Maximizing **Mining Asset Productivity**

Why Data-Driven Fleet Optimization
Requires a Mission-Critical Network

RAJANT

Introduction

Asset productivity is a top challenge facing the mining sector today, driven by increased pressure to process material at a lower cost per ton, **all while continually working to lower personnel safety risk.**

In response, mines are looking toward digital technologies that make their operations increasingly data-driven, with applications that enable them to better understand and predict asset health and performance, automate operations to lower employee exposure, proactively identify areas to reduce costs, and ultimately reach new levels of productivity.

While it is true that data is becoming the lifeblood of successful mines, equally as vital will be the network over which this data is delivered. When every second counts and every insight is of value to improving production yields, the network must enable instant access to real-time voice, video, and data without fail, dropped packets, or high latency. Importantly, it must uphold these mission-critical requirements in an environment that is rugged and ever-changing, supporting continuous connectivity to people and assets that are constantly in motion across the mine.

This white paper explores key digital innovations now available for mines to leverage in increasing asset productivity, and the requirements of a network to support these next-gen applications.

Unlocking Fleet Performance

Through Real-Time Digital Insights

The explosion of the Industrial Internet of Things (IIoT) has unleashed mines' ability to track virtually any aspect of a machine's operations. Equipment fleets can be equipped with sensors and wireless technology to stream real-time data on their health and performance back to the command center. From the machine's current location to its current tire pressure, operators can gain full visibility into the health status and performance of every asset, and be armed with the insights needed to keep fleets fully optimized.

WITH REAL-TIME ASSET MONITORING, MINES CAN:

- **Predict maintenance needs before failure:** Diagnostic data on the state and performance of equipment can be transmitted remotely and then paired with analytics to anticipate failures and output recommened maintenance schedules or corrective action to reduce downtime.
- **Decrease performance variability:** By comparing data from assets with high performance to those with lesser yields, operators can better identify root causes of operational issues and rapidly standardize all machines against those with the greatest output.
- **Maximize efficiency of machine movements:** Applying analytical engines to the real-time data collected, operators can identify scheduling and processing approaches to maximize equipment utilization and improve yield by as much as 3 to 10% in just months.[1]

THE NETWORK CHALLENGE:
Reliably Connecting Dispersed, Diverse Moving Assets

To realize the optimum value of a fully connected fleet, mining operations need both a network with readily scalable bandwidth and the ability to support unwavering mobile connectivity. As mentioned, the amount of sensors and related devices used to monitor equipment health and fleet performance continues to grow, along with the number of assets in the fleets themselves. Many of these sensor-based applications are bandwidth-intensive and demand low latency so that data can be rapidly delivered to command centers for real-time evaluation. As more monitoring applications are added to the network, there is greater potential for performance to get bogged down; but gaps in data equate to gaps in knowledge, so dropped packets and failed deliveries cannot be tolerated.

Compounding this challenge is the fact that the network must enable real-time data collection from a variety of equipment that is broadly dispersed across the mining environment. Many of these assets are continuously moving, and need to maintain unwavering mobile connectivity in order to reliably deliver insights on their performance and health.

Multiplying Asset Productivity

Through Autonomous Applications

Autonomy is a hot topic in mining, and for good reason. Studies have shown that automated hauling and drilling equipment can reduce operating costs and lower total cost of ownership by 15% to 40%[1] while enabling production to continue 24/7/365 without risking worker fatigue.

With fully autonomous equipment for haulage and drilling available, and automated blasting and shoveling solutions coming into use, mines have new opportunities to achieve multi-fold gains in productivity via assets that conduct key mining processes without direct operator oversight.

