



A Summary Report of the Impacts of Disruptive Technologies in the British Columbia Mining Sector

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About this Project

This report is part of *Remote controlled: The impacts of disruptive technologies in the Canadian mining sector*, which was designed to understand the impacts of disruptive technology adoption, including the scope of technologies that could disrupt traditional production practices and the future of work. For more information, please visit [our project website](#).

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Executive Summary

The mining sector in Canada is in an “age of disruption” (Stuart et al., 2015) where technology has the potential to reshape the future for workers and communities. Remote Controlled is a national research project that aims to understand the adoption of emerging technologies in the Canadian mining sector and the impacts on mining communities in rural and northern communities (Hall et al., 2025).

Technology in the Kootenay and British Columbia Mining Sector

This report summarizes findings from a case study of the Kootenay Region in the Province of British Columbia (BC).

Top Technologies

- Autonomous equipment and electrification of mines and mining equipment stood out as top categories both in the present and the future.
- Several technologies related to data collection and analysis were often discussed together and if we consider sensors, AI, machine learning, and software collectively, this becomes the dominant technology type.
- Technology development was discussed on a continuum, where technology can be adopted in its current form, but where continued advancements are projected.

Drivers of Technology Development and Adoption

- Top drivers were making mining more sustainable, managing risks and costs, improving mining operations, increasing productivity and efficiency, and worker safety. These were often discussed together, illustrating links between drivers.
- Drivers differed depending on the interview type, illustrating differing perspectives and motivations between interview categories.

Barriers to Technology Development and Adoption

- The top barriers identified by interviewees were mining culture and attitudes, high costs and inadequate funding to support tech adoption, and lack of skilled labour and workforce shortages.
- All three of these barriers were found in relation to discussions of autonomous equipment and electrification and there was alignment on the barriers between the interview categories.

Employment Impacts & Required Skills

- New jobs and job loss were anticipated. This paints a picture of the changing nature of work in the mining sector, including the changing physical location of work, the changing nature of the work, and shifts in who is doing the work.
- Needs for skills training and education cover a wide range of specific technical skills and areas of knowledge. Universal to all is the need for adaptability to deal with ongoing change and uncertainty.

Regional Development Impacts and Responses

- Discussions often expanded beyond technology specific into the impacts of mining on regional development broadly. Most technology specific comments related to opportunities for business development and expansion.
- There are a range of innovative and collaborative programs related to technology in the mining sector. The majority are provincial or national in scale.
- Mining dependent communities are aware of risks and opportunities, but face challenges in acting, particularly around proactively addressing uncertain risks.

General Influences on Mining Technology, Adoption, and Innovation

- There were mixed impressions on the influence of COVID-19. The pandemic was seen to have accelerated adoption of technologies that enhanced remote work and communications but decelerated regulatory approvals of other new technologies.
- There was no universal agreement on the factors that have the greatest influence on technology adoption in the Canadian mining sector. Responses related to the financial aspects (e.g., access to financing, costs) alongside government programs (e.g., incentives) and policies were the most often discussed.

Future Considerations

- Future technology adoption will be influenced by site-specific and operation specific considerations.
- The role of ESG considerations in influencing technology is likely to continue to increase.
- While rural communities face both opportunity and risks within this landscape of changing technology, there are barriers preventing them from responding proactively.

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1 Introduction and Context

The mining sector in Canada has entered an “age of disruption” (Stuart et al. 2015), where advances in technology are fundamentally reshaping the future of work and economic development. Globally, increased automation and digitalization in the mining sector are becoming a growing reality. For example, in Australia Rio Tinto’s Mine of the Future™ features autonomous (driverless) haul trucks that operate 24/7 from a control centre located over 1,500 kilometres away (Rio Tinto, 2022). Growing alongside these trends is a rich body of international research examining how emerging technologies are transforming mining operations and redefining the relationship between mines and the people and communities where they operate (McNab and Garcia-Vasquez 2011).

However, comparatively little is known about these technological shifts and the adoption of emerging technologies in the Canadian mining sector, particularly the community and regional level impacts and responses.

[Remote Controlled](#) is a national research project exploring technology adoption in the Canadian mineral mining industry and the future of work and economic development in four case study regions: Newfoundland and Labrador; Northern Ontario; British Columbia; and the Yukon.

1.1 Overarching Research Objectives and Methods

The key objectives of the research are to:

- (1) Determine the nature and extent of emerging technologies in the Canadian mining sector;
- (2) Examine how these technologies are reshaping the sector;
- (3) Identify what is driving the adoption of emerging technologies in the Canadian mining sector; and
- (4) Explore the impacts on mining communities/regions and the related responses by companies, organizations, governments etc.

To better understand technology adoption, impacts, and responses, we conducted:

- A **systematic scoping review** of articles in the *Canadian Mining Journal* to assess the main drivers, barriers, and opportunities for technology adoption in the Canadian mining sector between 2016 and 2024 (see Crabbe et al. 2025);
- A **survey** of Canadian mining representatives exploring the drivers, enablers and barriers to technology adaption in the mineral mining sector (see [Crabbe, 2023](#));
- **Interviews** in the case study regions with a range of Mining Industry Experts, Mining Company Representatives, Mining-Related Technology Company Representatives, and local and regional support organizations;
- The **creation of a novel dataset** of Canadian mining technology organizations to explore the national MineTech landscape (see Huneke et al., forthcoming); and

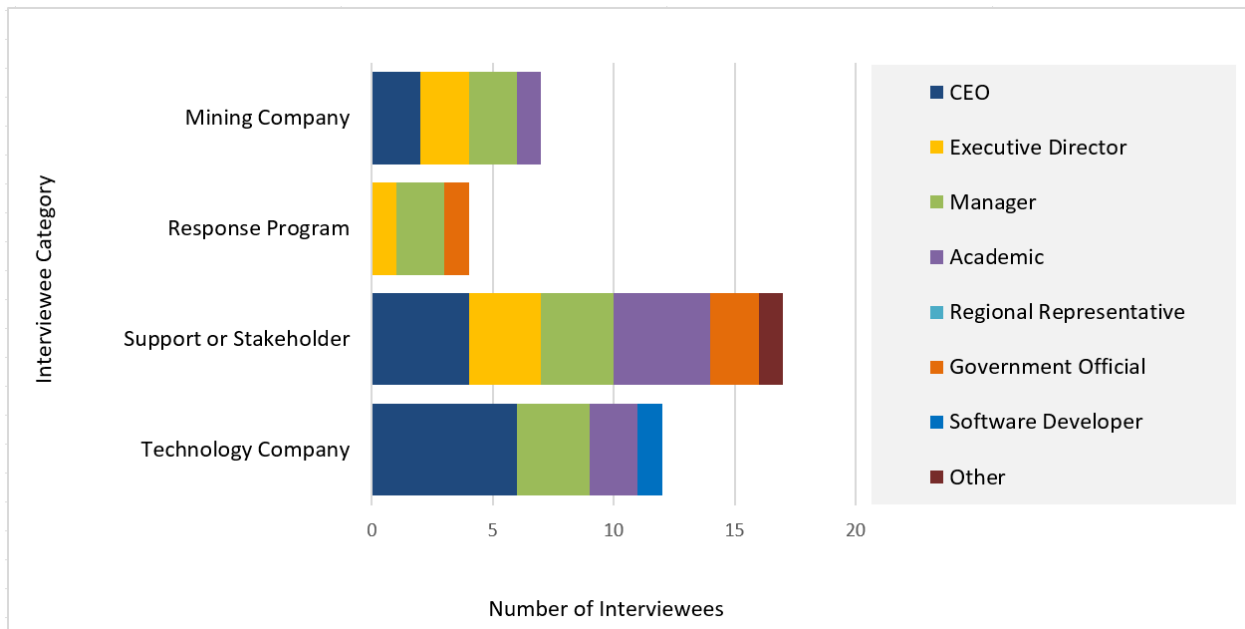
- A series of **MineTech case studies** exploring specific technologies and their potential impacts on the future of work and economic development (see Zhou, Huneke, and Hall et al., 2026a; 2026b; 2026c; Huneke and Hall et al., 2026).

