Rapid Longwall Entry Development with Continuous Haulage at Murray Energy's Marion County Mine

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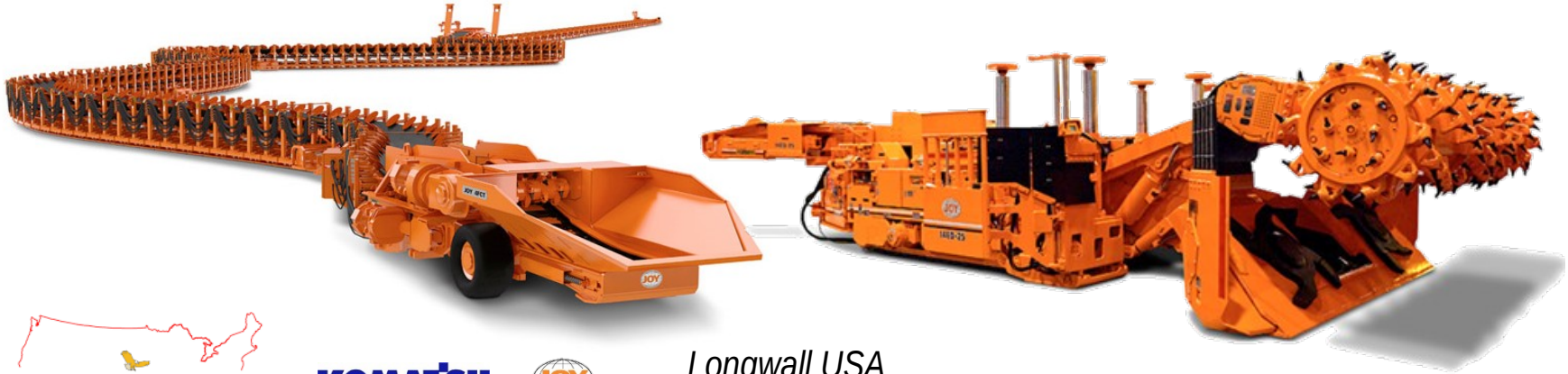

MURRAY ENERGY CORPORATION

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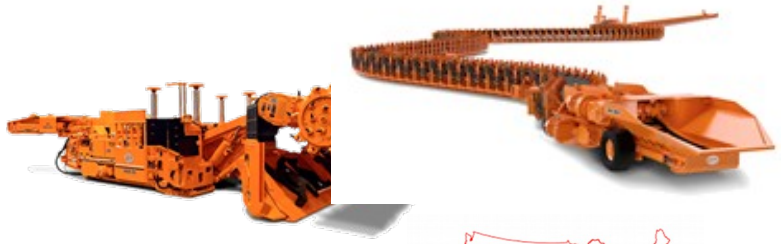
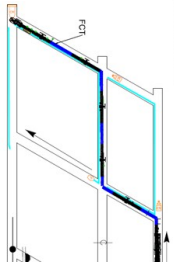
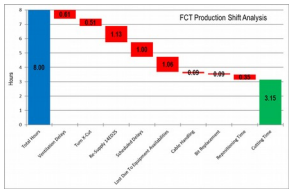
Longwall USA
May 2019

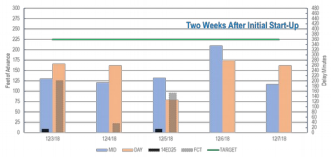
Topics of Discussion

- Marion County Mine – Overview
- Joy Rapid Entry Development Mining System
  - 14ED25 Entry Driver
  - FCT Continuous Haulage
- Project Planning – Equipment Integration
- Application Engineering
  - Underground evaluations, time studies
  - Productivity modeling, benchmarking
- Marion County Mine - Results
- Summary
- Comments/Questions & Acknowledgements









Marion County Mine - Overview

- Formerly Loveridge Mine; Murray Energy Corp. (MEC) acquired Jan 2016
- Located in Metz, Marion County, WV
  - Two 3-Entry Gateroad Development Sections
  - One Mains Development Section
  - One Longwall Development

2018 Mine Details

- No. Employees = 552 (468 UG)
- Production = 6.13 MTPA (5.56 tonnes) from the Pittsburgh #8 bituminous coal seam

Rapid Entry Development: 14ED25 Entry Driver

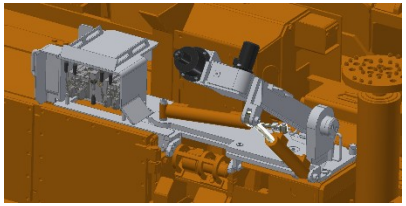
14ED25 Entry Driver
Mid-seam, simultaneous mining and roof/rib bolting machine

