Technology Innovations to Improve Industrial Health and Safety

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Introduction

Several weeks ago, two members of a mine proto team reportedly died during a search operation at a Johannesburg mine (McCain, 2021). They were part of a team searching for an employee missing underground off one of the mine shafts. Reports are that the rescue workers "were overcome by heat during the search". The dangers associated with heat exposure underground are well known. Yet, two people succumbed to heat stress during the operation in their bid to save a life.

Heat stress related incidents are not constrained to deep underground mining operations. In oil and gas drilling environments at the surface, extreme heat or cold conditions can also present a genuine risk. For example, typical conditions at drilling sites in regions in the Middle East, parts of Africa or Northern Australia involve high heat exposure from the sun and high humidity levels. The danger increases slowly over hours of exposure, leading to cramping, heat exhaustion and then heatstroke. Owners and the employers of field workers are responsible for ensuring worker safety. Workers must have easy access to water and shade/cooling areas and frequent rest periods. Despite having these precautions in place, monitoring, and ensuring compliance can be a challenge, and a mishap can have serious consequences.

Reports like the one in the opening paragraph, inevitably lead to a plethora of questions, including:

- Are serious accidents inevitable in heavy industry?
- Can accidents be prevented?
- Can the severity of accidents be reduced?
- Why, despite our best efforts, do fatalities continue to occur?
- Can technology play a role in improving safety performance?
- Are there emerging technologies that could result in a breakthrough improvement in health and safety performance in industry?

In this article, I provide some of the context around safety performance, the scope of process safety and the impact of Covid-19 as a catalyst for adopting digital technologies. I also cover some specific real-world examples of fast-developing technologies that are likely to impact health and safety performance in the future. It is expected that these emerging technologies will set a new benchmark in industrial safety performance.

Safety management and survival

Safety performance plateau

The United States Bureau of Labour Statistics publishes work-related injury and illness data for private industry. Figure 1 shows the aggregate data from 1973 to 2019 (NSC Injury Facts, 2020).