1.2 Kootenay and British Columbia Data Collection and Analysis

Interviews: Semi-structured interviews for BC were conducted in 2021, 2022, and 2023. A total of 37 interviews were conducted with 38 key informants¹. Interviews were categorized by the organization's role related to mining: industry experts² (17); mining companies (6); technology companies (11); and response programs (3). Interview guides were standard across the national project and differed by category. However, the phrasing and order of questions varied based on interviewee responses.

Key informants (interviewees) were classified according to their primary role at the time of the interview. Figure 1 illustrates the breakdown of interview category and interviewee role. While 'Regional Representative' was not the primary role of any interviewee, it would be a secondary descriptor for many.

Figure 1: Number of Interviews by Interview Category and Interviewee Type (n=38)



Source: Created by authors

¹ One interviewee was interviewed twice as they served dual roles: industry expert and response program. Two organizations were interviewed twice because they fit into more than one category: industry expert and technology companies.

² Industry experts include representatives from industry associations, governments, postsecondary institutions, and other similar organizations.

Beyond the completed interviews, an additional 42 invitations were issued. In most cases no response was received (26) or the invitation was passed up the chain of command and no response was received (9). In a small number of cases the invitee declined (3), the invitee talked informally with the team (2), or the invitee initially accepted but failed to respond to subsequent communication (2). Of the additional 42 invitations, half were issued to mining company staff and received no response, demonstrating industry reluctance to engage on this topic.

Key Documents: 10 key documents were identified by interviewees and through targeted web searching. These documents were coded to compensate for industry and regulatory players that researchers were unable to interview. Documents reviewed were:

- *Skills Roadmap Project Final Report* (Centre of Training Excellence in Mining, 2022)
- *BC Mining Innovation Road Map* (Mining Association of British Columbia, 2021)
- *Mining Jobs Task Force Final Report* (Government of British Columbia, 2018)
- *Ideas at Work- Improving the future through innovation and technology* (Teck, n.d.)
- *BC's Critical Minerals Strategy* (Government of British Columbia, 2024a)
- *Teck Race21 Examples*
 - *A smart solution to increase plant yield at Elkview* (Teck, 2022a)
 - *Innovation in train loading technology at Fording River* (Teck, 2022d)
 - *Improving health and safety through proximity detection* (Teck, 2022c)
 - *Digital water management at Fording River* (Teck, 2022b)
 - *Teck's Technology Transformation Programs Enhance Performance, Safety and Sustainability* (Teck, 2022e)

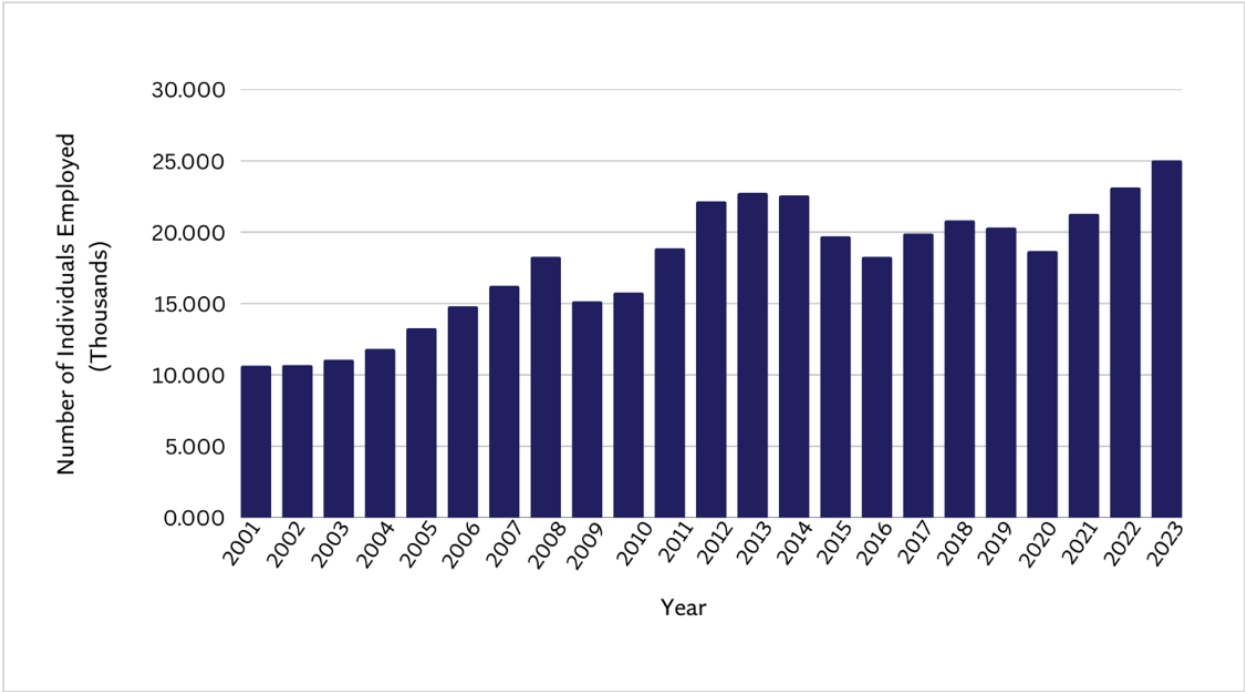
Analysis: A standardized coding framework was designed by the overarching project team and used to guide the analysis process. Coding was completed by two researchers, using NVivo coding software. Upon completing the first round of coding, analysis results were discussed and reviewed or spot checked by a different researcher to assure consistency.

2 A Brief Overview of Mining in British Columbia

Mining in BC includes a range of minerals (e.g., critical and other minerals), as well as aggregate and coal operations. There are mines across the province, including operating mines (active and temporary shutdown), proposed mine developments, and mines that are under “care and maintenance” (effectively closed but with the potential to resume operations at a future date) (Clarke, G., Northcote, B.K., Corcoran, N.L., Pothorin, C., Heidarian, H., and Hancock, 2024).

Mining, oil and gas extraction was estimated to have employed 30,800 people in BC in 2024 (Work BC, 2025a). According to Statistics Canada, the number of people directly employed within mining, quarrying, and oil and gas extraction in BC has trended upward, as shown in Figure 2.

Figure 2: Number of People in BC employed in Mining, Quarry and Oil and Gas Extraction



Source: Statistics Canada, 2024

Mining, oil and gas extraction is projected to have 10,200 job openings between 2024 and 2034, of which 57% are directly in mining (Work BC, 2025a). However, the majority of these jobs are replacing existing workers, with only 13% new jobs as the result of expansion (12% for mining specifically) (Work BC, 2025a).

The mining sector has a significant provincial economic impact, including government payments, as well as offering above-average wages and full-time work (PwC Canada, n.d.; Work BC, 2025b). However, mining is also sensitive to global economic conditions, putting the sector and dependent communities at risk of boom and bust cycles (Ryser et al., 2019; Work BC, 2025b). Employment is a key component of the sector, evidenced not only by the employment statistics, but by sector attitudes. For example, the majority (~80%) of BC businesses in mining, quarrying, and oil and gas extraction indicated that they were very unlikely or somewhat unlikely to adopt automation and digital technologies that may reduce employment over the next year (Government of British Columbia, 2024b).

Mining in BC experiences distinct topographical and regulatory differences when compared to other parts of Canada. From a physical environment perspective, BC is geographically diverse and can be hard to access. The province has an extended coast, as well as being one of the most mountainous areas in Canada. From a regulatory perspective, in 2019 BC’s Legislative Assembly became the first jurisdiction in Canada to adopt the Declaration on the Rights of Indigenous Peoples Act (UNDRIP) (Declaration on the Rights of Indigenous Peoples Act, 2019).

This act requires the government of BC to “*take all measures necessary to ensure the laws of British Columbia are consistent with the Declaration*” including free, prior, and informed consent over their traditional territories and redress for past actions (Declaration on the Rights of Indigenous Peoples Act, 2019). For mining and other resource extraction companies this could mean establishing community agreements, Indigenous oversight programs, benefits agreements, or other agreements with local Indigenous communities (Government of British Columbia, n.d.-a).

2.1 Mining in the Kootenay Region

The BC case study focused primarily on the Kootenay Region (the region), located in southeastern British Columbia, with an estimated population of 167,800 and a land base that includes four mountain ranges and the headwaters of the Columbia River. Natural resource extraction has been important for the region since colonization (Government of British Columbia, 2024b). The region has experienced positive and negative social and economic impacts from mining and this history remains prominent, evident in the names of communities and trails, as well as through the existence of ghost towns, abandoned mine shafts, and closed mine sites.

