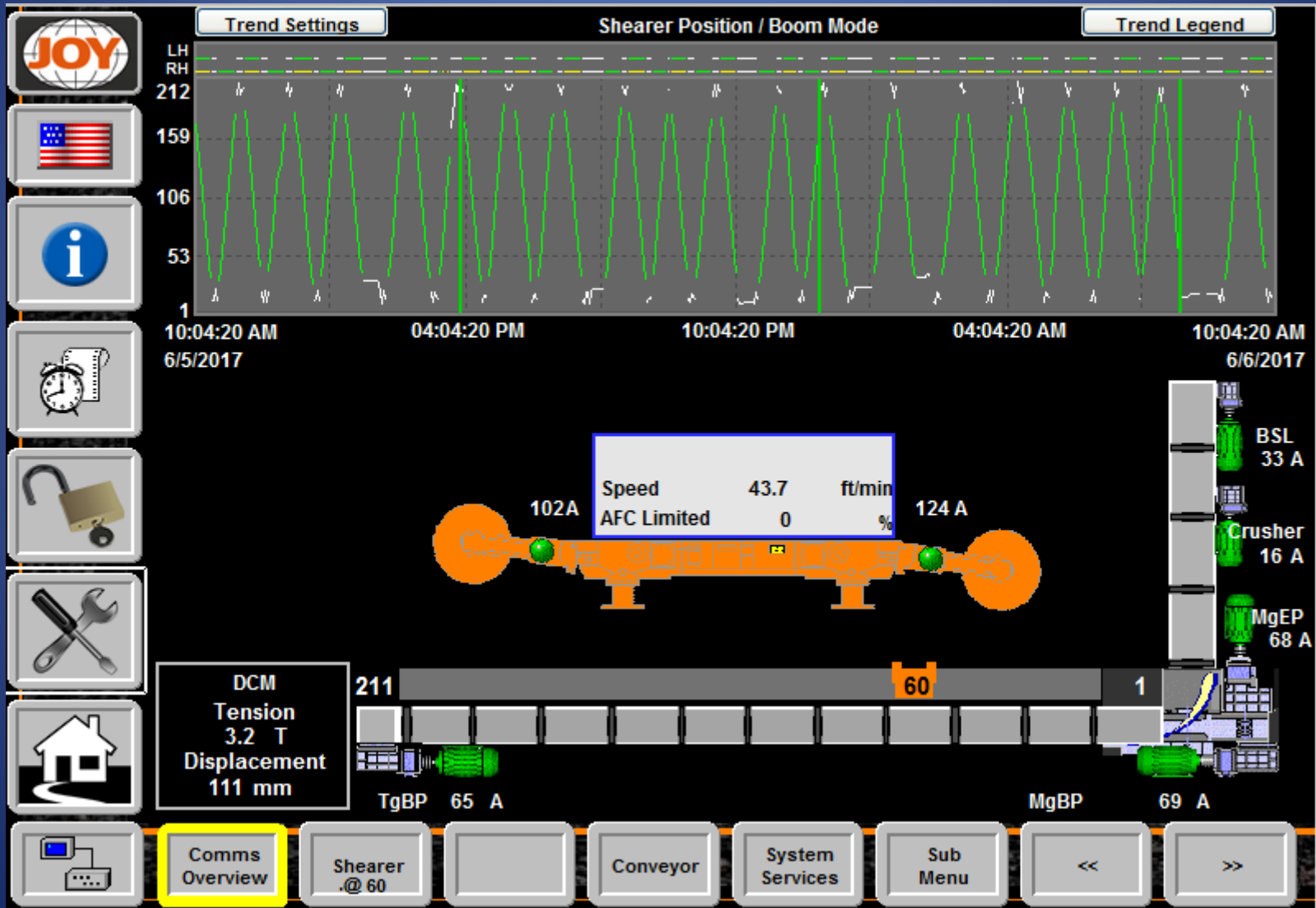
Right Drum

Pitch Correction	Target	Actual	Target	Actual	Target
2	-1	-0	81	79	-0
(in)	Top Picks		Bottom Picks		(in)