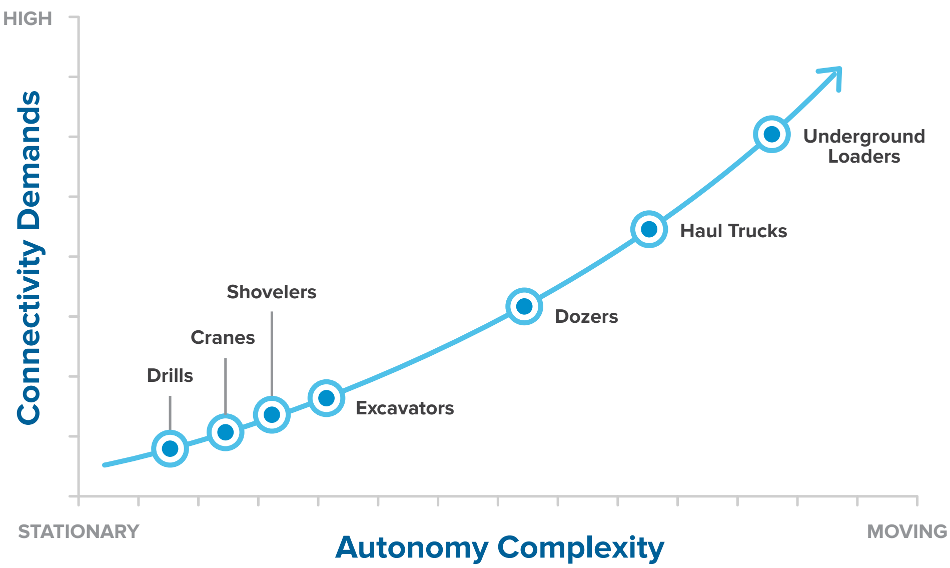
Mining operations around the world are currently at different stages of adoption as they test the waters of autonomy in their own environment.

THE NETWORK CHALLENGE:
Support for Mission-Critical Connectivity at Scale

The key to successful deployment of autonomous equipment at any stage is mission-critical connectivity. These assets must remain in constant communication with command centers in order to send and receive the data necessary to remain self-operational. If connectivity is lost, even briefly, the autonomous asset will shut down as a safety precaution. Shutdowns can also occur if data sent to the machine is delayed, as that could represent even a momentary loss of control.

Always-on connectivity can be relatively straightforward to achieve if autonomous equipment is largely stationery, such as an autonomous drill. The challenge becomes exponentially more complicated when the equipment must constantly move. Autonomous haul trucks, for example, will need to traverse large stretches of rough, harsh terrain and maneuver around obstacles along the way. Ensuring signals are not blocked or interfered with throughout these trips can prove difficult with most wireless network configurations, and could very well result with the asset stranded in place mid-trek.

No matter what autonomous assets a mine has deployed—or is considering deploying—today, it is all but a guarantee that they will want and need to implement more complex and mobile-enabled autonomy in the future. It will be critical to create a strong network foundation that can deliver continuous connectivity not just to static autonomous equipment, but also to equipment in motion, and do so reliably even as additional autonomous assets are added to the operation.



Protecting the Most Important Assets: Personnel

One of the most significant advantages of the above digital innovations is their ability to mitigate employee risk. Mines are constantly seeking ways to minimize worker exposure in their highly hazardous environments, and to keep personnel safe when they are performing day-to-day operations.

Through fleet management and monitoring, mines can readily track the location and status of workers operating equipment throughout the site, and are able to proactively identify potential equipment concerns or failures that could put those workers at risk.

Autonomy takes safety a step further by allowing the mine to remove people entirely from the equation in potentially dangerous situations. Autonomous equipment and vehicles can be deployed to work in the riskiest parts of the mine, without the need for human intervention, for tremendous safety gains. In fact, automated mining assets can reduce the number of people working in dangerous areas by more than 50%.[1]

Again, these applications can only be successfully deployed to protect personnel if they are running on a mission-critical network. Any breaks in communications between operating machinery, field workers, and the command center create safety hazards, and can quickly expose employees to unnecessary risk.

Evaluating Mining Networks:

A Decision that Should Also Be Data-Driven

Facing the industry directive to “do more with less”, a mine’s ability to capture and act on its equipment data directly correlates to its ability to drive future productivity gains. Therefore, it must select a network that can rise to the demands of data-driven mining applications, including the ability to provide scalable bandwidth, signal resilience, and mission-critical mobile connectivity.