The region is on the traditional territories of the Sinixt, Sylix, Ktunaxa, and Secwepemc peoples. Increasingly, partnerships with First Nations are shaping the mining landscape. One example of this is through Kakin Resource Corp., wholly owned by Yaq̓it ᑭa·knuq̓i ‘it with the goal of community empowerment, fostering socio-economic independence, and building a legacy of prosperity (Kakin Group of Companies, 2025).

The region’s mining operations have included gold, silver, copper, lead, zinc and other operations. Operations have been both underground metals mining and open pit mining. Today the region is best known for industrial mining and being home to BC’s most significant metallurgical coal operations (Ministry of Energy Mines and Petroleum Resources, 2018). Currently, there are at least 10 operating mines in the region, six industrial mineral (e.g., silica, gypsum) quarries and four large open pit metallurgical coal mines which can be found in the Elk Valley in eastern part of the region (Clarke, G., Northcote, B.K., Corcoran, N.L., Pothorin, C., Heidarian, H., and Hancock, 2024; Ministry of Energy Mines and Low Carbon Innovation, n.d.). There are also multiple smaller active mine sites, as well as mines that are under development.

Mining remains one of the largest employers in the region. In 2024 Mining³ directly employed 5,800 people in the region, with an estimated 2,100 job openings expected between 2024 and 2034, of which 71% are replacement of existing jobs (Work BC, 2025a). Concentration of mining, oil and gas activities within the region as indicated by its location quotient is highest in the East Kootenays (Economic Trust of the Southern Interior, 2023).

³ Note: employment for the aggregated category of mining and oil and gas extraction would be greater.

Teck has been the dominant mining player in the region. Teck's Sullivan Mine in Kimberley was once the world's largest lead mine, closing in 2001 after 92 years in production and laying off over 1,300 people (Government of British Columbia, n.d.-b; Natural Resources Canada, n.d.). The former mine is now a reclaimed site and solar mine (Natural Resources Canada, n.d.). The region is also home to Teck's Trail Operations, one of the world's largest smelting and refining complexes, in operation since the 1890s and employing over 1,400 people (Mining Association of BC, 2024; Teck, 2024a). At the onset of this project, Teck Coal operated the coal mining in the Elk Valley. Over the course of this project, ownership of these coal mining operations shifted, as the majority share in Elk Valley Resources was acquired by Glencore.

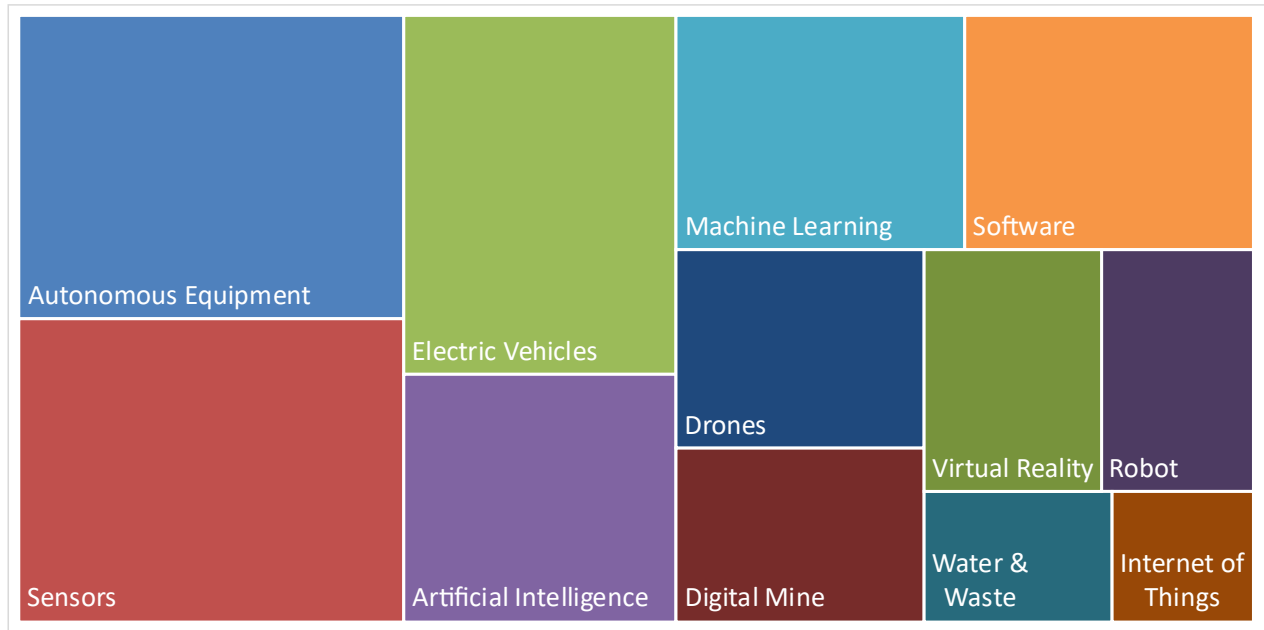
3 Technology Adoption in the Kootenay Region and British Columbia Mining Sector

3.1 Identified Technologies

Mining company and industry experts were asked to identify the top three technologies that have been adopted over the past five years by the mining sector in the Kootenay Region or in British Columbia. These interviewees were also asked to identify the top three technologies that will be adopted in the next five years. Technology company interviews explored specific technologies associated with those companies, which included discussions of these technologies in the present and future. Response program interviews and the documents reviewed included general and specific technology discussions, including current and future. As a result, all 47 files (interviews and documents) were reviewed for identification of current and future technologies.

Current Technologies: The identified technologies that the sector has adopted over the past five years are found in Figure 3.

Figure 3: Identified Top Current Technologies (n=47)



Source: Created by authors

One current technology that stood out as an independent category was autonomous equipment (19), which included vehicles as well as specific equipment (e.g., shovels) and discussion of fully and partially autonomous equipment and remote operations. As described by one interviewee, *“We adopted automated haul truck technology here in BC a couple years ago and it's going well.”* (British Columbia Mining Industry Expert 11). Electric vehicles and equipment (16) was also a large, standalone technology category including electrification of vehicles, equipment, and operations generally.

However, several technology types related to data collection and analysis were often discussed together in a way that made separating them challenging. When we consider sensors (19), artificial intelligence (AI) (11), machine learning (11), and software (11) together, this becomes the dominant technology type identified. One interviewee reflected that technology related to data analysis may be the most dominant and furthest advanced, but it lacks the visibility - and therefore prominence - of something like automation.

“Other” technology types were noted that did not necessarily align with one of the pre-determined categories. Within this group the only cohesive grouping related to technologies focused on water and wastewater treatment.

There were variations in technology identification between interview categories. Mining companies and technology companies both emphasized electric vehicles, while industry experts emphasized autonomous vehicles. In all cases, while individual codes for sensors, AI, machine learning and software were smaller individually, collectively those technologies related to data collection and analysis received the most emphasis. There was also variation depending on the

area of specialty or expertise of the interviewee. For example, interviewees with high levels of expertise related to exploration identified increased use of drones within the last five years.

Future Technologies: Technologies identified as those the sector will adopt in the next five years are found in Figure 4. Future technologies were largely discussed as advancements of current technologies, focused on how these technologies would evolve.

Figure 4: Top Identified Future Technologies (n=47)



Source: Created by authors

One of the key documents reviewed described BC’s ideal future mines as:

more digitally connected, enabling broad use of automation and autonomy, robotics, big data analytics and artificial intelligence. It will also be electrified and have a smaller environmental footprint. (Mining Association of British Columbia, 2021).

Similarly to current technologies, both autonomous equipment (28) and electric vehicles and equipment (21) were prominent categories. As described by one interviewee,

The other big one, I suppose, is electric haul vehicles. That’s a promising thing for us in particular. I mean, it doesn’t have to be automated right? You can still have a driver for it. But fuel is a significant cost and of course the carbon footprint. I’d love for the whole operation to go carbon- zero. – British Columbia Mining Company Representative 1

Stage of Development: Interviews were also analyzed for the stage of development of both current and future technologies. Most often the development stage was discussed on a continuum, where the technology can be adopted in its current form, but where continued advancements are projected. For example, autonomous equipment was acknowledged as a current technology, but the majority of comments indicated that it would continue to develop, which would increase its adoption.