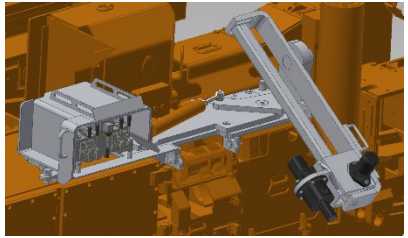
- Longwall entry development in variable roof conditions
- (2) Semi-automatic roof bolters
- (2) Hydraulic rib bolters
- Automated temporary roof support (ATRS) & rib protectors
- FACEBOSS – Diagnostic control system; - cutting parameter pre-sets

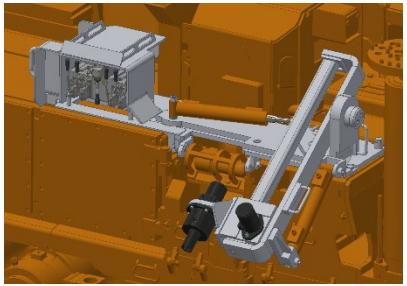
Rapid Entry Development: 14ED25 Entry Driver

Animation: Simultaneous Roof and Rib Bolt Installations While Mining

Rib Drill (1) each side



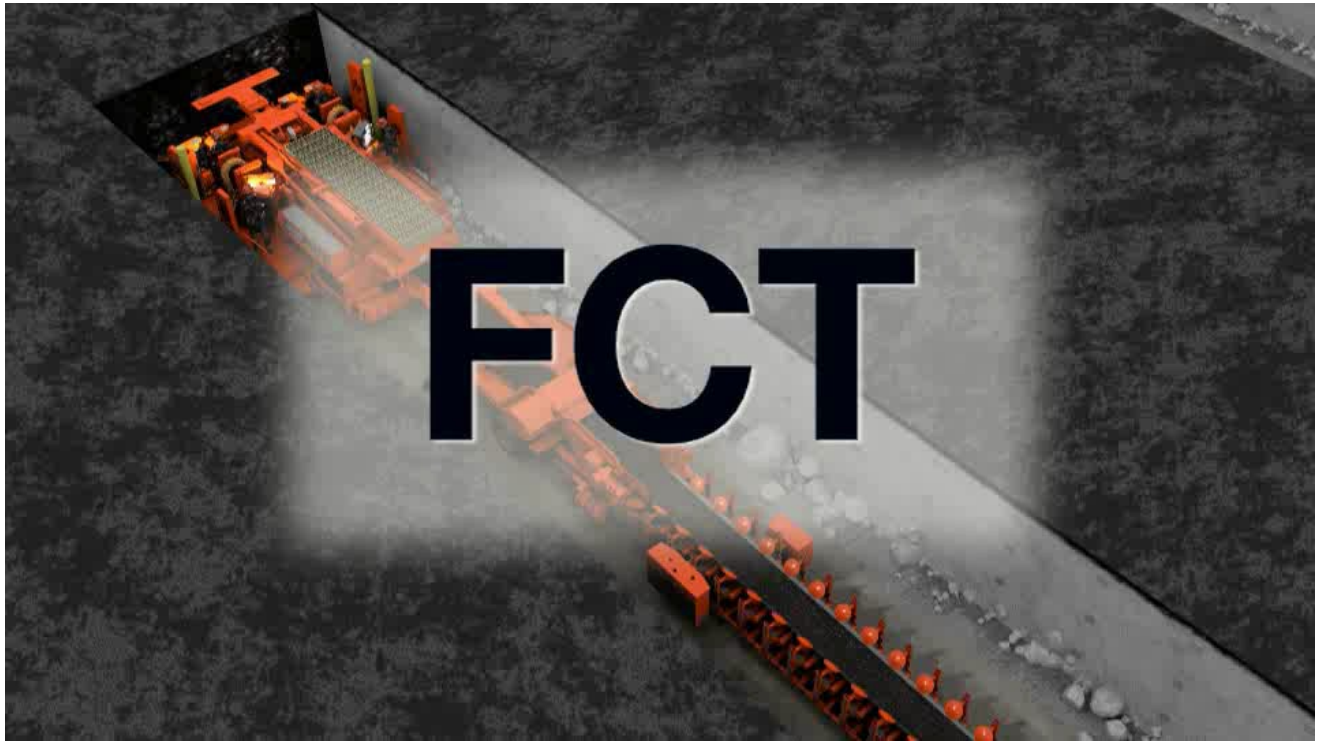




What is a Flexible Conveyor Train (FCT) ?

- Single operator system
- Trams and conveys material at the same time
- Conveys 27.6 tons/min (25 tonnes/min) at a density of 62.4 lbs/ft^3 (1000 kg/m^3)
- Hopper contains lump breaker with VFD controlled conveyor; Eliminates feeder breaker
- VFD Belt Drives and multiple VFD Traction Drives
- Follows the path set by the hopper
- Wet duster option (continuously dust while mining)

FCT Continuous Haulage - Dynamic Move-Up Unit (DMU)



- DMU - Interface between FCT & panel belt
- FCT trams up and over the inby end of section belt on top of DMU

Integration of the FCT Haulage – Planning is Key to Success

- Requires longwall mentality
- Collaborative effort between mine management, KMC support, service support & equipment operators
- Employee ownership in FCT performance
- Communication and collaboration between shifts
- Preventative maintenance focus
- Disciplined section choreography
- Outby support – ventilation, belt moves, power moves, track haulage installation, section supplies, outby belts

FCT Maintenance Schedule

Maintenance Chart - Mid Section

Use this table as a maintenance chart for the Mid Sections (car # 27 - 232).

