

>  
accenture digital

Industry X.0

# Digital Transformation in the Mining Industry

High performance. Delivered.

September - 2017

Strategy | Consulting | Digital | Technology | Operations



# DIGITAL TECHNOLOGY IN MINING

KEY FINDINGS

**INVESTMENTS IN DIGITAL TECHNOLOGY ARE INCREASING, AND FOR SOME, SIGNIFICANTLY SO.**

The power of digital to drive innovation is well recognized by business leaders –

**46%** strongly agree it is the biggest contributor.



**DIGITAL PROGRAMS ARE THE BIGGEST CONTRIBUTOR TO DRIVING INNOVATION IN OUR ORGANIZATION.**



▶ **82%**

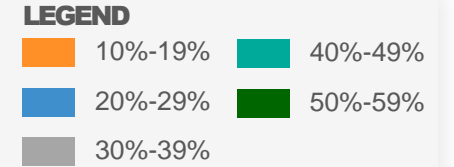
**OF BUSINESS LEADERS EXPECT THEIR ORGANIZATIONS' INVESTMENT IN DIGITAL TO INCREASE IN THE NEXT THREE YEARS—OF WHICH OVER A QUARTER (28%) BELIEVE IT WILL SIGNIFICANTLY INCREASE.**

Base: All respondents (n=201)



# MINE OPERATIONS IS WHERE DIGITAL TECHNOLOGIES ARE BEING EMPLOYED THE MOST

In which mining activities have you already employed digital technologies or plan to employ them in the next 3-5 years?



	EXPLORE/ ACQUIRE	MINE DEVELOPMENT	MINE	ORE PROCESSING	LOGISTICS	SALES & MARKETING
Robotics + automation (mobile and fixed assets) *	42%	47%	54%	45%	33%	24%
Advanced process control	22%	31%	37%	41%	23%	17%
Drones/UAV's	32%	30%	41%	24%	19%	11%
Remote operating centers	30%	29%	41%	36%	22%	17%
Mobile/tablet use	35%	36%	31%	26%	37%	36%
Wearables	32%	37%	41%	30%	23%	25%
Integrated planning	33%	32%	28%	30%	29%	27%
Digital platforms (cloud, etc.)	28%	25%	27%	19%	36%	39%
Real-time visualization of data	36%	28%	35%	31%	27%	23%
Real-time analytics	33%	28%	38%	30%	29%	23%
Predictive/machine learning analytics	34%	29%	29%	28%	24%	15%
Video analytics	39%	29%	33%	29%	17%	17%
Image analytics	32%	34%	37%	30%	21%	16%
Virtual simulation of physical environment	37%	40%	39%	18%	19%	15%
Artificial intelligence and cognitive computing	32%	32%	27%	30%	25%	20%
Social media	23%	24%	22%	22%	29%	47%
Cybersecurity	34%	32%	26%	24%	38%	33%
3D Printing	38%	27%	26%	21%	26%	16%

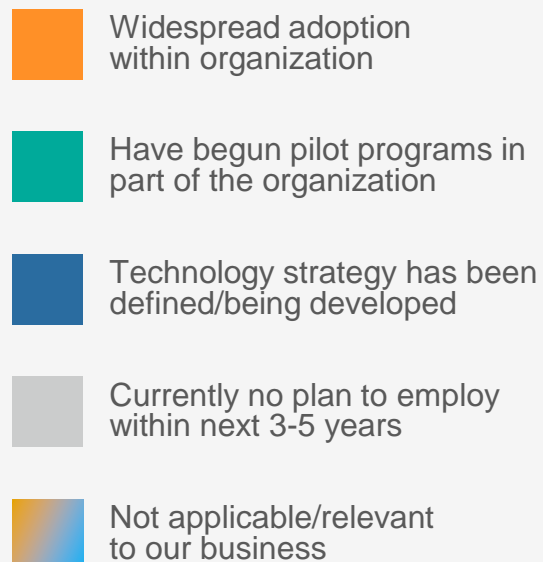
\* **Robotics + Automation (mobile and fixed assets):** refer to those instances where respondents have/plan to employ Robotics and/or Automation in each respective mining activity

Base: Instances where digital technologies have been deployed (i.e., in the planning, role-out or adoption phase)

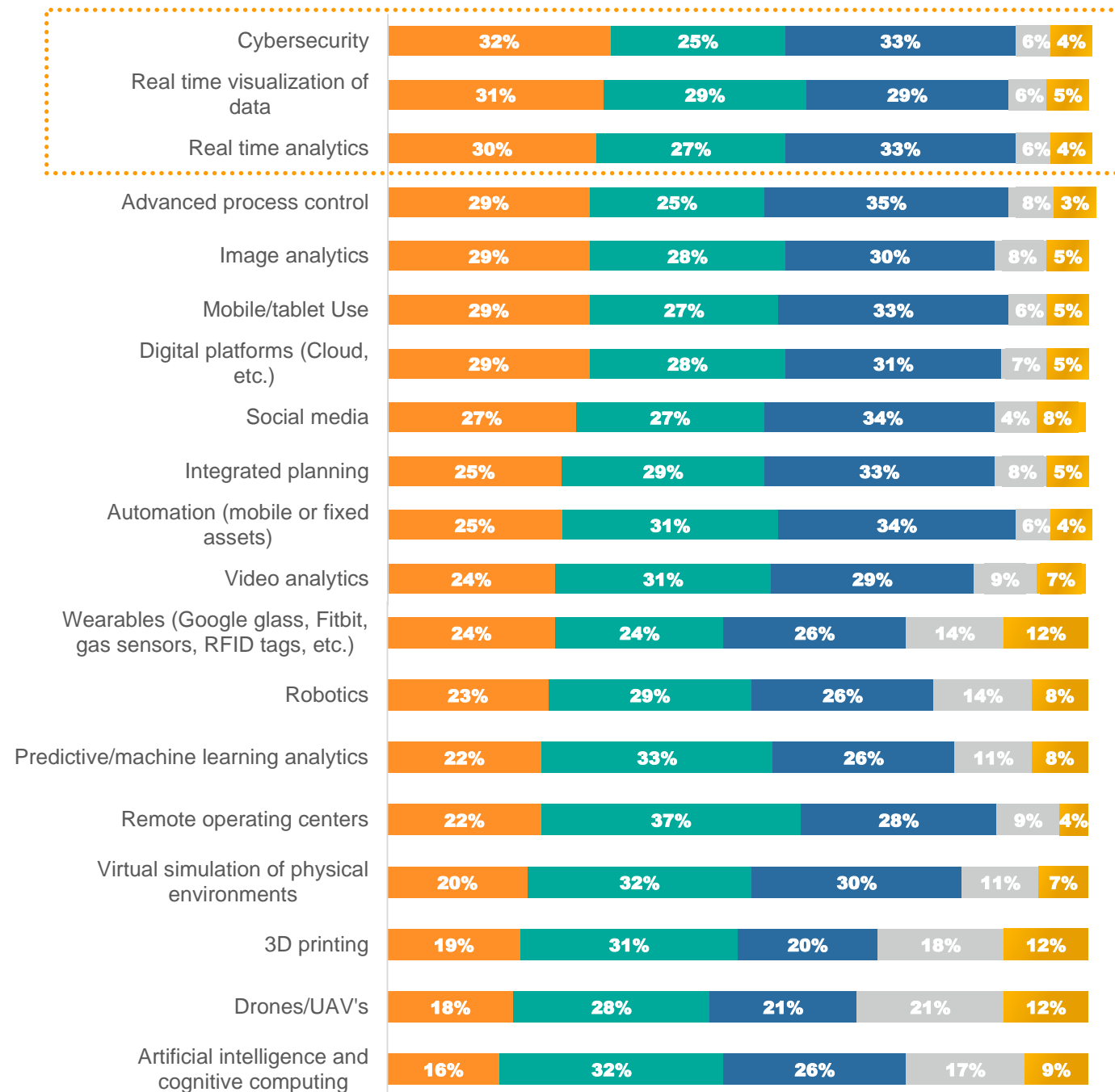
# DIGITAL TECHNOLOGIES THAT HAVE THE MOST WIDESPREAD ADOPTION ACROSS THE ORGANIZATION ARE CYBERSECURITY, REAL TIME VISUALIZATION OF DATA, AND REAL TIME ANALYTICS.

