Global Mining Standards and Guidelines Group

# GMSG Underground Working Group Stakeholder Survey Results

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# Introduction

The Global Mining Standards and Guidelines Group (GMSG) was created to be an organization to facilitate/drive implementation & development of standards and guidelines as well as act as a knowledge center and communication forum.

The GMSG Underground Mining Working Group aims to provide a central place for the underground mining community to share common needs and requirements, and drive the development of standards and best practices for the global industry.

In early 2013, the Underground Mining Working group distributed a survey to the stakeholders of the underground mining community in an effort to determine the priorities and needs of the industry in regards to the development and implementations of data and technology standards.

This document summarizes the result of that survey.

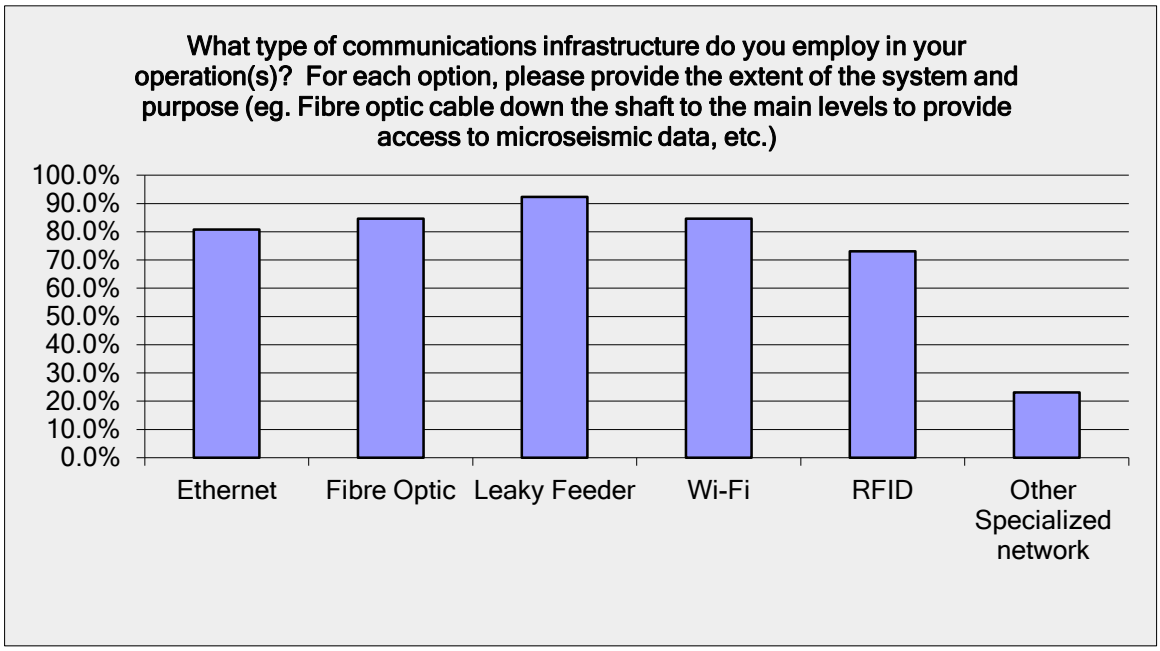
# Survey Results

## Question 1: Communications Infrastructure

What type of communications infrastructure do you employ in your operation(s)?

For each option, please provide the extent of the system and purpose *(e.g. Fibre optic cable down the shaft to the main levels to provide access to micro-seismic data, etc.)*

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Ethernet | 80.8% | 21 |
| Fibre Optic | 84.6% | 22 |
| Leaky Feeder | 92.3% | 24 |
| Wi-Fi | 84.6% | 22 |
| RFID | 73.1% | 19 |
| Specialized network (please provide name of system) | 23.1% | 6 |
| *answered question* | | 26 |
| *skipped question* | | 2 |



**Response Details**

| Number | Ethernet | Fibre Optic | Leaky Feeder | Wi-Fi | RFID | Specialized network (please provide name of system) |
|---|---|---|---|---|---|---|
| 1 | From Surface down to the unit | | | | | |
| 2 | throughout the mine for Computer and phone connection | To the levels to support the network | throughout the mine primarily for radio communication | none | in some areas of the mine for VOD tag reading | |
| 3 | | x | x | x | x | |
| 4 | run to some refuge stations for supervisors use | run through the mine for microseismic system | in all active mining areas | | | |
| 5 | Throughout the mines via control cabinets in or near each refuge station | Fiber Optic from surface to refuge stations as well as to specific instrumentation (microseismic, VOD) | Widespread | Surface only | some cases (trucks at Creighton Mine) | |
| 6 | | down communication bore hole or ramp for Internet, lan access | RFID Chip location and movement, mobile equipment and men | lan access | logistics real time management | |
| 7 | some mines down shaft out to belt drive Portable Mine power centers | some mines down shaft to main Swgr Line ups | none familar with | bottom of shaft | Not aware of use. | |
| 8 | Short distances from fibre terminations. Production level betwen wifi APs. | Most major substations, production areas, some development areas. | Most areas for voice comms. | Production level for LHD automation. | | |
| 9 | fibre down shaft to HP switch's | single and multimode down shaft | MRS throughout mine | no | no | mb+ |
| 10 | Integrator: We mainly see this on the level, occasionaly down shaft | Integrator: We mainly see this only down shaft | Integrator: We have some client sites with this technology on the level - most are trying to replace | Integrator: We see this in many sites on the level and throughout level | Integrator: We see this in many sites on the level and throughout level | |
| 11 | control system infrasructure | via partners | via partners | | | |
| 12 | Being used as monitoring system and some control capabilities for stationary underground systems. (pumps, fans,etc) | T-1 Mine is currently having fibre optics installed down the shaft to support computers. T-3 has fiber optics installed for computers. Birchtree has no fiber optics underground. | All 3 mines have extensive leaky feeder systems being used for radio transmision. | Not being used underground in Thompson. | T-1 utilizes RFID for the control system of the trolley locomotives on 3600 level. | |