⚠ WARNING

Before starting or operating the machine make certain that you have been trained in the proper operation of the machine, and are thoroughly familiar with all controls.

Description	Interval	Isolation Level		
		Full	Remote	None
Inspect the Chain/Deck Oiler for each of the following cars: • Car # 62 - 65 • Car # 106 - 109 • Car # 150 - 153 • Car # 194 - 197	Daily			X
Visually inspect the bottom rollers.	Daily			X
Replace the bottom rollers, if damaged or missing rollers are detected during inspection.	As Needed		X	
Visually inspect the Trough Rollers.	Daily			X
Replace the Trough Rollers, if damaged or missing rollers are detected during inspection.	As Needed		X	
Visually inspect the Mid Rollers.	Daily			X
Replace the mid Rollers, if damaged or missing rollers are detected during inspection.	As Needed		X	
Visually inspect the Edge Rollers.	Daily			X

Overview of System Sequence Operations

Click here for the video

Productivity Modeling – Determine Metrics for the Model

Performed studies at Marion County and Harrison County mines (KMC & MEC)

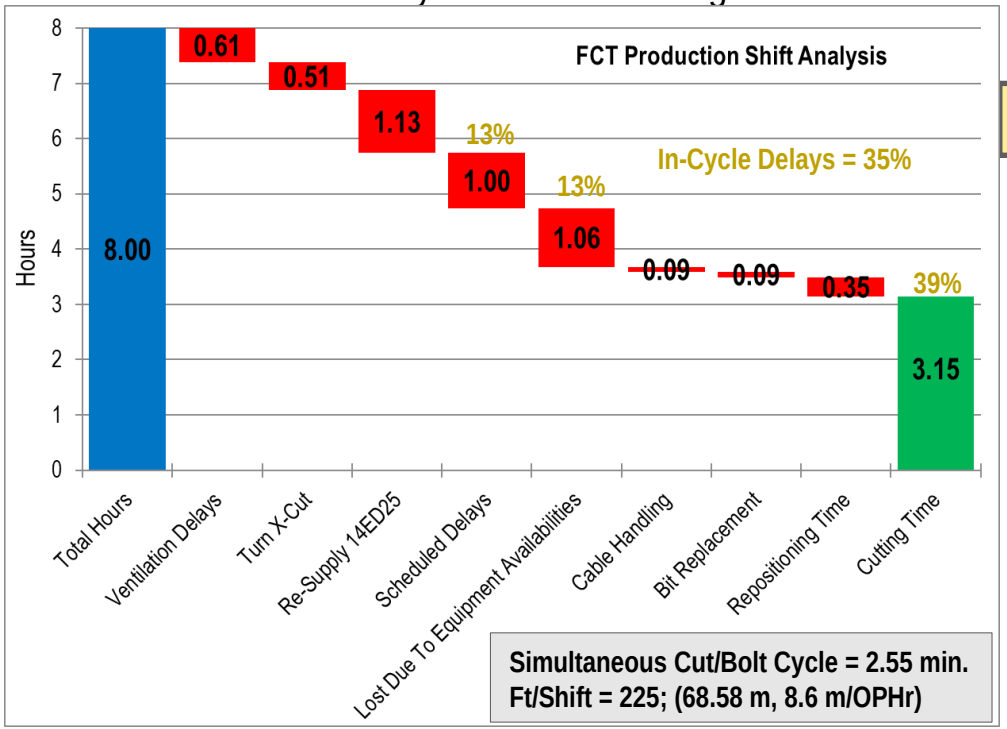
- 14ED25 Operator activities: sump, shear down, raise cutterhead, set ATRS, tram, etc.
- Roof & Rib bolt installation cycles
- Sump & shear distances, cycle variances
- Normal in-cycle delays

Average In-Cycle Delays from Time Studies			*Metric*
Bit Usage	**243**	tons/bit	220.4 tonnes/pick
Time to Change One Bit	**1.0**	min	
14ED25 Cable Handling Time/10 ft	**0.1**	min per 10 ft	per 3.05 m
Ventilation Delay-Install Tubing/Move	**15**	mins	
Install Add'l Tube/10 ft	**0.3**	mins per 10 ft	per 3.05 m
Supply 14ED25/Move	**40**	mins	
Turn XC (back-up, set sites, channel thru)	**45**	mins	

on, feet per shift)

KMC Productivity Modeling – Base Model

- Inputs: Time-studied metrics, Marion Co. mine equipment availabilities & 1West Tailgate mining sequence
- Validated with current production and mine management
- Determined KPI's – key factors in reaching modeled Ft/Shift