Please indicate your organization's current status regarding the deployment of the following digital technologies.

## LEGEND




Base: All respondents (n=201)



# REMOTE OPERATING CENTERS TOP THE LIST FOR WHERE MINING COMPANIES ARE RUNNING PILOT PROGRAMS ...

Please indicate your organization's current status regarding the deployment of the following digital technologies.

**LEGEND**

 Have begun pilot programs in part of organization




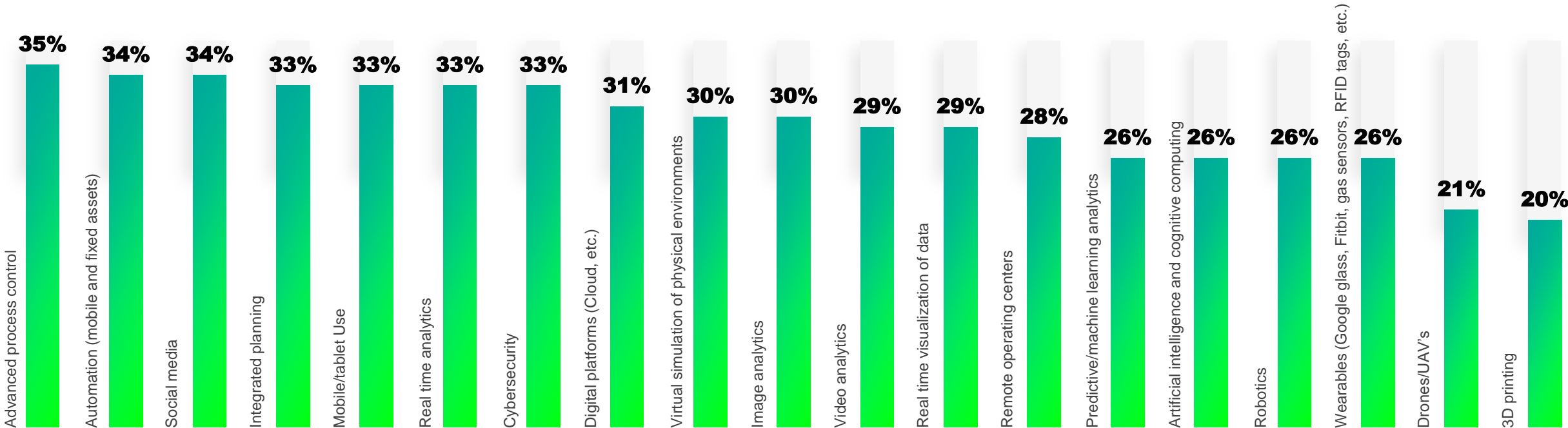
Base: All respondents (n=201)

# ...WHILE THE NEXT WAVE OF EMERGING TECHNOLOGIES IS MORE EVENLY SPREAD.

Please indicate your organization's current status regarding the deployment of the following digital technologies.

**LEGEND**

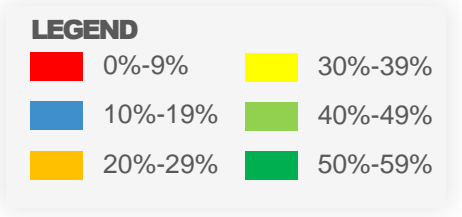
 Technology Strategy has been defined/being developed



Base: All respondents (n=201)



# RESPONDENTS REPORT THE **GREATEST BUSINESS BENEFIT** FROM LEVERAGING DIGITAL TECHNOLOGY COMES FROM IMPROVED WORKFORCE PRODUCTIVITY.



What are the greatest business benefits you currently derive from leveraging each of the following digital technologies?

	<b>COST REDUCTION</b>	<b>IMPROVED ASSET UTILIZATION</b>	<b>IMPROVED WORKFORCE PRODUCTIVITY</b>	<b>REDUCED CARBON FOOTPRINT</b>	<b>REDUCTION IN RESOURCES USED (WATER, POWER, CHEMICALS, ETC.)</b>	<b>IMPROVED SAFETY (E.G. REDUCTION IN LOSS TIME INJURIES)</b>	<b>BETTER STAKEHOLDER ENGAGEMENT</b>
Automation (mobile or fixed assets)	18%	15%	30%	15%	6%	9%	5%
Advanced process control	17%	19%	18%	12%	16%	12%	6%
Robotics	15%	18%	26%	13%	11%	12%	4%
Drones/UAV's	11%	16%	24%	20%	10%	17%	3%
Remote operating centres	18%	19%	24%	8%	14%	14%	3%
Mobile/tablet use	18%	15%	32%	8%	9%	7%	10%
Wearables	18%	11%	28%	18%	5%	14%	5%
Integrated planning	16%	22%	25%	11%	10%	9%	7%
Digital platforms (cloud, etc.)	19%	16%	21%	14%	10%	8%	11%
Real time visualization of data	19%	21%	25%	10%	11%	6%	8%
Real time analytics	18%	18%	29%	11%	10%	8%	6%
Predictive/machine learning analytics	20%	25%	23%	8%	9%	7%	7%
Video analytics	18%	20%	27%	9%	10%	10%	6%
Image analytics	18%	20%	25%	13%	13%	7%	5%
Virtual simulation of physical environment	14%	17%	30%	11%	11%	12%	4%
Artificial intelligence and cognitive computing	17%	15%	29%	13%	11%	8%	7%
Social media	16%	17%	20%	9%	6%	3%	27%
Cybersecurity	16%	12%	15%	11%	8%	23%	9%
3d printing	21%	14%	26%	16%	8%	7%	7%

Base: Instances where digital technologies have been deployed (i.e., in the planning, role-out or adoption phase)

The greatest barrier to securing greater business value from digital is data security concerns.

