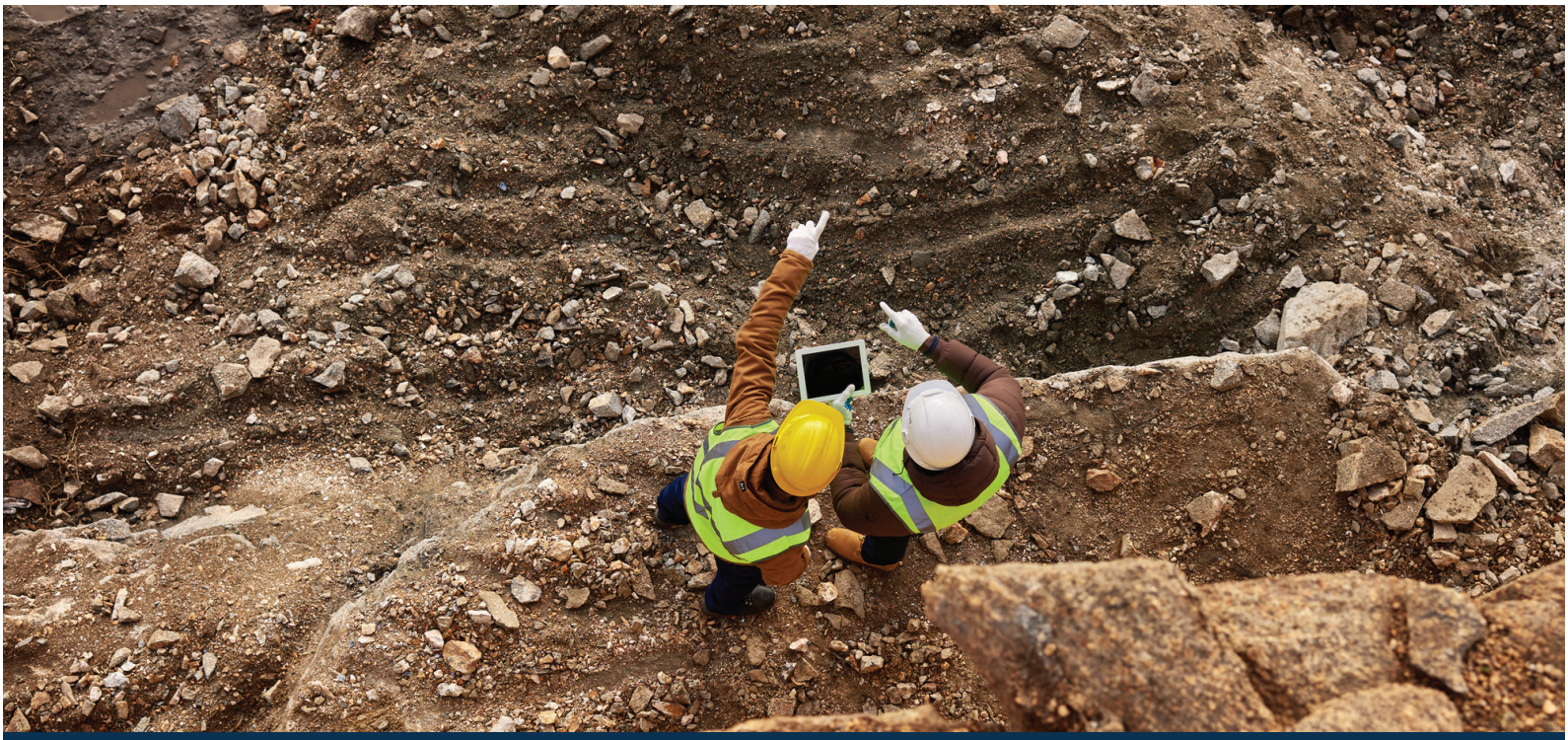

Balancing the potential impact of new innovations and technologies

on the mining and mining supply services workforce over the next 3-5 years

a research project exploring new technologies and the impact on occupations and skills that will be required

a partnership project of Workforce Planning for Sudbury & Manitoulin and The Labour Market Group

Sudbury & Manitoulin Workforce Planning
Planification en main-d'oeuvre

The Labour Market Group
Guiding partners to workforce solutions.

March 2023

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INTRODUCTION

The mining and mining supply services sectors are at different stages of supporting and adopting new technologies and innovations based on various internal and external drivers. Preliminary findings from a November 2022 research project conducted by University of Waterloo examining technology adoption[i] identified the following **top four key drivers in the decision to adopt new technologies**:

74.2%
productivity and efficiency

57.1%
accessing deeper and more difficult mineral deposits

47.5%
health and safety hazards

25.1%
labour shortages

Other factors such as environmental concerns, ESG (environment, social and government), and compliance with government regulations played a smaller yet noteworthy role.

