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I4 MINING

How the Mining Sector can **Achieve Zero Harm with Industry 4.0 Technology.**

How insights, interoperability, instruction and intelligence will enable miners to achieve their Health & Safety goals - and reach Industry 4.0 status in the process.

Down to Zero.

Of the 'zero' goals that miners are striving towards, zero harm is the most emotive.

In the developed world, fatality and injury rates have trended downwards year-on-year for decades, however in the past 20 years or so, improvement has somewhat plateaued.

In 2020, there were 29 mining-related fatalities in the US (down one from 2019 and following rises in 2017 and 2018*) and in Australia, five people lost their lives in 2020 (down from 9 in 2019, but six have died during 2021 to-date †). Whilst such low numbers could be considered a success, it's not enough.

Existing Industry 1.0 to 3.0 technologies have played a huge role in the massive improvements we've seen in the past century, (as has miners' focus on safety, improvements in mine design and construction, as well as enforced regulatory minimums), however it's very unlikely that they will be able to take us any further - additional improvement without change will be very hard to come by.

Industry 4.0 technologies present the mining sector - arguably for the very first time - with the opportunity to actually reach zero harm; an objective that most of the world's largest miners have committed to strive for ‡.

Continued overleaf.

* Source: https://www.amsj.com.au/29-mine-related-deaths-in-us-in-2020/
† Source: https://www.safeworkaustralia.gov.au/statistics-and-research/statistics/fatalities/fatality-statistics up to 14-Oct-21
‡ Source: Principle 5 of the ICMM Mining Principles charter - https://www.icmm.com/mining-principles/5

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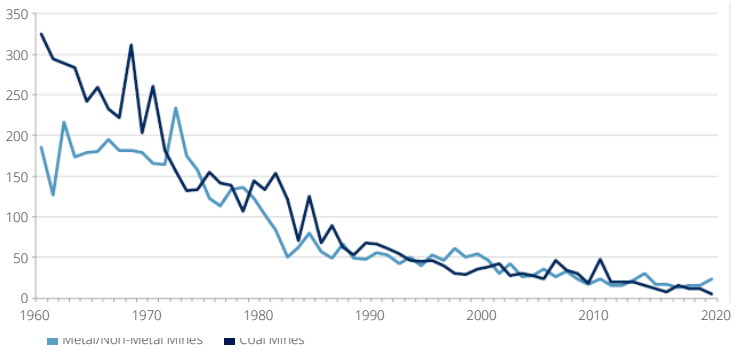
Historical US mining fatalities.



Source: US Mine Safety and Health Administration

From taking people out of harm's way, enabling real-time monitoring and threat mitigation, through to AI-led interventions that can predict and remedy danger before it even occurs; the mining sector now has at its disposal the tools to make mining as safe as office work - in fact, in some instances, by making it just that.

This report will examine the means and methodology through which miners can leverage Industry 4.0 technology, (as well as just exactly what that is), to enhance their health and safety footing, and explore the means through which zero harm can be achieved.

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The relationship between Industry 4.0 technology and zero harm.

Mines are the embodiment of a hazardous working environment. With humans interacting with dangerous machinery and plant, hazardous and toxic materials, electricity, explosives, cliff edges, underground tunnels and much more; the sheer number of ways that someone in that environment can come to harm is extensive.

The mining sector has been very good at putting in place safeguards, processes, policies, and procedures that have taken harm measures to where they are today. Health, Safety and Risk assessments, training and other human elements have never been more comprehensive, although adherence and reporting can always be a challenge.

The US's Mine Safety and Health Administration (MSHA) has multiple mining accident classifications* and there's even more that the mining sector needs to consider beyond mineral extraction.

Each of these comes with its own set of individual technologies that can be applied to prevent or protect from each individual type of incident. Better PPE, safer Plant, improved mine design etc. will always play a role however the true path to zero harm can be lost in this detail.