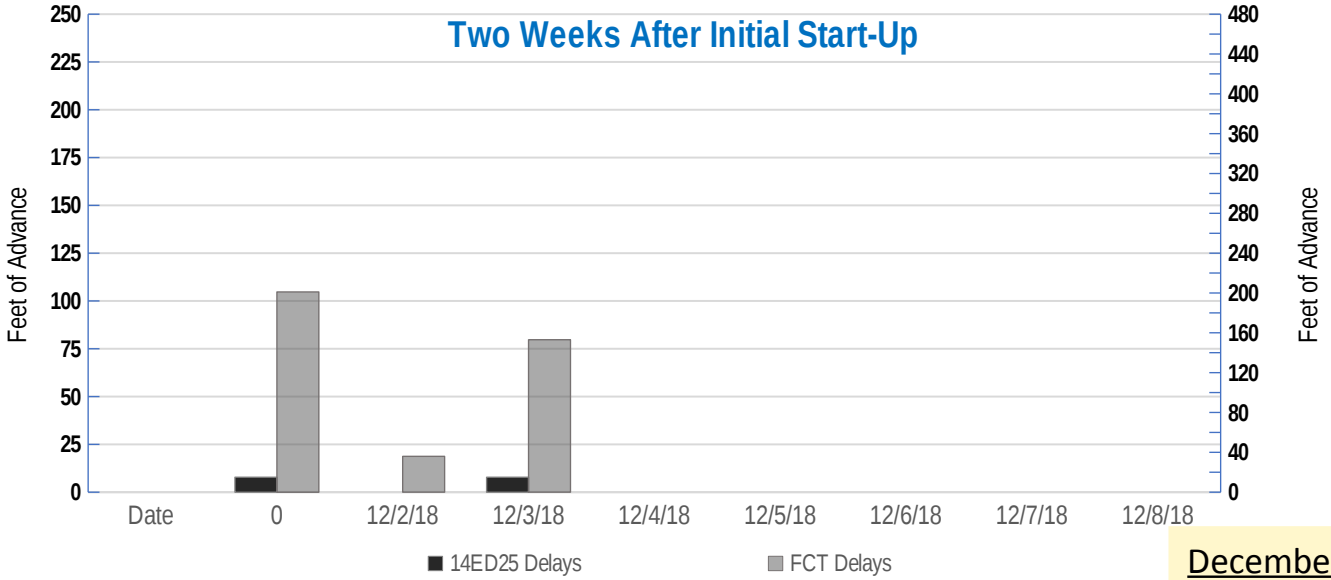


Production Optimization → **"Stretch" Models**

Identify improvements to increase production
- Decrease in-cycle delays
- Faster move/re-supply times
- Increase operator efficiency (experience)

Model the changes
- Increase cutting time
- Increase overall feet per shift

System Performance – Two Weeks after Start-Up



- Production began mid-November ’18
- Crew Schedule - (6) days per Week:
- (2) 8-Hour Shifts per Day; Crew Overlap - Hot Seat
- (1) 8-Hour Maintenance Shift per Day

<u>December Highlights</u>

- Top Producing Shifts:
  - 12/12 - 249 ft, 75.9 m
  - 12/17 - 251 ft, 76.5 m
  - 12/28 - 340 ft, 103.6 m
- December Avg = 174 Ft/Shift, 53 m
  - (-) 23%

Validation of Model – Benchmarking after System Ramp-up

14ED25 PERFORMANCE BENCHMARK MARCH 19-20, 2019					
	Mining Cycle Normal Conditions (min)	Mining Cycle Adverse Conditions (min)	Mining Cycle Average (min)	Roof Bolt Cycle (min)	Rib Bolt Cycle (min)
Productivity Model - Harrison Co.	2.55 (2.68)			1.6	0.7
Time Study - Marion Co.	2.4	3.2	2.7	2.2	0.7

System ramp–up: Feb. 2019

Crew Schedule - (6) days per week

- (3) 8-Hour Shifts per Day; Crew Overlap - Hot Seat
- (7) Idle Shifts per Week – (2) Maint., (2) B&P, (3) Sunday
- Crew observed – top production crew

Identified variances in metrics used in "Base Model"

- Intermittent "clay veins" in roof required additional bolting; extended cycle times
- Hard cutting conditions (pyritic concretions in coal seam)
- Extended entry to entry move time
- Decreased availability - 14ED25 & FCT unplanned maintenance delays

March Highlights

- Top Producing Shifts:
  - 3/9 - 309 ft, 94.2 m
  - 3/18 - 272 ft, 82.9 m
  - 3/24 - 301 ft, 91.7
- March Avg = 170 Ft/Shift, 51.8 m
  - (-) 24%

Continued System Analysis – Implemented Changes/Improvements

Early April

- Streamlined idle shift maintenance processes; fewer equipment delays during production hours
- Continued operator training
- Decreased in-cycle delays