While each factor has a significant impact on the consideration and/or adoption of technology, research on workforce skills that will need to transition, support or sustain new technologies and innovations is almost nonexistent. Although important, current research conducted by MiHR[1] (Mining Industry Human Resources Council) and others on the mining and mining supply workforce, tends to use traditional supply/demand models and global market projections (i.e. lower global nickel prices), where the industry is contracting, remaining stable (baseline measure), or expanding/growing. Based on these approaches and assumptions, even if the industry remains relatively stable, it is clear that regardless of new technologies that are introduced, future labour shortages are imminent. It also acknowledges that older workers are or will be retiring and attracting new entrants across various occupational categories including the skilled trades, continues to be low.

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[1] *MiHR – Mining Industry Human Resources Council; for more information go to: www.mihr.ca*

As a result, with the mixed yet sometimes rapid pace of new technological changes, **it is critical to identify the technologies and the enhanced or new skills and occupations that will be required to support them**.
At the same time, this needs to be balanced with current industry demand and the necessity to continue operations. It is not like a magical wand where all things will change at once. It will be a progression and transition that could be gradual or swift but nevertheless, is already underway.

For those businesses that embrace new innovations and technologies, it is imperative to understand the workforce skills that will be required to support these changes.
The adoption of new technologies such as GPR (Ground Penetrating Radar) is challenging if no one knows how it works, how to use it, how to fix it or how to interpret the resulting data. Some companies may choose to wait on the sidelines until true and tested technologies are available, or other drivers (as noted above), make it a necessary part of business operations. Those businesses that decide not to embrace new technologies may be left at a competitive disadvantage.

There is a need to assess the type or status of new technologies along with the workforce skills or new occupations that will be required. And of parallel importance, it is necessary to identify opportunities that exist to train, re-skill or up-skill the current workforce and/or attract new workforce entrants with advanced skills based on projected industry need.

The pace of adoption across the mining and mining supply industries will become a significant driver. A good example of this is the push towards BEV (Battery Electric Vehicles). There are a number of internal and external drivers that are advancing the pace of adoption. However, there is an equally important consideration; the new workforce skills that are required to support this new technology. This has already become apparent for heavy duty equipment mechanics that were trained on diesel-fuelled equipment. If they are not properly trained (or up-skilled) on new BEV, it could have catastrophic results. Local colleges are beginning to offer specialized training on BEV and some companies are developing in-house training modules in an effort to keep pace with the changes.

In an effort to explore the impact of new technologies on workforce development, **Workforce Planning for Sudbury & Manitoulin[2] in collaboration with The Labour Market Group[3] (both of whom are workforce planning boards funded by the Ministry of Labour, Immigration, Training and Skills Development) agreed to survey industry leaders in their respective geographical areas**. These local boards also contracted an experienced individual with significant knowledge of the mining industry and familiarity with industry leaders to conduct key informant interviews.

The results of these surveys and interviews are highlighted in this report. It should be noted that similar to emerging technologies that are developing, this report is focussed on a point in time as new technologies, new needs and new workforce skills will continue to grow, shift and change. For example, it is expected that in the future, advancements in remote operations will result in workers no longer being required to go underground. This new reality is imminent, not somewhere in the distant future.

RESEARCH OBJECTIVE

The objective of this research project is to understand the workforce skills that will be required to support the range of new technologies and innovations that are or will be implemented over the next 3-5 years in the mining and mining supply services sectors in northeastern Ontario. As noted, many of these changes are driven by, but not exclusive to: improving safety and efficiency, mitigating risk, minimizing the environmental footprint, reducing production and workforce costs, increasing global competitiveness, and increasing profitability.