The answer is Industry 4.0 technology that is capable of monitoring and analyzing mining operations in real-time, predicting potential problems and triggering action, shutdowns or guiding improvements (e.g. an individual that's risk taking) to stop impending harm.

The path to zero harm, Industry 4.0, and the need for extreme interoperability.

The fourth industrial revolution - where businesses build upon their use of computing power and automation with the adoption of intelligent, autonomous systems that can leverage complex data sets and machine learning to deliver AI-driven enhancements in real-time - is the missing piece in zero harm goal attainment.

There are a vast number of opportunities for miners to transform in the context of health and safety, both operationally and strategically via the adoption of new forms of IT, Mining Technical solutions (MT), Physical Technology (PT) and Operational Technology (OT) into existing operations. However, zero harm (and true Industry 4.0 transformation) will be achieved by finding better ways of doing things, the enhanced usage of data, and improving how people interact with it and a mine's operations - not the technology itself.

Achieving zero harm is a significant endeavor, only made more complicated by the complexity of mining operations, systems and technologies - it can't be achieved overnight by plugging in a single piece of technology that makes you Industry 4.0 and switching it on.

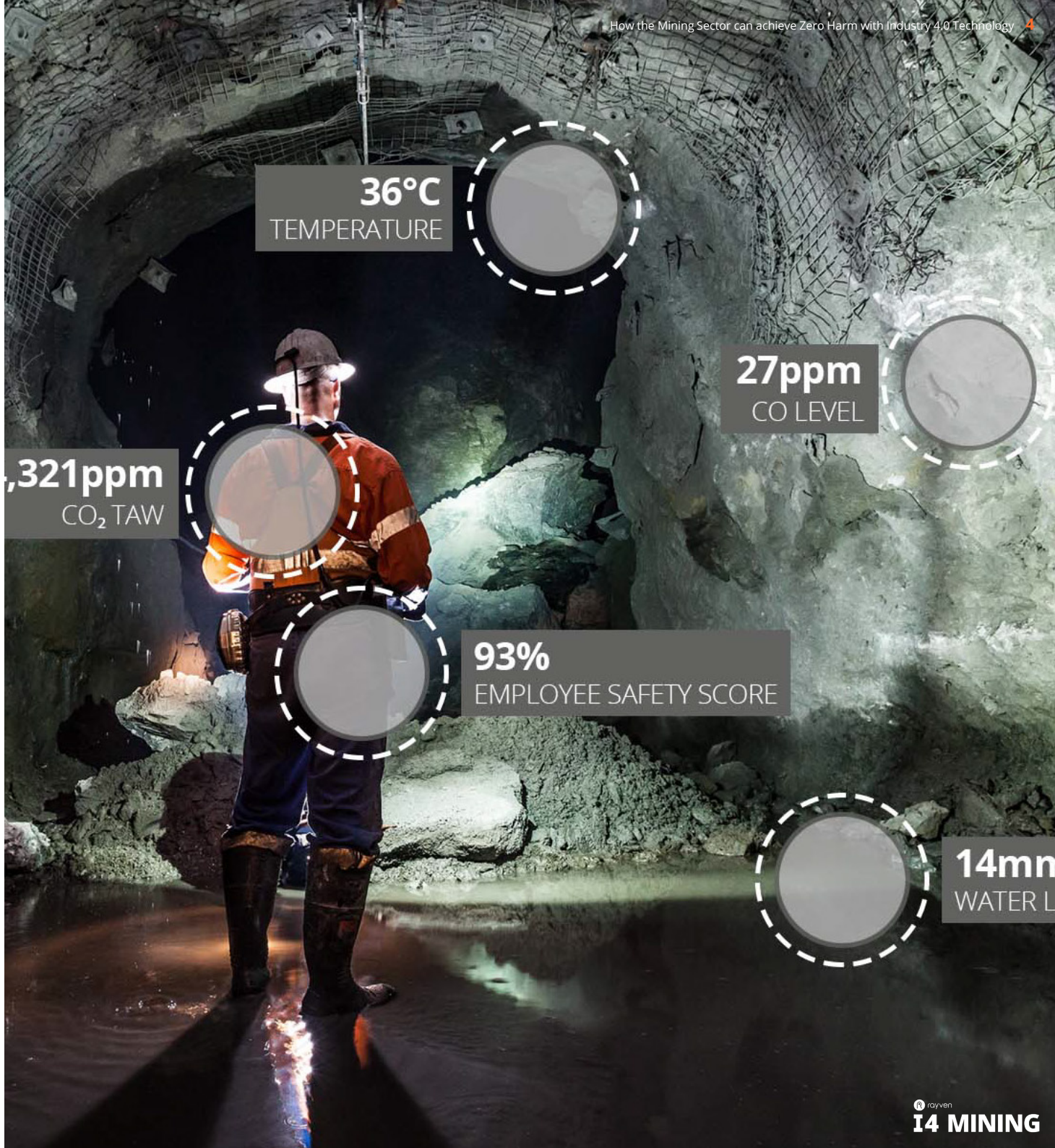
No, the path to achieving Industry 4.0 status is via the adoption of a suite of use case-specific solutions that can be deployed and then integrated with one another piece-by-piece, function-by-function.

