Creating Human-centered Smart Mines of Tomorrow

Aarti Soerensen and Elisabeth Clausen from the Institute for Advanced Mining Technologies (AMT) at RWTH Aachen University explore the impact of digitalization on the sustainability of the mining industry

Mining companies today are being challenged in their traditional ways of doing business. The expectation to operate more sustainably while significantly improving productivity means that miners are under two kinds of pressure.

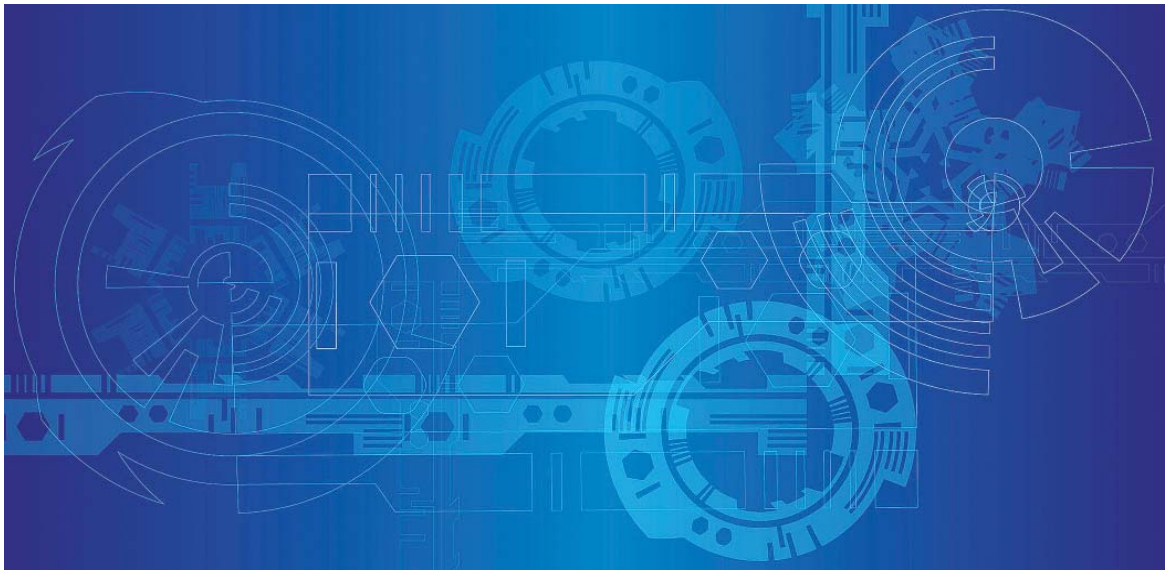
On the one hand, companies must address challenges inherent to the industry, such as changing geological conditions and rising operating costs along with volatile commodity price cycles. To date, digitalization and automation have been key in creating measurable improvements in productivity and cost management. On the other hand, miners must adapt to the rising expectations of various stakeholder groups, including investors, communities, governments and consumers who are increasingly judging companies by their footprint as well as safety records and benefits to employees.

Never before have miners had to rethink their role within society like they need to today. This value shift means that more responsible and sustainable business practices are now considered essential for the long-term survival of mining companies.

Consequently, digital transformation and automation have become central to the discussion on how mining companies can master the challenges of the future, including sustainability. There is no doubt that technologies for realizing digitalization, automation, and electrification are important enablers in improving miner's triple bottom line and thus can contribute to maintaining the trust of stakeholders. However, the complex relationship between digitalization and sustainable business practices has not been investigated systematically until recently.

In 2020, a two-part study (Clausen, Sörensen et.al, 2020: Assessment of the Effects of Global Digitalization Trends on Sustainability in Mining Part I and Part II), which was commissioned as part of the in-house research project "Sustainability in mining and in mineral supply chains" at the German Federal Institute for Geosciences and Natural Resources (BGR) set about doing this. The joint project was conducted by the Institute for Advanced Mining Technologies of RWTH Aachen University together with Brenk Systemplanung.