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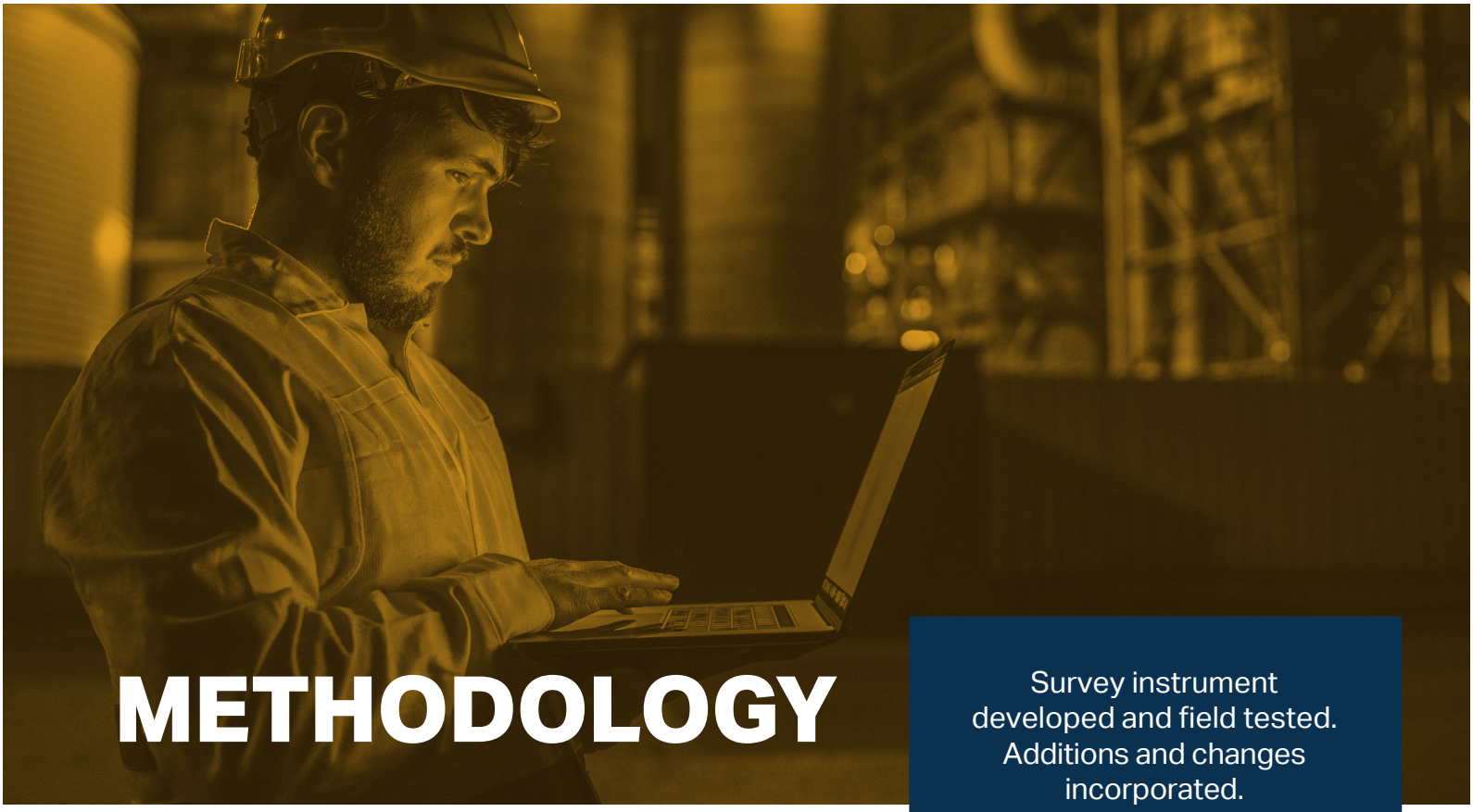
[2] *For more information on Workforce Planning for Sudbury & Manitoulin go to: www.planningourworkforce.ca*

[3] *For more information on The Labour Market Group go to: www.thelabourmarketgroup.ca*



METHODOLOGY

A survey instrument was developed and field-tested with several experts. Suggested additions and changes were incorporated. Surveys were emailed to the mining sector database by each workforce planning board along with reminders every few weeks to complete the survey. The length of time the survey was open in each workforce planning board area varied. Additionally, other stakeholders such as MineConnect[4] and the economic development department at the City of Greater Sudbury were asked to share the survey with their contacts.

Key informants provided qualitative support to the more quantitative information that came from the survey results.

In all, the combined efforts resulted in approximately 60 responses, mostly from key industry leaders. This included responses from owners and upper level management, as well as IT/high tech and human resources directors. Together, they helped to create a more comprehensive picture of what is happening in the mining and mining supply services sectors and the new skills and occupations that will be in demand.

Survey instrument developed and field tested. Additions and changes incorporated.

Surveys emailed to mining sector database/ key stakeholders

Key informants provided qualitative support to survey results

Results helped to create a more comprehensive picture of what is happening in the mining/mining supply services sectors and the new skills/occupations that will be in demand

[4] *MineConnect-Ontario Mining Supply and Services Association; for more information go to: www.mineconnect.com*

LIMITATIONS

The biggest limitation to this research project is the fact that **very little research has been done in the field on this topic worldwide** and as a result, the literature is almost nonexistent. This made it challenging to formulate the survey questions and relevance of what information was needed to assess future workforce skills in these sectors yet balance this with today's realities and skills requirements.

Additionally, local mining and mining supply service companies are significantly different in size and as noted, at various stages of exploring and/or adopting new technologies and innovations. While companies were asked to decide who could best answer the questions being posed in the survey, responses came from a variety of sources such as company CEOs, business owners, IT leads, HR and others. As with all surveys, it was also challenging to get employers to respond. This is why key informant interviews were used to supplement survey responses. This was not only invaluable, but complementary to survey responses received.