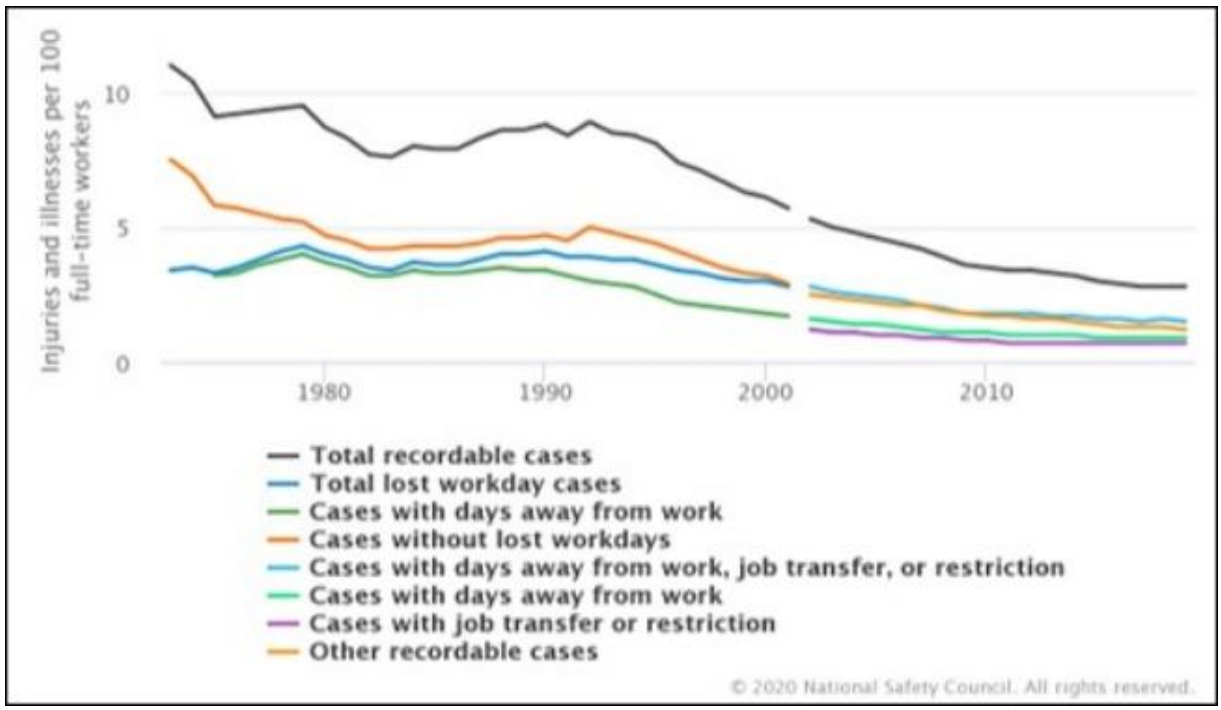

Figure 1: Work-related-injury and illness incident rates, private industry, United States, 1973-2019 (NSC Injury Facts, 2020)

Figure 1 shows that there has been a decrease in total recordable cases over time. It also shows that after 2015 the incidence rate did not materially change. Have our safe work practices reached some artificial constraint in the period after 2015, and can any further improvements be made if there is no significant change in the way we approach safety going into the future?

Accenture (2018) places this safety performance plateau in the context of pertinent organisational safety focus areas since 1960, as shown in Table 1.

Table 1: Safety focus areas since 1960 (Accenture, 2018)

Time Period	Safety Focus
1960 - 1980	Improvements in equipment design
1980 - 1995	Advances in safety management systems
1995 - 2005	Focus on behaviour and safety culture
From 2005	Focus on prescriptive rules and obligations, management accountability
From 2018	A plateau reached against the target of "Zero Harm". Further progress is inhibited by a lack of investment in digital systems and the changing employee demographics resulting in shifting levels of engagement and individual performance

Accenture concludes that new investments in digital technologies could be a way to break out of the 2018 stasis and that these technologies will enable entirely new health and safety approaches and solutions.

The impact of Covid-19 on safety

A year after the work by Accenture, the Covid-19 pandemic broke out, and a significant change was forced onto everyone. With many office workers locked down and made to work from home, factories were obliged to run on reduced staff levels, and strict new protocols for controlling the pandemic had to be introduced.

The impacts of Covid-19 on manufacturing have affected every aspect of a typical factory, drilling site or mine. Dar et al (2021) found that restrictions imposed by local and national authorities have had the most impact on activities. This was followed by unavailability of transport and workers, a scarcity of raw materials and a shortage in demand for products. The authors propose a high-level generalised framework for industry to best manage the disruptions caused by the pandemic, comprising the following three steps (Dar et al, 2021):

- **Survive**: Be responsive to tackle problems as they arise to ensure continuity of business. A key consideration during this transition is to ensure worker safety, both from the virus and from industrial hazards. Readjustment of operations, the workplace and supply chains will be necessary. Remote work should be facilitated.

- **Stabilise**: Stabilise and improve productivity and reduce losses by getting used to the new normal. Training and change management in the workforce will be a high priority for the manufacturing operation during this phase. This includes efforts to improve collaboration and morale by opening new communication channels between shop floor/factory workers and other parts of the business.
- **Sustain**: Adopt new best practices and continuous improvement processes. During this phase, the focus is on responsiveness and flexibility to ongoing changes arising in the environment. Continuous improvement programmes should be reinforced. Innovation and creativity are essential to nurture. Environmental, social, and economic factors should be factored in when evaluating the outcomes of any adjustment in the business.

The effect of Covid-19 and the response by industry has been to accelerate the use of emerging digital technologies across all aspects of the business, including health and safety management. According to a survey by McKinsey & Company, Covid-19 has pushed companies over the technology tipping point and transformed business forever (LaBerge et al, 2020). They believe that Covid-19 has speeded the adoption of digital technologies by several years, and that many of these changes could be here for the long haul. Figure 2 illustrates the surge in the digitisation of products and services across several regions and shows an acceleration of the adoption of digital technologies of between 6 and 11 years.