It identified leading technological trends shaping the transformation of the industry, assessed current levels of implementation in digital initiatives, ascertained challenges and opportunities with respect to implementing digitalization initiatives, and investigated the effects of digital technologies on aspects of sustainability from a global perspective. The subsequent article summarizes some of the key findings.



To take full advantage of digital technologies, all parts of an operation need to be integrated into a comprehensive IIoT infrastructure. (Image: Unsplash)

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Trends and Challenges in Digitalization

A suite of 15 technologies was identified to be shaping the extraction of minerals and metals today through digitally connected, integrated, automated and electric mines. These are, in order of their level of implementation or adoption, based on the study results, including automation, the Industrial Internet of Things (IIoT), remote operation centers (ROCs), connected workers, robotics, drone technology, electrification, 3D printing, integrated software platforms, advanced analytics, simulation and visualization, cloud computing, big data management, cybersecurity, and e-learning.

These technologies aim to make mining operations safer, more productive, reduce operating costs, and help mining operations remain competitive. However, despite many good examples and some impressive results achieved through their implementation, the study confirmed that the mining industry is still far from realizing the full potential of digitalization.

One key finding of the study was that mining companies seem to prioritize and focus on optimizing certain areas of their operations and do not implement all available technologies in a single operation. This is further compounded by the fact that IIoT infrastructure is usually limited to specific parts of operations. However, to take full advantage of the available digital technologies, all parts of the operation and all pieces of equipment need to be integrated into a comprehensive IIoT infrastructure.

Consequently, the potential for data gathering and connectivity between different machines, sensors and connected workers is currently limited, but is considered to be high for future development. Additionally, creating added value from the data that is already available in a way that supports de-

cision-making processes remains a big challenge, one that mining companies need to master on a broader scale.

From a technological perspective, there is little doubt that digitally connected, autonomous and electric mines will soon become the norm. The transformation though will likely be through incremental changes until mining operations move toward comprehensive, operation-wide technology implementations, and from implementing discrete technological solutions to more holistic, system approaches.

A second finding was that, while there are technological challenges that can slow down the implementation of digital initiatives, including interoperability and standardization as well as legal issues (data ownership, liability issues, cyber security), the most pressing challenges that mining companies face are related to people. According to the study, talent management followed by change management and challenges around managing innovation and collaboration are some of the greatest barriers.

The management of change is pivotal and cannot be underestimated in digital success. This includes keeping employees engaged and diversifying the workforce, breaking down departmental silos and changing management cultures, successfully adopting and integrating new technologies, and innovating collaboratively with suppliers and research institutions.

Another aspect of people management concerns the management of talent. Further, people management means managing collaborations with OEMs and technology providers, startups, research institutions and other partners in order to innovate collaboratively. This kind of collaborative innovation and technology development can and will play an important role in further advancing the industry.

People management also extends to the management of stakeholder expectations, especially with regard to investors, communities, and end-consumers in order to secure capital, keep or gain their social license to operate, and ensure transparency and responsibility of supply and value chains.

Safer, More Productive Mines

The study results suggest that digital technologies have to date mainly had a positive impact on all aspects of sustainability, most notably the social, socioeconomic, ecological and economic dimensions. The highest impact can be observed for the social and the economic pillars resulting from the implementation of automated, remotely operated machines as well as ROCs and surface control rooms.

With regard to the social pillar, including safety and terms of employment, moving people away from hazardous areas provides obvious improvements in health and safety. Moving workers to surface control rooms that are sometimes hundreds of kilometers away from the operation, means that the quality of the work environment is improved. Workers may be able to follow more regular work schedules and stay closer to home and families.

For those required on site, wearable devices are being used to track the workforce during operations, monitor fatigue levels, and provide the means to communicate with employees and remove them from hazardous events. Reducing travel times also increases the productive work time available.

Providing more attractive and safer working environments opens up opportunities for attracting diverse talent, including women. Another impact of digital technologies is on training opportunities through simulation and modeling, utilizing virtual or augmented reality tools, as well as through e-learning.