* Source: https://arlweb.msha.gov/fatals/accidentclassifications.asp

Each of these solutions will improve singular (or more) aspects of your operations' health & safety (or other parts of your operations that's interrelated, such as environmental monitoring), but will then also need to connect to something that's capable of a supremely high-level of interoperability, which can analyze all of the data that's coming from these solutions (plus other systems or data sources inside and outside your organization) to identify trends, relationships and insights hidden in the 'Big Data' you're accumulating. The platform also needs to be capable of taking direct action to prevent harm or identify where and how a business (or individual employee) needs to improve, optimizing on an ongoing basis based on changing variables and performance - it's not about analyzing all the data; it's about identifying the pertinent data to safety in this maelstrom, monitoring it accurately in real-time, and then using predictive analytics to stop harm from occurring or find safer ways of operating.

What is being described here is a new piece of technology that's needed to sit in the middle of every Industry 4.0 business and/or operation to analyze and orchestrate: an integrated AI + IoT platform.

The AI + IoT platform is critical because it's the one place in an organization where all of its data (both historical and real-time, from any system, sensors or data lake) can flow and be standardized for analysis, where machine learning algorithms can be leveraged, and where cross-functional decisions - made by human or AI - can be orchestrated and executed: it's an Industry 4.0 organization's brain.



Why Industry 4.0 is about AI and IoT.

IoT and AI technology are distinct sets of interrelated technologies in the context of Industry 4.0 technology. To simply delineate the two:

IoT: Collecting the right data. ✚ **AI:** Using machine learning to do something with it.

IoT: IoT or IIoT (Industrial Internet of Things) technology enables miners to collect real-time data about their operations via infield sensors; through links from OT, MT, PT and IT; as well as via third party resources (such as weather forecasting). This data then enters a platform through which it is combined and can be examined via dashboards to assess performance in real-time and sometimes even execute simple automations based on 'if this then that' business logic.

On its own, IoT presents miners with opportunities for transformation and improvement, removing the need for people to enter hazardous environments to take measurements but cannot deliver true Industry 4.0 transformation on its own as it lacks the critical decision-making and predictive analysis required to meet the definition.

AI: The AI element of an Industry 4.0 solution is about the applications and subsequent actions taken as a result of the use of machine learning algorithms being applied to the data sets collated using IoT technology and the platform's other integrations.

To operate, you need to have in place a way to record and compare the interactions of all of the potential variables that go into an operation so that machine learning algorithms can be applied to the data sets to spot trends, relationships and uncover optimizations.