First and foremost, autonomous material handling, autonomous trucking. These are the stuff of sci-fi maybe 20 years ago. For a person who did a lot of robotics, I'm really surprised how well this technology is working. It still needs a lot of fine tuning. There are a lot of jagged edges, and you have to really smooth them down. But we have truck fleets on mine sites in BC and also in Alberta that are fully automated. – British Columbia Mining Industry Expert 4

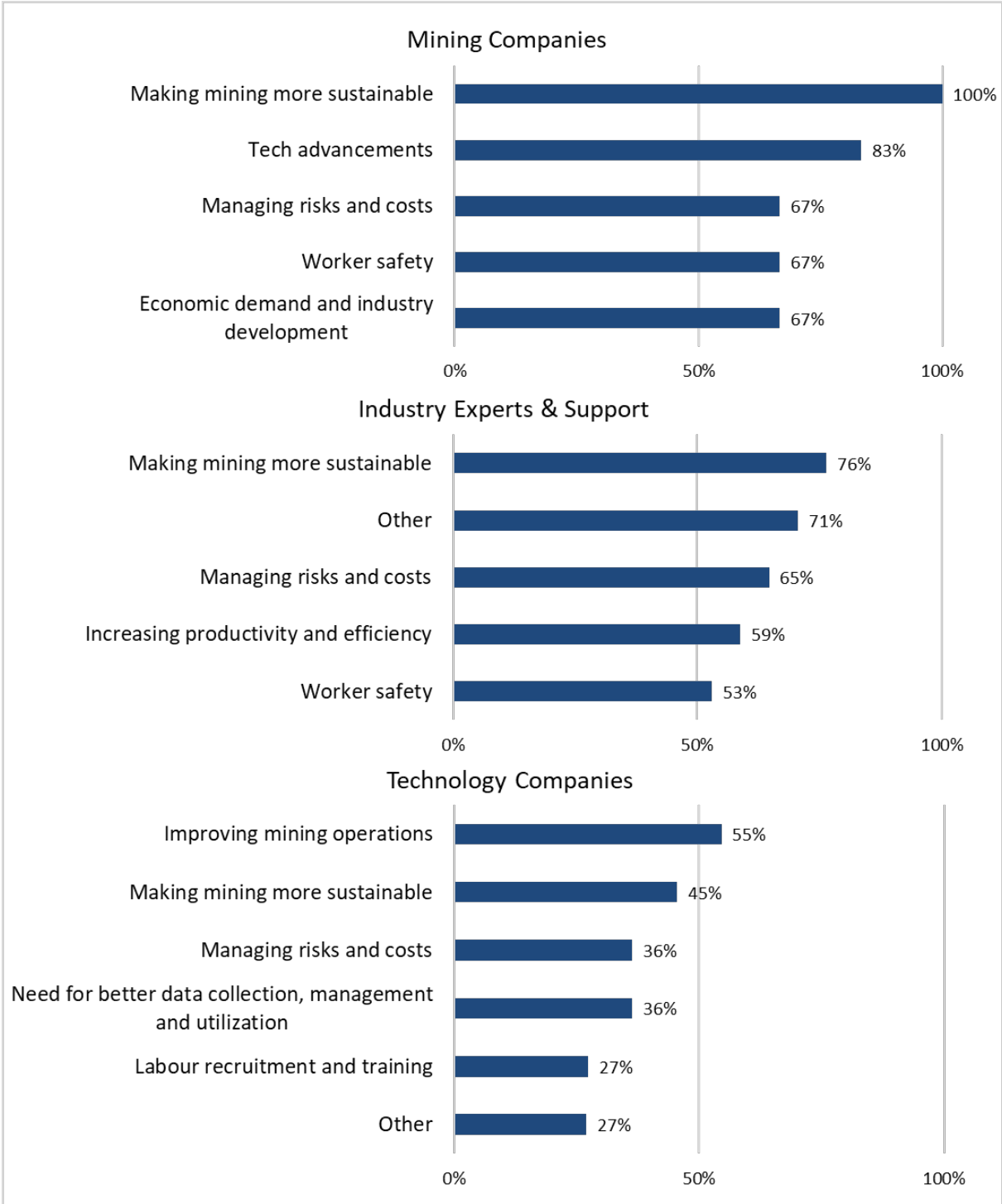
3.2 Drivers for Technology Adoption

Interviews with industry experts, mining companies, and technology companies (34)⁴ were asked about drivers that enabled development or adoption of the current and future technologies they identified. Several drivers were discussed as influencing the development and adoption of these technology types in the mining sector in the Kootenays and BC. Examined collectively, the top drivers identified by interviewees were making mining more sustainable (24), managing risks and costs (19), improving mining operations (15), increasing productivity and efficiency (15), and worker safety (15). “Other” drivers (17) were also identified where comments were more generalized (e.g., government requirements generally versus environmental regulation).

The top drivers identified differed based on interview category, suggesting differing perspectives or motivations. As shown in Figure 5, 100% of mining company interviews identified making mining more sustainable as a driver of technology, followed by differing levels of agreement on the other top drivers, including technological advancements, economic demand, managing costs and risks, and worker safety. No specific driver achieved 100% agreement from technology company interviews or interviews with industry experts. For example, technology companies identified improving mining operations, making mining more sustainable, managing risks and costs, and the need for better data collection, management and utilization as the top drivers for technology adoption. While interviews with industry experts identified making mining more sustainable, other drivers, and managing risks and costs as the top drivers for technology adoption and overall had a greater variety of responses. Some drivers were often discussed together, making them challenging to separate. These drivers and the connections between them are examined further below.

⁴ This question was not asked for response program interviews and was not applied to key documents as this topic was not explicitly discussed and would have required interpretation not supported by the material.

Figure 5: Top Drivers as Identified by Interview Category (n=34)



Source: Created by authors

3.2.1 Sustainability, Operations, and Productivity

Making mining more sustainable was the overarching top driver identified by interviewees. However, it is important to note that while many interviewees explicitly discussed sustainability, as they expanded their responses other underlying aspects and connections became apparent. For example, a mining company representative discussed sustainability as related to both improvements to environmental impacts (minimizing waste) and productivity (maximizing output), with both driving technology adoption:

If you're able to use technology to reduce fuel burn or save money somewhere, it obviously makes projects more economical or more amenable to being done. Or to get into autonomous technology or some of that type of stuff, you can maybe mine in areas that you couldn't necessarily do otherwise ... So, we're minimizing the waste we've got to move and we're maximizing the ore we can get out of the ground. Which is good on the money front. But it's also good from an environmental standpoint. – British Columbia Mining Company Representative 2

Other interviewees made similar connections between technologies that are both more sustainable and result in cost savings, improving overall operations.

Additionally, sustainability was often discussed related to general government regulatory and policy requirements (captured in the “other” code) and public perceptions of mining – Environment, Social, and Governance (ESG). As mentioned in section 2, mining projects in British Columbia are subject to the United Nations Declaration on the Rights of Indigenous Peoples. Some interviewees described technologies being adopted to enhance sustainability as a catalyst for gaining local support. As explained by British Columbia Mining Industry Expert 4:

Especially in Canada, especially in BC, you won't have a mine if you don't have a license, and you won't have a license if you don't have good relations with the First Nations, and people who are really in the lands and so on and so forth. So, I would say these technologies would help get the license. Why, because even the First Nations are really supportive of electrified fleets instead of diesel fleets. They can feel it in their noses when the emissions are not there. They can see it in the water quality when all the bad things come with carbon emissions are not there. And they understand the fact that an electrified fleet means power on the mine site, and power in the region is very important.