**MORE THAN A THIRD**

▶ **37%**

**BELIEVE THAT DATA SECURITY CONCERNS CONSTITUTE THE BIGGEST BARRIER TO ACHIEVING GREATER BUSINESS VALUE FROM DIGITAL.**

Base: All respondents (n=201)



ON OPERATIONAL BENEFITS  
**RESPONDENTS  
REPORTED**

▶ **47%**

**BETTER  
PERFORMANCE OF  
EQUIPMENT**

▶ **42%**

**COST SAVINGS**

▶ **40%**

**BETTER DECISION  
MAKING**

# What **operational benefits / process enhancements** do you expect to derive from your current and future investments in digital?

Select your top 3 where 1-Greatest benefit

## LEGEND

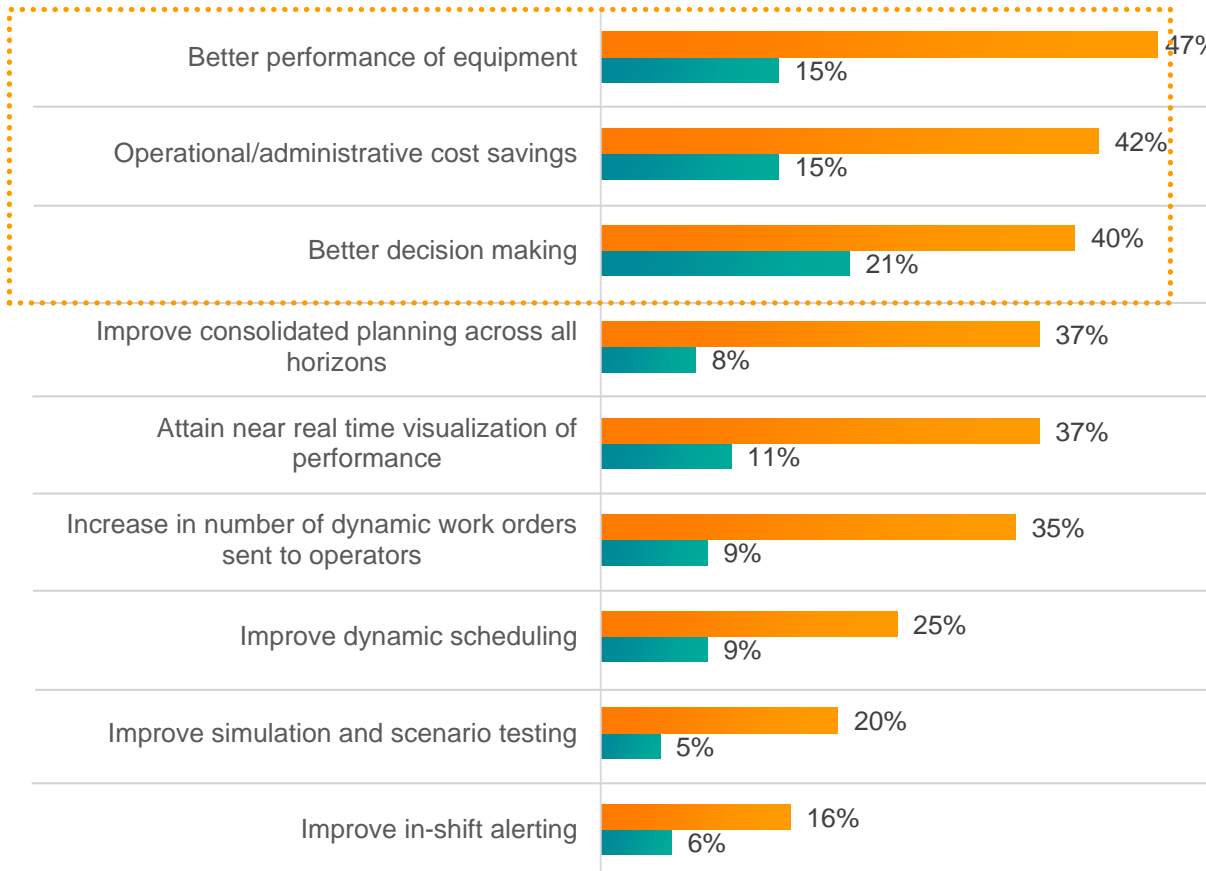


Within top 3 benefits

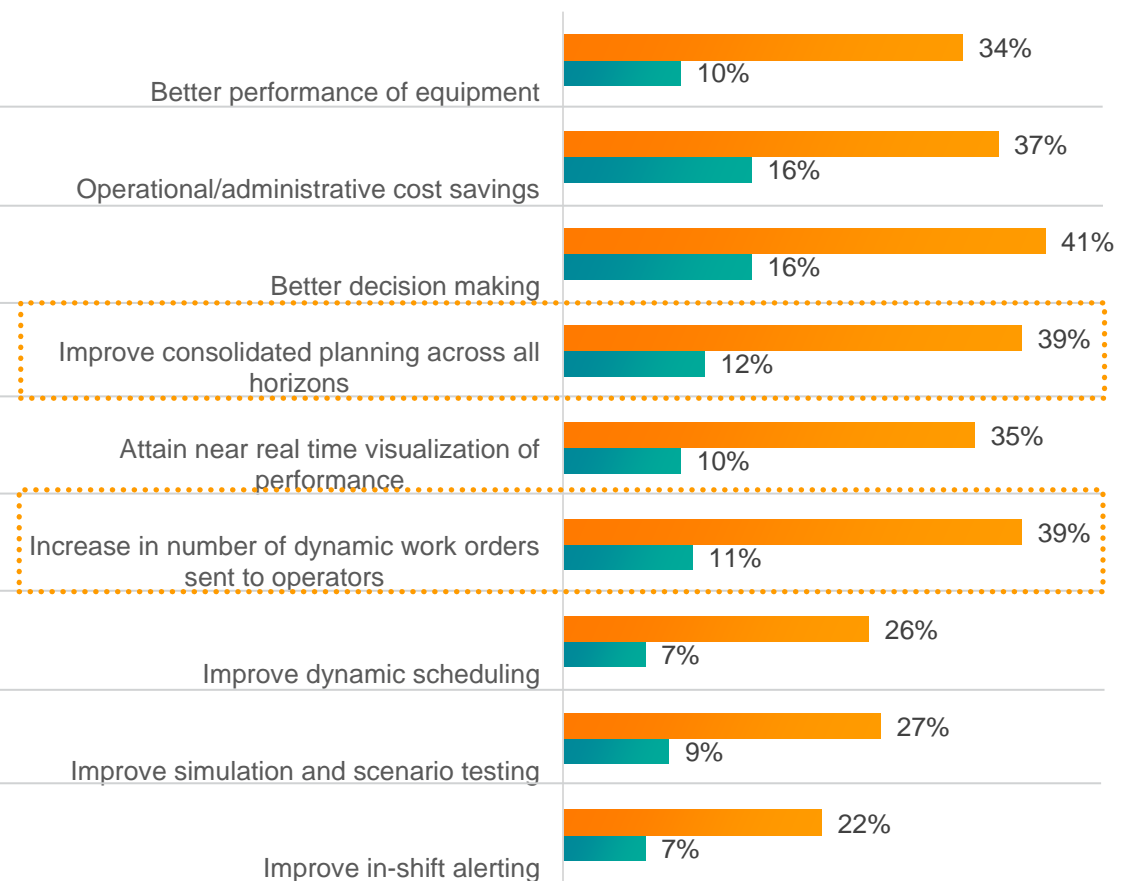


Top 1 benefit

## CURRENT INVESTMENTS



## FUTURE INVESTMENTS



# THE MAJORITY OF ORGANIZATIONS ARE **RELATIVELY SATISFIED** WITH THE **OUTCOME OF THEIR DIGITAL INVESTMENTS**

How satisfied is your organization with the outcome of your digital investment over the past year? Select one.