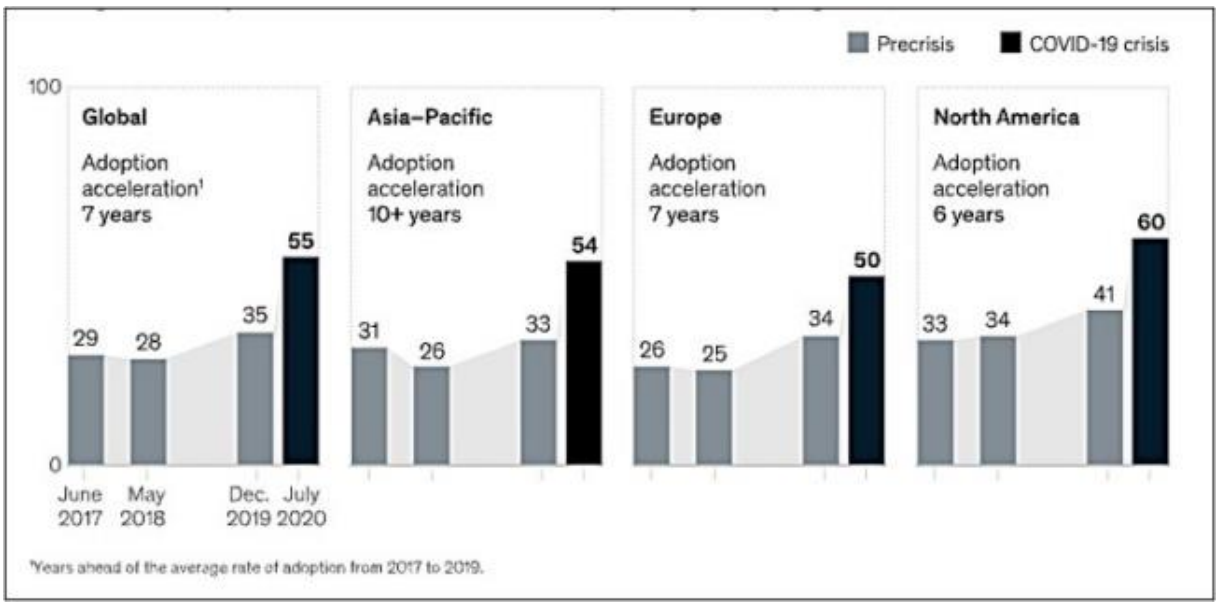

Figure 2: Increased share of products and services that are partially or fully digitised to July 2020 (LaBerge et al, 2020)

Process Safety Management and the project environment

Process safety management (PSM) defines a framework for managing hazards in the process industries and is intended to reduce the frequency and severity of incidents

resulting from releases of chemicals and/or energy. Render (2018) noted that the OHSA Process Safety Management programme is a framework that applies through all the stages of a project from concept design, to detailed design, and to operations.

Figure 3 shows the extent of the OHSA Process Safety Management Framework and sets out the 14 elements for managing health and safety and ultimately protecting workers.

Figure 3: Elements of OSHA's process safety management programme (Adapted from Wikipedia, 2021)

Many of the technological responses to the Covid-19 crisis intersect with most of the elements of the PSM framework. For example, "employee involvement" is impacted by the working from home (WFH) regulations. Likewise, WFH affects "training". Elements such as "compliance audits" and "management of change" are being converted to digital platforms by companies seeking to collaborate with their remote workers.

How relevant are these emerging technologies to a new project? At the early stage of a design, the philosophies are established. Environment, health, and safety (EHS) and information and communications technology (ICT) system philosophies are typically documented as part of this process. These will influence and guide the subsequent detailed design work. Therefore, at the early stage of every new project, it is vital to

provide for these emerging technologies to future-proof the operation and allow the future business to take advantage of this innovation.

Emerging technologies for enhanced health and safety performance

Opening remarks

In the first part of this article, I have provided some of the context around safety performance, the scope of process safety and the impact of Covid-19 as a catalyst for adopting digital technologies. In the remaining sections, I cover some specific real-world examples of fast-developing technologies that are likely to impact health and safety performance in the future. It is expected that these emerging technologies will set a new benchmark in industrial safety performance.

Covid-19 has introduced new requirements for controlling workplace practices and prevent the spread of the virus. Many of the technology investments first intended to enforce Covid-19 can be leveraged going forward to improve overall safety performance.

Of course, the following use cases are not constrained to deep mines or remote oil drilling operations; they are just as applicable to any industrial environment, including construction sites, factories, workshops, warehouses, ports, etc.

The connected worker concept

Connected worker solutions can improve workplace safety by empowering front-line and lone workers with devices and wearables that connect through a software application to support functions in the business.