For Industry 4.0-status and zero harm goals to be reached, this needs to be done in real-time, with interventions executed through automation before they're lost or before they occur, e.g. preventing accidents etc. Over time (and with growing data sets) machine learning algorithms find new and more effective ways to operate - they get better - and multiple ones can be applied to the same data to experiment with new use cases or test alternative approaches (via digital twins).

It is with the combination of IoT and AI that we get to the heart of what people mean by Industry 4.0 status: having operations that utilize machine learning-led automated interventions in real-time that self-optimize over time on an ongoing, incremental basis.

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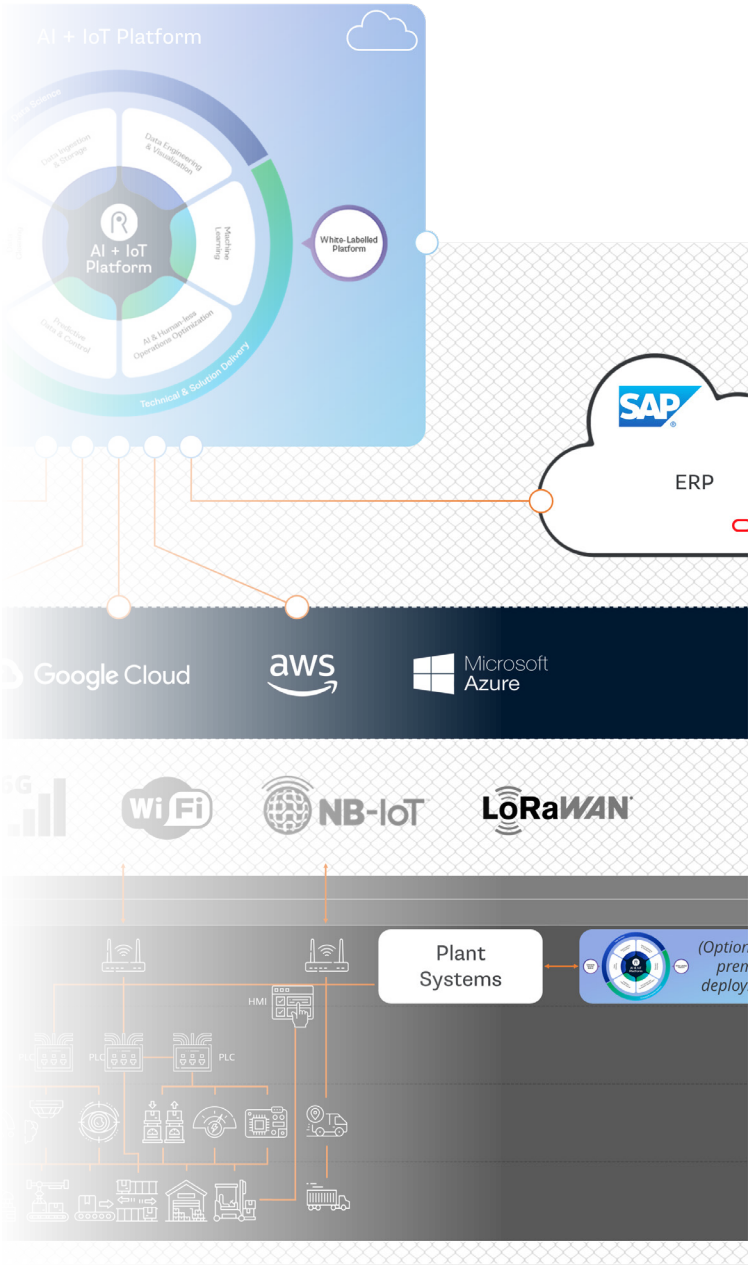

Health & Safety Industry 4.0 applications in mining.

It's, broadly, not possible to list every possible scenario and potential type of harm that may arise whilst mining.

