Unanswered Challenges in the World of Heavy Industry and Mining

Within the worlds of Heavy Industry and Energy/Natural Resources (ENR), mining is a business that is decades behind in terms of the use of technology, protocols, and systems that can have a positive impact on people, society and profitability.

Overall, Heavy Industry faces big challenges brought about by a long history of low risk attitudes, closed systems, and the technological immaturity of entrenched legacy equipment. At the same time, they are starved for what only innovative approaches can provide: new ways to increase asset efficiency, decrease costs, insure worker safety and productivity, and deliver more competitive products in the market.

Mining is a perfect test bed for innovation in the world of Heavy Industry. It is a business that has lived on nothing but small incremental change, steadfastly avoiding much that might disrupt the status quo. Additionally, if a technology can provide hardiness and success in its uniquely tough and gritty environment, there are many other business environments waiting that face similar challenges, but with far less daunting surroundings.

Mining also provides challenges where both economic and quality of life issues can be addressed simultaneously. That’s a dual challenge worthy of attention.

"The mining industry is in desperate need of a technology intervention."

Dr. John R. Spear, Professor of Civil and Environmental Engineering, Colorado School of Mines
Can Technology Replace the Proverbial Canary in the Coal Mine?

The mining industry is in desperate need of a technology intervention. The manner in which the industry currently monitors the quality of air and dangerous gas-related safety for miners is not all that far removed from the days of “canaries in the coal mines.”

In many underground mines today, a person is sent out every hour to traverse the mine, manually read sensors, and document the status of oxygen levels, dangerous gases, and escape routes. This is recorded on physical boards at a central location. A mine manager performs a standard analysis on the data in order to make decisions on how to regulate oxygen levels inside the mine. This ancient methodology does not allow for any real-time monitoring and automated response to changes in conditions, and it also requires an individual to be placed in a potentially hazardous situation.

While the mines may have sensors, many are not connected to intelligent networks that could supply safer real-time recommendations. And the networks that do exist have largely dated “homegrown” software.

So in thinking about this current state and the need for technological intervention, the industry question should become:

“Can we automate air and dangerous gas monitoring and generate related alerts and ventilation on demand? And could we do it in a way that makes the mines safer for workers as well as brings economic benefits to the operators?”

NTT i³ Looks for Big Unique Challenges in IIoT

NTT i³ looks to identify those “dark areas” that exist within the “industrial environments” of sensors, networks and data – and then explore the ways that hidden data can be brought into the light to make a difference. Always in our consideration is the use of technology to improve the quality of human life, as well as provide economic benefits to enterprise companies.

We seek important challenges that extend beyond a single narrow industry. While we may develop a prototype in a specific business segment, we strive to define and deploy the technology against a broader context into adjacent businesses.

Because of our belief in the dynamic nature of organizations, we seek to maximize technology interoperability and flexibility. We fight against the closed historic and single-vendor approaches that plague many industries.
Full Lifecycle Innovation

Innovation starts with the ambitious and once hidden idea, but it doesn’t stop there. True innovation is about both thinking and doing – taking an idea and an opportunity and shaping it into something real with the capacity to address significant human and business problems.

Full Lifecycle Innovation is what we call our four-phase approach to innovation. It is a practical approach to one of the most creative and essential practices in business today – transforming ideas into marketplace realities.

Open Innovation is where we scout for those initial ideas and real world insights that may spark an innovation opportunity and fuel an early stage exploration through prototypes. We seek a balance between casting a wide net for ideas and looking for ways that we can leverage the strength of our core competencies, the powerful assets of our partner operating companies, and relationships with startups and researchers.

In the Applied R&D phase, we use the baseline that we built with our initial ideas and early prototype feedback, and dig in more deeply with collaborative pilots with actual customers in real business situations. We look for and work with partners that have the guts, ambition, patience, and willingness to champion a project that may well upend their own status quo.