Sequence Step #	Sequence Step Name
10	Run of Face to TG

Transition To Next Step	End Position
Machine Position	205.8

JOY Home Screen

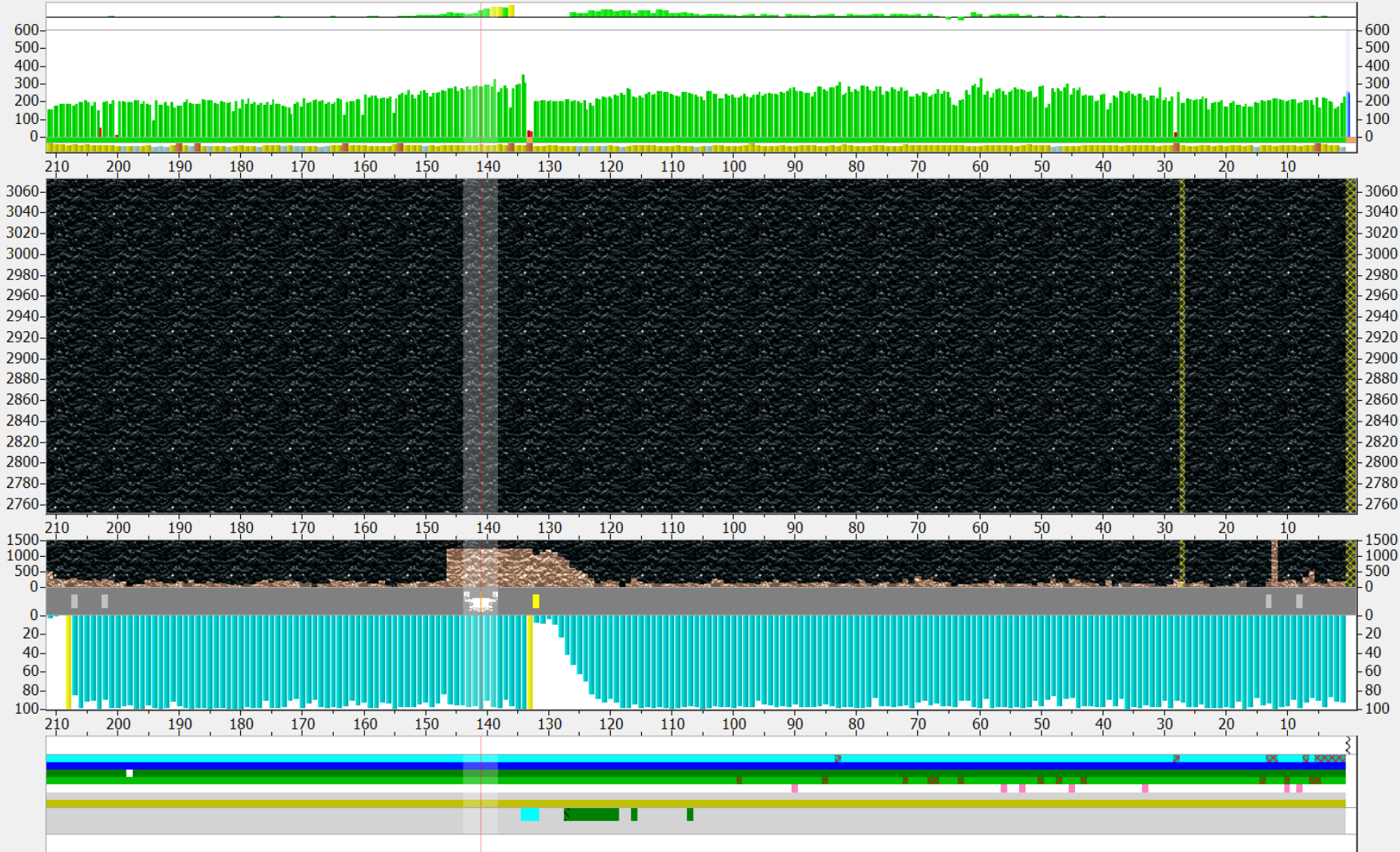


CAT VCU Screen



141.0

<==



Mine Monitor

- Alarm and Status Information
 - Power Cars, Emulsion Pumps, Roto-Jet Pumps
 - Emulsion Supply, Water Supply
 - Underground and Overland Belts
 - Longwall Communications Networks
 - Longwall Methane Monitor Status
 - Mine Wide CO Monitoring
- Operators relay fault information to maintenance personnel for accurate and quick troubleshooting.