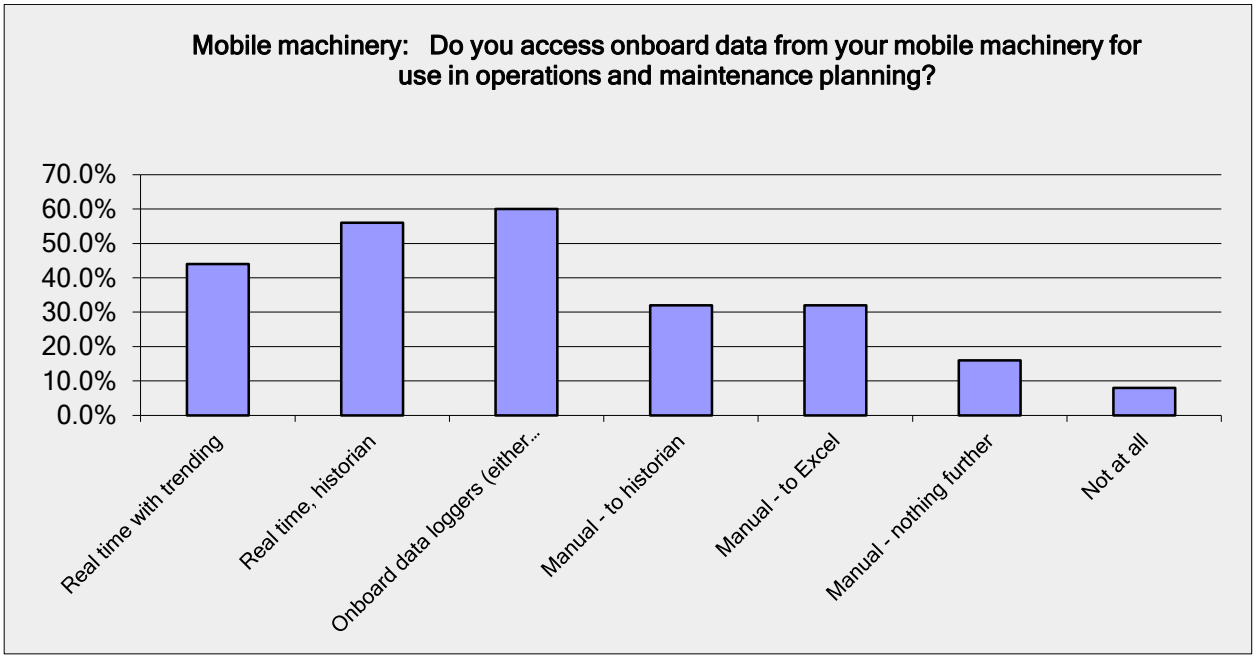
| | | | | | | |
|---|---|---|---|---|---|---|
| 13 | Installed in all infrastructure locations and utilized on personnel location Access points. | Installed in all shafts and portal entrances to key points. Set up as double and triple redundency. | Utilized from surface at portal or shaft collar throughout all of underground. | Utilized in main shop and meeting areas. Also available from personnel tracking access points. VOIP phones. | Utilized for personnel tracking, fixed equipment and rolling stock. Looking to implement materials and consumables transfered underground. | Cisco, MST, Motorola |
| 14 | Ethernet backbone on surface | | Down decline | Surface transmitting for mobile devices | | |
| 15 | YES | YES | YES | YES | YES | BROADBAND |
| 16 | Ethernet to OSIsoft PI interface data collector nodes | | | | | |
| 17 | | Down incline ramp/ for the operation of control system | Down incline ramp for mine wide communication | On surface for the communication override on operating system | | |
| 18 | Yes full mine coverage | Down the shaft and to the electrical sub station on each production level | Used as we have been developing the mine . Not our longer term communication system | Mine wide | Tags for equipment and people. | Profibus standard for device level communication |
| 19 | Yes, backbone | Yes, backbone | No | Yes, for mobile machines to transfer data to and from the machine | Yes, for location and tacking | |
| 20 | | Site wide including 100% of the underground | 100% of underground but being phased out due to WiFI | Site wide including 100% of the underground | Tags on all lamps and equipment | |
| 21 | down ramp to mine load centres | down ramp to mine load centres | down ramp to mine load centres | down ramp to mine load centres | on mobile equipment and cap lamps | |
| 22 | | | LF from surface down shaft and/or decline | Fiber from surface | RFID for positioning | 800MHz, high bandwidth radio for underground fleet management |
| 23 | computers on surface and underground | surface and underground for fixed plant equipment monitoring | radio and blasting | RFID underground and surface and computers on surface | Underground and surface | |
| 24 | all locations | down shaft | lateral and decline openings | surface only at this point | testing on equipment | |
| 25 | To lunchrooms and garages | Down shaft to access multiple systems | Donw shaft & throughout mine primarily for communication | Baby steps at this point in time | Not universal but on equipment and personnel | |
| 26 | cat 5 in all work place and office underground | in each level, and big area, for seismic system camera, plc and cat 5 ethernet system | mostly for the voice evrey where and for the data inside the shaft | just in the big garage and shop | ??? | no |

## Question 2: Current Onboard Data Access, Mobile Equipment

Mobile Equipment: Do you access onboard data from your mobile machinery for use in operations and maintenance planning?

| Answer Options | Response Percent | Response Count |
|---|---|---|
| In real time with trending? | 44.0% | 11 |
| In real time but stored in historian for post-interrogation? | 56.0% | 14 |
| Onboard data loggers (either 3rd party or OEM)? | 60.0% | 15 |
| Use of manual slips – entered into historian? | 32.0% | 8 |
| Use of manual slips – entered into Excel or other data trending software? | 32.0% | 8 |
| Use of manual slips – with no further interrogation? | 16.0% | 4 |
| Not at all | 8.0% | 2 |
| Other (please specify) | | 7 |
| *answered question* | | 25 |
| *skipped question* | | 3 |

| Number | Other (please specify) |
|---|---|
| 1 | not all equipment has telemity the manual system covers all eqipment |
| 2 | we have 2 machines with real time trend |
| 3 | not applicable |
| 4 | System is being built. Not yet operational |
| 5 | Real-time payload information for fleet management / production tracking |
| 6 | Want real time acquisition & use of data |
| 7 | from the mobile it just for mechanics tech. |

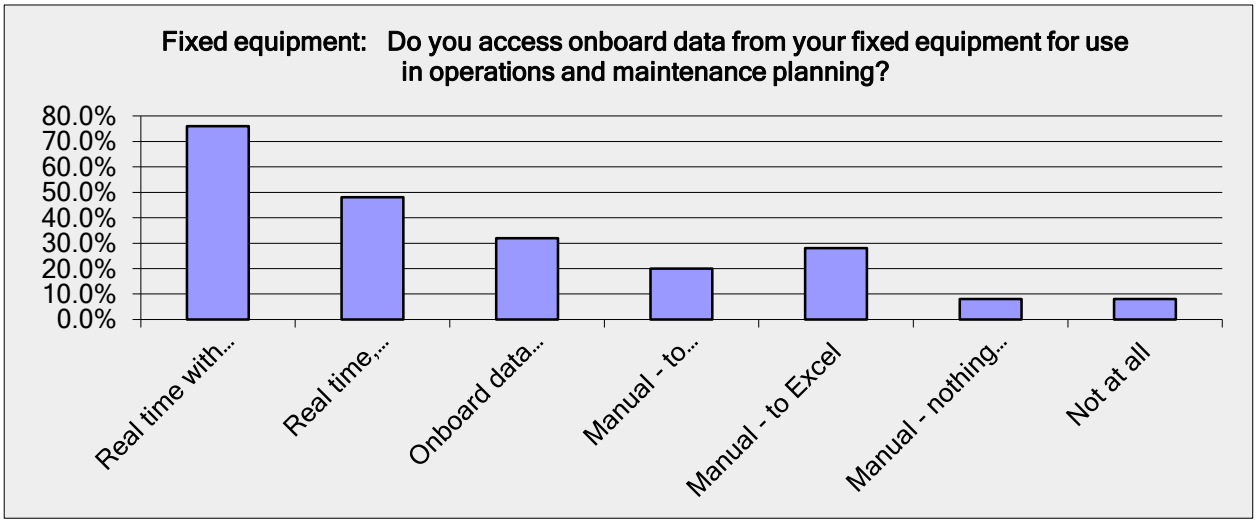


## Question 3: Current Onboard Data Access, Fixed Equipment

Fixed equipment: Do you access onboard data from your fixed equipment for use in operations and maintenance planning?

