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Freight at the End of the Tunnel

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The United States freight railroads have received approximately \$760 billion on capital expenditure and maintenance expenses from 1980 to 2021.

These expenses were related to locomotives, freight cars, tracks, bridges, tunnels and other infrastructure and equipment, which are all essential to efficient

rail mobility. In the most congested urban areas, underground railways are a feasible alternative mode of transportation, creating a smooth and faster passage for carrying

freight and passengers to many desirable locations, ensuring cargo and goods are delivered on time. Underground tunnelling is the critical enabler behind delivering

underground passages for these railways.

Underground tunnelling projects face a myriad of challenges due to the robust and harsh environments that make it difficult to deploy and operate network systems within them. Complex tunnel layouts inherently lead to obstructions that limit how far wireless signals can travel. As a result, traditional single radio wireless systems cannot function optimally, and fibre is often used to achieve reliable connectivity. These systems are high-cost and difficult to change as tunnel construction progresses. What's needed is a flexible wireless network purpose-built to overcome range and reliability challenges underground with rapid, dynamic and cost-effective deployment.

Creating the Foundations of Rail

A growing population, the desire for sustainable transportation and infrastructure systems, and the need to minimise surface disturbance have increased tunnelling and underground construction in urban areas. Tunnels are effective for rail operations as they protect the railway tracks within them from weather effects, such as snow and rain, as well as providing a faster path to destinations. Thus, tunnels reduce the overall maintenance cost of the rail system.

Whether building a new tunnel or renovating an existing underground structure on land or underwater, tunnel construction sites are inherently complex environments. Tunnelling and construction

projects for transportation require real-time monitoring of underground conditions to ensure safe and efficient operations.

As freight railroads account for roughly 40% of US long-distance freight volume, more than any other mode of transportation, seamless and cost-effective construction of rail infrastructure, such as tunnels, is required to keep essential freight items on the move. Not only does the nature of tunnelling create many challenges, the complexity of technological advances in the industry has added further considerations for operators. Tunnelling and heavy construction sites are vast and require a reliable network system to enable vital communications. Base stations, GPS-guided machines, and other advanced heavy construction applications require reliable network connectivity to run effectively, which traditional serial radios, Wi-Fi and even LTE simply cannot provide.

The industry needs an easily deployable and flexible wireless network to provide a solution to the rugged environments created by heavy construction technology and applications to enable jobs to progress faster, at a lower cost. Rajant Corporation's Kinetic Mesh® technology provides a better, mission-critical network alternative.

Rajant's Tunnel Vision on Wireless Connectivity

Rajant's Kinetic Mesh® wireless network enables fully mobile, mission-critical communications to meet safety mandates for real-

time worker communications and tracking. It also keeps applications running that improve efficiency, enhance overall safety, enable surface condition surveying and speed up tunnel construction.

Rajant provides a high-bandwidth, fault-tolerant mesh network that can be readily deployed to connect personnel and equipment. It also supports the growing number of Wi-Fi clients that are being used across these sites today, as every Rajant BreadCrumb® node has an integrated Wi-Fi service for compatibility with virtually any commercial off-the-shelf Wi-Fi device such as laptops, tablets, smartphones, IP cameras, sensors and other IP devices. Kinetic Mesh® performs reliably even in areas with varied terrain, like rolling hills or dense foliage, that is present in tunnelling operations because it deploys BreadCrumb® wireless network nodes that autonomously manage data routing around obstructions and local interference.

In addition to real-time communications, the Kinetic Mesh® supports live-streaming video surveillance, machine telemetry and sensor data from equipment collecting data on underground conditions, including groundwater level and the ground's response. As a result, the remote command centre has real-time insight into an operation's status as it occurs underground.

Unearthing the Potential of Rail

Rail is essential to transporting freight, creating the most efficient route to various destinations. The

advances in technology require connectivity to enable its influence in the tunnelling sector. Safety and productivity in the construction of tunnels are vital in ensuring that the rail industry can function to its full potential.

Rajant's Kinetic Mesh® provides mission-critical connectivity required to ensure continuous communications with personnel, equipment, and autonomous systems in even the most remote areas of tunnels. On a single network, you can run multiple bandwidth-intensive applications that improve productivity while at the same time increase safety – from real-time monitoring of ground conditions and structures to fleet management, video surveillance, equipment health monitoring, remote robotic inspections, and more.

Network connectivity is mission-critical in tunnelling and other underground construction projects. With the capacity to create networks without fixed infrastructure, Kinetic Mesh® allows underground operations to flexibly establish and extend connectivity in challenging tunnel environments, enabling data, voice, video, and autonomous applications where needed. Rajant's multi-radio, multi-frequency architecture provides the low latency, high throughput and resilient performance required to run advanced rail applications.

For rail operators, selecting the most appropriate wireless network is critical in successfully powering greater safety, efficiency and autonomy in underground operations.

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