Given this, the findings expressed in this report are limited and need to be reviewed with caution. Companies that did not respond may not be adopting any new technologies or innovations or may be too busy running their business to consider how technologies may benefit them. In other instances, companies may be unwilling to share information that they may feel is proprietary.

However, the report does provide a starting point to examine how new technologies and innovations will undoubtedly impact the future skills needed in the mining and mining supply workforce as some companies forge ahead and others proceed with caution or wait in the wings.

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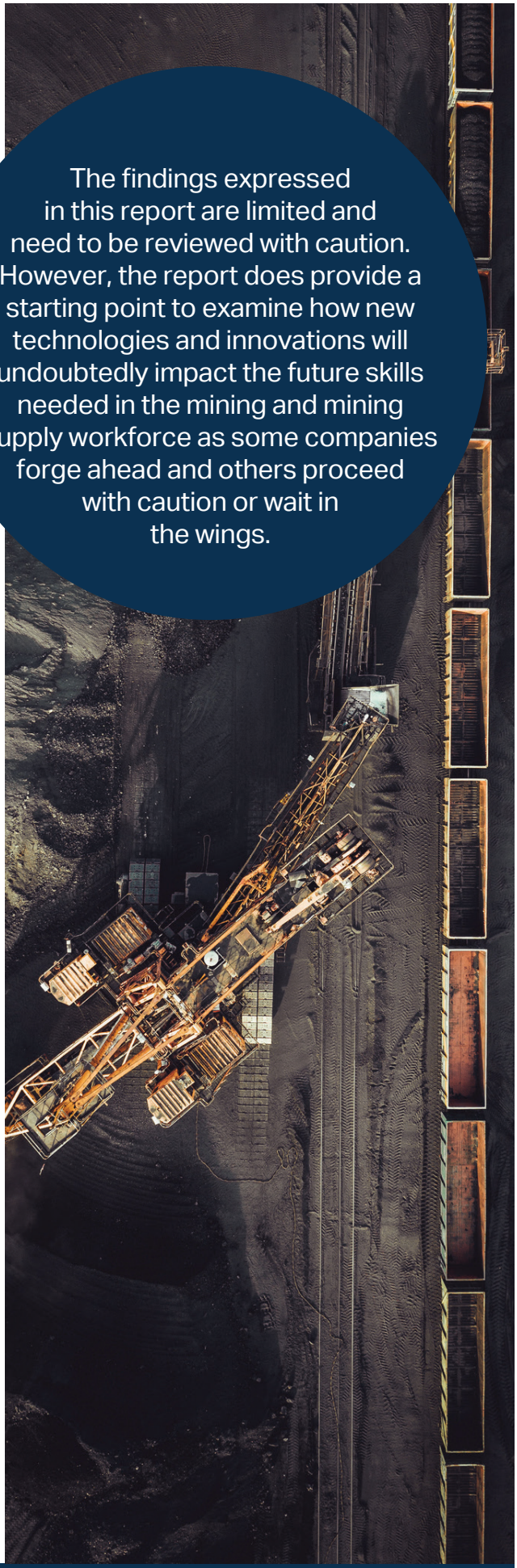

FINDINGS

NEW AND DEVELOPING TECHNOLOGIES:

Things are rapidly changing and evolving in the mining and mining supply services sector – but not for all local businesses. Some have explored and committed to new innovations, while others are reluctant to consider or adopt them.

While the reasons vary, **respondents provided a significant list of new technologies and innovations that are in varying stages of development or adoption**. Definitions for some of these new technologies and innovations are provided in the endnotes. Additionally, while these new technologies have been sorted into various categories, this list is by no means exhaustive. It is also important to note that respondents identified two other important considerations:

1. There is a synergy across each of these categories requiring system integration and understanding. As one company executive stated, companies will no longer require single person knowledge but will need generalists who understand the requirements of the entire system.

2. New metrics will need to be developed to ensure that there is a constant evaluation loop of new technologies and innovations to measure their impact and success.

ADVANCED ROBOTICS/ EQUIPMENT

- **AI (Artificial Intelligence)**
- **ML (Machine Learning)** – machines that learn and adapt using algorithms
- **AR (Augmented Reality)** – enhanced training methods and real-time guidance for inspections, audits and diagnostics
- **Agile mobile robots** – enhanced scanning and surveying in harsh and dangerous environments
  - Boston Dynamics devices[ii]
  - Drones and remote controlled devices

AUTOMATION

- **RPA (Robotic Process Automation)**[iii]
- **Automated data collection** (rather than manual) – people, vehicles, equipment[iv]
- **Mechatronics**

AUTONOMOUS SYSTEMS

- **Autonomous mines** – more digital and autonomous technologies
  - Mining and extraction methods
  - Tramming and mobile equipment
  - **Deep mining applications** (continue mining in areas less inhabitable to humans)
- **Digital transformation**