Returned to "Normal" mining conditions

- Hard coal cutting, but few pyritic concretions
- Fewer clay veins, competent coal roof
- Fewer bolting delays, 14ED25 increased mining time

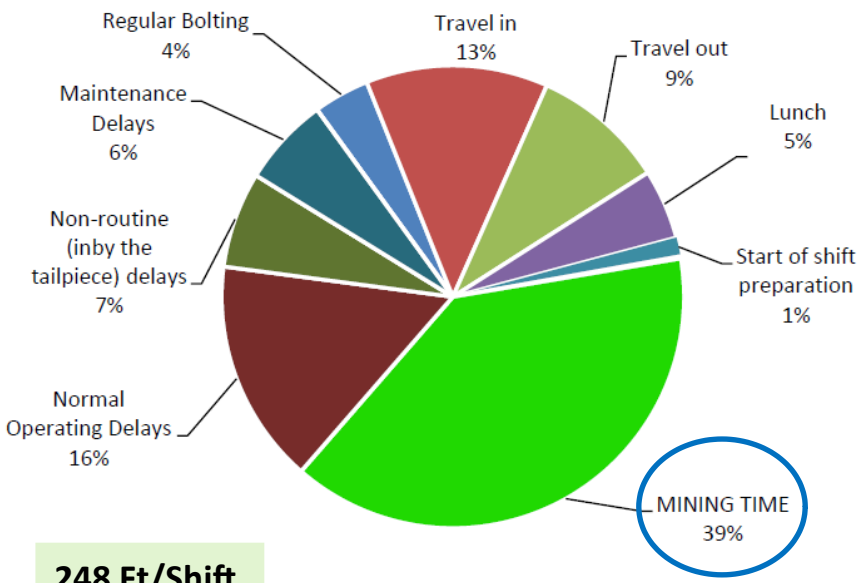
New Production Records Set (4/29)

- Production Record for Single Shift = **361 Ft** (+ 60%)
- Total Daily Production Record = **869 Ft** (+ 29%)

April Highlights

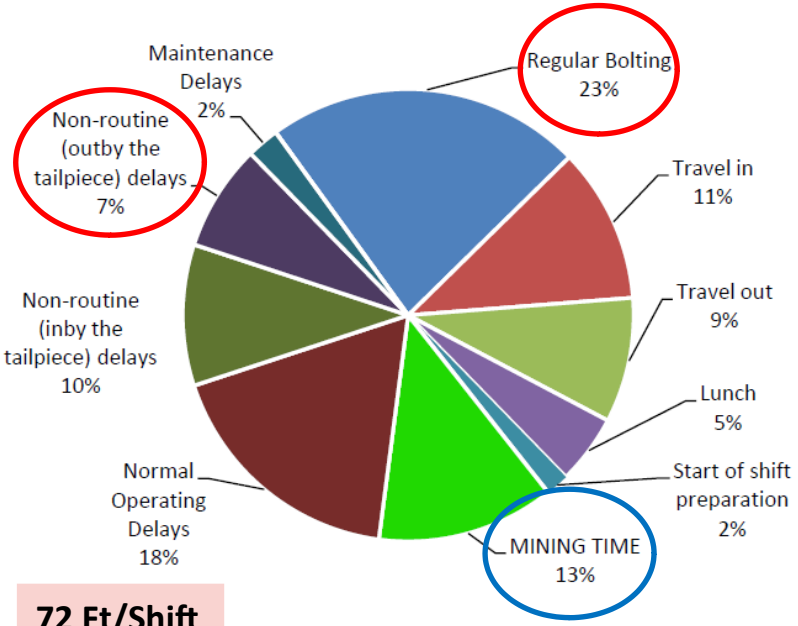
- Top Producing Shifts:
  - 4/20 - 304 ft, 92.7 m
  - 4/29 - 361 ft, 110 m
  - 4/29 - 280 ft, 85.3 m
- On 4/29, all (3) shifts achieved +225 ft/ shift
- April Avg = 178 Ft/Shift, 52.3 m
  - (-) 21%

Shift Evaluations: Production > 225 ft vs Production < 225 ft



248 Ft/Shift

- Constants: travel in/out, shift prep, lunch
- **Mining 40% of available time**
- Variables: non-routine, maintenance, bolting delays
- Maintenance can be both constant & variable (managed)



72 Ft/Shift

- Constants: travel in/out, shift prep, lunch
- **Mining 13% of available time**
- Increased: bolting – adverse roof & non-routine delays
- Can non-routine delays be minimized? Bolting varies w/conditions

Mining System Comparison – MB & SC vs ED & FCT

Marion County Mining Systems Comparison					
Highest Months Feet Mined 2018 (excl. first, last, bleeder)	MAY	AUG	SEP	TOTAL FT	AVG
Miner bolter, loading machine, (2) SC haulage	6,732	6,534	7,089	20,355	6,785
meters mined	2,052	1,992	2,161	6,205	2,068
Total Feet Mined per Month (post ramp-up)	FEB	MAR	APR	TOTAL FT	AVG
14ED25 Entry Driver & FCT continuous haulage	8,524	9,689	10,280	28,493	9,498
meters mined	2,598	2,953	3,133	8,684	2,895
% Difference in Advance Rates	**27%**	**48%**	**45%**	**40%**	**40%**