Accidents can occur at any point in time, from falling off an office chair, resting arms outside of moving vehicles to the improper handling of explosives. Whilst there may be a novel (or old) technology that can solve these individual aspects, such as new carriages to carry workers, the electrification of plant, etc.; when talking about Industry 4.0 technology, what we're really trying to do is provide new ways to analyze risk holistically (using machine learning) and then improve functions to achieve a strategic business objective (not a technology one) based on that analysis.

Therefore, to explore the application of Industry 4.0 technology in mining, it's important to focus on operational areas where the application of an AI + IoT platform can have significant impacts, rather than the analysis of a particular technology (such as the electrification of assets or driverless technologies).

Enhanced plant and equipment performance:

Time to failure & predictive maintenance.

There are many things that go into the failure of machinery. Poor operation, different terrains, as well as the failure of individual parts. With real-time monitoring of machinery and the use of predictive algorithms that can utilize data from multiple sources, such as real-time temperature and vibration measurements coupled with forthcoming usage and operator schedules, it's possible to predict when an asset is going to fail, why and what the remedy is. This not only makes it possible to predict when machinery needs to be serviced (versus when it's scheduled to be, simply because it's been 6 months since its last check), but also identifies what the fix is (reducing maintenance crews time in the field) and prevents the development of problems that could cause hazardous failures.

Real-time catastrophic failure prevention.

Real-time monitoring of assets and plant, even with the use of predictive machine learning algorithms, need time and large data sets to be able to predict 100% accurately (it's also a moot point as to whether this will ever be achieved). Therefore, using an AI + IoT platform, it's possible to analyze the real-time data measures and implement fail-safe machinery shutdowns should a catastrophic failure be impending by understanding operational norms, the outcome of previous breaches of them and by being able to identify from real-time measures where recovery won't be possible; directing machinery to shut down immediately via automated intervention.

Long-term performance pattern analysis.

It's possible to analyze data sets across fleets to identify and predict asset performance. As well as optimizing output and improving uptime, high-level performance is a good indicator of safety. Additionally, through identifying patterns (such as how long it takes for an asset to start or whether it does better at a certain time of day), you can use these insights to further enhance safety by changing shift patterns and ensuring the correct personnel are on-site at the right time.

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Real-time employee, environment, asset & operations monitoring:

Deliver proximity alerts + real-time Permit To Work. Many of the injuries and deaths that occur on mining sites are due to people being in the wrong place at the wrong time, doing something that they shouldn't be doing (e.g. using a tool close to electric cabling), or through an unforeseen failure resulting in an action, such as inundation, gas explosion or rock fall. An AI + IoT platform enables you to, via the use of wearables and the real-time monitoring of environmental and mine conditions, aggregate data in real-time and identify when someone is going to come to harm, sending alerts and stopping machinery before an injury occurs.

Establish employee safety scores. Through the analysis of real-time data monitoring via wearables, comparing it with environmental measures and operational understanding, it's possible to monitor employee performance based on the individual aspects of their role, such as how safe they're being. This could help identify when, for example, an employee is tired or beginning to make small mistakes and could be about to come to harm or whether they're consistently following required compliance norms at any given moment.

Enhanced safety walks + inspections. The real-time, remote monitoring of environmental and mine measures is a more accurate, safer way of conducting these critical safety procedures. However, taking this a step further, you can use machine learning to predict how these variables are affected by third party data (such as weather) or your operations, providing you with real-time analysis that identifies problems in the afternoon that weren't there in the morning, or that can predict the development of risks.

Improved training. It's possible to monitor the impact of workforce training initiatives, identify what does and doesn't work, as well as spot individuals who need further support in particular areas of their role via comparing the performance of employees both before and after training via the use of real-time monitoring and the aggregation of data from other sources, such as productivity and output measures.

