

**“Co-Innovation: A Bridge Between Silicon Valley and Natural Resource Producers”**

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Thank you Chairman Lamborn, members of this sub committee, distinguished gallery and congressional aides. It’s an honor to be allowed this opportunity to testify before you today and discuss the convergence of two important industries that are as diverse in maturity as they are in their respective cultures.

My name is Carl Brackpool and I serve in two roles, first as Research Associate faculty at the Colorado School of Mines. Second, I’m employed as an Innovation Team Member with the NTT Innovation Institute, a public sector technology company based in Palo Alto, California, in the very heart of the Silicon Valley.

Colorado School of the Mines is consistently ranked as one of the top colleges for higher learning in the United States. It is also recognized around the world for its high caliber of graduates, ongoing research programs in Mechanical & Electrical Engineering, Environmental studies, Chemistry, Petroleum, Sustainable Energy, Microbial and Surface and Underground Mining.

As a technologist with over two decades of work in breakthrough hardware and software advances, I’ve held a variety of positions with diverse companies such as Walt Disney Imagineering, in the Advanced Technology division at Microsoft, and exploring new products and services at AT&T, Polycom and T-Mobile.

My work in Energy and Natural Resources, or ENR, is now in its fifth year, after I went underground for the very first time in my life to test a new communications technology, primarily focused on mine safety, in mid 2011.

This is when I need to point out that, until five years ago, I sat squarely opposite of ENR because of a long held environmentalism and eco ethics propensity. I lamented resource production companies as reckless polluters who seemed to be given impunity in the aftermath of each disaster that were caused by mechanical, human, or process failure. Sometimes all three.

After accepting a challenge to test a legacy telecommunication technology in the mining sector, I recall sitting at lunch in West Virginia with coal miners as they explained their hardships, frustration and a sense of dread for their future and ability to support their loved ones. I quietly nodded and focused on my plate, with a pit in my stomach since I had been an antagonist for the past 35 years.

I had worked with integrated circuits; rode a carbon fiber mountain bike; drove a car made of metal alloys (with an internal combustion engine!); and I wrote words of support for anti-oil and mining-critical forums on my tablet, computers and smartphone--the phone containing more than 7 rare earth elements that can only be found under the earth's surface.

I did not admit to them that I had once belonged to the groups that called for curtails and bans on the extraction and processing of coal, other minerals, metals, petroleum and gas.

Simply, I was naïve and a hypocrite.

As I spent increasing time with coal, metal and mineral (hard rock) miners, I learned it's difficult to get new, quality technology into their production operations. For coal, salt and trona, permissibility certification from MSHA can take up to 3 years, and even then once a product is developed, the constant theme from operators and their procurement heads is,

“I'm interested, but who were the first five to buy it before me?”

This caution, a strong suspicion of anything new, is from investing in products that failed to live up to claims in actual production or else the mining operation shuttered before realizing a positive return on the capital expense investments due to fluctuations in commodity market prices. The path to adoption is admittedly slower than other industries.

Another hurdle to innovation traction is that we've mined rocks in the U.S. for over 500 years; the Egyptians, Greeks and Romans mined for ore to support their civilizations thousands of years ago. And yet the mining methods from these eras have remained simple and predictable, which supports a mindset of, “If it's not broke...”

Throughout the next several years, I realized I had become a miner, but with a distinction; one with a foot planted in each camp: high tech computer and communications expertise, and now versed in the extraction and processing of energy, metals and minerals. This was pointed out to me several times and from that encouragement I accepted my first year position with School of Mines to be an evangelist and strive to bring these groups together.

I remember the moment when I finally understood my responsibility. I spent a week in my MSHA 40-hour training to earn my 5000-23 certification for surface and underground. I earned

my “Miner Card,” which allows me to work in any mine in this country, with the appropriate site-specific hazard awareness reviews.

Since then and over the years I’ve worked with Natural Resource companies who are eager to gain a greater knowledge of new technologies from outside mining that could improve production and save lives. Wearing my other hat, I spend 50% of my time educating my colleagues, peers and friends in Silicon Valley about the industry and how it functions. We have open and productive discussions that ultimately end with a mutual acceptance that mining is essential to our society, even to the point we’re exploring asteroids for ore bodies that will perpetuate evolution of people. I always initiate these by posing a hypothetical question:

“If your inventions and breakthrough technologies can save one life or help ensure environmental regulatory compliance, are you willing to meet in the middle?”

Turning to my new, respected friends, partners and leaders in Energy & Natural Resources I continue, “Will you be open to joint research and tempering a defensive posture of, “If you don’t like what we do, then turn off your lights!’?”

The answers from both is, “Yes, absolutely.”

What they know is that focusing heavily upon safety and compliance has the same effect as if all initiatives were concentrated on optimizing operations for maximum economic returns. The rising tide raises all.