Unfortunately, many wireless networking options fall short of these requirements because of their inability to support dynamic mobility. Those issues are compounded by the fact that mining terrain is rough and continually changing, with weather conditions that run the gamut. A mine’s network topology is never static and the outdoor environment is harsh, but Wi-Fi, LTE, and point-to-multipoint (PtMP) networks are all inherently fixed systems that were initially constructed for indoor settings. The lack of industrial-strength reliability leads to dropped data packets, high latency, and compromised application performance – culminating in a loss of operational data, safety, and productivity that mines can simply no longer afford.

Wi-Fi, LTE, and point-to-multipoint (PtMP) networks are all inherently fixed systems that were initially constructued for indoor settings.

The Rajant Kinetic Mesh® Difference

Providing mining equipment and personnel with the ability to simultaneously move and communicate requires a wireless communications network that is smart enough to adapt quickly to changing topographies and conditions without dropping communications. Rajant’s private wireless Kinetic Mesh network embodies these characteristics because it was built from the ground up to connect rugged, outdoor, industrial, highly mobile environments. The network autonomously and continuously self-optimizes to deliver bandwidth-intensive applications in real-time, even when faced with adverse network conditions.

The following section provides a technical comparison of Wi-Fi, a network architecture commonly deployed in mines today, and Rajant Kinetic Mesh, to reveal the key differences in their ability to support next-gen mining applications and more productive, safer operations.

Rajant’s private wireless Kinetic Mesh network was built from the ground up to connect rugged, outdoor, industrial, highly mobile environments.

Comparison of Network Characteristics as Required by Mines

Scalable Bandwidth

Wi-Fi	Rajant Kinetic Mesh®
• Mobile clients can only connect to infrastructure nodes (access points). Only one connection can exist between a mobile node and an access point at any time.	• Rajant BreadCrumb® nodes can be interchangeably fixed or mobile, and can direct traffic via multiple peer connections simultaneously.
• One frequency is dedicated to infrastructure-to-mobile node communications, and one to infrastructure-to-infrastructure node communications, greatly limiting total bandwidth availability.	• Every BreadCrumb supports up to 4 frequencies and can simultaneously send and receive information on different frequencies, using any to provide localized access for Wi-Fi clients. This significantly increases the capacity of each transceiver.
• To comply with IEEE standards, each Wi-Fi access point must equally divide its available bandwidth among its connected clients. Therefore, bandwidth to each client is decreased as more clients are added to the network.	• Kinetic Mesh® networks are readily scalable to hundreds of high-bandwidth nodes, as each additional BreadCrumb increases the number of potential paths to direct data.

Consistent High Throughput

Wi-Fi	Rajant Kinetic Mesh®
• Wi-Fi depends on a controller node to manage traffic, which results in higher latencies and service interruptions when there is a change in network characteristics or physical configuration.	• There is no controller node in a Kinetic Mesh network. Every BreadCrumb is equipped with Rajant's patented InstaMesh® networking software, which autonomously orchestrates traffic via the best possible path(s) at the moment and enables the network to react in real-time to changes in network topology, load, and environmental conditions.
• Wi-Fi also uses Layer-3, which requires more administrative chatter and further adds to latency issues, particularly when roaming.	
• Because Wi-Fi dedicates frequencies, there is increased potential for slowed traffic and congestion because data can only travel one way to reach the application server.	• Kinetic Mesh networks act as distributed Layer-2 switches with proprietary forwarding capabilities and as-needed Wi-Fi access-point service.
• Wi-Fi assesses routes based only on RSSI, not accounting for other significant performance factors like interference or congestion. If adverse network conditions are encountered, the system has no way to route around the issues and will result in data delays or dropped packets.	• Because each BreadCrumb can leverage all available frequencies and paths for all network functions, data from one peer can be forwarded to another on a different frequency and/or redundant or alternative path at the same time, resulting in extremely low latency even if adverse network conditions like congestion or interference are encountered.