The ED & FCT have shown increasing rates of advancement over the MB & SC:

- The difference in overall feet mined = +8,138 ft (2, 481 m); 40% increase over MB & SC
- Feb – Apr, ED & FCT development has increased its' own rates of advancement by 21%
- Data indicate an overall accelerated gateroad completion time

In Summary

- Project planning and continued evaluation of system performance - critical to installation, integration, and continuous improvement of the Rapid Entry Development System
- Since project ramp-up (Feb), 1 West Tailgate has achieved 77% of 225 feet per shift; overall advance rate exceeded MB/SC gateroad development
  - Best Feet Mined per Shift – 361 feet/shift; Same day all (3) shifts exceeded 225 feet – 869 feet/day
  - 40% increase in advancement rates over MB/SC best 3-month's average (2018)
  - 40% increase in total feet mined per month
- Continued evaluation of the mining system and mining conditions has identified key potential performance improvements
  - Scheduled equipment maintenance essential to achieve high equipment availability
  - Operator's efficiencies improving - continued training from highly experienced individuals makes a difference
  - Streamlined and planned equipment move sequences essential from both entry to entry and for the FCT move-up process
  - Optimize processes/decrease delays; ventilation setting and move-ups, scooping & rock dusting, entry to entry moves, panel move-ups

Questions or Comments

ACKNOWLEDGEMENTS

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Jason Howell, FCT Maintenance Coordinator – Marion Co.
1West Tailgate Foremen and Crews
Bryan Howard, Mine Engineer – Marion Co.
Tyler Reed, Continuous Mining Coordinator – Harrison Co.

Komatsu Mining Corporation Group
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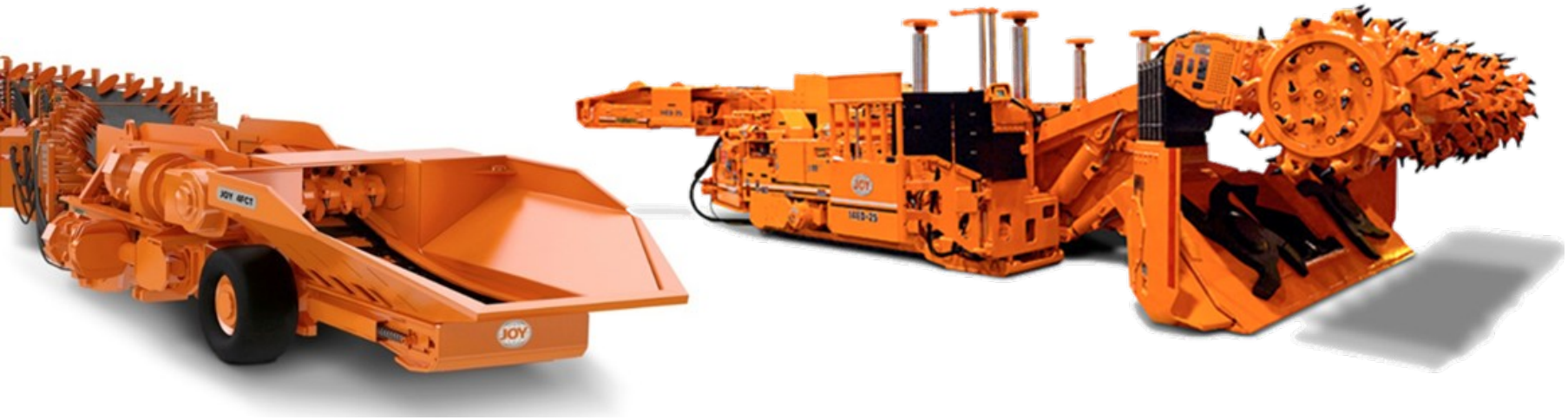
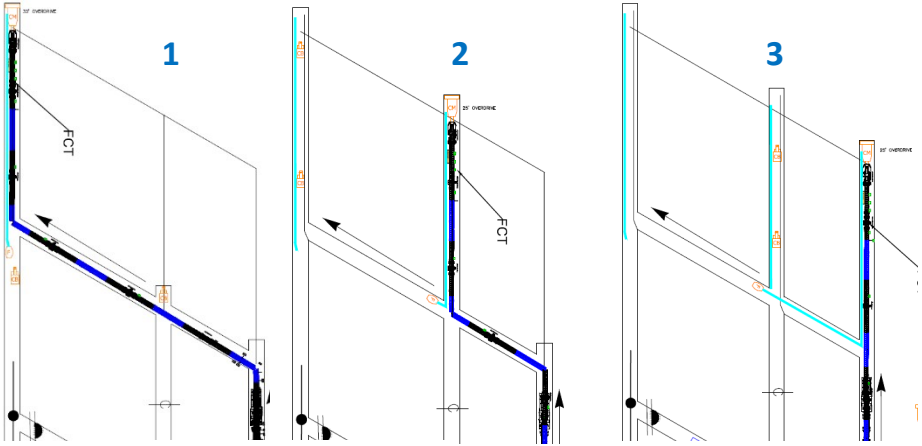
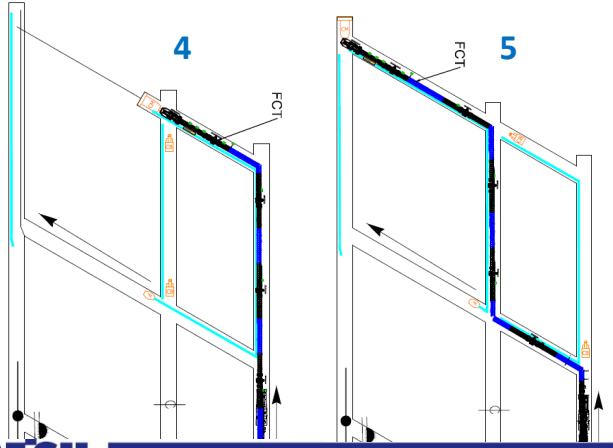
Craig Fancher, NAPP Regional Sales Manager
Andrew Marburger, Mechanical Engineer, FCT Group Leader
Robert Schon, Mechanical Engineer, Entry Development Systems
Mike Watkins, Engineer, Continuous Haulage