3.2.2 Managing Risks and Costs and Worker Safety

The importance of managing risks and costs and prioritizing worker safety were often discussed together as prominent drivers by several interviewees, particularly from mining companies and interviews with industry experts. Safety was often in the forefront. As described by one mining company representative:

You can send a piece of equipment that doesn't have an operator on it into places that you can't in good conscience send a person, right? Or, if you do, the list of things you're going to have to go through to ensure that you eliminate the risk, or reduce the risk let's say, you never eliminate it, but to reduce the risk as much as possible. Here you're going to be able to do things that would otherwise appear to be higher risk because you're not endangering a human. – British Columbia Mining Company Representative 2

However, these two drivers were connected by the risks and costs associated with unsafe working environments. Like with sustainability, risks and costs included impact to ESG, particularly risks to the social license to operate associated with unsafe working environments. This social risk was accompanied by a monetary cost. For example, technologies like equipment automation, artificial intelligence, machine learning and augmented reality were all identified as increasing worker safety as well as decreasing associated risks and costs from unsafe work environments. This was described by British Columbia Mining Industry Expert 5:

In the past there have been very, very traumatic accidents that happen in a workplace and even during the training process when people are on site doing training, accidents can happen. And the cost to businesses or industries when those accidents happen can be in the millions of dollars. So, if the training can happen outside of the dangerous or you know, unsafe environment, that's you know, that's a massive cost savings. You know when we're talking a few hundred thousand dollars to develop the application, if it's saving millions, and people's lives that's probably a very good investment.

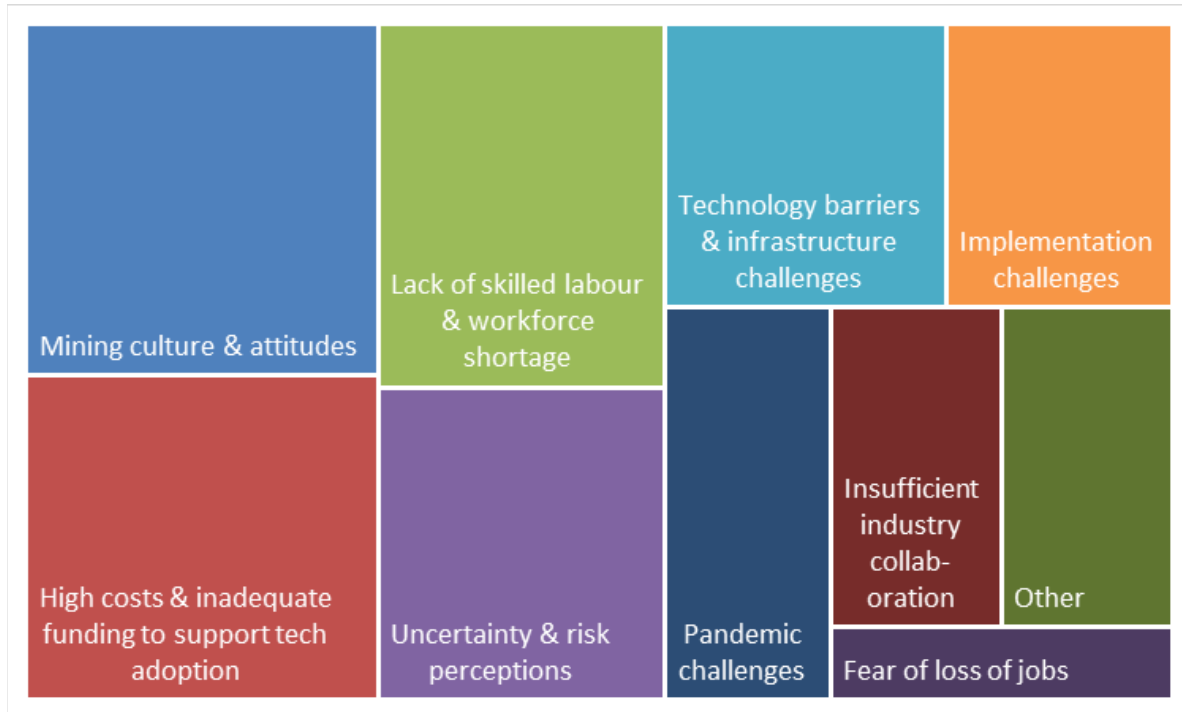
The importance of risks, costs, and safety and their interconnections as drivers were echoed in statements from multiple interviewees. As summarized by one interviewee, *"I mean they only adopt technology because either they can save money and increase production or make a safer environment."* – British Columbia Mining Industry Expert 15.

3.3 Barriers to Technology Development and Adoption

Industry experts, mining companies, and technology companies (34)⁵ were asked about barriers to the development or adoption of the current and future technologies they identified. Examined collectively, Figure 6 shows barriers identified by interviewees, including the top ones of: mining culture and attitudes (25), high costs and inadequate funding to support tech adoption (23), and lack of skilled labour and workforce shortages (21). Unlike drivers, there were few "other" barriers identified.

⁵ This question was not asked for response program interviews and was not applied to key documents as this topic was not explicitly discussed and would have required interpretation not supported by the material.

Figure 6: Top Identified Barriers (n=34)



Source: Created by authors

Also unlike with the drivers, there was alignment on the barriers between the interview categories. We further explored barriers as they related to specific types of technologies and found that the top three barriers - mining culture and attitudes, high costs and inadequate funding, and lack of skilled labour and workforce shortages - were all often found in the same discussions as autonomous equipment and electric vehicles. Barriers were more often discussed in isolation, with fewer connections between them.

3.3.1 Mining Culture and Attitudes

Interviewees commonly discussed two aspects related to the barrier of mining culture and attitudes, those related to attitudes of mining workers and those related to broader sector norms, both of which influenced technology adoption. Multiple interviewees identified resistant attitudes from within the mining workforce. For example, one industry expert expressed that individuals who have worked in mining for a long time can be resistant to technology adoption:

A lot of the new technologies are being adopted by the young, sort of up and comers in the industry. So, part of it has taken a really long time because the old timers, and yes, we actually call them old timers in our industry and they appreciate it, aren't technology adopters. They are folks who really have thrived

living in the bush and don't enjoy technology, and don't want technology out there. – British Columbia Mining Industry Expert 6

Similar statements were echoed by interviewees from mining companies and technology companies. When asked what stops companies from adopting technology, a mining company representative stated, “100% it’s employee resistance” - BC_Mine_5. It was suggested by one interviewee that the Kootenay Region may be particularly resistant to or fearful of technology adoption. However, other interviewees suggested that resistance was more related to demographic characteristics, primarily older males.

From the broader sector perspective, there was a perception of reluctance within the mining sector to be the first company to adopt a new technology, but instead a ‘race to be second’. This was seen as a substantive barrier to technology adoption, as described by one technology company representative:

...getting those first customers to just try it was the hardest thing. Because it seemed like everybody was really interested in what we were doing, and they liked the value proposition. But they all wanted to know, who else have you worked with. ...it took us a year or so I think just to get someone to try it. And then, and then we had results to show and after that it was a lot easier. – British Columbia Mining-Related Technology Company Representative 11

Interviewees discussed the factors they felt contributed to this, including high financial costs associated with new technology as well as long time horizons and strict regulations, with contribute to a culture that is more risk adverse and traditional. One technology company interviewee characterized the industry as “very stagnant. It’s been doing things a particular way for a very long time, and it’s very resistant to change. Because it costs a lot to change. If you get it wrong [...] it could be terminal.” – British Columbia Mining-Related Technology Company Representative 8.

3.3.2 High Costs or Inadequate Funding

High costs and/or inadequate funding was the second most prominent barrier identified by interviewees for developing or adopting new technologies. Specific to technology development, the most identified barrier was cost, including the initial cost of the technology. It was observed that cost barriers can vary depending on the size of the operation. As described by one interviewee, “for academics, the Canadian government provides some resources and so it’s more possible for large companies that can pay for it. For small companies or small to medium enterprises, this is where I think they would struggle the most.” – British Columbia Mining-Related Technology Company Representative 1.

Mining operations are high-cost environments, necessitating that technology development or adoption be able to offset or overcome these costs in some way to be possible. A mining company interviewee discussed this in relation to electrifying their operations:

BC Hydro has said to us, you know, if you went to a full electric site you would have to really help pay to rebuild the entire backbone of this corner of the province. So, hundreds of millions of dollars to help us reduce our environmental footprint. Which, we don't have hundreds of millions of dollars. – British Columbia Mining Company Representative 3

The challenges related to cost also extend to training employees, as explained by one industry expert:

The barrier for adopting technology is cost. The cost of the equipment, the cost of the hardware, and the cost of producing the training material. And it's expensive. You know, on each piece of like a [virtual reality] headset for instance, that the trainee would need is somewhere between \$5,000 - \$10,000. So, if you want to do a classroom of 10 people that's a huge cost. – British Columbia Mining Industry Expert 5

Additionally, some interviewees expressed frustration with access to government funding and support to develop technology. Again, this related to size of operations. As expressed by one technology company, *“To access any kind of funding from a government grant type position...if you're going to borrow money in order to move your technology to the next level. Literally, there are so many hoops to be jumped.”* – British Columbia Mining-Related Technology Company Representative 3.