HEALTH AND SAFETY FOR WORKERS

- **Collision avoidance systems**
- **Tracking solutions** for personnel and assets
- **Biometrics monitoring**[v]
- **Reduction of emissions** (BEV equipment)

SENSORS AND SONAR

- **Optical sensors** on mining equipment and miners
- **Sonar**
- **Seismic monitoring systems**[vi]
- **LiDAR (Light Detection and Ranging)**[vii]
- **Laser Range Finder (LRF)** – use of a laser beam to measure precise distances
- **GPR (Ground Penetrating Radar)** – use of electromagnetic waves to detect contrasts in soil
- **Gamma sensors** to detect radioactive materials

REAL TIME DATA

- **Cloud based technologies** – uses the internet to allow real-time access to store and analyze data[viii]
- **Internet of Things (IoT)**
- **Data acquisition, storage, management, analysis**
- **Accelerated access through dashboards**
- **Onboard telemetry**[ix] (automatically collects, transmits and measures data remotely)

IMPROVED EQUIPMENT/ REDUCTION OF EMISSIONS

- **BEV (Battery Electric Vehicles and mobile equipment)** – operate on batteries that store electricity; eliminate diesel from mine sites
- **Electrification**
- **Electric conveyors**
- **Ventilation on demand**

DIGITIZATION

- **Computerized or digital devices/systems**
- **Digitized data**

SOFTWARE

- **Low-code development platforms**[x]
- **Open source ERP (Enterprise Resource Planning)** – resource planning software system where source code is public
- **ALM (Application Lifecycle Management)** – integrated system where all teams are involved in the planning, application and lifecycle of a software application
- **Environmental health and safety software**
- **CNC (Computer Numerical Control)** – preprogrammed computer software for factory tools and machinery used in manufacturing

REMOTE OPERATIONS

- **Remote controlled equipment and operations**, including tele-remote (from surface or remote locations)
- **Remote mucking, rock breakers, loading and other equipment**

SMART MINING TECHNOLOGIES

- "**Smart mining uses private cellular connectivity, edge computing, and IoT sensors to transform job site data into intelligence**. For example, smart sensors placed throughout underground mine shafts can proactively alert miners to the presence of toxic gas and low-oxygen areas." (celona.io)

COMMUNICATIONS

- **Communication infrastructure**
- **Use of virtual boards** – interactive whiteboards for teaching, sharing information, links, and communication
- **LTE (Long Term Evolution) cellular devices** – wireless data transmission
- **Evaluating efficacy of 5 or 6 G**
- **Enhanced WIFI meshed networks, Bluetooth, enhanced features for Leaky Feeder Infrastructure**[xi]

OPERATIONAL PROTOCOLS AND TRAINING

- **Training** - VR (Virtual Reality) and AR (Augmented Reality) with prototyping; simulation
- **Digitizing payroll**
- **Electronic payroll system** – self serve model
- **Use of contact tracing technology** (due to pandemic)

MINERAL DEPOSITS AND ORE CHARACTERIZATION

- **Ideon Technology** "new cosmic ray muon tomography technology uses sub-atomic particles from space to locate mineral deposits" (CIM)[5]
- **More directional drilling**
- **New grades of aluminum and steel**
- **Real-time sensing of ore grade and waste rock** (i.e. MineSense)[6]

OTHER

- **Laser technology** (welding, cladding)
- **Low carbon technologies**

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[5] *CIM Magazine; for more information go to: https://magazine.cim.org/en/*

[6] *MineSense a pioneer in digital mining solutions; for more information go to: https://minesense.com/*

SKILLS AND OCCUPATIONS:

Key informants and survey respondents were asked to identify the new skills that will be required; the new occupations that will be in demand; and what occupations will be most impacted by new technologies and innovations.

NEW SKILL SETS REQUIRED:

- ☑ digital literacy
- ☑ advanced computer skills
- ☑ use of cloud-based technologies
- ☑ how to operate and interpret new equipment technology (drones, LiDAR, micro-seismic monitoring)
- ☑ ability to remotely operate equipment
- ☑ operation and maintenance of new technology (need to transition in steps)
- ☑ specialists to generalists – disappearance of single person dependencies
- ☑ new aptitude skills
- ☑ system analysis and evaluation
- ☑ combination of creative skills and technical skills

NEW/IN-DEMAND OCCUPATIONS:

As noted, many respondents feel that there will be a move away from specialists towards generalists who understand how the "system" works. System integration plays a key role to advancing technological change. At the same time, those surveyed recognized that **certain highly-skilled specialties will be in demand** and that there will be global competition for these occupations. With the exception of a few occupations, many of these are not generally included in current mining workforce research studies that have been undertaken. They include:

Engineers (mining engineers, software developers, processing engineers, data engineers)

Mechatronics specialists | **Testing technicians** | **Digital transformation managers**

IT specialists | **Data managers, scientists, analysts, predictive analysts**

Technologists | **Coaches** | **System integrators** | **"Change" managers**

Programmers | **Machinists** | **AI and ML specialists** | **Electronics designers**

Safety professionals | **Fleet analysts** | **Heavy equipment computer technicians**

Drillers (noted by respondents that drillers are difficult to find)

OCCUPATIONS THAT WILL BE AFFECTED:

- Equipment technicians and operators
- Underground production development miners
- Front-line supervisors
- Professional development coaches
- Safety professionals
- Various administrative positions: clerks (data entry, payroll, material recording, stock-keeping); accountants/bookkeepers; and executive secretaries
- Heavy truck and bus drivers
- Skilled trades: heavy duty equipment technicians; electricians; mechanics; millwrights
- Locomotive engineers
- Manual surveyors, inspectors and drillers
- Instrumentation specialists

Note: Occupations listed here were identified as jobs that will be impacted. Retraining or up-skilling may be required to meet the developing demands of new technologies.

EMBRACING NEW TECHNOLOGIES AND INNOVATIONS:

Survey respondents and key informants clearly recognized the needs, challenges and benefits of exploring, integrating and adopting new technologies and innovations. They also acknowledged that various drivers are impacting the way they operate their business and the adoption of new technologies. One of the most current and influential drivers is the move to BEV which will change various aspects of mining and the mining supply services sectors as a whole.

Other prevalent drivers identified in this survey include: health and safety; social responsibility; economics; short and long term viability; sustainable solutions and local procurement (made in Ontario/Canada); efficiency/proficiency; environment (climate change, recycling, green technology) and government policy/pressure. ESG as a collective driver worldwide includes: Environment (bio-diversity, tailings, noise, air, energy, carbon foot print); Social (human rights, gender, labour practices, vulnerable populations, health and safety, security) and Governance (legal compliance, ethics, transparency). These drivers will continue to have a profound impact on current and future decisions and business models in the mining and mining supply services sectors.

Many of those interviewed also identified some key areas that will need attention in addition to the drivers. These include the need for system integration as already noted; a paradigm shift; hiring change managers (to navigate digital transformation, adoption of technology, shift mind and skill sets, and prepare the workforce); data-driven decision-making; as well as strategies to bridge the generational divide, attract/retain new workers, and source/outsource global talent.

RECOMMENDATIONS:

Various recommendations were made to address some of the issues discussed in this report. As an example, one company has implemented a "logical change" committee and is working with the local union to help prepare the workforce in advance of new skills that will be required and changes that are being planned to support a smoother transition.

Other suggestions include:

BRIDGE THE GENERATIONAL DIVIDE:

- older workers tend to be supervisors and more comfortable with spreadsheets
- younger workers are more comfortable and not intimidated with new technology
- explore pairing or mentoring opportunities
- increase efforts/opportunities for knowledge transfer (differing skill sets)
- acknowledge experience vs. risk

EDUCATION AND TRAINING:

- use micro-credentials to up-skill or retrain
- increase support for Work Integrated Learning (where students participate in co-ops, apprenticeships, etc.)
- improve skilled trades system (various challenges noted) and address ongoing problems with the apprenticeship system, trades exams, etc.
- provide money to train
- develop new programs to support system integration and change management
- offer mechatronics (combine robotics, electronics, computer science, telecommunications systems, control and product engineering)
- address process to change/revamp college programs which is currently too slow

FORM INDUSTRY PARTNERSHIPS:

- create "think tank" to address tech innovations/changes
- work together to leverage efforts
- explore more sustainable solutions
- global sourcing of talent
- outsourcing technology needs and innovations (keep proprietary technology in-house)
- balance outsourcing

DEVELOP METRICS TO:

- measure technology impact and success
- assess workforce skills needed
- support and embrace data-driven decision-making

INDUSTRY-WIDE AWARENESS CAMPAIGN:

- improve industry image
- attract younger workers
- use "gamification" to promote tech skills and as an attraction strategy
- create "wow" factor – similar to what is used in deep space exploration by NASA

CULTURAL DIVERSITY AND EQUITY:

- attract more diverse groups
- promote and incorporate equipment with less physical requirements to support attraction

WORKPLACE HEALTH AND SAFETY:

- support mental health and wellness
- support a more balanced approach to home and work life

INCREASE FUNDING AND SUPPORT:

- for technology and new innovations
- to offset cost of new battery-electric vehicles and equipment
- to retrofit infrastructure of older companies

ROADMAP TO SKILLS DEVELOPMENT, ATTRACTION AND RETENTION:

The advancement and rapid pace of new innovations and technologies in the mining and mining supply services sectors requires attention.
Although each company is at different stages of considering or adopting new ideas and ways of doing business based on various drivers, times are changing. To ignore these changes could impact domestic and global competitiveness and ultimately harm those companies that are unwilling or unable to keep up with the pace. They will be left behind or may simply close their doors. This would be disastrous to the sector.