A PC INCOMING: 11993 V

A PC T1 SEC: 3911 V

B PC INCOMING: 11958 V

B PC T1 SEC: 3950 V

HG INCOMING: 569 V

SHEARER LOCATION: 47

MOTOR	STATUS	CURRENT
SHEARER (APC)	RUNNING	187 A
CRUSHER (APC)	RUNNING	16 A
S LOADER (BPC)	RUNNING	33 A
TFC (APC)	RUNNING	61 A
HFC #1 (BPC)	RUNNING	62 A
HFC #2 (BPC)	RUNNING	62 A

SEQUENCE ALL MOTORS	BELT RUNNING
APC CONVEYOR FORWARD	BPC CONVEYOR FORWARD
CONTROL AT HEADGATE	SHEARER CONTROL @ LCC
FACE LOCKOUT OK	CRUSHER REMOTE SW ON
FACE LO INTERLOCK	MM/ES INTERLOCK
CH4 < 1% AT TG	METH MONITOR OK
CH4 < 1% AT SHEARER	DUMP VALVE ENERGIZED

VFD	LAG	STATUS	SPEED	EMUL PUMPS CONTROL AT HEADGATE	
PUMP #1	LAG 1	LOADED	48 %	BOOST PUMP	RUNNING
PUMP #2	LAG 3	LOADED	48 %	BOOST PRESSURE: 32	BOOST SETPOINT: 5
PUMP #3	LEAD	LOADED	49 %	PUMP PRESSURE: 4404	PUMP SETPOINT: 4400
PUMP #4	LAG 2	LOADED	49 %	ROTO-JET PRESS: 700	ROTO-JET SETPOINT: 700
ROTO JET PUMP #1		RUNNING	87 %	EMULSION LEVEL: 74 %	WATER TANK LEVEL: 82 %
ROTO JET PUMP #2		RUNNING	87 %	RJ PUMPS IN AUTO	RJ PUMPS CONTROL AT HEADGATE