3.3.3 Lack of Skilled Labour and Workforce Shortages

The lack of skilled labor and workforce shortages was the third most commonly identified barrier by each interview category, impacting both technology development and adoption. There were various aspects to this, from general workforce shortages to sector recruitment issues, and specific technology skills challenges.

A mining company representative described that they anticipated challenges finding workers with the specialized skillsets required for some technologies:

I would say some of the more advanced technologies that I would have in mind, things like machine learning...I foresee it being somewhat difficult to recruit knowledgeable talent from the region. – British Columbia Mining Company Representative 1

The same individual clarified that this is their suspicion, but that they have not confirmed whether or not this is the case. However, this suspicion is important because it indicates the initial hesitations that exist in the sector regarding technology adoptions, before even starting the process.

Some interviewees expressed concerns that the education system is not preparing the workforce with the required skillset, as described by one industry expert:

The barrier is getting the right people and getting them trained, and as you probably are well aware, our colleges and universities aren't necessarily up to speed on what's exactly needed. So that's been a barrier, and I believe that colleges are trying for sure, but to pivot quickly is difficult when it's a pilot project. – British Columbia Mining Industry Expert 2

Additionally, technology companies articulated challenges attracting skilled workers to the mining sector due to misconceptions or unattractive qualities of the sector, as explained by a technology company interviewee:

We need to find a way to attract younger people to these types of industries. And maybe help them understand that it's not so much about getting dirty every day. You're not just digging a hole. There's a whole other set of layers and responsibilities to this. – British Columbia Mining-Related Technology Company Representative 8

3.4 Impacts on Employment, Skills, Education, and Training

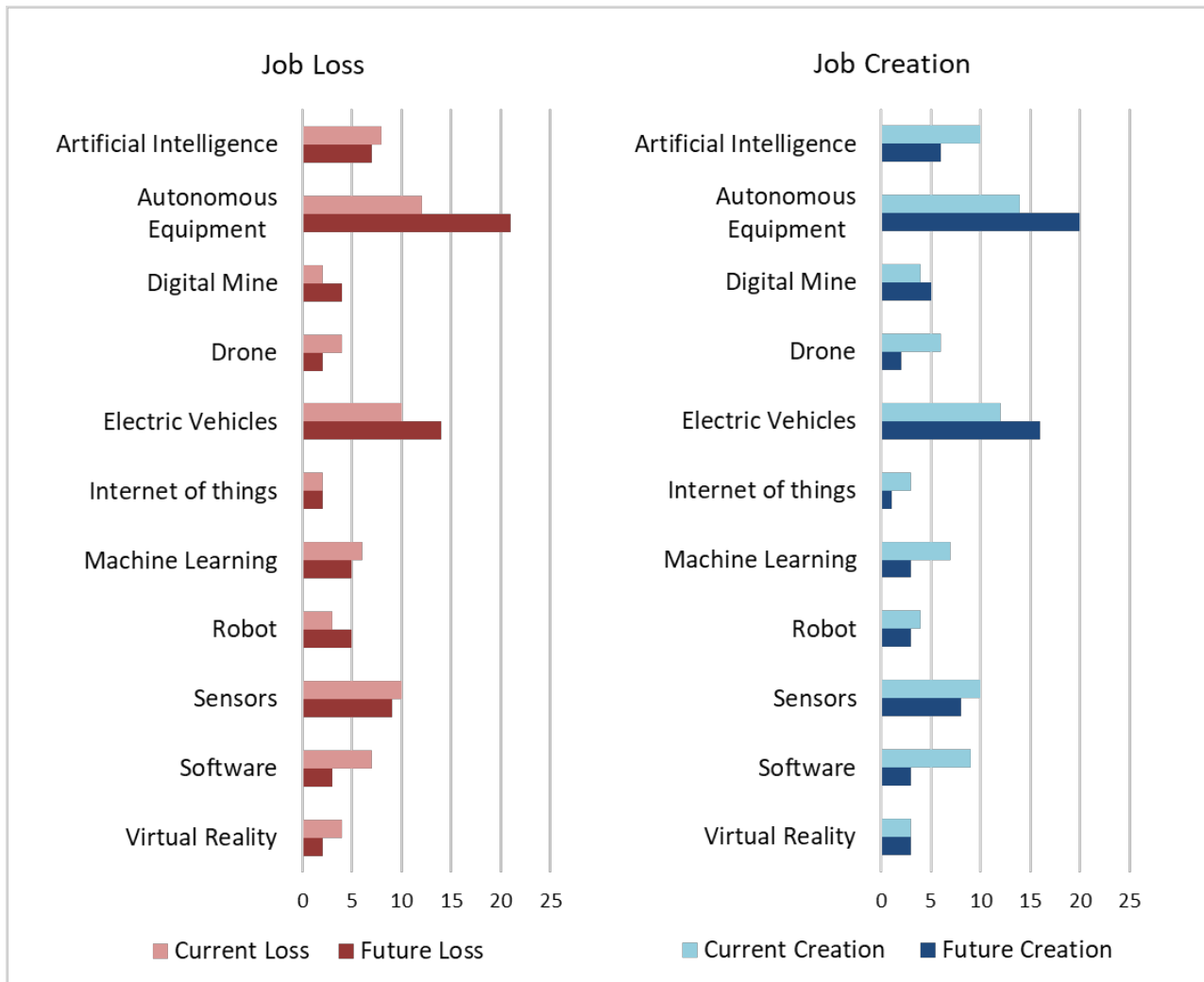
Beyond the barriers to technology posed by the lack of skilled labour and workforce shortages, interviewees were specifically asked about the current or anticipated impact of technology adoption on employment and whether new skills, education, and training was or is needed. All interviewees and the key documents were analyzed for impacts related to employment and skills, education, and training.

3.4.1 Impacts on Employment

Of the 47 files (interviews and documents) analyzed, 42 of them explicitly discuss impacts of technology adoption on employment. In terms of the specific types of impacts, the most prominent category was the creation of new jobs (31), followed by the loss of jobs (27), no impact to employment (20), need for retraining and upskilling (16), and opportunities to attract new talent (16). Additionally, just under half the files discussed general shifts in employment within the mining sector.

Technology, Job Creation, and Job Loss: Data related to the creation of new jobs, and loss of jobs were closely related. Figure 7 explores which technologies appeared alongside discussions of job loss and job creation and shows that these conversations most often involved autonomous equipment and electric vehicles. This is unsurprising as these were the two most discussed technology types.

Figure 7: Current and Future Technologies Associated with Job Loss and Job Creation (n=47)



Source: Created by authors

It was common for interviewees to discuss job loss and new jobs together. This often related to the “no employment impact” code, with many – but not all – saying there would be no net loss in employment if you consider new jobs added against jobs lost. As expressed by one community interviewee:

“... they're expecting the same amount of people or a similar amount of people to be working at [site location]. That doesn't mean they'll live in town. I don't think they're expecting fewer workers. But those workers may be different.” – British Columbia Response Organization Representative 2

However, those who disagreed with no net loss felt that despite new jobs, that on balance there would be job losses.

This may help to explain, at least in part, why fear of job loss was not identified by many as a barrier to technology adoption, while the lack of skilled labour and worker shortages was. When considered together, this paints a picture of the changing nature of work within the mining sector. This includes the changing physical location of work, both within the mine site itself (e.g., on site command centres) and away from the mine site completely (e.g., technology enabling remote work). This also includes a change in the nature of the work itself – the type of work and its location in the supply chain, as well as who is doing the work, in terms of skills required, who is being hired, and whose jobs are being phased out or lost (e.g., jobs more likely to be low skill, often employing vulnerable populations).

3.4.2 Need for Skills, Education, and Training

There were 39 of the 47 analyzed files (interviews and documents) that explicitly discussed needs related to skills, education, and training. Technology changes were seen to have an impact on all current and future workers. Most often discussed were new and advanced knowledge in specialized areas (31), as well as technical skills (23) and re-skilling the current workforce (20). A large number (25) of documents discussed related topics, including delivery of training, uncertainty related to rapid change, increased skills across positions, and adaptability.