▶ **3%**

**MY ORGANIZATION IS NOT SATISFIED WITH THE BENEFITS ATTAINED FROM INVESTMENT IN DIGITAL; HARDLY ANY OF OUR EXPECTED BENEFITS WERE DERIVED**



▶ **64%**

**MY ORGANIZATION IS RELATIVELY SATISFIED WITH THE BENEFITS ATTAINED FROM INVESTMENT IN DIGITAL; SOME OF OUR EXPECTED BENEFITS WERE DERIVED**



▶ **33%**

**MY ORGANIZATION IS EXTREMELY SATISFIED WITH THE BENEFITS ATTAINED FROM INVESTMENT IN DIGITAL; MOST OR ALL OF OUR EXPECTED BENEFITS WERE DERIVED**

Base: All respondents (n=201)

# THE CLOUD HAS ARRIVED **IN MINING**

▶ **81%**

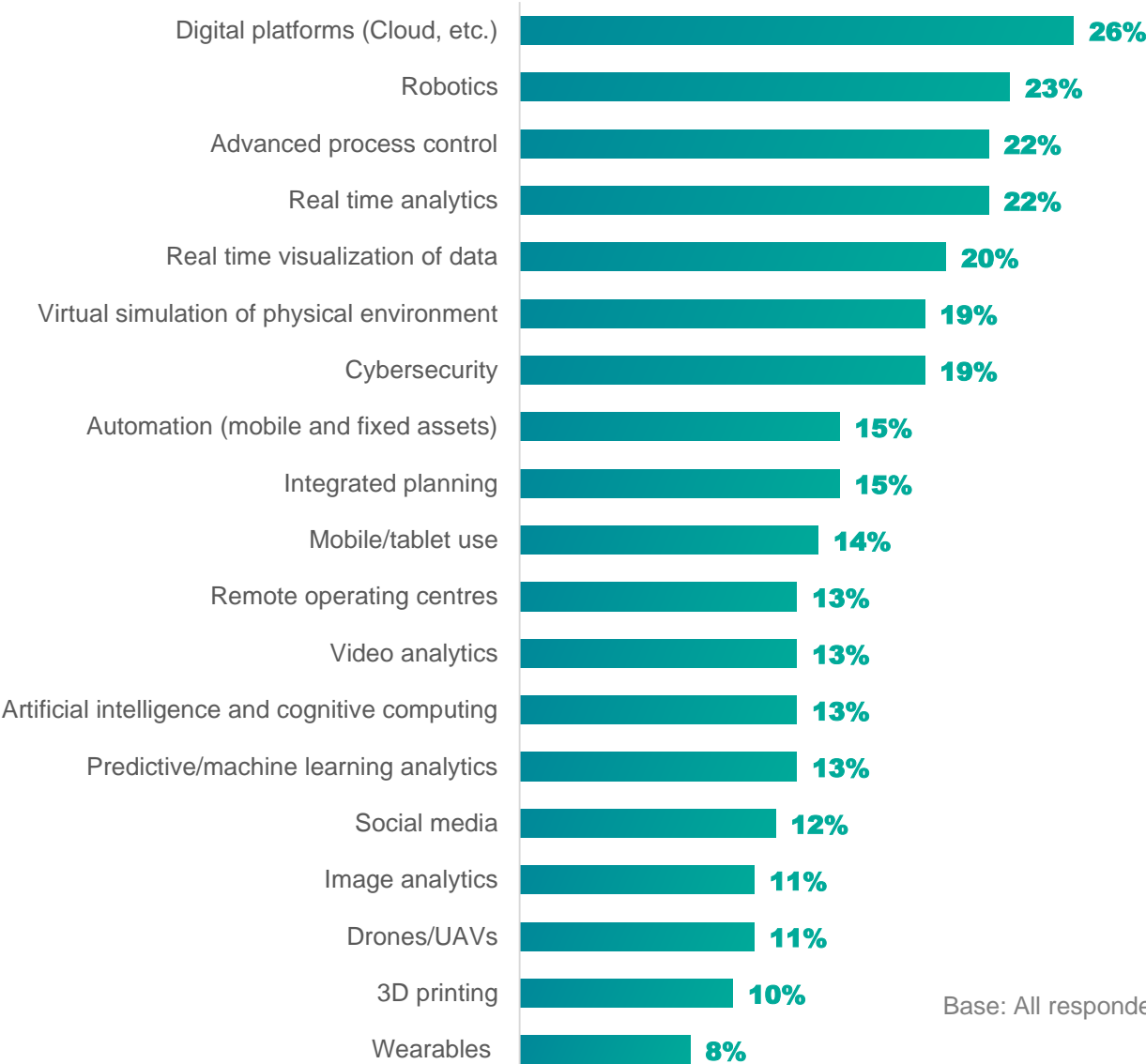
**HAVE ALREADY ADOPTED,  
OR PLAN TO ADOPT, A  
FORM OF CLOUD.**



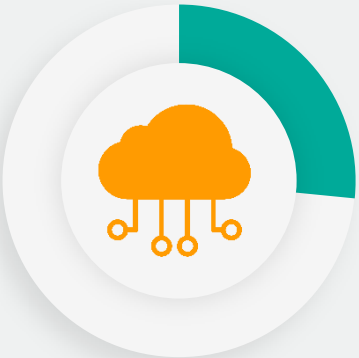
Base: All respondents (n=201)

# Please rank the top three digital technologies that you think provide the most potential for transforming your business over the long term.

Select your top 3, where 1=Provides the most potential.