FAULT RESET

MAIN MENU

AFC LOCKOUT

A POWER CENTER STATUS

B POWER CENTER STATUS

C POWER CENTER STATUS

FAULTS

WARNINGS

HEADGATE STATUS

PUMPS STATUS

[C PC] EMULSION TANK HIGH TEMPERATURE WARNING

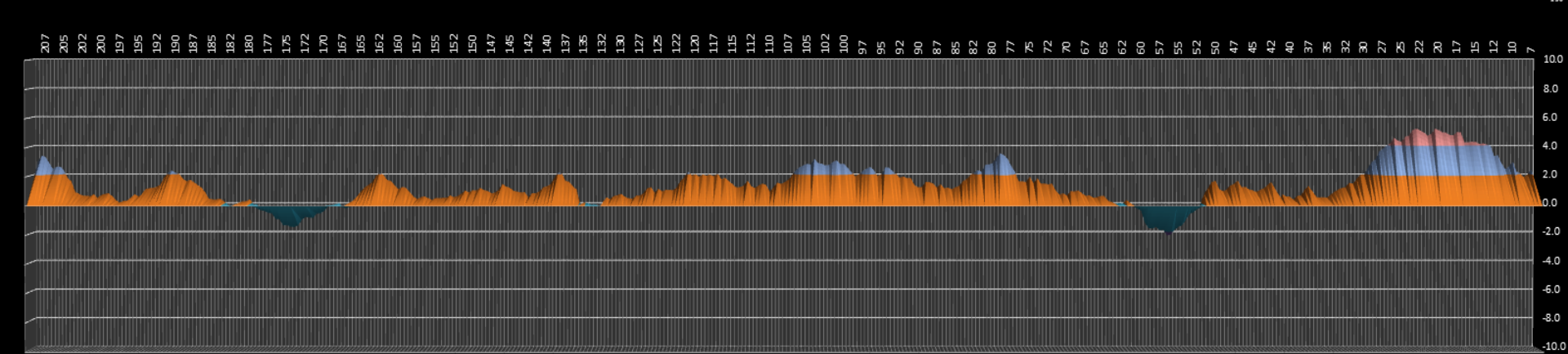
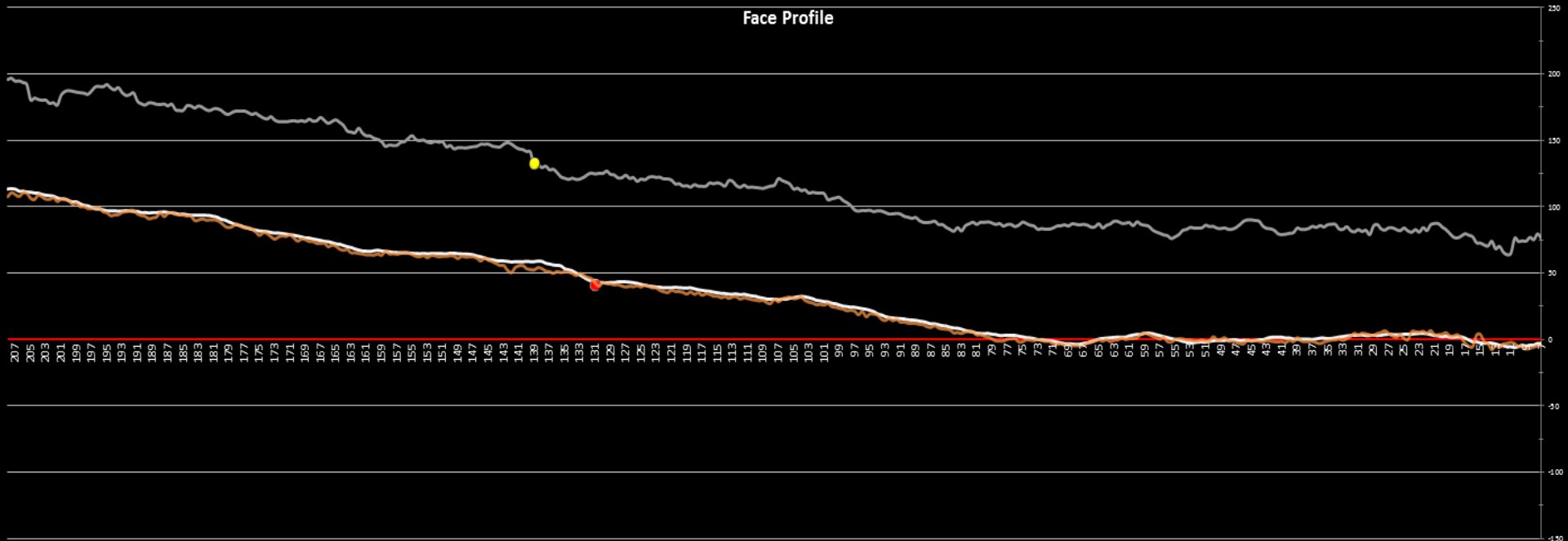
Face Profile/Pitch Graph

- Provides Operators a View of the Face
- Reference to Remotely Cut Bottom
- Use to Manage Rolls on Face
- Mark Shields & Low/High Spots on Face.



Longwall Graph

Face Profile



Cameras

- Shearer
 - 8 Cameras, 2 Lights
- AFC
 - 2 at HG
 - 2 at TG

Integration of People & Technology



Integration of People & Technology

- Massive amount of effort at all levels
- Operators took ownership of the project and were committed from the beginning
- Production Foremen call out observations as they conduct fireboss runs
- Maintenance personnel took ownership of cameras and maintenance to support remote operation
- Utilization of all the information/control available to the operators
 - 12 cameras, 2 lights, mine monitor, CAT, JOY, Graph. Took ownership to learn the various screens and how they apply
- Personnel developed understanding and ability to recognize faults remotely, and accurately relay that information to the correct personnel.