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Holistic operational analysis:

Process optimization (Digital Twinning). Current best practices in mining are reliant on doing the same thing, day after day; following best practice. This makes the analysis of deviations in current practice, in an effort to find better ways of operating, difficult because those are the very behaviors that are trying to be avoided. With digital twinning, it is possible to test new operational models or set algorithms with the task of analyzing all the current variables and finding better ways of functioning without risking harm. As long as there is a way of measuring success, then any scenario can utilize machine learning and be tested.

Plant, mine, country and cross organizational analysis. The aggregation of data from multiple sources across an entire organization makes it possible to uncover best practices, identify superior assets and plant (e.g. by brand, age, model etc.), as well as identify areas for improvement based on much larger data sets. This works at the short-term, site level, but also will improve the results being made via longer-term optimizations (e.g. better staff training) and takes away the barriers that sometimes exist between departments and business units.

Remote operations + superior skill set identification. The application of industry 4.0 technologies to leverage the ability to operate machinery remotely and leverage superior skill sets is an obvious one. Through the use of detailed data analysis, it is possible to examine individuals' performance who conduct similar functions in a business. By doing this, organizations can understand what it is that makes them better so that they can upskill a wider workforce, or even set-up remote control and operations rooms that enable top performers to conduct their highly-skilled roles across multiple sites without ever having to visit sites and be potentially put in harm's way on transport or other on-site activities (e.g. moving amongst unmanned vehicle operation).

Aggregated risk profiling. The operation of certain types of machinery at very high temperatures isn't a problem in itself, but it could be if the external temperature rises beyond norms or an external heat source, such as a welding torch, is applied in close proximity. Using an AI + IoT platform you can create algorithms that can explore the impact of certain activities and provides the ability to create accurate, aggregated risk scores that can't and mightn't be foreseeable.

Standard operating procedure adherence + safety margins. Putting in place all of the safeguards and procedures needed to achieve zero harm is always going to be ineffective if incidents aren't reported, standards aren't followed or if the safety margins that they are based upon are insufficient. Through real-time monitoring of assets and employees, it's possible to identify where deviations are occurring, where margins are insufficiently strict (or even where they're too constraining), as well as pick up on the small incidents that may never make it onto incident reports but which, occurring repeatedly over time, may be a key lead indicator of a problem that could have potentially more catastrophic consequences.

Improved emergency performance. Using an AI + IoT platform, it is possible to analyze how previous incidents occurred and the effectiveness of previous responses. By creating a score for each individual aspect, businesses can analyze where improvements can be made and decrease the likelihood of an injury turning into a fatality in the future.

As long as there is a way of measuring success, then any scenario can utilize machine learning and be tested.

Added advantage.

There are numerous other applications and potential benefits that can be derived from the use of Industry 4.0 technology, such as reducing the manual and error-prone reporting burden, the retention of knowledge and freeing team members from repetitive work to focus on other aspects of their role - making it easier for employees to consider safety standards and apply them correctly. It also makes it easier for management to adopt competency-based risk management practices, ensure that they have the full picture when it comes to real-time safety performance and make better decisions that will enable them to achieve zero harm workforce goals.

The thing that all of these benefits have at their center, though, is the correct application of technology; namely an AI + IoT platform that has access to the right data in real-time from all potential sources via extreme interoperability, which is then coupled with in-field real-time sensors to, comms and networks, and other safety-related technologies, such as wearables.

Where to from here and implementation.

The first step is to Identify a particular safety objective that forms part of a zero harm program that can be used to test efficacy, as well as an individual (or small multi-disciplined team who would be directly affected by it) who will be capable of championing and running the project.

From there, they must explore the use case, identifying all of the potential variables that go into the safety of this particular function; including plant, human, process, environmental, asset etc.

Once established, it is necessary to explore where the data gaps are. Is there certain data that cannot be collected at this stage? Is real-time data accessible? What's the internal skills gap when it comes to the necessary technology, implementation or data analysis and use of AI?

At this point, if it's not already occurred, it is prudent to look for the right suppliers. Critical to developing an Industry 4.0 footing is an AI + IoT platform, so this should be the starting point - an understanding of mining operations and expertise is a good place to start, as many providers are industry agnostic or lack the in-depth understanding of a sector to add true value during solution development.