Appendices



Gateroad Layout and 14ED25 & FCT Mining Cycle

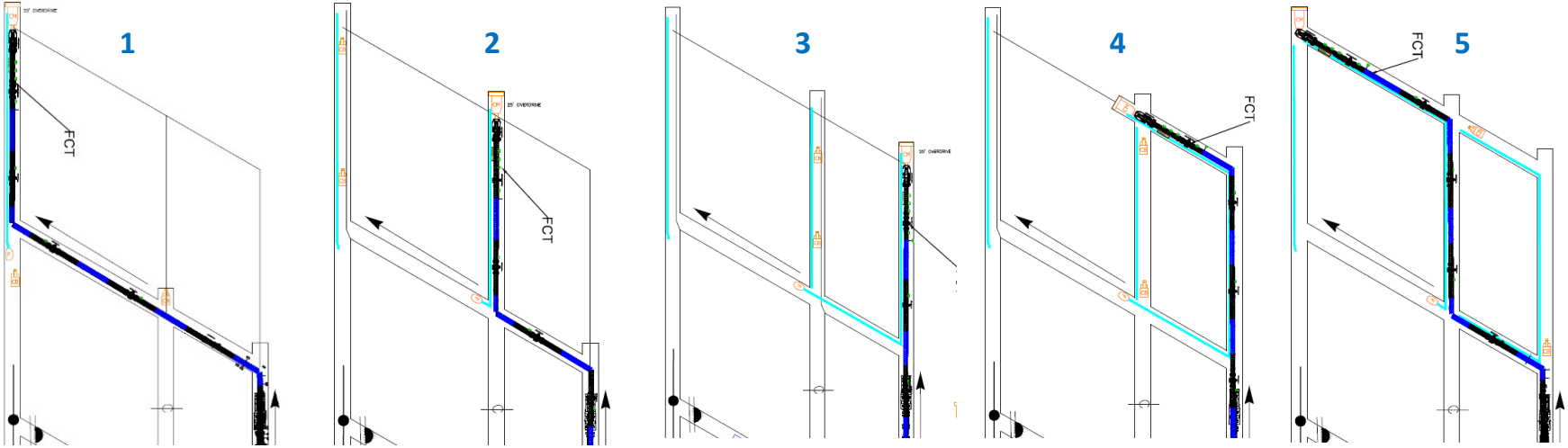




- Base Model 1 Proposed Cycle **(1-5)** = 4.0 shifts/1.3 days
- Base Model 2 Proposed Cycle **(1-5)** = 3.9 shifts/1.3 days

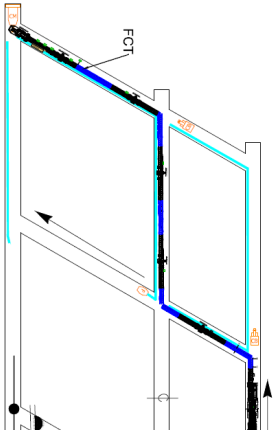
Gateroad Layout and 14ED25 & FCT Mining Cycle