Looking at the economic pillar, automation and ROCs along with advanced data analytics, simulation and modeling and integrated platforms all have a significant impact on economic efficiency. However, it should be noted that these technologies require significant capital investment in both new and retrofitted equipment as well as a reliable communication and data transmission network, such as Wi-Fi or 5G.

If an IoT infrastructure is put in place, technologies such as digital twins, and simulation and visualization technologies can contribute to big increases in economic efficiency through more reliable production levels. Further, machine-learning processes enable predictive maintenance, flagging equipment that is on the verge of failure and in need of maintenance, which helps reduce costs associated with repair and machine downtime. The study results suggest that investing in the appropriate suite of technologies based on the requirements of the respective operation has helped mining companies to significantly improve productivity and economic efficiency.

Socioeconomic and Ecological Impacts

With respect to the socioeconomic pillar, which includes workforce and local value creation, as well as land use, impacts, conflicts and material use, the analysis showed that there are positive as well as potentially negative effects from digitalization and automation.

From a positive perspective, digitalization can provide important tools for improving community engagement and training opportunities for the local workforce through simulation and modeling, as well as open communication platforms and virtual reality tools that enable virtual mine tours. These can help improve engagement with local communities and the wider public to build trust, prevent conflicts and strengthen the social license to operate. Another positive impact on local value creation could be achieved by providing free Wi-Fi connectivity to surrounding communities.

A potentially negative impact may result from automation as many workers fear job losses through replacement by machines, which could

lead to conflict. However, the study showed that mining companies are treading carefully in this area, investing in in-house training for local workforces and may even slow down the pace of automation to manage the transition in a socially responsible way. While automation and digitalization do imply a trend toward higher skilled jobs, extensive layoffs were not reported during the study interviews, but rather the need for retraining and upskilling existing workforces.

With respect to the ecological pillar, which includes biodiversity, mine-water management, emissions, mine waste and energy use, the study found an impact on monitoring capabilities for water quality, energy consumption and emissions through digital technologies as well as from the electrification of mining equipment. Thus, the impact of digital technologies on the ecological pillar was found not to be as high as on the other pillars with other, non-digital technologies, expected to have a larger impact, especially in areas such as exploration, tailings management and mineral processing.

Interestingly, the geographical location of the mining operation has a low influence on the level of implementation of digital initiatives as well as sustainability performance. Rather, the analysis revealed that the implementation of digital technologies seems to be driven by company priorities intended to address various stakeholder interests. However, regional challenges related to sustainability can exist, such as proximity of the mining operation to communities, the existence of indigenous communities, or the site's remoteness and lack of infrastructure, scarcity of water in high altitudes and dry areas.

An Integrated Approach to Digitalization and Sustainability

Digital transformation and sustainability are no longer optional but important means for ensuring future competitiveness and market positions — not only addressing customers or competitors but also reaching out to other stakeholders such as neighboring communities or employees, i.e., the social license to operate. The results of the study clearly indicate that while digitalization and sustainability are often discussed separately, in reality these two areas have become inseparable and are closely interconnected.

Thinking about digitalization and sustainability more closely points to what we at the AMT call the "human-centered smart mine." It's easy to think that technology itself is automatically a leveler. But, at its core, a truly smart mine needs to be more than digitally connected and autonomous, it has to be human-centered and environmentally conscious in order to be fit for the future.

A focus on this human center transcends just the people on the mine site or the neighboring communities. It includes the wider society that interacts, judges and relies on the outputs of mining. Therefore, success today cannot only be measured through improved decision-making and optimized operations. As we move further into a digitalized and low-carbon future, emerging technologies can be harnessed to empower people, providing a compelling way to deliver shared prosperity for the mining sector and wider society.

To conclude, mining companies can benefit from thinking about digitalization and sustainability together by more carefully placing people and sustainability at the forefront of digital transformation. The human-centered smart mine gives mining companies a strong pathway for growth, trust and sustainable outcomes.

To find out more, access parts 1 and 2 of the study at www.bgr.bund.de/EN/Themen/Min_rohstoffe/Produkte/produkte_node_en.html?tab=Commodity+reports.