From there, with their assistance or with in-house skills, examine the technology stack that is going to be needed. Central to this is how to collect the data needed to monitor the variables identified in real-time from in-field hardware or systems your organization has (new and existing), the networks and comms needed to capture it, as well as developing (or buying) the machine learning algorithms that you're going to use to improve health and safety in this use case.

From here, it's about the deployment, roll-out and internal communication/transition plan. Every operation and site is unique, but there are commonalities across mines and operations that can be applied to every situation across projects.

The best approach is to start small and scale. Pick an easy-to-monitor use case without too many variables, where improvement can be clearly measured, and look to apply it to a single site. This enables you to deploy the technology fast (sometimes in weeks), reduces costs and risks, and provides you with a pilot program through which you can start collecting and analyzing data, testing optimizations, and judging its success.

Once making a measurable impact, it's time to scale across multiple sites and to capture bigger data sets from across operations - by leveraging them at this stage you will speed-up and enhance the optimization loop. Working with a partner that can work with you over the longer-term and, critically, knows how to scale will reduce costs, speed-up the deployment process, and reduce further development cycles.

Work with someone who is a digital native, can explore your operations in relation to your business objectives, who understands the sector, knows the current technology, and has a global network of best-in-class partners who can provide you with the future-proofed technologies that you need to create complete Industry 4.0 solutions: talk to Rayven about I4 Mining.

Ready-to-go mining solutions

Discover I4 Mining's pre-built AI + IoT solutions or speak to us about your bespoke needs.

Health + Safety

Achieve zero harm to workforce, simply.

I4 Mining's Health + Safety digital mining solution enables you to connect all of your people, plant and systems to utilize historical and real-time data; preventing workforce harm across your operations and enabling you to achieve your zero harm objectives.

Environment + Community

Making zero harm to environment easy.

I4 Mining's Environment + Community digital mining solution is a complete environmental monitoring, management and compliance solution that enables you to monitor your operations in real-time and use AI to predict, prevent and remediate breaches, fast.

Asset Monitor + Maintenance

Achieve 100% scheduled uptime & increase tonnage.

I4 Mining's Asset Monitor + Maintenance solution is a real-time asset monitoring, utilization optimization & predictive maintenance solution all-in-one. It enables you to improve plant performance across your operations, from drill rigs and motor graders, to pumps and HVAC equipment.

Yield + Production

Increase yield, prevent breakdowns and find efficiencies.

I4 Mining's Yield + Production digital mining solution enables you to monitor and analyze all of the variables that go into material extraction, screening and processing to uncover improvements and then seize upon them. It Increases yields, prevents breakdowns and finds efficiencies using the platform's IoT, AI and adaptive real-time data analysis.