Base: All respondents (n=201)



▶ **26%**

**DIGITAL PLATFORMS  
(CLOUD, ETC.)**

# IT-OT CONVERGENCE IS WELL UNDERWAY...

WITH MORE THAN HALF

▶ **56%**

**REPORTING THEIR  
ORGANIZATIONS ARE  
CONSIDERING MERGING  
THEIR IT AND OT  
DEPARTMENTS  
IN THE NEXT  
12 MONTHS.**

Base: All respondents (n=201)





# TRANSFORMATION IS AVAILABLE NOW

## CONNECTED MINE

- Mine to Port in the cloud Info integration
- Connected data Analytics

## AUTONOMOUS TRAIN LOADING

- +2** tons/car
- Faster train Loading
- Even cargo distribution

## AUTONOMOUS YARD

**+10%** tons/h  
in Reclaiming & Stacking

## PREDICTIVE PRODUCTION MANAGEMENT

- Plant Debottlenecking
- Root Cause Analysis

## IT/OT CONVERGENCE

- Faster digital program adoption
- Faster project implementation

## APC

**+2%** tons  
in Production Increase

## ROC

- Operating Cost Reduction
- Local infra Reduction
- Supply Chain optimizations

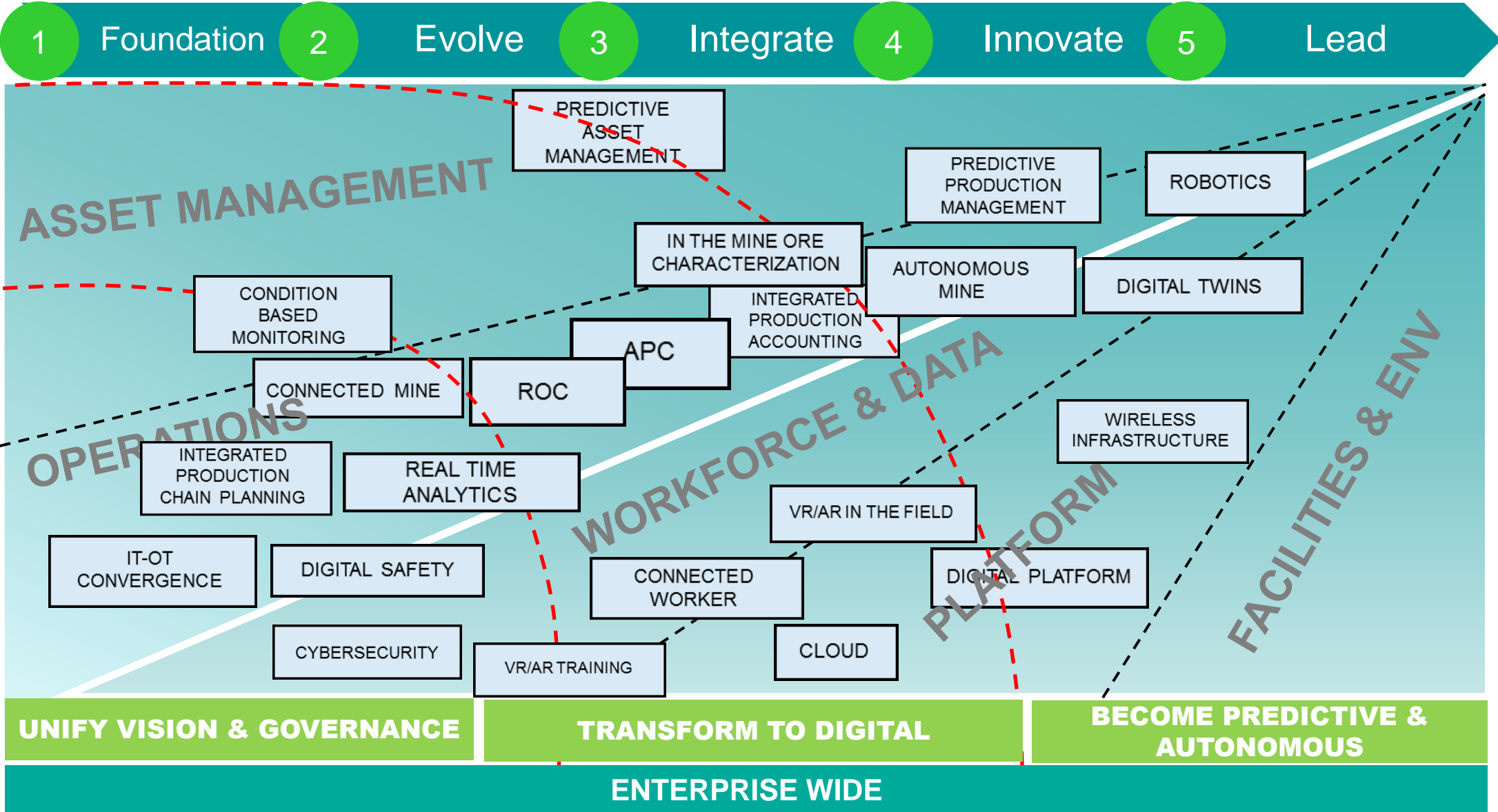
## DIGITAL TWINS

- Best Operating Scenario Selection
- Next Best Action

## PREDICTIVE ASSET MANAGEMENT

**+20%** Uptime  
**- 25%** Maintenance costs

# SIMPLIFIED DIGITAL MINE ROADMAP



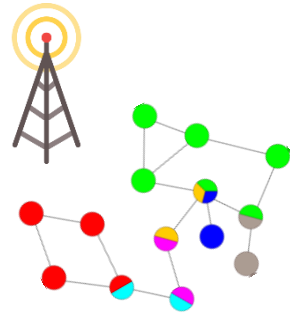
# HOW DOES A DIGITAL MINE LOOK LIKE?

## DEFINED IT-OT GOVERNANCE



(UNIFIED ARCHITECTURE,  
ONE GOVERNANCE)

## CONNECTED



(ROC, CENTRALIZED INFRA,  
MOBILITY)

## ANALYTICS SUPPORTED



(PREDICTIVE ANALYTICS,  
DIGITAL TWINS)

## OPTIMIZED



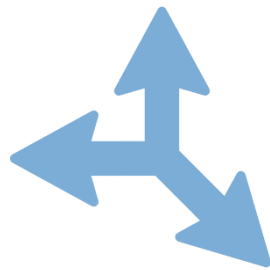
(APC, DIGITAL TWINS)

## WORKER EMPOWERED



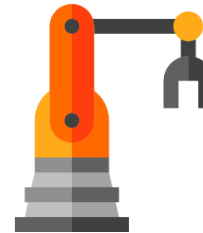
(WEARABLES, VR/AR)

## FLEXIBLE



(MAKE TO ORDER, PULL)

## AUTONOMOUS



(MINE, YARD, TRAIN LOADING,  
PORT)

## PREDICTIVE



(IN THE PIT ORE CHARACTERIZATION,  
ON THE FLY BLENDING, DYNAMIC  
CONC. SET-UP)

# WHAT MOST ADVANCED MINERS ARE DOING?

*“The cognitive digital twin is a digital representation, augmentation, and intelligent companion of its physical twin as a whole, including its subsystems and across all of its life cycles and evolution phases.” —Dr. Ahmed El Adl - Accenture*

## INTELLIGENT DECISION MAKING SUPPORT – COGNITIVE DIGITAL TWINS

### OPERATIONAL INTELLIGENCE ENGINE



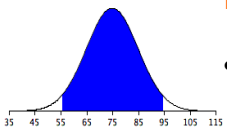
- Scenery evaluation and next best action recommendation – What-If Analysis
- Operational Knowledge Accumulation – “Active Learning”
- Determine performance based on ore quality determined by on-line ore characterization, % fines, tons/h, target ore quality, and other operational factors

### PREDICTION ENGINE



- Keep process on-spec anticipating disturbances and process variation
- Define predictive models for assets (maintenance), unitary processes and overall processes
- Characterize abnormal operations states based on multivariate process statistics.
- Recommend actions to operators and management
- Predict ore quality, and production throughput based on big data.