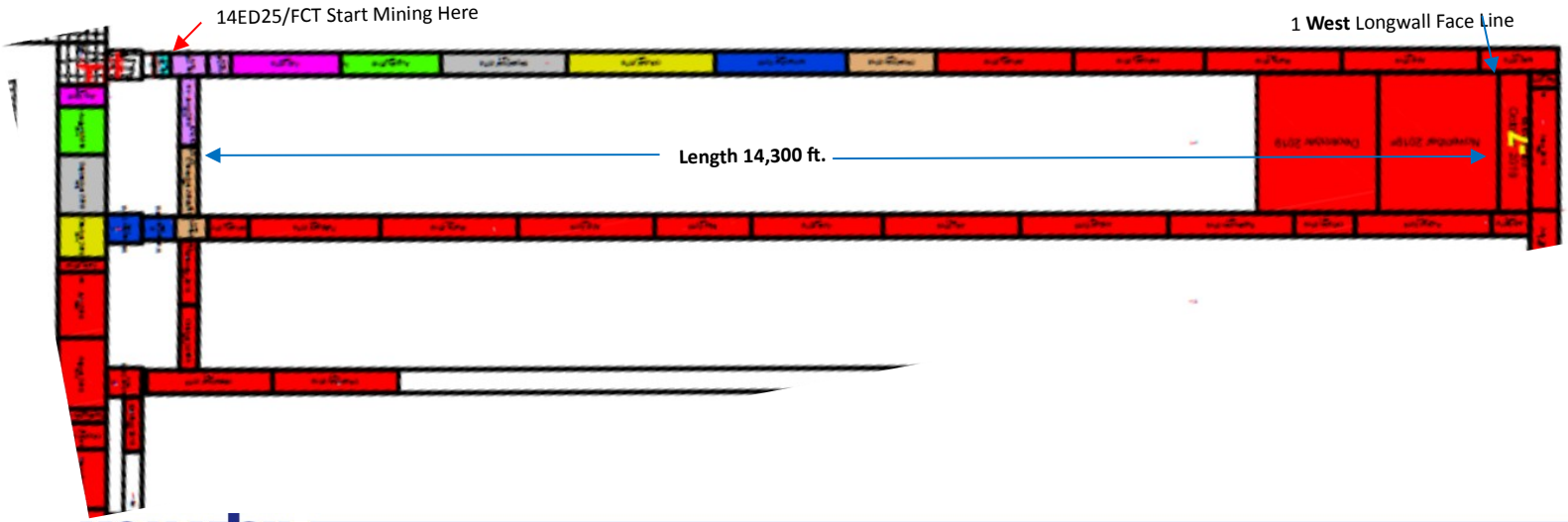
Proposed Marion County Mining Cycle = 5–Cut Sequence



Estimated Panel Completion – Base Model Inputs

- Base Cycle (200 ft. linear advance, 850 ft. total feet mined per cycle) = 3.8 shifts/1.3 days
- Estimated time mining to LW face = 4 months
- Estimated time mining to LW face, including recovery entries = 4.5 months .





14ED25 Sump & Shear Cycle

Sump & Up Shear Cycle Summary		
Tons Per Sump Cycle	20.0	Tons
Average TPM	7.8	TPM
Miner Advance Rate	1.7	ft/min
Miner Advance per Cycle	4.3	ft
Tons Per Foot	4.6	Tons
Tons Per Hour	470	Tons

Murray Internal Analysis/AE Time Study

225 ft./shift (increase of 1.25x current development rates)

- 14ED25 – 1.0 ft / min (AE TS - 2.6 min cycle @ 4.3 ft. -1.6 ft / min)
- Bolting 1 min 49 secs for 8‘ bolt (AE TS - 1.58 min. for 8’ Combination bolt)

Mining Delays (Time reporting over 6 mths) – Overall 260 mins delay / shift (KMC Stretch 1= 276 mins)

- Pre-Op WV State law, parameters 18 min/shift (AE TS - 20 min/shift)
- Supplies (carry 240 ft) 28 min / shift – potential to improve (AE TS - 30 min/shift coincides w/lunch)
- Servicing and bits 28 min / shift – potential to improve (AE TS - 30 min/shift coincides w/lunch)
- Rock Dusting 51 mins per shift – potential to improve (AE TS - 6.5 min/40 ft.)
- Adv Tubing, Fan move 35 mins / shift – potential to improve (AE TS - 20 sec/10 ft.)
- Move Miner Cables 32 mins / shift (AE TS - 45 sec - occurred once during shift @ Harrison Co.)
- Belt delays 40 mins / shift (AE TS - Marion County - 120 mins Harrison County -15 mins)
- Equipment Delays 28 mins / shift (AE TS - 30 mins - Harrison Co. 14ED25 electrical)

Available Mining minutes 220 mins (KMC Stretch 1 = 204 total mining time)

RED - Values Higher than Murray Reported GREEN - Values Lower than Murray Reported

Estimated Panel Completion – Base Model Inputs

- Base Model Cycle (200 ft. linear advance, 850 ft. total feet mined per cycle) = 3.8 shifts/1.3 days
- Base Model indicates 920 linear feet per week
- Estimated time mining to LW face = 4 months
- Estimated time mining to LW face, including recovery entries = 4.5 months
- Murray timing – see below 11 mos.