| Answer Options | Response Percent | Response Count |
|---|---|---|
| In real time with trending? | 76.0% | 19 |
| In real time but stored in historian for post-interrogation? | 48.0% | 12 |
| Onboard data loggers (either 3rd party or OEM)? | 32.0% | 8 |
| Use of manual slips - entered into historian? | 20.0% | 5 |
| Use of manual slips - entered into Excel or other data trending software? | 28.0% | 7 |
| Use of manual slips - with no further interrogation? | 8.0% | 2 |
| Not at all | 8.0% | 2 |
| Other (please specify) | | 7 |
| | *answered question* | 25 |
| | *skipped question* | 3 |

| Number | Other (please specify) |
|---|---|
| 1 | Rockwell on all belt drives |
| 2 | There is very limited real time data currently being collected. |
| 3 | not applicable |
| 4 | System is being built. Not yet operational |
| 5 | mine hoists only |
| 6 | Want real time acquisition & use of data |
| 7 | all equipement are monitor and control from surface and underground |

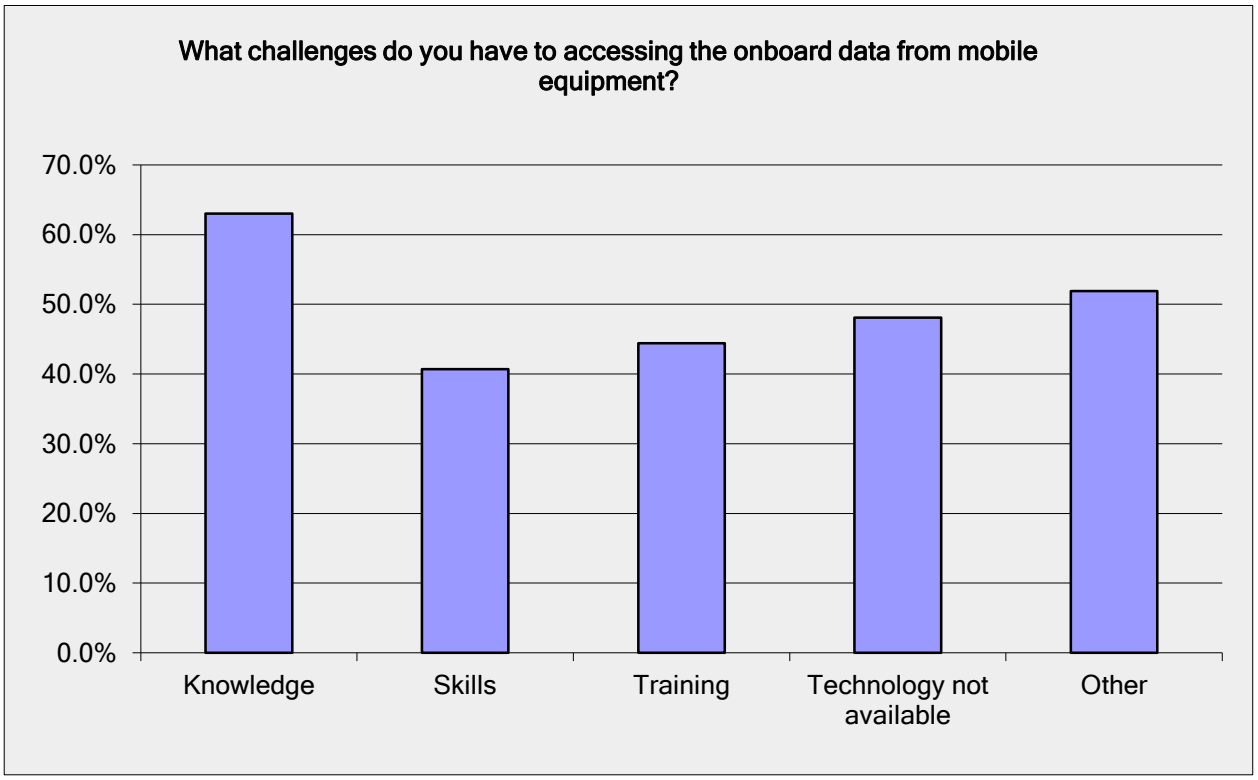


## Question 4: Challenges Accessing Mobile Equipment Data

What challenges do you have to accessing the onboard data from mobile equipment?

**Results**

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Knowledge | 63.0% | 17 |
| Skills | 40.7% | 11 |
| Training | 44.4% | 12 |
| Technology not available | 48.1% | 13 |
| Other | 51.9% | 14 |
| *answered question* | | 27 |
| *skipped question* | | 1 |



**Response Detail**

| Number | Knowledge | Skills | Training | Technology not available | Other |
|---|---|---|---|---|---|
| 1 | Joy | | | lean workforce | the technology is not in an open data schema |
| 2 | High number of technicians at the plant with limited expose to new technologies, training has to be done on site. | No standardised training, is outside of what the trades men in my department have for skills | Training is primarily OEM based and is not consistent accross the fleet. | Current infrastructure is not in line with available data distribution set ups on mobile equipment | Tooling can be specialised and expensive. Software requirements are different for each manufacture |
| 3 | | | | | work load to keep it works and investment |
| 4 | | | | | I'm not familiar with this data |
| 5 | Not widespread | Not widespread | Not widespread | RFID systems not widespread - limited funds to expand | |
| 6 | | | No training completed | | |
| 7 | | | Personal may not have necessary laptops or recording info while in proximity of equ. | older equipment needs updating with capability | logistics locating the equipment |
| 8 | Interpretation of data can be problematic. Documentation is not always complete, and firmware/protocol changes are somtimes not communicated. | Individuals with IT and engineering problem solving skills hard to attract and retain in support roles. | Problem solving skills are difficult to train | Mobile equipment self diagnostic systems are not as mature as in fixed plant. | Reliability of technology does not yet match that of base machines, meaning the data access or log hardware is often neglected as it doesn't stop the primary equipment function. |
| 9 | field communication systems | | | | |
| 10 | Lack of documentation/knowledge of file/data format, communication protocol | | Lack of documentation/knowledge of file/data format, communication protocol | Some sites do not have wirless methods of remote retrieving data from equipment. | |
| 11 | awareness | skillset | | | |

| | | | | | |
|---|---|---|---|---|---|
| 12 | Many different systems | Many systems and little experience | Little has been provided | Technology exists but each supplier is promoting a different system | |
| 13 | Finding resources with the knowledge of the new technology. | Finding resources with the skill set.. | Finding resources with the training for both technology and sophisticted electronics. | The technology is present from most major manufactures or third party integration. | |
| 14 | | | | | data not made public for researchers to access |
| 15 | | | | | Cost |
| 16 | DO NOT KNOW WHAT THEY WANT | 3RD PARTY INSTALLATION AND MAINTENANCE | | ACCESS TO ONBOARD NETWORKS | OEM WANTS TO CONTROL DATA RELEASED |
| 17 | | | | Data logger technology is relatively new, especially thoses that communicate through open protocols like OPC/OPCUA | |
| 18 | Contract labour | Contract labour | Contract labour and tools | Tools | |
| 19 | | | | | Planned and being built no operational data yet. |

| | | | | | |
|---|---|---|---|---|---|
| 20 | Local knowledge varies greatly between different markets. | New area of exertice is needed that is not often pressent at the mines. | | | This is a new animal that needs good maintenance practices, processes and personel in order to be working properly. It involves everythig from machine knowledge, communication knowledge, infrastructure knowledge and computer knowledge. Also, this should be implemented the right way in the organization, otherwise it is a risk that it is only seen as big brother watching. The IT department also needs to be invloved at an early stage to make sure tat all aspects are considered. |
| 21 | Sandvik/Symbio not big on training or documentation | | Not much provided by Sandvik | | |
| 22 | NA | | | | |
| 23 | | | | | Obtaining relevant info from OEM in order to develop interface to machine |
| 24 | confusion as to what is accessible | some lack of | lack of training personnel time | no | |
| 25 | understanding what data is saying | | | | |
| 26 | Lacking | Lacking | Lacking | Available but costly | Need consistant platforms for the technology and open system acquisition |
| 27 | | | | | some equipment have and not availlable becaus the protocol are so closed and many equipment don't have any access |

## Question 5: Data Collection Methods

With the different types of engines and not all ECM data points being available, how do you gather the required data?