### PROCESS VARIABILITY ANALYSIS AND CONTROL

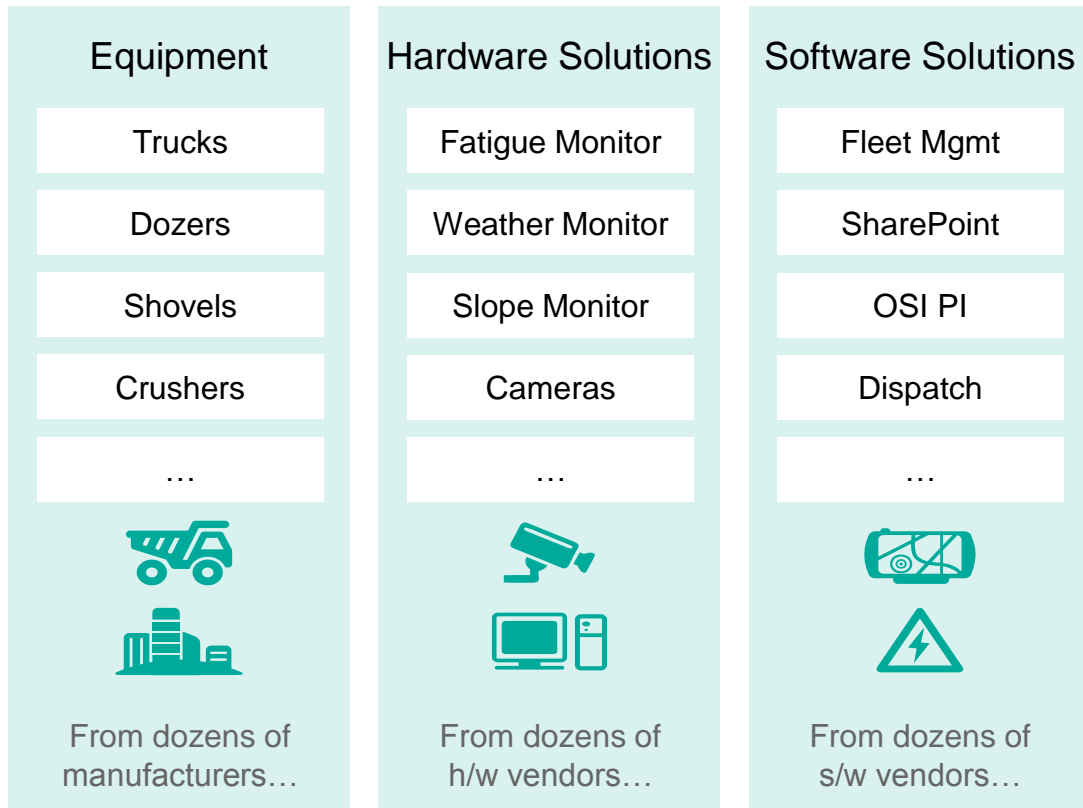


- Process variability root cause analysis: contribution plots and analysis

# CONNECTED MINE

## Client Problem

Distinct, silo'd, on-prem solutions from dozens of manufacturers & vendors means no full end-to-end view across the entire mine



## Accenture Connected Mine Solution

Presentation



IoT Platform



Sensors & other data sources





OVERVIEW

# Connected Mine



Last page update  
Up to date



**Bruce Garcia**  
Operations Supervisor

Current Shift Previous Shift

MONDAY, 31-OCT-2016

## Total Material Mined



### MINE PRODUCTIVITY

ACTUAL  
**39,170 tons/hr**

SHIFT TARGET  
**19,479 tons/hr**

#### TOTAL MATERIAL MINED

**147,894 tons**

143,573

#### HEAP LEACH MINED

**13,860 tons**

11,056

#### DUMP LEACH MINED

**14,551 tons**

18,657

#### ROM LEACH MINED

**119,483 tons**

104,478

### CRUSHERS

CONE JAW

Material Delivered to Cone

**33,908 tons**

Long Queue Time



Heap Leach	24,144
Dump Leach	9,764

### TERRAIN



### EQUIPMENT

20	Active	Running
17	Active	Delayed
2	Inactive	Available
11	Inactive	Unavailable

### ALERTS

ALARMS DELAYS



**Kaycee Tolman**

TR18's tons per hour is 75% below target  
31-OCT-2016 10:20:11 AM



**Jerry Medina**

TR32: Jerry Medina - Fatigue Detected : Critical (88%)  
31-OCT-2016 10:19:22 AM



**Overtruck Alert**

Excess of 5 trucks  
31-OCT-2016 10:21:47 AM



**Crusher Warning**

ConeCrusher1 has a long queue time  
31-OCT-2016 10:21:35 AM



ALERTS



ANALYTICS



SETTINGS



Terrain Visualization

Crusher Matrix Visualization

Mine Planning Documents



OVERVIEW



MATERIAL



EQUIPMENT



OPERATORS



ALERTS



ANALYTICS

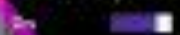


SETTINGS

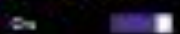


FULL VIEW

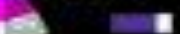
Show daily cuts



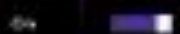
Show downs



Show trucks



Show drills



Show drill holes



SH03



ROAD TIME HOUR

2.451

JOB CYCLE TIME

0.69 mins

CURRENT CYCLE

Active-Delayed

STOP TIME

5.7 mins

HILL TIME

2.01 mins

# OF TRUCKS WAITING

2

LAST MATERIAL MINES

High Grade

ELEVATION

4105.05 M



SH01

SH02

SH03

SH04

SH05

SH06

SH07

SH08

SH09

SH10

SH11

SH12

Terrain Visualization

Material Flow

Crusher Matrix Visualization

Mine Planning Documents

OVERVIEW

MATERIAL

EQUIPMENT

OPERATORS

ALERTS

ANALYTICS

SETTINGS



**SH03 >** 

COMPLIANCE TO PLAN	AVG QUEUE TIME
<b>N/A</b>	<b>1.75 mins</b>
TONS PER HOUR	SPOT TIME
<b>704</b>	<b>0.25 mins</b>
CURRENT STATUS	# OF TRUCKS WAITING
<b>Active-Delayed</b>	<b>0</b>
IDLE TIME	ELEVATION
<b>2.27 mins</b>	<b>4106.85 ft</b>
LAST MATERIAL MINED	
<b>High Grade</b>	

SH01	SH02	SH03	SH04	SH05	SH06	SH07	SH08	SH09	SH10	SH11	SH12
------	------	------	------	------	------	------	------	------	------	------	------