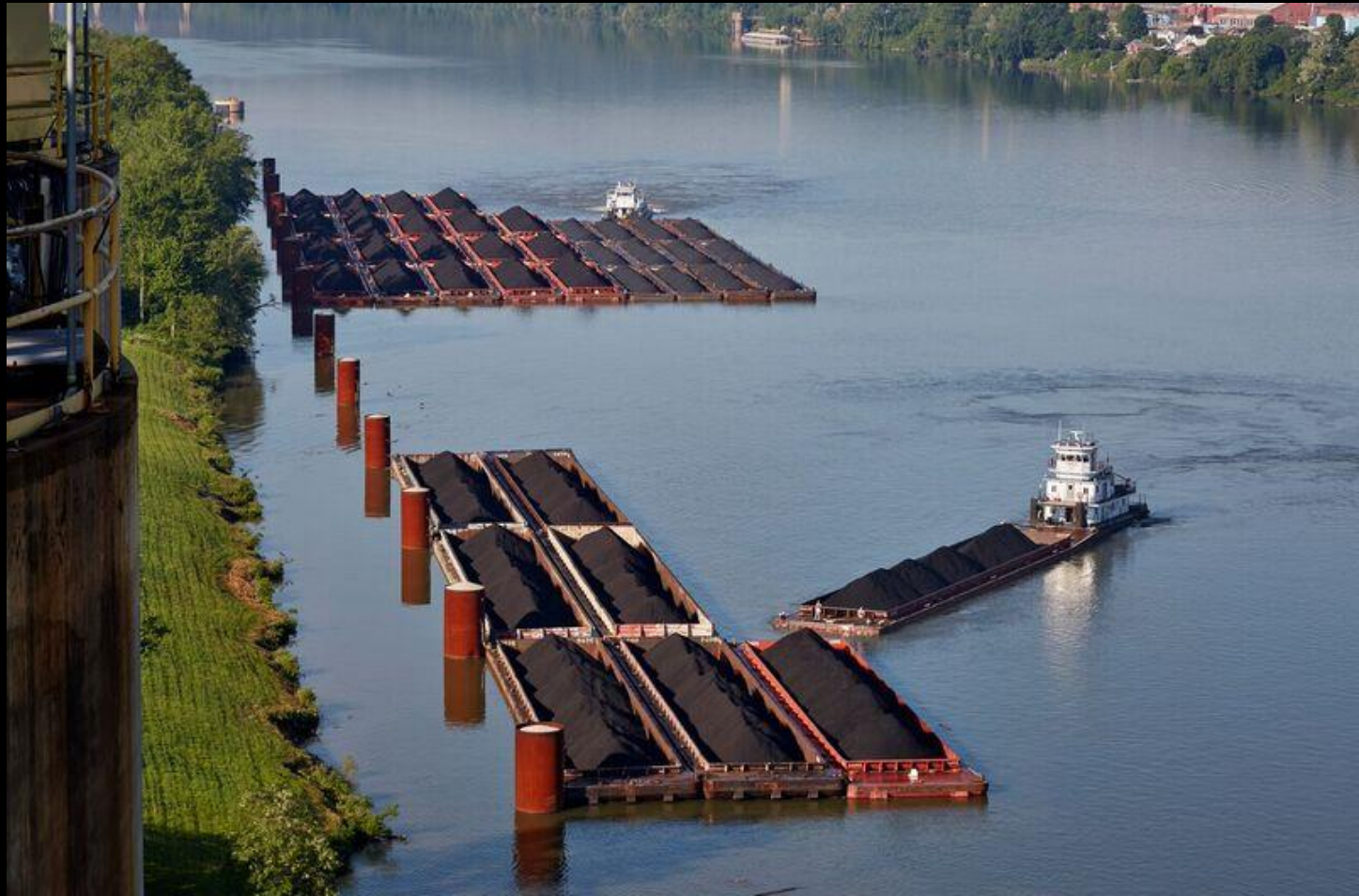


Future Advancements

- Working with JOY to further develop ASA
- Improved camera quality through HD Cameras and Infrared technology
- Integrating Landmark for automated face alignment and gate-end steering
- Remote operation of shields which requires real-time locations of all face personnel
- Horizon control of shearer















Eric K. Anderson - General Manager

Eric.Anderson@arlp.com



Robert Colaw - LW Maint. Coordinator
Rob.Colaw@arlp.com

Kyle Faykus - Automation Engineer
Kyle.Faykus@arlp.com