Collectively, most companies in these industries are influenced by the same drivers, some of which are external and some of which are internal. Health and safety, efficiency, profitability, and expected labour shortages are common and shared drivers which may present a unique opportunity when it comes to promoting the industry, attracting new entrants (domestic or international) and maximizing the skills of the current and future workforce. Although this research project can only address what is currently happening with technology at this point in time, the workforce and skills needed requires a much longer, fluid and adaptable strategy.

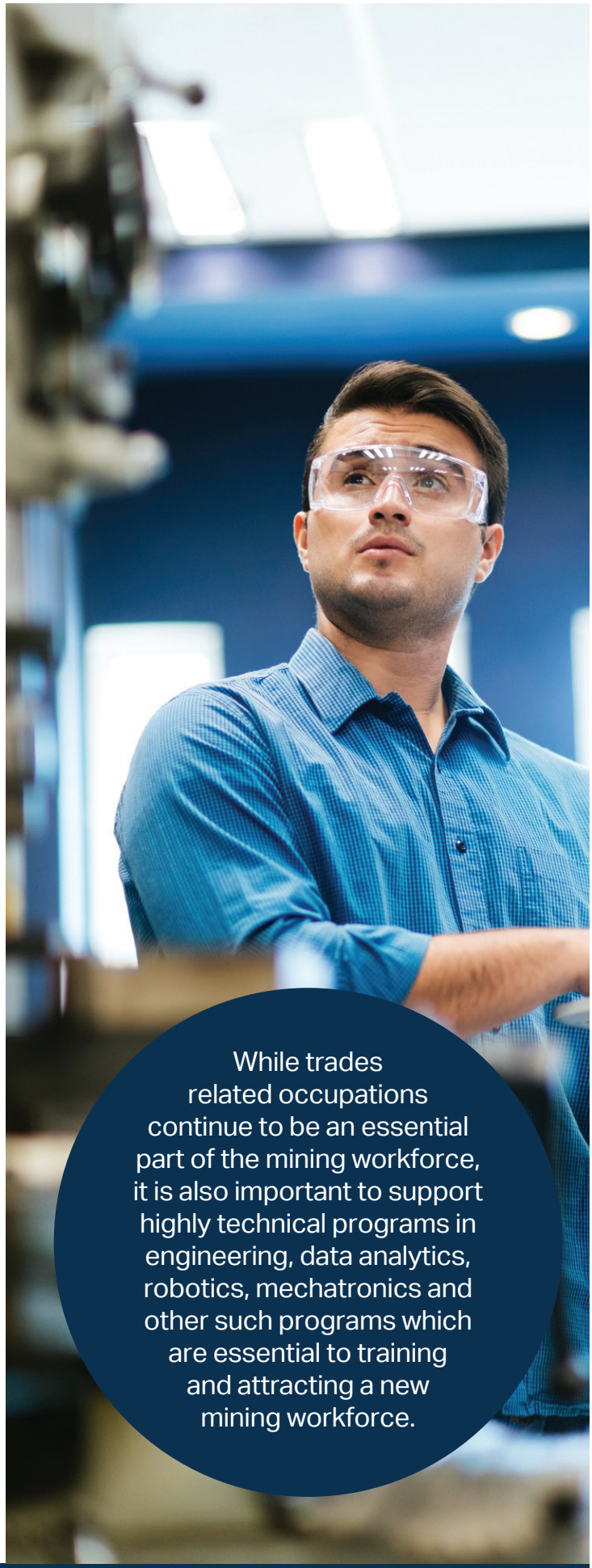
While most companies want to advance, they also want to capitalize on the experiences and knowledge of their older workforce but acknowledge the challenges and resistance that exists when it comes to the adoption of technological changes that require digital skills. At the same time, they recognize that younger workers are much more willing to take risks and fully embrace new technologies. Finding ways to bridge this generational divide will be key to maximizing everyone's skills and abilities. Various strategies proposed include the formation of intergenerational teams, mentorship opportunities, system integration teams and shared training.

The companies surveyed and interviewed also focussed on the perceived negative image of the mining and mining supply services industries and felt it is contributing to a lack of new and younger entrants. Companies could work together to build an awareness campaign to illustrate the new and exciting things happening in their industry. Some have even suggested that technological changes and advancements in mining could be compared to NASA's space program to make it more appealing and attractive. Additionally, it was suggested that industry promotions capitalize on the use of gaming skills which is now being used for simulation training exercises for various occupations in other industry sectors, such as the military (i.e. fighter pilots).