The need for skills training and education covered a wide range of technical skills and areas of knowledge. These related to the adoption of multiple technology types – particularly related to computers, digital literacy, and information processing. But these were also discussed generally, extending beyond the specific adoption of technology, and including need for “soft skills” related to communications and collaboration.

Adaptability as a required skill overlaps with new areas of knowledge, technical skills, and reskilling the existing workforce. Adaptability was seen as critical for current and new employees to deal with change and uncertainty and was thought by some to be key to the ability of current employees to re-skill. One interviewee observed that:

[P]eople are going to have to learn to adapt in order to be employed... So if you were a driver before, and you are willing to change your skill set. But if you're not, then you might have a problem staying there... – British Columbia Mining Industry Expert 3

Related to the observation above of changes to the type of work and who is being hired, interviewees often related discussions of new skills and education to mining sector recruitment, and the need to target not only highly skilled people, but those with different backgrounds from those traditionally associated with the mining sector. As described by one mining company interviewee:

I've talked about communication skills, I've talked about agility and learning and the desire to have continuous learning. Something that I would add to that is collaboration. ... to wind it back to the future of work conversations we've had internally. The feedback I got was like okay, so you want people who can learn something very quickly, join and collaborate with a group of people they may or may not have worked with in the past, and work quickly to solve, solve problems together, potentially remotely, where they're not in person for a long time. I was like, yeah, that's it. And they're like, so you pretty much want basement video game players who participated in massive multiplayer games. I'm like bingo! – British Columbia Mining Company Representative 4

3.5 Impacts on Regional Development

All interviewees were asked to discuss the impacts of technology adoption on rural development, including business development, infrastructure, community investment, and development agreements. The key documents were also reviewed for discussion of impacts on regional development, resulting in a total of 47 files analyzed.

Discussions related to this question often expanded into the impacts of mining on regional development broadly, beyond technology specific. This resulted in a collection of files where the positive impact of mining on regional development generally (20) was identified. Observations included positive social impacts – often facilitated through increased engagement made possible through technology. A smaller number of files (6), with representation from across interview categories, discussed the negative impact of mining on regional development generally, with comments often relating to the local impact on housing shortages.

Excepting impacts to employment and skills, the impacts of technology on regional development were challenging to separate from the general impacts of mining. Technology was often discussed as an enabler. One interviewee felt that the impacts are more indirect, are not as fast or dramatic, and are made more complex due to other related factors, making it hard to clearly point to the impact of technology. This interviewee observed:

So are we important? Yes. Are we are we making a difference? Is mining having an influence on the economy? Absolutely. And technology is part of that story. But we've got to be realistic that we're not necessarily the fastest quickest, most dramatic mover in BC or anywhere else, for that matter. – British Columbia Mining-Related Technology Company Representative 9

Business Development: The most often discussed technology related regional development impact was business development (33). These impacts were typically framed as potential business development impacts related to the expansion of existing businesses and the creation of new ones. These discussions included business development within the interviewee's own organizations, the broader community and region, as well as bigger provincial or national scales. Specific technology types associated with these opportunities were virtual reality, data

collection and analysis technologies – particularly artificial intelligence. There were some concrete examples of business development provided, like Metal Tech Alley, a Trail BC based initiative started to build business opportunities related to the smelter and refinery complex, which is exploring circular economy initiatives, including battery recycling (Lower Columbia Initiatives Corporation, 2023).

The technology companies interviewed provide an interesting window into the potential for technology-related business development, particularly in rural areas. Within the Kootenay Region there were few local technology companies that specifically serve the mining sector, with those that exist targeting multiple sectors. Locally based technology companies were small, often startup companies, and the mining sector – as observed across interviews – is hard to break into from a technology perspective. For example, two technology companies interviewed began in the same small rural community within the region. One company failed and the other relocated to a large centre in another province – illustrating difficulties related to rural technology business development, particularly in a region where a dominant mining company (Teck) is in itself a technology development company as well as a mining company. For example, Teck’s Race21 business transformation program aimed to renew the company’s technology infrastructure, exploring automation and robotics, and apply advanced analytics and AI (Teck, 2020). Teck’s Technology and Innovation Group, born out of Race21, describes itself as “proven digital technology built for miners, by miners” (Teck, 2024b).

Other Development Impacts: The impacts of technology were also identified related to community investment (17) and infrastructure (15). In the case of community investment, this was most often more generalized, relating to investments from mining companies into community, described by one interviewee as *“an important part of their presence in a region to provide some investments that benefit the community, whether in education, social infrastructure, sometimes indigenous partnerships as well.”* – British Columbia Mining Industry Expert 14. From an infrastructure perspective, the need for electrical grid upgrades was discussed as critical for the electrification of mines, as was the need for internet connectivity improvements for mining operations. Development agreements were not explicitly mentioned in any interview or document.

3.6 Innovation Programs and Responses to Impacts

Innovative Programs: During interviews with industry experts, mining companies, and technology companies, interviewees were asked to identify organizations creating innovative programs related to mining technology or innovation. Key documents were also reviewed with this in mind. Table 1 lists programs identified.

Table 1: Identified Innovation Programs⁶

Program	Lead Organization	Scale	Description
Athena Pathways	Collaboration: academia, government, industry	National	Technology focused skills training targeting women
BC Mining Innovation Hub⁷	Government of BC in partnership with industry, academia, federal government	BC	Component of the Innovation Road Map. Support innovation, training for workers in new technologies, regulatory excellence, environmental management and low-carbon approaches
BC Mining Innovation Road Map	Mining Association of BC led collaboration with industry and government	BC	Guide to establishing BC as a globally competitive mining region with a culture and regulatory regime that supports innovation and a future prepared workforce
BC Net Zero Innovation Network Mines to Clean Energy	Foresight led collaboration with industry, government, academia	BC	Transforming mining operations with clean energy systems
Bradshaw Research Institute for Minerals and Mining	University of British Columbia with industry partners	BC	Mining focused research
Canada's Global Innovation Clusters	Government of Canada	National	Investment in innovation and commercialization
Centre of Training Excellent in Mining	Coast Mountain College with industry partners	BC	Virtual hub that facilitates collaborative, innovative training opportunities
Energy & Mines Digital Trust	Government of British Columbia	BC	Digital tools supporting sustainable economic development and maintaining environmental protection
NRC Industrial Research Assistance Program	Government of Canada	National	Innovation funding for small and medium sided businesses
Metal Tech Alley	Lower Columbia Initiatives Corporation	Regional (Kootenay)	Cluster development program
Next AI	Collaboration: academia,	National	Program for artificial intelligence-based ventures and technology commercialization

⁶ While these programs were current when identified, not all remain available or in operation at the time of writing.

⁷ [Announced in 2021](#), current status unknown.

	technology sector industry		
Norman B Keevil Institute of Mining Engineering	University of British Columbia	BC	Bachelors and Masters level education in mining engineering
Race 21	Teck	International	Business transformation program aimed at modernizing the technology foundation, accelerating automation and robotics, connecting data systems to enable analytics, and empowering employees
Selkirk Technology Access Centre	Selkirk College with industry partners	Regional (Kootenay)	Advanced manufacturing equipment access and training

Source: Created by authors

Beyond specific programs, multiple organizations were identified, primarily post-secondary institutions, government agencies or departments, or industry associations. Organizations included those identified in Table 1, as well as non-BC based organizations and programs (e.g., NORCAT, MICA).

When considering the innovative programs identified, the majority are collaborative programs including the public and private sectors. Also worth considering is that not all programs have an exclusive focus on the mining sector, and the majority are provincial in scale, followed by national initiatives, with few regional scale initiatives. Lastly, while each includes or leverages technology, few were explicitly identified as a direct response to technology change and few solely focus on technology.

Response Programs: Interviewees were also asked how companies, industry associations, governments, unions, post-secondary institutions, and other stakeholders have responded to the impacts of technology adoption. There was crossover between the innovative programs identified in Table 1 and the responses to impacts identified by interviewees. Similarly to innovative programs, responses were typically collaborative, and led by post-secondary institutions, governments, and industry associations. From a scale perspective, there were few regional or community scale responses to changing technology in the mining sector reflected in the key documents (10) or interviews with industry experts, mining companies, and technology companies (34).