In this mining investigation, we focused on the two early phases of Open Innovation and Applied R&D, with activities such as:

- **Design Thinking**
- **Idea Discovery**
- **Market Insights**
- **Resource, Partner, and First Customer Identification**
- **Initial Prototypes**
- **Pilot Implementation**
Innovation Discovery and Development

Between Sept 2015 and March 2016, a team of engineers and industry experts from NTT i³, the Colorado School of Mines, and the Edgar Mine focused on field insights, design thinking, prototype iteration, and an initial deployment test.

For our first prototype I was inspired to use HomeGenie in the prototype as a result of some experimentation for my own home automation system

- NTT i³ team member
The Prototype

Rapid prototype development and iteration begins in the Open Innovation phase. The focus is on architecting an approach to the problem that supports the initial divergence of ideas, while being flexible and vendor-agnostic. In the Applied R&D phase, technology solutions begin to converge as the prototype is shaped into a deployable model for pilot testing with a partner. The prototype used and monitored in the pilot then provides the team with the opportunity to:

- Validate and/or iterate on their hypothesis.
- Begin to identify future potential partners in new industries facing a common need.
- Note the opportunities to create product from the prototype.

The working prototype currently deployed in the Colorado School of Mines’ Edgar Mine demonstrates important communications capabilities needed in IIoT including: machine to cloud, machine to machine, and machine to human.

- Legacy sensors were upgraded and connected to a network, while new more intelligent sensors were added to gather data points in real-time about gas levels, airflow direction, and doorway status.
- These sensors are connected via gateways to a self-propagating intelligent network that can be automatically expanded and managed.
- The network enables the data to be stored locally or in the cloud.
- Data is analyzed against policies that address the question “Do changes in the data indicate a problem in the mine?”
- The data, analytics, and KPIs are viewed in dashboards by human operators (either local or at HQ) who can then send commands back to the appropriate machines to change conditions in the mine.
- A gateway enables commands to travel back through the network and change the state of relevant infrastructure in the mine such as fans and doorways.
- Aggregated data in the cloud enables the generation of analytics and visualizations for long-term planning and forecasting.
- In the near future, this architecture could incorporate machine learning, leading to the automation of certain parameters of change in the mining environment as a result of the data.

To concept, build, test and deploy the prototype over a period of a few months, the team of engineers and mining experts used a variety of hardware and software technology from startups, the Open Source Community, and NTT i3’s own platform and intellectual property.
Pilot Results and Moving into the Near Future

By adding intelligence to the existing network and sensors in the Edgar Mine, we have successfully implemented our prototype for ‘ventilation on demand.’ Efficiency was added not only through intelligent monitoring of environmental status, but also by enabling variable control of equipment such as fans. This evolved systems from operating in a simple binary on-off mode, to more nuanced levels of control responding dynamically to conditions in the closed environment. As a result, we observed 10% energy savings in just the first 2 weeks of the pilot program along with a projected 120 man hours saved per year. For mid-sized mines that are not currently attempting to optimize the air flow dynamics in their enclosed environments, we would expect to see 30% in energy savings.

As we continue this investigation into the impact of “ventilation on demand in close environments,” we will not only look for additional mines for pilot test beds, but also investigate opportunities for deployments in adjacent heavy industries and enclosed industrial spaces. These might include the food and beverage industry, underground construction, and clean rooms.

In the near future, we can see this technology architecture evolving to embrace the “sensing revolution” of the Industrial Internet of Things with “nanoized sensors” being deployed remotely on demand in mines and other environments via drones. Could we then have a world in which no human life is risked below ground, environmental quality is maximized, and the economic costs are minimized?

Those are worthy challenges for our teams and for the industry.

“The challenge of using IoT to provide ‘ventilation on demand’ at CSM’s Edgar Experimental Mine was initially daunting but ultimately a ‘breeze’ – and worthy because it addresses both issues of economic benefit and increased human safety in an industry that has often been slow to embrace changes to the status quo.

- Dr. Priscilla P. Nelson, Professor and Head, Department of Mining Engineering, Colorado School of Mines