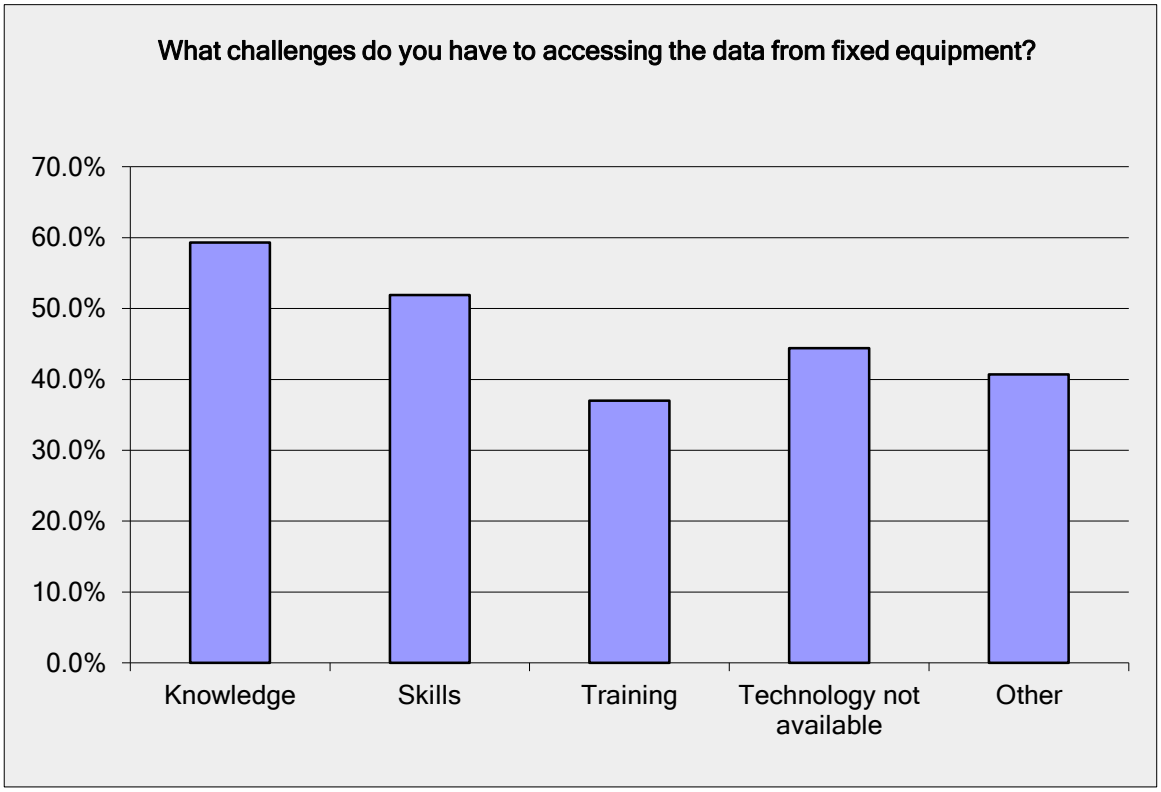
| Answer Options | Response Count |
|---|---|
| | 20 |
| *answered question* | 20 |
| *skipped question* | 8 |

| Number | Response Text |
|---|---|
| 1 | Currently data is collected onto a lap top and uploaded as required. This practice is limited and labour intensive. It also is only done during the P.M process |
| 2 | Portable computer |
| 3 | Manual recording equipment set up for specified peroids of time. Plug in PCs with software to enable download of data for analysis. |
| 4 | OEM data interfaces, augmented by additional sensors and dataloggers. |
| 5 | Need to survey manufacturors for each type. If they will not give us the information we need to access, we have to figure it out and use best guesses/trial & error. |
| 6 | via onboard control system state RAM |
| 7 | Data gathered from PM sheets or printouts of ECM downloads |
| 8 | Currently have to rely on the OEM service to provide this data. |
| 9 | not applicable |
| 10 | J1939 PORT<br><br>SNIFF THE ONDOARD DATA NETWORK |
| 11 | I would presume from the OEM through proprietary equipment |
| 12 | Manual inputs |
| 13 | Standards were available, directly to sensors through various specialized solutions. |
| 14 | Either via WiFi or paper |
| 15 | NA |
| 16 | Individual interface developed for each model |
| 17 | manual download |
| 18 | oil analysis, diesel exhaust analysis |
| 19 | Not all data gathered. The benefit is known but the retro costs are prohibative. |
| 20 | good only with the ecm of the write manufacture equipement and relly closed protocol |

## Question 6: Challenges Accessing Fixed Equipment Data

What challenges do you have to accessing the data from fixed equipment?

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Knowledge | 59.3% | 16 |
| Skills | 51.9% | 14 |
| Training | 37.0% | 10 |
| Technology not available | 44.4% | 12 |
| Other | 40.7% | 11 |
| *answered question* | | 27 |
| *skipped question* | | 1 |



**Response Detail**

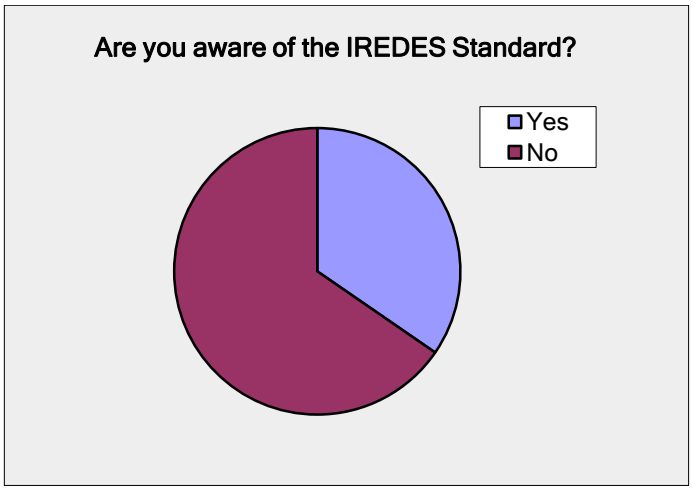
| Number | Knowledge | Skills | Training | Technology not available | Other |
|---|---|---|---|---|---|
| 1 | | lean workforce | | not all drives come with telemetry | |
| 2 | n/a | n/a | n/a | n/a | n/a |
| 3 | x | | | | |
| 4 | | | | | Data access is restricted because of licence costs |
| 5 | Knowing where and which PI tags | Ad Hoc - resources not available | PI training not delivered for everyone | Not at all minesites | |
| 6 | Not sure of range of data capture available nor the reporting format | | | | |
| 7 | | | | | logistics and time required to gather info personally when staff unavailable. |
| 8 | Legacy systems often have missing documentation and proprietary interfaces. | Legacy equipment can be difficult to maintain skills to support. | Older systems have limited training available from vendors | | |
| 9 | none | | | | |
| 10 | Lack of documentation/knowledge of file/data format, communication protocol | Lack of documentation/knowledge of file/data format, communication protocol | | some site do not have hardwire or wireless network to reach fixed equipment location for remote retrieval. | |
| 11 | little issues | | | | |
| 12 | | | | | The main issue has been a lack of focused effort to properly gather and compile data into a usable format. |
| 13 | Finding resources with the knowledge of the new technology. | Finding resources with the skill set.. | Finding resources with the training for both technology and sophisticted electronics. | The technology is present from most major manufactures or third party integration. | |
| 14 | | | | | data not made public for researchers to access |