Of the three supplemental interviews aimed at identifying or elaborating on response programs, two were with staff related to planning and development within two of the Kootenay communities with the highest concentration of mining activity (i.e., the Elk Valley and the South Kootenay/Trail Region). These interviews provided insight as to what responses to the changing technology landscape within the mining sector exist (or not) at the local or regional level.

Within both interviews there was a shared awareness of the vulnerability of communities that are reliant on the mining sector. As characterized by one interviewee when discussing economic diversification:

We're really not looking for a diversified economy. We're looking for something that's a bit more robust. ... And if something goes down at that mine, the town's gonna feel it. It's a quarter of our population. And that's just directly employed, that's not adjacent. And if that closes down, if there's a lockout, the restaurants are suffering, the gas stations are like, everybody's suffering. So it's so big that we can diversify. But when the sleeping giant moves, everybody feels it. – British Columbia Response Organization Representative 2

However, the interviews also identified that changes within the mining sector were more complex than being strictly negative or positive. As described by one interviewee:

It's definitely a story of opportunity that's happening here as opposed to, you know, like, just automation is coming, and therefore we might lose jobs story. It's much more complex here than that. – British Columbia Response Organization Representative 3

These discussions traced a pathway of connections between changes in the mining sector (including but not exclusive to technology related impacts) and a wide range of important local topics, including demographics, housing, infrastructure and services, and workforce. However, when it came to what locally driven responses exist, there were few identified programs beyond business development and investment and attraction activities. In both interviews, interviewees identified local capacity limitations as the primary challenge. One of the interviewees also highlighted that beyond capacity, there are few mechanisms that allow local government to do something other than react after problems occur:

It's more of a response, rather than addressing because we have no direct relationship. We have no regulatory power on the mine site. It's out of our hands, so they can operate independently. – British Columbia Response Organization Representative 2

Collectively, what is suggested by the innovative programs and the response programs is that they are primarily concentrated at larger scales with larger actors that have substantial decision-making power. At the local scale, communities are aware of risks and opportunities, but face challenges in acting, particularly when it comes to proactively addressing uncertain risks.

3.7 COVID-19 and Mining Technology Adoption

Interviews with industry experts, mining companies, and technology companies (34)⁸ also included questions about how COVID-19 impacted technology adoption in the mining sector generally. Responses were mixed, with 19 interviews discussing that the pandemic accelerated technology adoption, 6 interviews discussing that the pandemic slowed technology adoption, and 7 interviews discussing that it did not change the pace of technology adoption. One interviewee observed that it depended on what the technology was, while another mentioned that some technologies accelerated, while others slowed.

Those who expressed that the pandemic increased the pace of technology adoption, generally identified technologies related to remote work and communications. Additionally, some of these individuals felt the pandemic increased employer understanding of the need and benefits of technologies such as automation. A few comments noted an increase in automation at their job but were unsure if this correlated with the pandemic. A small number of comments stated that COVID-19 identified gaps in business that technology could fill, thus increasing the rate of technology adoption.

Interviewees who felt COVID-19 slowed technology adoption in the Canadian mining sector described slower than normal regulatory processes to approve new technologies, in addition to companies being more financially conservative, as reiterated by a technology company interviewee:

Because of all of the unknowns around the pandemic, I think it probably also put a bit of the breaks on some technology adoption. Because companies didn't know what was happening next, and so from a cash flow investment perspective, they may have been a little bit more hesitant to try some of these new technologies. – British Columbia Mining-Related Technology Company Representative 2

Interviewees noted that generally all aspects of business slowed down during the pandemic, including supply chain shortages that impacted both technology adoption and general operations.

Other individuals felt that business operated as usual during the pandemic and there was no change in the pace of technology adoption, as described by an industry expert, *“If you were planning to buy an electric truck you still bought that electric truck. I think you're probably still chugging along on your path to do the things you need to do.”* – British Columbia Mining Industry Expert 11.

⁸ This question was not asked for response program interviews and was not applied to key documents as this topic was not explicitly discussed and would have required interpretation not supported by the material.

3.8 Factors Influencing Technology Adoption

Interviewees (n= 34)⁹ were also asked general questions about mining technology, adoption, and innovation, including what factors have the greatest influence on technology adoption in the Canadian mining sector. Responses went beyond the specific technologies discussed during the interviews, exploring the sector more broadly. Interviewees provided a range of responses, with no single response in the majority.

Responses related to the financial aspect of technology adoption were the largest group (13). This included access to financing as well as general comments related to the influence of the high costs of technology adoption within the mining sector. As described by one interviewee:

It may be obvious for good reason that there's capital intensity required. Whether it be for the actual smelting technology or mine development. But there's an awful lot of money that has to go in at the front end. And it takes a long time, often, to pay it back. So, that kind of sets the tone for the way in which innovation and decisions are made. – British Columbia Mining Industry Expert 10

Incentives – largely government programs – were often discussed in relation to cost (8). While there were no substantive differences between interview category, what was apparent was how differences in the size of a mining operation can impact the influence of both incentives and costs. As described by one industry expert:

Obviously, it's going to be something that the operators can afford to implement. There's been some subsidies out there from the government for electrification projects that have really helped some of our mines to get over the hump. – British Columbia Mining Industry Expert 11

From the perspective of the operator of a small mine, existing incentives can be out of reach for small operations:

And maybe my view is tinged from being in a capital constrained environment. I've actually had to defer a lot of R and D because the only way to line up a project that's going to cost half a million bucks is to have half a million bucks, spend it, and then try to get a credit back for what you spent. That's not workable for us. – British Columbia Mining Company Representative 1

Often related to incentives were government policies (7), which were dominated by ESG, primarily connected to First Nations, as well as environmental pressures.

⁹ This question was not asked for response program interviews and was not applied to key documents as this topic was not explicitly discussed and would have required interpretation not supported by the material.

Responses related to organizational culture (8) and risk management and worker safety (7) were the other largest categories of responses. Discussions often weighed the need for proven technology alongside the role of organizational culture. While there were comments related to the “race to be second” as described in section 3.3.1 above, there were also comments underscoring how the culture of leadership makes a substantial difference in influencing technology adoption, which included the personal motivations of individuals as well as the overarching cooperate culture.

4 Future Considerations

It is expected that new technologies will continue to evolve and be adapted in differing iterations across BC’s mining sector and in the Kootenay Region. The top future technologies identified were consistent with the top current technologies – with discussions focused on the continuous advancement of these technologies and how they may see more widespread adoption. This is characterized through discussions related to autonomous vehicles:

“As far as what I can see forthcoming and what’s already starting to make headway in the industry in BC would be autonomous vehicles. Especially on the hauling side. But a lot more are working on autonomy. I know there’s two or three mines in the province, or two or three companies in the province that are pushing hot and heavy to get that really underway.” British Columbia Mining Company Representative 2

However, what this looks like in practice for mining companies depends on various factors, including place-specific factors – the specifics of the landscape and what is being mined, but also on the size of operations. The reality of technology adoption for global companies like Teck differ dramatically when contrasted to smaller mining operations.

While operational efficiency and worker safety are important drivers of technology change, so too is a changing landscape related to ESG, particularly in BC where the DRIPA legislation is changing the landscape surrounding First Nations relationships and decision making. An increasing need for technologies aimed at decreasing the environmental impact (e.g., energy and water use) of mining was also identified:

I think what we’re going to see is probably things related to the environment. I think we’re going to see drilling techniques that are a little bit cleaner and circulate water a little better. And I think we’re going to see a movement away from diesel. – British Columbia Mining Industry Expert 6

Workforce projections for the mining sector anticipate thousands of jobs in the next ten years, however the majority of these are acknowledged to be replacement of existing workers (Work BC, 2025a). However, a small number of interviewees questioned whether all existing jobs will be replaced. As described above, there was some debate within the interviews over whether or

not the creation of entirely new jobs would result in the same size of workforce. The interview data demonstrated a quickly changing skills landscape, particularly related to new technologies, shifting the types of jobs, who is doing them, and potentially changing where these jobs are located.

From the perspective of rural communities that depend on mining operations, mining remains fundamental to their economies. However, both uncertainty and risk are acknowledged locally, as stated by one interviewee, *“as much as we would like to be proactive, it is going to, at this point, be more of a reactive process.”* – British Columbia Response Organization Representative 3.

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