From those early introductions and sessions, we commenced interviews with Subject Matter Experts, heavy industry owners, operators and the mining equipment manufacturers. Those led to developing problem statements and then crafting Use Cases with an emphasis on solving a common problem for each Proof of Concept by employing ideation and rapid prototyping, methods regarded in Silicon Valley to quickly explore ideas until a breakthrough solution is discovered.

With this template, in October 2015, we successfully launched our first joint project between NTT Innovation Institute and the ENR industry, as a whole, with support from mining industry experts tasked with reducing energy consumption in order to stay viable and profitable in a contracting marketplace.

In this inaugural exercise, we focused on ventilation and the associated electricity required to satisfy the mine ventilation plan as the single highest line item under operational expense.

This *Ventilation on Demand* demonstrated the incorporation of “Internet of Things,” sensors, software, wireless networking and cloud computing to only provide respirable air and render harmless dangerous gases where and when needed, as opposed to the practice of running the fan systems at peak capacities.

The Proof of Concept objectives were to validate that mid-cap to small mines can create an efficient and safe ventilation system using mostly existing assets and thus significantly lowering the cost of implementation and optimizing day-to-day operations.

Using this first win as a model for engagement we're accelerating programs with the rapidly growing number of software and hardware tech firms in Silicon Valley interested in proving a variety of emerging technologies in our space. Companies like Microsoft and Cisco have already participated in defining similar research programs for underground and surface mining tests, leveraging Big Data science, Machine Learning, Artificial Intelligence, Fog Computing out at the network edge and nearest those sensors deep in the mine; all of this riding on a broad spectrum of old and new communications methods repurposed for harsh environments.

The now household term, "the Internet of Things," or "IoT," proposes a significant increase in the number of sensor and data points for monitoring considerably more and varying types of conditions during operations. This results in collecting higher volumes of data that can then be analyzed and converted into actionable information, increasingly through the cloud and halfway around the globe. IoT will grow and thrive in an ecosystem with advances across each and every aspect of operations.

As for other leading edge trends, wearable technologies with Nano-sized sensors and significant computing power embedded into the very textile fabrics will enable human platforms, mobile platforms for storing and transmit data, while the technology is no more obvious or cumbersome than an athletic undergarment. The CDC through its research bodies, NIOSH and OMSHR will be using these wearable to calculate a worker's motions and exertion to assess the potential for long term repetitive motion injuries.

We're testing Virtual Reality goggles underground and in surface mining, providing a Heads Up Display, similar to those pioneered by our U.S. Aerospace and Defense companies for fighter pilots, and to give instant situational awareness of a miner's working environment with alerts for dangers and conditions that could become hazardous. These VR realms and the content overlays provide a technician with a stream of real time telemetry; libraries of technical manuals to complete tasks and enable repairs by a single worker with both hands free and thus shaving critical time during each step of their work day.

In the areas of unmanned operations, in concert with the rise of automated mobile extraction and haulage equipment, Silicon Valley researchers and companies are joining those strategies by demonstrating self-powered and self-guided unmanned vehicles. These bots and drones provide a safer and highly efficient alternative to humans in hazardous situations, whether it's gas detection underground or employing fixed wing UAV's to image large tailings ponds to monitor water concentrations and containment berm integrity, with far greater image resolution and frequencies of data sampling.

This pallet of current and proposed work could only be achieved by building a relationship of strong trust, cooperation and understanding. Together the challenges that face the Natural

Resources sector can be solved and the United States is leading a movement for advances in high tech and our efforts are anticipated to yield breakthroughs in safety communications; greater tracking of humans and assets working in close and often dangerous proximity; and superior operational efficiencies providing only the highest degree of monitoring and management of waste byproducts and ensuring water quality oversight.

The positive trend is a joint and collaborative effort to break down eco ethics barriers and bridge all gaps with a common purpose. Our combined vision is indeed a, “Mine of the Future,” with fully autonomous equipment, employing Artificial Intelligence and machine self-awareness, learning to adapt as conditions change. In Silicon Valley we’re proud to invent “disruptive technologies.” In mining, the word “disruption” frightens leaders and stakeholders, because it means downtime, safety concerns and loss of revenues. So, we still have some areas for improving and getting to know one another; the steel toed boots will eventually stand side-by-side with those in sandals and sneakers. This can only occur with encouragement from our government agencies committed to programs that incubate ideation and prototyping while encouraging transparency and the sharing of knowledge.

When times are good in Natural Resources R&D looks for long range wins from technology trials and understanding long ROI’s for innovation. However, when our financial outlook is flat or the mining and petroleum industries are in contraction, we’ve been genuinely surprised to recently discover that budgets shift, but not to curtail invention and discovery spending, but rather towards near-term wins, incremental improvements, designed to protect business models in order to survive and weather our cyclical industry.

Thank you again for your interest, your ongoing support and this opportunity to appear before you today. We welcome future invitations to return with more examples and news of progress and advances from the unified efforts of Silicon Valley and their Energy and Mining partners in the United States.