| | | | | | |
|---|---|---|---|---|---|
| 15 | | | | | Cost |
| 16 | WHAT IS AVAILABLE | NEED AN ELECTRICAIN OR ELECTRICAL/INSTRUMENT TECH | | | |
| 17 | | | | In some cases no smart instrumentation, old analog controls not tied to the control system. | |
| 18 | automated data collection(PI) | automated data collection(PI) | automated data collection(PI) | automated data collection(PI) | |
| 19 | | | | | Planned and being built no operational data yet. |
| 20 | Not done | Not done | Not done | Not done | Not done |
| 21 | Limited | Available | limited | To a certain extent | |
| 22 | inconsistent | inconsistent | non existent | improper databases | |
| 23 | | | | | Protocols |
| 24 | no | no | no | no | time to tie equipment into underground data backbone |
| 25 | | predictive maintenance | | | |
| 26 | Lacking | Lacking | Lacking | Costly | |
| 27 | | | | | NO problem |

## Question 7: IREDES Awareness

Are you aware of the IREDES Standard?

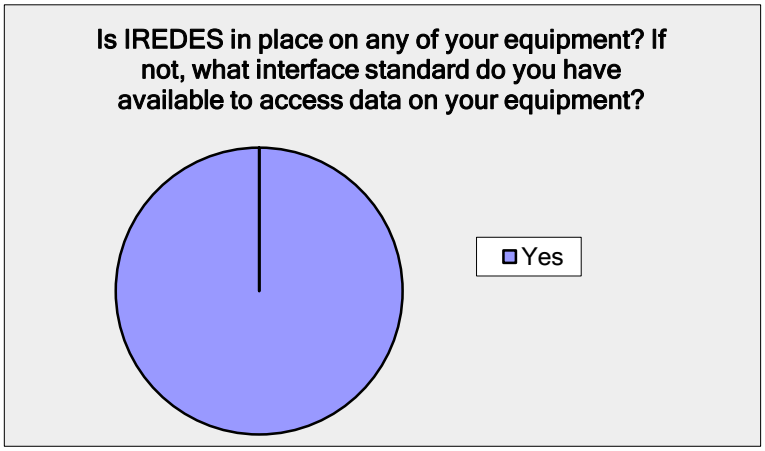
| Answer Options | Response Percent | Response Count |
|---|---|---|
| Yes | 34.6% | 9 |
| No | 65.4% | 17 |
| *answered question* | | 26 |
| *skipped question* | | 2 |



## Question 8: IREDES Utilization

Is IREDES in place on any of your equipment? If not, what interface standard do you have available to access data on your equipment?

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Yes | 100.0% | 5 |
| No (please specify what other standard) | | 11 |
| *answered question* | | 5 |
| *skipped question* | | 23 |




| Number | No (please specify what other standard) |
|---|---|
| 1 | ? |
| 2 | IEC 60929 |
| 3 | OEM standards like VIMS, and vendors who abstract OEM systems (Modular, Isaac Instruments etc) |
| 4 | No standard, generally much of the equipment uses proprietary standards |
| 5 | Unsure is our equipment meets this standard |
| 6 | Not at this moment. The IT Department utilizes the current standards for WIFI, Bluetooth and Ethernet protocol. |
| 7 | not applicable |
| 8 | I don't know |
| 9 | Proprietary |
| 10 | dont know |
| 11 | ?? |

## Question 9: Current Standards In Use

What data access, data transfer and data connectivity protocols do you have in place for underground mobile and fixed equipment?

| Answer Options | Response Count |
|---|---|
| | 27 |
| *answered question* | 27 |
| *skipped question* | 1 |

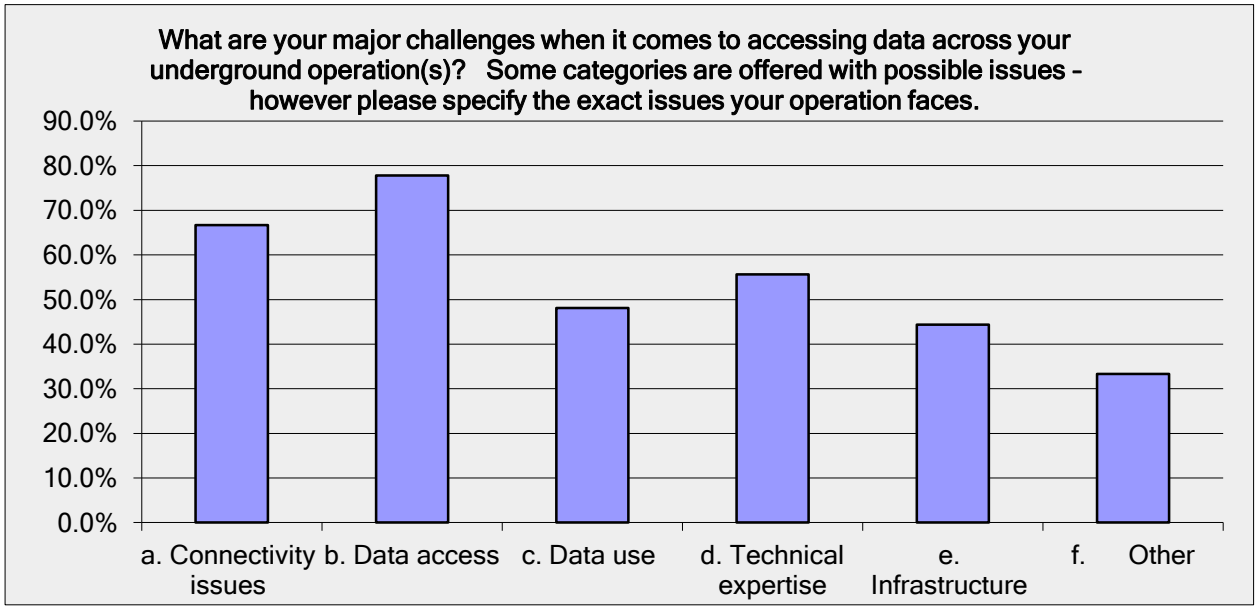
| Number | Response Text |
|---|---|
| 1 | rockwell factory talk on the belts<br><br>Joy smart services on the miners and feeders |
| 2 | Un aware |
| 3 | fews |
| 4 | Most of our data is collected on manual slips and entered to a data warehouse. It can be accessed by those with permission to run our reporting tools. Data transfer is manual and connectivity is minimal. |
| 5 | PI Datalink, PI Process Book |
| 6 | Fiberoptics with RFID interigators in portals and key work locations as well as all main haulage connection points. |
| 7 | TCP/IP |
| 8 | Access: Manual pre-start slips, Sandvik TCS/IREDES, CAT VIMS, Atlas RCS/IREDES, SQL, OPC.<br><br>Transfer: RS232, USB stick, TCP/IP/Ethernet/Wifi, IEEE 802.5.4 (Zigbee etc)<br><br>Connectivity: physical download, wifi or other wireless in some cases |
| 9 | fixed-- modbus +<br><br>fixed Ethernet modbus TCP |
| 10 | as an intergrator we work with what our client site have in  place |
| 11 | Ethernet, Modbus, serial, |
| 12 | I am not aware of the protocals |
| 13 | We try to follow IEEE standards. |
| 14 | not applicable |
| 15 | None |
| 16 | MOBILE: IREDES (OPC-UA) - STREAMING<br><br>IREDES TRANSACTIONAL<br><br>FIXED: MODICON ETHERNET |
| 17 | Currently using XML data files in IREDES format at Coleman Mine, and storing the data in the PI data historian |
| 18 | ECM for Mobile fleet , PI for fixed plant |
| 19 | Wireless ethernet |