OVERVIEW



MATERIAL



EQUIPMENT



OPERATORS



ALERTS



ANALYTICS



SETTINGS

Connected Mine

# Pit cameras visualization



Last page update  
None



Bruce Garcia  
Operations Supervisor

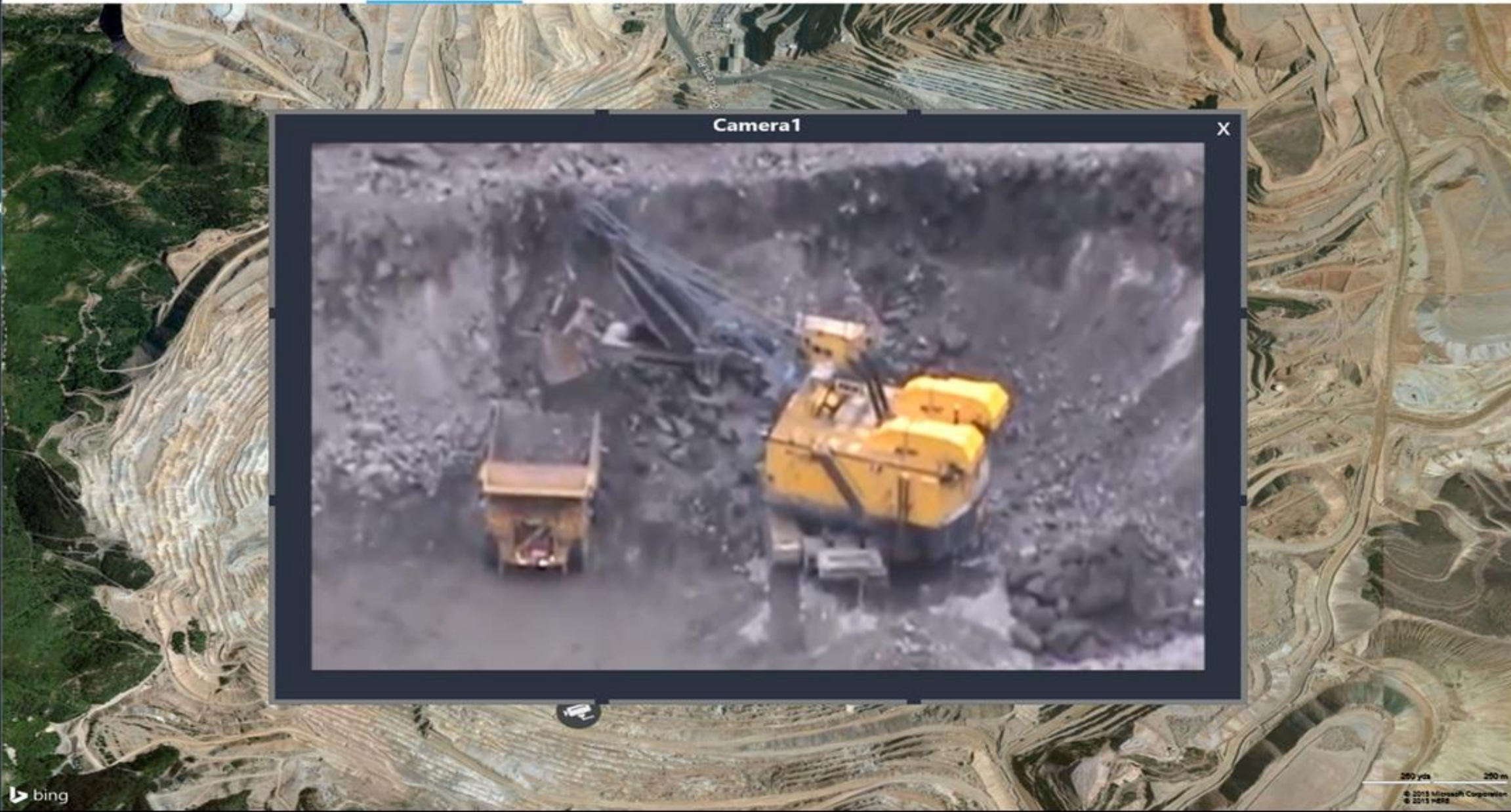


Trucks

Shovels

**Cameras**

Mills



Camera1



250 yds 250 m

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bing



OVERVIEW



MATERIAL



EQUIPMENT



OPERATORS



ALERTS



ANALYTICS



SETTINGS

# Connected Mine



Last page update  
Up to date



**Bruce Garcia**  
Operations Supervisor

< **SH03** [Brittney Reiner](#) EQUIPMENT / SHOVELS / ACTIVE-DELAYED

## SH03

REASON  
[Short shovel move](#)

LOCATION  
**B5750SR1**

OPERATOR  
[Brittney Reiner](#) >

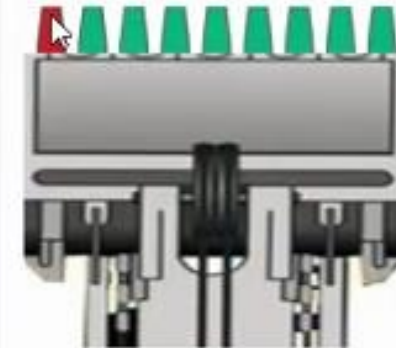
TIME IN STATE  
**02:02:41**

**Spot Time (mins)** 0.25

**Load Time (mins)** 1.21

**Idle Time (mins)** 2.27

## TOOTH METRICS SYSTEM HEALTH



Data Age 766 s

Ping 16

Points / Hour 1335

## SHOVELS PAYLOAD

	TPRH	AVG PAY	+ LOADS	UNDER LOADED	BELOW TARGET	ON TARGET	ABOVE TARGET	OVER LOADED	INVALID PAY
Crew 0	704	43	131	1%	11.5%	6.9%	5.5%	1.4%	18%

## PREDICTIVE MAINTENANCE ALARMS

ALARM NAME	ALARM CONFIDENCE	TTF	URGENCY
------------	------------------	-----	---------

*No Available Record*



Terrain Visualization

**Material Flow**

Crusher Matrix Visualization

Mine Planning Documents 



**BLASTED STOCK**

**67,850 tons**

69,917

	Actual	Plan	Cu	Au	As
Northern	30,546t	29,563t	0.60%	0.8g/t	0.25%
Western	16,935t	20,540t	1.20%	0.9g/t	0.50%
Southern	20,369t	19,814t	0.90%	0.3g/t	0.72%

**SHIPPING**

5,875 tons (5,599 tons)

**PORT STOCKPILES**



7,847 tons (7,847 tons)

**PLANT STOCKPILES**



10,401 tons (10,304 tons)

7,772 tons (7,847 tons)

13,538 tons (13,713 tons)

