Rajant, PBE Group, and Australian Droid & Robot Make History with **Successful Autonomous Remote Mine Inspection**

Adversity and a keen focus on sanctifying safety galvanized a limestone mine to innovatively address the inspection and restoration of operations following a collapse using an autonomous robotics solution.

In August 2021, disaster struck when a 100-year-old limestone mine in the Southeastern part of the United States collapsed unexpectedly. This was a result of subsidence further causing a massive event underground where the pillar and roof collapsed. Violent air blasts up to 190 mph flew debris and dirt through portals and ventilation shafts. The failure of old pillars left enormous subsidence measuring 800 ft. across and 100 ft. deep.

The mine was evacuated beforehand from a veteran worker who noticed something was wrong that day. Mining Safety and Health Administration deemed no one return working in the mine until an unmanned survey was able to ensure safe conditions. Enter Rajant Kinetic Mesh® wireless networking with powered backhaul affixed to ADR's unmanned robots and the integration know-how of PBE.

The Challenge

Underground, no internet or fiber backbone was available deep into the structure. Before the collapse, the mine was utilizing a two-way radio system over a leaky feeder that did not withstand the incident. Moreover, it lacked sufficient bandwidth to support any unmanned robot or drone inspection mission. By eliminating the human factor in favor of an autonomous system, multiple technologies were needed to facilitate 'safety by separation.'

The partners banded together to form one ecosystem to explore the unknown environment within the mine after the blast and avoid any

The Mine

- Limestone underground operation in the United States

The Partners

- **Rajant:** Pioneers peer-to-peer radio communications enabling real-time voice, video, and data to connect machines, robots, and people together as part of a secure private mobile network

- **PBE Group:** Provides an adaptive and flexible integrated solution where reliance on safety and productivity is essential within the mining, tunneling, construction, and associated markets.

- **Australian Droid and Robot (ADR):** Designs and constructs specialized ground and aerial robots offering fully-integrated robotic solutions such as remote inspection of inaccessible areas.

Solution Components

- 10 ADR Explora XL unmanned robots
- Rajant DX2 BreadCrumbs®

Outcome and Impact

- Personnel safety and separation from underground collapse threats
- Job restoration for local workforce employed over decades

wrong step that could trigger implosion. Rather than send a mine rescue team into life-threatening situations, ADR provided a fleet of robots offering a credible application. The distance of communications needed to extend at least 1800 feet into the mine and had to be designed from the ground up with a network capable of high bandwidth and low latency reliable communications. Transmitted data included LiDAR for 3D modeling of the mine's interior and dynamic high-definition video.

The Solution

Rajant's Kinetic Mesh network provided a robust and reliable communication infrastructure that was efficiently deployed for the project, enabling long-distance, low latency wireless networking without infrastructure. The remote inspection robots, equipped with Rajant BreadCrumbs®, entered the underground area and continued to relay a communications signal to each other through a daisy chain, high bandwidth mobile connection. With no network or systems in place, the operation needed to handle data backhaul and power the robots. BreadCrumbs were also installed at the surface site providing high bandwidth between the mine entry and the operation center.

A key portion of the communication was PBE's fiber inserted into the mine establishing the first node in the entry. By staggering the ADR Explora XL unmanned robots, connectivity continued mobility, navigating the debris, into the collapsed area bringing the Kinetic Mesh network as deep as possible. There was a total of eight robot hops with an additional two hops transmitting within the mine back out to the central command above the surface. The network infrastructure points extended were maximized at 1.7 km underground, feeding video data up to 80 Mbps per second.

ADR Explora XL unmanned robots are a customizable universal platform that can host various features such as cameras, gas sensors, robotic arms, and, in this case, use LiDAR. The LiDAR created a virtual 3D model of the mine giving context to the visual stream provided by the onboard video. Through this interface, the engineers controlling the

> "When we learned about the need for unmanned inspection after the collapse, we focused on finding the best solution for fast, flexible deployment and high performance. The mine needed a high throughput, flexible data network to support a broad and changing set of inspection deployments. The Rajant Kinetic Mesh technology was the clear choice for this need."
>
> **— Rob Koch**
> Director of Technology, PBE Group

robots were able to see and experience the collapsed zone separated safely from harm. Even within the deepest part of the mine, through ten robot hops, the data was transmitted real-time coming in under a quarter of a second latency. This was extremely important in navigating the mine through the debris of each pillar and investigating the state of damage from the air blast.

The Results

Hitting a milestone of 1.7 kilometers, the underground mine inspection is the deepest in history.

From the swift unmanned inspection within a week, the Mine Safety and Health Administration (MSHA) cleared the crew to begin remediation efforts within the mine. With the innovation amongst ADR, PBE, and Rajant, the timeline for the limestone mine to begin operations was extremely expedited and safeguards were established. With existing Rajant BreadCrumbs in place from this emergency effort, the mine operator looks to install a full Rajant Kinetic Mesh network in the future.

If the mine needs to investigate a problem again, they will be able to deploy a single ADR robot back into the tunnel. Unlike traditional Wi-Fi or the tried leaky feeder, the high bandwidth and reliable Kinetic Mesh network will support all video, voice, and data transmission for a future-proofed, automation-enabled operation. This collaboration of wireless mesh and autonomy will continue to successfully tackle the challenges of underground mining to ensure safety is at the forefront.

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