| | |
|---|---|
| 20 | -IREDES xml files either transferred with USB sticks or via Ethernet/wifi<br><br>-Realtime data via proprietary protorcol over wifi<br><br>-OPC |
| 21 | I don't know |
| 22 | i don't know |
| 23 | CAN & proprietary |
| 24 | DeltaV, Bluetooth Wi-Fi |
| 25 | Fixed only - PLC's monitor loading pocket, dewatering, bulkfilling |
| 26 | Done not have this knowledge |
| 27 | Mobile, each company have owned<br><br>fixed equipement we use PLC and no problem |

## Question 10: Major Challenges

What are your major challenges when it comes to accessing data across your underground operation(s)? Some categories are offered with possible issues – however please specify the exact issues your operation faces.

| Answer Options | Response Percent | Response Count |
|---|---|---|
| a. Connectivity issues (eg. No standard system, No standard method for communication, Lack of reliability of communication system, etc.) | 66.7% | 18 |
| b. Data access (eg. Use of manual slips and data entry, No system to access data from multiple machines, Lack of real time data, Lack of data integrity, Data errors, No standard method to access data, Closed system and no access to the data, Too many types of equipment and non-standard access methods, Costly to access on board data, etc.) | 77.8% | 21 |
| c. Data use (eg. No standard KPIs, Not easy to interrogate the data, No business system to show data trends, Not easy to investigate data for trends etc.) | 48.1% | 13 |
| d. Technical expertise (eg. Lack of internal technical experts, Lack of external technical experts, Too many non-standard approaches, etc.) | 55.6% | 15 |
| e. Infrastructure (eg. Expensive, Not reliable, Non-standard, etc.) | 44.4% | 12 |
| f. Other | 33.3% | 9 |
| *answered question* | | 27 |
| *skipped question* | | 1 |



| Number | Connectivity | Data Access | Data Use | d. Technical expertise | e. Infrastructure | f. Other |
|---|---|---|---|---|---|---|
| 1 | we move our power centers every two to three days and we have to disconect and reconect | | | | | the PLM modems have a lot of noise issues on the supper secitons |
| 2 | Currently the infrastructure is leaky feeder and is not integrated to support data collection | Too many types of mobile equipment without a common data collection approach | Te data is not real time, information is generally inputted and collected manualy | | | |
| 3 | | | | | | we have a lot of information and a good back bone |
| 4 | The system is not managed well so data collection is not reliable | Data reporting is too slow for daily use, reporting system is not well understood by majority | Data based decision making is not a mature culture here | Not always available | | |
| 5 | | Lack of communication system, closed system usually the case | Limited KPIs set-up, immature operational performance | Limited skills available due to lack of resources | Some "higher-tech" infrastructure available - capital constraints | |
| 6 | | manual entry degrades data reliability | | lack of internal and external expertise | expensive,language restricted, requires custimization | |
| 7 | | electrical protection protocols different protocols having | | too many different software languages evolving at same time. | | lack of organization std of information, |
| 8 | Lack of wireless coverage and backbone communications. Lack of standard data models and communication protocols, requiring custom system integration. Onboard hardware reliability. | Still using manual reporting for some key processes, leading to lack of quality and integrity of data. Lack of realtime decision making data/KPIs. Some closed OEM systems restricting access to data. Use of non-standard time models, making comparison of machines or vendor systems difficult. | Limited use of standard KPIs. Lack of decision support tools for site personnel (shift and weekly planning). | Lack of internal technical experts on site, for support and optimisation. Many manual reporting systems using Excel etc. | Cost of infrastructure deployment in brown-field operations. Reliability and support issues around technology infrastructure underground. Use of non-standard comms protocols and hardware by OEMs. | Business case for underground technology is not easy - relatively small volumes of equipment and slim margins keep OEM R&D spend low (and distributed across fragmented customer requirements). |

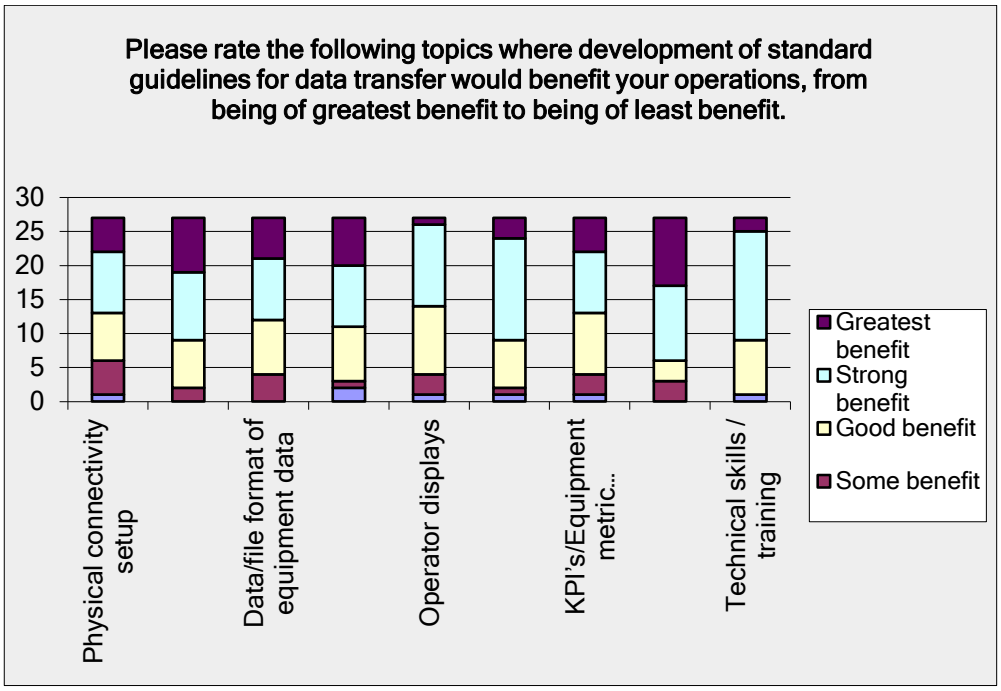
| | | | | | | |
|---|---|---|---|---|---|---|
| 9 | Infrastructure (eg. Expensive, Not reliable, Non-standard, etc.) | Technical expertise (eg. Lack of internal technical experts, Lack of external technical experts, Too many non-standard approaches, etc.) | | | | |
| 10 | unreliable communications, lack of accessible/widespread wi-fi | lack of standard data/file formats for equipment types | differences in client network structures/access policies. no standard kpis, no standard storage structure. | | hesitation from industry to utilize modern infrastructures | |
| 11 | intermittent, security | noise, integration of data and 3rd party protocols | | in some cases | | |
| 12 | No standard system | All | All | Lack of internal technical experts | All | The main issue has been a lack of focused effort to properly gather and compile data into a usable format. |
| 13 | Continually have issues with fiber splices and terminations due to dusty and equipment exhaust. Internal issue. | Personnel change positions and take knowledge with them. Just when you get someone trained they transfer to a new postion or leave company. | It is a challenge keeping the data in a meaningful report and ontime to properly utilize. | Lack of personnel with Underground knowlegde of communications. What works on the surface does not always work underground. | No standard for equipment developed or forward thinking for expansion and upgrades. | |
| 14 | | data not made public for researchers to access | | | | |
| 15 | | | | | | Cost of system for our project stage and budget |
| 16 | REQUIRE WiFI, LEAKY FEEDER TO LOW BANDWIDTH, STORE AND FORWARD CAP[ABILITIES REQUIRED WHEN OUT OF RANGE OF ACCESS POINT | CLOSED SYSTEMS | NO STANDARDS, PEOPLE WANT DATA BUT DO NOT KNOW WHAT TO DO WITH IT | LACK OF BOT INTERNAL AND EXTERNAL EXPERTISE | VERIES DEPENDENT UPON AGE AND MINE REQUIREMENTS | TOO MANY PROPRIETARY SYSTEMS, NO MANAGEMANT GUIDANCE |
| 17 | no wireless equipment in place, lack of infrastructure | No standard on board data logger technology | No Standard KPI's, this needs definition | Lack of vendors in this space | Expensive, security architecture needs definition | |
| 18 | | Bulk of mobile and stationary information are manual inputs. | | | | |
| 19 | | | | | | In implementation Will know challenges once in use |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | Coverage of infrsastructure and methods for handling senarious with intermitent coverage | Yes all of the above | | Yes all of the above | Yes all of the above | |
| 21 | Np problems with data | Just need to develop procedures and management routines | Being implemented onsite | More a lack of training than ability | | |
| 22 | no standards for comms | manual downloads no real time trending | not real time | mix of equip, lack of standard | non-standard; no standard | |
| 23 | Low bandwidth and incomplete coverage | | | | | |
| 24 | some reliablility issues | | | | | |
| 25 | | Not at a maturity stage where available data is analyzed closely for the purpose of predicitive maintenance/process out vs capability | | | | |
| 26 | Multiple systems through evolution with no integration capacity | Human error or lack of care for manual slips and slip entry | Code required | Technical piece plus retro costs | Costs | |
| 27 | in the main area no problem, but in the gallery and stop no access except leaky feeder | no system to access date from multiple machine | no real databas , no kpi | so many kind of system, no expertise in all | outside the main area, I never see a real accessible system at a good price | no |