Mobile Connectivity

Wi-Fi	Rajant Kinetic Mesh®
• Wi-Fi is fixed, not mobile. When a mobile node moves out of range of its current access point, connectivity to that access point is lost and the node must try to connect with a new one.	• Every node in a Kinetic Mesh® network is mobile. As nodes move, InstaMesh® automatically adapts to the changes, establishing new links in real-time while keeping the network available, intact, and secure.
• Even if the new access point is readily available, the node's previous connection must be broken before a new one is formed, resulting in a temporary loss of communications, higher latency, and dropped packets. The network periodically but regularly loses connectivity as part of its normal operation.	• In-motion BreadCrumbs® remain connected to other nodes while forming new connections with approaching nodes. As a result, Kinetic Mesh never has to break communications to form new connections.
• The problem is exacerbated when trying to expand coverage over large areas and to mobile clients throughout that area. Pools can be made to combat this, but roaming will still need to occur between pools.	• BreadCrumbs can be affixed to manned and unmanned vehicles and roaming equipment to augment or create infrastructure ad-hoc, connecting hot zones to provide ubiquitous mobile coverage over widespread areas.

Mission-Critical Reliability at Scale

Wi-Fi	Rajant Kinetic Mesh®
• The controller node in a Wi-Fi network creates a potential bottleneck and point of failure. Infrastructure nodes also represent potential points of failure as the access points for mobile clients.	• There is no controller node in a Kinetic Mesh network and therefore no single point of failure. Its node- and frequency-level redundancy provides built-in reliability without the added cost of purchasing "backup nodes".
• To create redundancy, additional infrastructure nodes can be purchased to serve as backups, although this inflates overall deployment cost.	• Automatic Protocol Tunneling (APT) feature establishes multiple ingress and egress points to increase usable bandwidth, deliver data to client devices faster, and further eliminate failures.
• Because Wi-Fi employs a "Break-Before-Make" approach, in which mobile clients continually break and re-establish connectivity as they move between access points, it cannot support continuous connectivity to mobile assets with mission-critical reliability.	• Kinetic Mesh employs a "Make-Make-Make-Never-Break" approach, in which BreadCrumbs remain connected to other nodes while forming new connections with approaching nodes, to maintain mission-critical mobile reliability.
• A Wi-Fi controller node is unable to proactively synchronize peer assignments with changing operational and network dynamics, limiting its ability to scale beyond a relatively small number of nodes in a rapidly evolving environment.	• In a Kinetic Mesh network, a single BreadCrumb node could have hundreds or even thousands of pathways over which data can be sent and received. As a result, as more nodes are added, the network grows more resilient.

KEY MINING CONSIDERATIONS:

Network Durability and Security

While Wi-Fi access points and mobile clients have been repurposed from indoor use for industrial outdoor settings, Rajant's Kinetic Mesh® BreadCrumbs® were designed from the start to be fully ruggedized. Their use began in military theaters, and with IP67-designed dust-tight and water-tight enclosures and military-grade security – including multiple cryptographic options, configurable data and MAC address encryption, and configurable per-hop, per-packet authentication between BreadCrumbs – these nodes are built for reliable, secure operation in harsh mining environments.

Rajant Kinetic Mesh Networks:

Delivering Proven Productivity Impact Across World-Leading Mines

Mines are exploring new opportunities to extract and process more material at less cost and risk to personnel.

Applications that enable operators to proactively monitor equipment health, predict maintenance needs, make real-time adjustments to improve fleet performance, and seamlessly control manned and unmanned roaming assets have become essential to improving asset productivity – and in turn, so has the mining network.

The need for reliable, real-time communications will only intensify as mines begin to further capitalize on the opportunities of autonomy, and with that will grow the requirement for mission-critical mobile connectivity.

Rajant Kinetic Mesh networks are proven in their ability to support all the productivity- and safety-enhancing applications that top mines need, with the unwavering reliability they demand. Deployed in large, leading mines across the globe, these private wireless networks are providing fully mobile, highly agile, and dynamically adaptable wireless mesh connectivity that is powering transformative gains.

References

1. https://www.mckinsey.com/industries/metals-and-mining/our-insights/productivity-at-the-mine-face-pointing-the-way-forward

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Learn why the world's top mining companies rely on Rajant Kinetic Mesh networks for the continuous, fully mobile connectivity required to power today's data-driven mining operations at www.rajant.com/datadriven.