However, creating excitement cannot be done through education alone, but through opportunities for hands-on experiences to explore equipment and participate in activities to highlight new technologies. Where possible, opportunities to introduce students to the industry should be supported by both employers and the education system. It is equally important however, to acknowledge that career choices made by students are also driven in part by their parents. This could be a significant influencer (negative or positive) in communities that have been reliant on the ups and downs of industries such as mining.

It was suggested that an industry think tank be created to collaborate on attraction and identify skills that could be provided by college programs or micro-skills training which would not only showcase new technologies but benefit the industry as a whole. While some essential training is already being deployed for BEV by local colleges, more students would benefit from seeing and experiencing the application of drone technologies, seismic monitors, remote controlled equipment, AI in action and/or the use of AR or VR tools.

While trades related occupations continue to be an essential part of the mining workforce, it is also important to support highly technical programs in engineering, data analytics, robotics, mechatronics and other such programs which are essential to training and attracting a new mining workforce. Many of these occupations will be needed to work with and maximize the benefits of new technologies. This would also include embracing and opening the doors to attract a more diverse workforce. The development of an inventory of programs (micro-skills, college, university and other training facilities) could also play a critical role here not only to promote the industry as a whole, but to showcase the range of talent that is needed, and program supports available to meet those needs.



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Similarly, much like what we have witnessed over the years in Ontario with the skilled trades, all of these programs need to offer hands-on experiences to make them representative of the jobs and opportunities available. As in many industries, employers express concern about the lack of experienced and available talent. In addition to the post secondary Program Advisory Committees (PACs), it is important for education institutions to allocate appropriate human and fiscal resources to work directly with local mining and mining supply services employers. This could help to bridge the student to employer gap, focus on the workforce development needs of industry, ensure relevant/current training, and facilitate a direct connection from education to job opportunities and employment in the industry.

Without exception, all companies recognize that the competition for global talent is and will continue to be intense and challenging. The companies that participated in the survey and interviews identified that the search for qualified talent is difficult. The competition is not only for highly skilled technical positions, but for experienced skill trades occupations as well. Advocacy by provincial and federal governments to recognize foreign credentials, facilitate access and reduce barriers to international talent is crucial to augment the mining and mining supply services workforce.

The Ontario government has recently adopted the new *Ontario's Critical Minerals Strategy unlocking potential to drive economic recovery and prosperity 2022-2027* which recognizes the immense contribution that the mining and the mining supply industries make to overall economic growth. While expanding exploration strategies, embracing new technologies and innovations, and supporting the industry are essential to accessing critical minerals, the training, skills and availability of the current and future workforce is of equal importance. Ontario's Critical Minerals Strategy recognizes this and includes "growing the labour supply and developing a skilled labour force" as the sixth pillar of this strategy.

Many companies in this industry recognize that growth cannot be done in the absence of a highly skilled, trained and talented workforce to fill their needs in various mining and mining-related occupations. This research is an important first step in creating a roadmap for identifying and up-skilling the current mining workforce while preparing for the future workforce that will be needed to remain open for business and to ensure companies can be competitive in a global market. As new innovations and technologies will continue to be developed, a parallel process needs to be embraced for the development and growth of the current and ever-changing workforce of the future.

END NOTES: DEFINITIONS

[i] Technology Adoption in Canada's Mineral Mining industry Preliminary Findings, University of Waterloo Power Point Presentation

[ii] Boston Dynamics – an American engineering and robotics design company that builds robotic machines with mobility, dexterity and agility to access difficult and challenging environments, including mines

[iii] Robotic Process Automation – software robotics that uses intelligent automation technology to perform repetitive tasks

[iv] Mechatronics – multidisciplinary field that combines mechanical and electrical engineering to design and maintain autonomous equipment including robotics

[v] Biometrics monitoring – sensors that are embedded into wearable devices and Smartphones and other objects to track and collect biological, physiological and/or behavioral data

[vi] Seismic monitoring systems – uses sensitive seismographs to detect and locate nuclear explosions that occur underground; and distinguish them from natural or man-made seismic events such as earthquakes and mining explosions

[vii] LiDAR – remote sensing that uses light in the form of a pulsed laser to measure distances to the Earth for precise three dimensional information

[viii] IoT – "describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet" (Oracle.com).

[ix] Onboard telemetry – wireless technology for real-time transfer of digital data; can be used to monitor and implement key activities

[x] Low-code development platforms – "software development approach that requires little to no coding to build applications and processes. Instead of using complex programming languages, you can employ visual interfaces with basic logic and drag-and-drop capabilities in a low code development platform." (kissflow.com)

[xi] Leaky Feeder Infrastructure – offers two-way communication that is clear and the high-speed transfer of data underground

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