## Question 11: Standards Development Needs

Please rate the following topics where development of standard guidelines for data transfer would benefit your operations, from being of greatest benefit to being of least benefit.

| Answer Options | Greatest benefit | Strong benefit | Good benefit | Some benefit | Least benefit | Response Count |
|---|---|---|---|---|---|---|
| Physical connectivity setup | 5 | 9 | 7 | 5 | 1 | 27 |
| Communication protocol with data loggers | 8 | 10 | 7 | 2 | 0 | 27 |
| Data/file format of equipment data | 6 | 9 | 8 | 4 | 0 | 27 |
| Format of data in historical repository | 7 | 9 | 8 | 1 | 2 | 27 |
| Operator displays | 1 | 12 | 10 | 3 | 1 | 27 |
| Equipment alarms/alerts | 3 | 15 | 7 | 1 | 1 | 27 |
| KPI's/Equipment metric computations/formulae | 5 | 9 | 9 | 3 | 1 | 27 |
| Communication infrastructure | 10 | 11 | 3 | 3 | 0 | 27 |
| Technical skills / training | 2 | 16 | 8 | 0 | 1 | 27 |
| | | | | | *answered question* | 27 |
| | | | | | *skipped question* | 1 |



## Question 12: Data Access/Transfer Areas of Focus

In terms of improving ease of data access and transfer, describe up to 3 areas of focus where you would benefit most from the immediate development of a standard or guideline.

| Answer Options | Response Percent | Response Count |
|---|---|---|
| Key area of focus | 100.0% | 27 |
| Second area of focus | 88.9% | 24 |
| Third area of focus | 66.7% | 18 |
| *answered question* | | 27 |
| *skipped question* | | 1 |

| Number | Key area of focus | Second area of focus | Third area of focus |
|---|---|---|---|
| 1 | standard data format | robust communication infrasructure | retro fitting older equipment |
| 2 | Mobile equipment real time data ( equipment condition, performance, location ect...) | Material movement and delivery systems | |
| 3 | - | - | - |
| 4 | Equipment connectivity for transferring onboard data to surface | Common data format | KPI development |
| 5 | Core Mobile Equipment - Primary Tram | Process Managment - Fill systems/Hoist systems | |
| 6 | Standard protocols for multiple brands of equipment | band load reduction for dense data transmission | |
| 7 | WiFi | | |
| 8 | Development or adoption of standard data models and protocols, allowing use of a common language amongst different OEM systems without extensive systems integration “glue” | Development or adoption of standard interface protocols for low level OEM systems, primarily aimed at realtime data for operator displays and communication amongst machinery (OPC-UA/ISA95 etc) | Development of flexible mining process models, allowing OEMs to adopt a common representation which could be adapted to different customers without large amounts of effort, ideally resulting in increased speed of development and promoting innovation. |
| 9 | standard hardware platform | consistent software platform | |
| 10 | standard data/file format | standard physical connections/communication protocol | standard format of historical data |

| | | | |
|---|---|---|---|
| 11 | people communications of standards between mobile, undergraound and plant | universal data storage and integration | production and energy optimization |
| 12 | Infrastructure | Technical Skills training | KPI's |
| 13 | Equipment to Remote Access Point | Remote Access Point to Network | Wireless Infrastructure |
| 14 | standardized reporting on energy consumption and factors of influence | energy efficiency initiatives implemented in mining industry | performance of implemented energy efficiency initiatives over time |
| 15 | imaging software for surveys | | |
| 16 | MOBILE EQUIPMENT DATA NETWORKS | MOBILE EQUIPMENT SPECIALIZED SENSOR INATALLATION | DATA MULE - THE ABILITY TO STORE AND FORWARD DATA WHEN OUT OF RANGE FROM HOT SPOT |
| 17 | Fixed equipment | mobile equipment | environmental |
| 18 | data collection inter phase for equipment | xed plant interface | Production stats |
| 19 | Production monitoring | Mtce information | Personnel tracking (Into the ore stoping area's) |
| 20 | Maintenance data | Work order standard to send work orders to a machine and repotr back | |
| 21 | Conditional monitoring of all mobile equipment | Process monitoring of all mobile equipment | Signal continuity |
| 22 | real time data acquisition | | |
| 23 | Standardized protocols | N/A | N/A |
| 24 | removal of duplicate/conflicting data | ability for everyone to access the information | ease and speed of access |
| 25 | wi-fi | rfid | real time data monitoring |
| 26 | Standardization | Open / common software development | |
| 27 | have one commun protocol | establish standard information data shhet and kpi | Find a good, cheap and reliable communication system |

## Question 13: Valuable Data

List the top 5 most desired pieces of data re: your equipment or network, to which you currently do not have immediate access.