A connected worker device can monitor employee vital signs, environmental conditions and exposure, location, and ergonomic factors. Modern devices are small, consume very little power and therefore ideally suited to be used permanently at work. Specially designed rugged devices can be worn or fitted in regular clothing or as part of PPE (personal protective equipment), even in the harshest environments. Devices with additional features and a large screen can be carried into the workplace (for example, ruggedised tablets, phones, visors, or sensors). These larger devices can communicate and synchronise data with wearables – much in the same way a Fitbit or Apple watch communicates with a consumer's mobile phone.

Some examples of PPE with embedded devices for use in the mining environment are shown in Figure 4. All these devices are designed to ultimately communicate data wirelessly to a network. Most modern devices and software platforms also have an offline mode to cater for when there is no network.

Figure 4: Embedded wearable safety systems (Mardonova & Choi, 2018)

Figure 4 shows some prototype examples of wearable devices used in mining (Mardonova & Choi, 2018). They include (a) a sensor-equipped mine safety vest; (b) a miner wearing Smart Eyewear; (c) a miner using Smart Headset; (d) sensor-equipped safety helmet; (e) industrial smartwatch. The technologies will continue to improve from these early prototypes, driven by advances in consumer electronics.

Environmental monitoring

In our mining example, a device that measures cumulative heat exposure might have alerted the affected workers or their colleagues to the severity of their condition in time so that relief teams could be mobilised. In the oil field example, measured heat stress parameters could alert the workers and supervisors about the dangerous exposure levels in time for corrective action or emergency measures to be implemented.

Vital sign monitoring

Vital sign monitoring such as pulse, breathing rate, oxygen levels, and body temperature can prevent incidents by triggering proactive interventions. The biometric data collected can also generate health records over time and confirm there has been adequate protection from PPE routinely used.

Fatigue monitoring

Operators of heavy machinery for extended periods must be awake and alert to operate safely. Fatigue can be difficult to detect. Fortunately, there are new devices that can analyse brain activity and monitor fatigue in real-time. These devices are already in use in trials at mines in the Northern Cape, South Africa (Mardonova & Choi, 2018).

Abnormal pattern detection

Connected worker devices can detect incidents such as slips or falls, alerting response crews. In the case of lone workers on large sites, these devices can track the location of workers, improving visibility and control of work and improved safety. In an emergency, this location data can speed up the tracing of people on more significant sites to ensure a safe and complete evacuation.

Ergonomic monitoring

Suitable devices are also available for measuring and recording ergonomic factors that impact worker health. Posture, lifting technique, light (lux) levels can all have a detrimental long-term impact on the body. Proper monitoring with proactive alerts can reduce this risk. Devices measuring vibration in the arms can help manage the risk of long-term injuries in workers who handle power tools for extended periods.

Air quality and toxic gas detection

Exposure to other harmful environmental conditions can also be monitored. For example, exposure levels to specific gases can be better controlled using wearable devices with sensors designed for a particular range of toxic gases. This is the digital equivalent of taking a caged canary down a mine to test for methane gas.

Remote assistance

During complex or dangerous tasks, remote assistance can be provided to front-line workers visually using specially designed smart glasses/visors with a built-in camera and augmented displays with two-way communication capability. This will allow specialised support from a remote office to front-line workers during maintenance or complex machinery troubleshooting. Scarce skills can serve multiple factories or sites from a single remote location.

Covid-19 controls

In the context of Covid-19, connected worker devices can be used for contact tracing in the workplace to monitor the potential spread of the virus and enforce social distancing rules.

Other Examples

Several other examples of connected worker solutions are emerging, including solutions for remote training and skills development, point of work risk assessment and information around hazards, and the coordinated communication of work instructions.

Practical considerations

Data infrastructure

Significant amounts of data will be collected from new connected devices in a typical factory environment, and this information will need to be captured, stored, and processed to produce meaningful insights and actionable outcomes. This will require a proper ICT (information and communications technology) infrastructure that can support a range of devices and integrate existing business and manufacturing systems.

A well-architected system for managing this large volume of data will have many benefits over several standalone point solutions. For example, the right system architecture will allow artificial intelligence (AI) applications to analyse the data and predict safety parameters. Companies are now offering new AI-driven safety platforms that combine sensor data with behavioural science models to provide a holistic view of the workforce and assets in real time.