OVERVIEW

MATERIAL

EQUIPMENT

OPERATORS

ALERTS

ANALYTICS

SETTINGS





OVERVIEW



MATERIAL



EQUIPMENT



OPERATORS



ALERTS



ANALYTICS



SETTINGS

# Connected Mine



Last page update  
Up to date



**Bruce Garcia**  
Operations Supervisor

< ✔ **TR02 Earl Roberts** EQUIPMENT / TRUCKS / ACTIVE-RUNNING

## TR02

REASON  
**Production**

LOCATION  
**S12**

LAST SHOVEL  
**SH01 >**

OPERATOR  
**Earl Roberts >**

TIME IN STATE  
**03:10:24**

Truck Productivity (tons/hour) **860**

Average Payload (tons) **251**

Tons Hauled (tons) **2,048**

## NUMBER OF DUMPS

TOTAL 27



12

■ Number of dumps at crusher

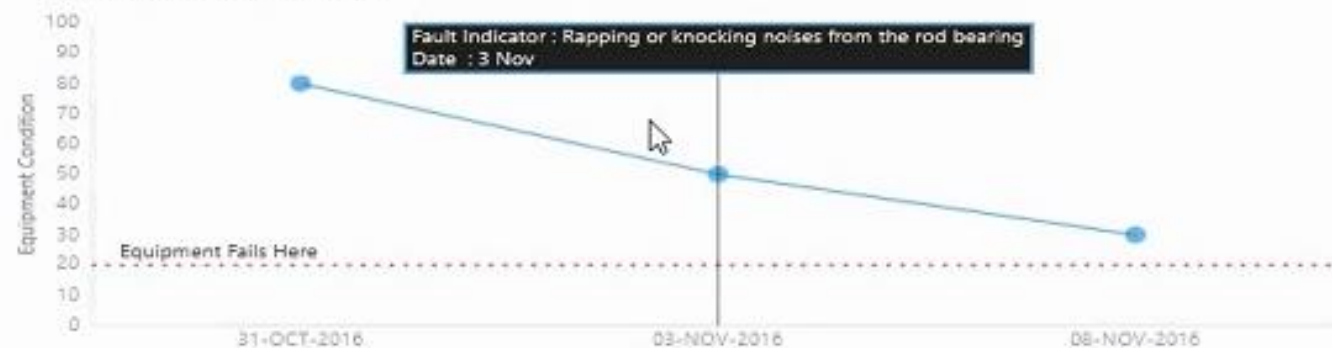
15

■ Number of dumps at stockpile

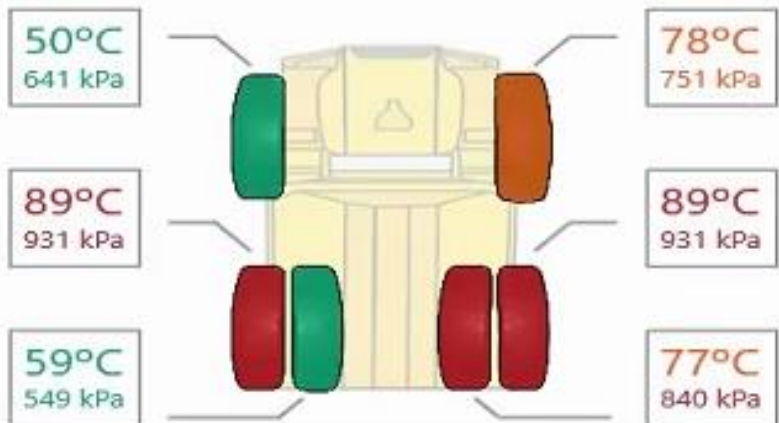
## PREDICTIVE MAINTENANCE ALARMS

ALARM NAME	TTF	URGENCY
> Indication of low oil pressure	10 days	Moderate
Engine Vacuum leak	15 days	Urgent

### INDICATION OF LOW OIL PRESSURE



## TIRE STATUS





OVERVIEW

MATERIAL

EQUIPMENT

OPERATORS

ALERTS

ANALYTICS

SETTINGS

< SEAN JENKINS TR47 OPERATOR / TRUCKS

## GENERAL



OPERATOR NAME  
**Sean Jenkins**

ASSIGNED TRUCK  
[TR47 >](#)

TONS HAULED  
**1,931**

CREW  
**7**

FATIGUE PREDICTION SCORE (TIME TO EVENT)

TTE < 2hrs	TTE 2-4 hrs	TTE 4-8 hrs	TTE 8-12 hrs
85%	1%	2%	1%



## LIST OF ALARMS

REASON	TIME
TR47's tons per hour is 50% below target	10:20:08 AM
TR47's status is now Inactive (Unavailable)	10:17:52 AM
TR47: fatigue - other eye-closure (drowsiness)	10:13:45 AM
TR47: Sean Jenkins - Fatigue Detected : Critical (84%)	09:19:22 AM
TR47's equivalent flat haul is 34% below target	06:19:01 AM
TR47: Sean Jenkins - Fatigue Detected : Critical (83%)	05:19:22 AM

## TONS HAULED

TPRH <b>97,130</b>	TONS HAULED <b>1,931</b>	IDLE AT CRUSH <b>8.1 mins</b>	TONS DELIV CRUSH <b>322</b>
FIRST HOUR TONS <b>316</b>	LAST HOUR TONS <b>264</b>	SHIFT CHNG EFF <b>741%</b>	EPH <b>5,680</b>

## LIST OF DELAYS

REASON	TIME IN STATE	TIME
Road block	00:52:22	10:16:46 AM
Delay at shovel	01:55:42	10:04:15 AM
Delay at dump	02:08:31	09:28:13 AM
Safety inspection	00:16:34	09:08:12 AM
Fueling	00:29:48	06:42:00 AM

## PREDICTIVE FATIGUE





MONDAY, 31-OCT-2016



# DIGITAL TURNAROUND

The Accenture Digital Turnaround as a Service solution incorporates contractor and asset **tracking technology, mobility applications, tablets** and **cloud analytics** to drive industry transformations.

## TURN AROUND CHALLENGES

-  Safety risk heightened due to 1000's being on site
-  **Schedule and Budget** overruns on average **15-30%\***
-  Contractor **time on tools** averages less than **50%\***
-  **5-15 %** discrepancies in **contractor billings**

## EXAMPLE CASE STUDY

- Used tags to perform asset tracking, productivity monitoring, travel time reduction, and other activities
- Accelerated Implementation time frame and operational in **70 days**
- **Wi-Fi already installed.**, extended mesh wireless network w/ **35 access points**
- **~2000 contractors** on site per day
- High degree from participation from **40 vendors**
- Tagged rented equipment and vehicles for location and usage tracking

## VALUE PROPOSITION:

**Enhance Safety**  
**Increased Productivity (5-15%)**  
**Reduced billing discrepancies (3-5%)**  
**Potential for shorter outage cycles**

## SERVICE PLATFORM (Near Real Time Visual Analytics)



\* AP Networks Turnaround database covering more than 200 turnarounds



# SAFETY REINFORCEMENT: IMPERATIVE DESIGN

Cameras with data analytics are installed to reinforce worker safety:

- Worker without PPR: vest, hard hats, etc.
- Unmanned critical zone
- Electronic fence invasion
- Other abnormal situations



“Walking the talk” with Digital



# QUESTIONS ?



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