| Answer Options | Response Percent | Response Count |
|---|---|---|
| 1 | 100.0% | 27 |
| 2 | 85.2% | 23 |
| 3 | 74.1% | 20 |
| 4 | 66.7% | 18 |
| 5 | 59.3% | 16 |
| *answered question* | | 27 |
| *skipped question* | | 1 |

| Number | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | precise location tracking | | | | |
| 2 | Prod stat slip data, meter readings | Location of equipment and men | Performance of equipment including haulage rates | Drill and bolting plan informatin both fed to and taken from the equipment | Material tracking and delivery |
| 3 | - | - | - | - | - |
| 4 | location | utilization | productivity | maintenance alarms | maintenance schedule |
| 5 | Scooptrams | Haulage Trucks | Drills - ITH / Tophammer | Drills - Jumbos / Bolters | Sandfill systems - pouring controls for quantity and quality |
| 6 | Grade of material in transit | ventilation quality | | | |
| 7 | electrical fault power parameters at time of failures in protective relays. Voltage, Current, frequency, | | | | |
| 8 | Location | Production / development / task completion rate | Real-time asset health events / metrics | Real-time environment monitoring | |
| 9 | mobile equipment data | remote stationary infrastructure | | | |
| 10 | as an integrator this is site/client dependent. | | | | |
| 11 | energy | energy | energy | energy | energy |

| | | | | | |
|---|---|---|---|---|---|
| 12 | Hr. meter readings | Realtime production data (volumes/cycles ect) | Realtime Operating Data ( Temp, speed, pressures, etc) | GPS - positioning data | Ambient work place conditions ( temp, Humidity, Gases) |
| 13 | Equipment Hours. Fixed and Rolling Stock | Equipment Alarms | Equipment Health | Fixed Equipment Flows, Pressure and Levels | |
| 14 | energy consumption (disaggregated for all sources) | production | mining depth | ore grade | mining method |
| 15 | Location services | image transmittion | | | |
| 16 | PAYLOAD - NO RELIABLE SYSTEM | FROM AND TO WITH WHAT PRODUCT (RFID) | EQUIPMENT MONITORING AND DIAGNOSTICS | AIR QUALITY SENSOR NETWORKS FOR VOD | MEDICAL AWARENESS AND HEAT STRESS |
| 17 | Hoist Production | Material handling performance | Mobile equipment performance and production | Energy | environmental |
| 18 | Heath of equipment | Hours of operation | real time production | Enviromental conditions(real time) | operational status of fixed plant equipment |
| 19 | Heath of mobile equipment | Production information | Location tracking | | |
| 20 | Location | | | | |
| 21 | Condition monitoring on older equipment - Drills | Process monitoring on older equipment - Drills | Condition monitoring on non-Sandvik equipment from one source | | |
| 22 | downhole piezos | drainage gallery flows | mine discharge | trending | acquisition |
| 23 | N/A | N/A | N/A | N/A | N/A |
| 24 | whether equipment is up or down and why | automated real time truck tonnage tied to pickup location | equipment hours | fuel usage | dynamic engine parameters |
| 25 | personnel and equipment tracking | visible traffic control | equipment condition monitoring | warehouse & inventory tracking | GPS capability underground |
| 26 | LHD tonnage record from stope to orepass | Real time equipment monitoring | Real time personnel monitoring | Supply distribution (in/out) | Air quality/flow |
| 27 | Mobile scoop tram | Mobile jumbo | mobile production drill | mobile bolter | all mobile service equipment |

## Question 14: Industry Wide Standards

Please comment on what you feel the tactical and strategic value of industry-wide standards or guidelines for data access would be for your underground operations.

| Answer Options | Response Count |
|---|---|
| | 27 |
| *answered question* | 27 |
| *skipped question* | 1 |

| Number | Response Text |
|---|---|
| 1 | Currently we are reliant on Joy to provide us with our data. if Joy followed a standard we could use alternative systems. |
| 2 | Would ensure the technology is better shared with all involved. Create standards to ensure regulations are met as they pertain to wireless technology. |
| 3 | We ahave a lot of information and automatisation. When we want smthing new we just have to ask for and we do it |
| 4 | It would give senior management confidence to make infrastructure investments. Communications technology changes so quickly, it doesn't make sense to invest in something that won't be supported a couple years later. |
| 5 | Improve real-time analyses, track overall Equipment Effectivenss (OEE) including Availability and Utilization. Facilitate the management of Operational Risk. |
| 6 | the ability to monitor in real time the KPI of value stream. Being able to reallocate physical or staff resources based on changes in actual vs plan performance. |
| 7 | would evolve the technology faster by focusing initiatives. Communication components would all be able to talk to each other. |
| 8 | Methods of integrating the data from multiple pieces of equipment or OEM systems currently exist, but mostly at the historian level. Standards would allow real-time integration of the data using common metrics and models. It would also ideally reduce the wasted expenditure on both OEM R&D and system integration, and allow reduced skill/knowledge sets to support the same amount of equipment. |
| 9 | very high value |
| 10 | having standards such as these in place would simply our commissioning and design work as well as allow for higher quality systems for our clients. |
| 11 | seamless integration with the rest of the facility |
| 12 | Industry-wide standards should reduce costs by reducing upgrades/Obsolescence |
| 13 | As we have standards for almost every area in the Underground realm this is one that is continually shopped around for equipment. With a large number of companies getting into the R&D of this type of equipment it seems like every company has a different means of communication. |

| | |
|---|---|
| 14 | As a researcher focused on reducing energy consumption in the mining industry I believe that it would be invaluable to gain access to data which is not currently made available to researchers. This includes energy consumption as well as the factors which affect energy use in a mineral operation such as production, mining depth, ore grade and mining method among others. I also believe that a central repository with standardized reporting on implemented energy efficiency initiatives and their performance would facilitate assessment of these measures and may enhance dissemination of best practice. Increased transparency in energy matters would allow mining industry to progress in this area by providing data to researchers which would allow development of innovative solutions. |
| 15 | Not thought about it. |
| 16 | 1. BECOMES NO EQUIPMENT SPECIFIC - LOWER COST FOR DATA SYNERGIES<br><br>2. STANDARDIZED DATA REQUESTS<br><br>3. ONLY ONE SYSTEM TALKING TO NETWORK (ONE ANTENNA ON A PIECE OF EQUIPMENT)<br><br>4. CORRECT DATA INPUT (MINIMAL MANUAL ENTRY)<br><br>5. COST SAVINGS RELATED TO DATA CAPTURE AND USE (STANDARDIZED DASHBOARDS, ETC) |
| 17 | Standard policies, procedures, and guidelines across the entire operations for data connectivity and access to plant information |
| 18 | To be able to midigate potencial production equipment failures and be aware of status of equipment is in my mind the greatest gain. Having a universal interface with equipment and a monitoring system is critical. |
| 19 | Value in accessing and implementing equipment / from different suppliers. Value in maintaining equipment based on the required knowledge. |
| 20 | It would speed up the development of fleet managment tools and also make it possible to have common systems for muli vendor senarious. Less time will be spent on customized solutions and integration projects. A healthy eco system will bring new and innovative solutions faster to the market and reduce the dependency for having a singel supplier suppling the complete solution. I think standars is the way to go to achieve that.Comparing other industries that allready done this journey will prove that. |
| 21 | A definite improvement to both |
| 22 | consistency across a single site |
| 23 | Interoperability of different productivity-enhancing systems |
| 24 | ease of transfer of information skill and data across the industry |
| 25 | Mines deeper and farther from shafts, require the next shift in efficiency/reliability to reduce unit costs. A communication infrastructure foundation will enable this shift to occur |

| | |
|---|---|
| 26 | Strategic by allowing increased efficiency & utilization of resources; Tactical in have=ing the ability to know where people, equipment and supplies are. |
| 27 | it must be world wide, the equipment comming from everywhere |