An integrated approach to the management of wearable data will allow companies to have real-time visibility of workers in the field and the status of tasks. Detailed procedures such as maintenance or shift handover will be significantly enhanced and better controlled when following an integrated approach. Contractors and employees alike will be empowered with real-time context-sensitive information that would otherwise have been obtained manually, a time-consuming process.

Technology selection

Selecting the most appropriate connected worker solution will depend on several factors, including:

- **Business case:** There will need to be a business case based on tangible benefits – such as improved safety, productivity, responsiveness etc.
- **Work objectives:** Specific use cases will be selected depending on the specific objectives, the work's complexity, and priority.
- **Available budget:** The requirement to invest in additional communications infrastructure needs to be assessed as this could be relatively costly.
- **System support:** Support and management of the systems and the data generated will also need to be factored into the decision. Outsourcing this to a managed

services provider might be a way to gain access to these skills without the need for specialised in-house skills.

- **Privacy concerns:** Privacy and other considerations might limit the adoption of devices that collect and process private data – this will need to be evaluated together with employees affected, considering the applicable privacy legislation.

Benefits of connected workers

There are several benefits in a typical industrial plant stemming from an integrated connected worker solution. Some examples of these benefits include:

- **Communication:** Improved communication between the control room and the connected field operators.
- **Performance management:** Improved measurement and calculation of leading KPI's relating to operational performance and safety.
- **Risk management:** Improved hazard identification, better risk assessment and improved use of barriers and/or mitigating controls.
- **Behaviour modification:** Encouraging the right behaviours through gamification (recognition such as awarding badges or special status).
- **Emergency response:** Improved emergency response coordination by locating and alerting field workers more quickly.
- **Remote skills transfer:** Two-way communications and support for workers involved in complex tasks requiring less specialised skills on-site and cost reductions.
- **Access to information:** The connected worker has improved access to relevant information such as safety data sheets, plant status, instructions, observations, and more.
- **Incident investigations:** Streamlined incident investigations and better incorporation of lessons learned into working procedures.

Closing Remarks

The Covid-19 pandemic has accelerated the adoption of emerging digital technologies in the industry. Technologies around the connected worker promise to help organisations achieve even higher levels of health and safety performance than ever before and set a new standard for operators of industrial facilities. Successfully harnessing this opportunity will require understanding the potential use cases and benefits, a viable business case, and an adequately architected platform that allows for vast amounts of data and integration to other systems. While the emerging technology is evolving fast and being proven in existing operating factories and mines,

it is vital that capital project teams also take note of these developments and include these concepts into the design philosophies for the plant of the future.

References

Accenture (2018) *Adopting digital to break the EHS performance plateau.* Pdf document available from Adopting Digital to Break the EHS Performance Plateau (accenture.com). Accessed on 3 October 2021.

McCain, N. (2021) *Two rescue workers die during search operation.* Available from https://www.news24.com/news24/southafrica/news/two-rescue-workers-die-during-search-operation-at-johannesburg-mine-20210922. Accessed on 5 October 2021.

NSC Injury Facts. (2020) *Work-related incident rate trends.* Available from https://injuryfacts.nsc.org/work/industry-incidence-rates/work-related-incident-rate-trends/ Accessed on 5 October 2021.

Dar, M.A., Gladysz, B. & Buczacki, A. (2021) Impact of Covid-19 on operational activities of manufacturing organisations - A case study and Industry 4.0-based Survive-Stabilise-Sustainability (3S) framework. *Energies* 14(7):1900. https://doi.org/10.3390/en14071900.

LaBerge, L., O'Toole, C., Schneider, J. & Smaje, K. (2020) *How Covid-19 has pushed companies over the technology tipping point—and transformed business forever.* Available from https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-COVID-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever. Accessed on 5 October 2021.

Render, C. (2018) *Effective Process Safety Management.* Available from https://www.ownerteamconsult.com/effective-process-safety-management/. Accessed on 5 October 2021.

Mardonova, M. & Choi, Y. (2018) Review of wearable device technology and its applications to the mining industry. *Energies* 11(3):547. https://doi.org/10.3390/en11030547.

Wikipedia. (2021) *Process safety management*. Available from https://en.wikipedia.org/wiki/Process_safety_management. Accessed on 4 October 2021.