Energy + Resources

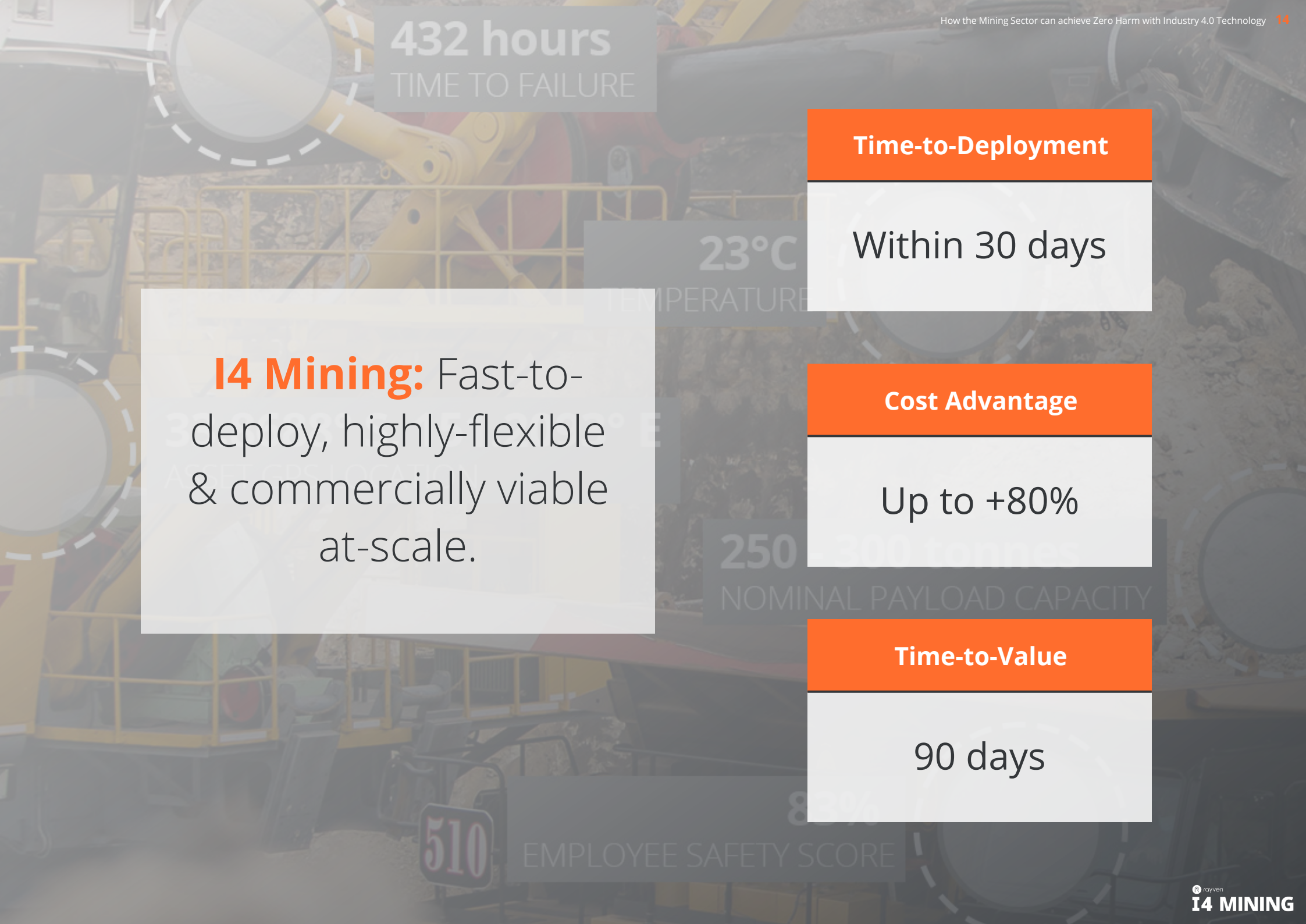
Turn real-time energy + resource data into tangible cost and carbon savings.

I4 Mining's Energy + Resources digital mining solution enables you to optimize the usage of the costly inputs that go into your operations and reduce waste; delivering you immediate efficiencies and dramatically improving profitability, fast.

Oversight

Get a single source of truth and advanced analytics to reduce risk & solve compliance challenges.

I4 Mining's Oversight digital mining solution improves real-time strategic decision-making, enhances risk assessment and reduces the reporting burden by providing you with up-to-date, accurate data in an easy-to-use predictive analytics engine. Beyond that, Oversight gives you the ability to execute those decisions, both manually or via AI-led automation.



I4 Mining: Fast-to-deploy, highly-flexible & commercially viable at-scale.

Time-to-Deployment

Within 30 days

Cost Advantage

Up to +80%

Time-to-Value

90 days

Want to see how an advanced AI + IoT platform is used in the real-world?

Watch the **Discover Rayven** video.

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I4 MINING

Next generation Industry 4.0 digital mining solutions.