Professional and Commercial Applications

- Construction Site Communications
- Oil, Gas, and Mining Remote Operations

Construction Site Communications

Large construction sites present the same communication challenges as wilderness SAR operations: large area, no existing infrastructure, frequently changing layout, and need for resilient communications that works when cellular is congested or attenuated by metal structures.

The Construction Site Communication Problem

Modern construction sites cover large areas - a commercial building site might span multiple city blocks, and a highway project might stretch for miles. Challenges include:

- Metal structures (rebar, framing, equipment) can significantly attenuate or block cellular signal inside buildings under construction (reinforced concrete and steel framing attenuate rather than uniformly block, and the effect is highly variable)
- Large metal equipment (cranes, concrete pumps) can shadow or reflect cellular signal locally
- Temporary cellular coverage varies as towers are installed and removed during site development
- Workers spread across multiple floors, structures, or areas need rapid communication for safety and logistics

Mesh Applications on Construction Sites

Important: LoRa mesh is a best-effort, low-bandwidth text/telemetry layer with no guaranteed delivery and seconds-scale latency under load. It is a supplementary channel only and must never replace OSHA-compliant life-safety controls (audible alarms, spotters, confined-space attendants, and dedicated lone-worker systems).

- **Crew foreman coordination** - Foremen on different sections of a large site maintain text communication when walkie-talkie range or cellular fails
- **Safety advisories** - Rapid broadcast of non-time-critical safety advisories. Mesh is best-effort and must **not** be the primary alerting system for imminent crush/struck-by hazards (crane swing, equipment movement) - those require OSHA-compliant audible alarms, spotters, and direct line-of-sight signaling. Use mesh only to supplement, never to replace, dedicated hazard-warning controls; a dropped packet means a worker may never receive the alert.
- **Material delivery coordination** - Gate guards, receiving teams, and crane operators coordinating lifts and deliveries
- **Equipment tracking** - GPS nodes on high-value mobile equipment (generators, compressors, specialized tools) visible on site map
- **Worker check-in** - Position check-ins can **supplement** but not replace OSHA-required confined-space attendants and dedicated lone-worker safety systems. Confined-space entry is OSHA 1910.146-regulated and requires an attendant and reliable two-way comms. LoRa frequently cannot transmit out of metal-enclosed or below-grade confined spaces, and a missed check-in is not a reliable indicator of distress - it may simply be a dropped packet, so do not rely on mesh as the safety-monitoring system for isolated or confined-space work.

Implementation Considerations

Construction sites present unique challenges for mesh deployment:

- **Moving infrastructure** - The site layout changes weekly or monthly. Repeater placement should use temporary mounts (pipe clamps on scaffolding, magnetic mounts) rather than permanent installations.
- **Power availability** - Most construction sites have temporary power; use solar for outdoor nodes and plug-in power for indoor or semi-permanent nodes.
- **Equipment theft risk** - Secure repeater nodes in locked weatherproof enclosures or in existing locked site equipment rooms.
- **Dust and vibration** - Construction environments are hard on electronics. Use robust IP67 enclosures and inspect connections after major demolition or paving work.

Oil, Gas, and Mining Remote Operations

Oil and gas facilities, mining operations, and remote industrial sites often operate in areas with no cellular coverage, where reliable communications are safety-critical and where the cost of conventional radio infrastructure is prohibitive for widely distributed sensor networks.

⚠ **Critical safety warning - hazardous (explosive) atmospheres.** Wellheads, gas pipelines, separators, fuel and solvent storage, coal/grain/sulfide dust areas, and many mine zones are **classified hazardous locations**. Electronics deployed in a classified explosive atmosphere must hold **intrinsic-safety or explosion-proof certification** under the applicable scheme - ATEX (EU), IECEx (international), or NEC 500 Class I Division 1/2 and NEC 505 Zone (US). **No consumer LoRa board (Heltec, LILYGO/T-Beam, RAK, etc.) carries this certification**, and it cannot be made compliant merely with "additional engineering" - an uncertified device in an explosive atmosphere is an ignition source. Consumer LoRa hardware must **never** be installed in a classified explosive atmosphere. Use only certified, purpose-built equipment in those areas, and confirm classification and equipment ratings with a qualified hazardous-area engineer.

Pipeline and Wellhead Monitoring

Oil and gas operations face a constant challenge: critical infrastructure (wellheads, compressors, separators, pipeline pressure taps) is scattered across remote terrain that may span hundreds of square miles. Conventional SCADA solutions require licensed radio systems, cellular modems, or satellite connectivity - all expensive to deploy and maintain.

LoRa mesh can provide a low-cost, **supplementary, non-safety, latency-tolerant** telemetry layer in *non-classified* areas only:

- **Pressure and flow monitoring** - In non-classified areas, battery-powered pressure sensors can report low-rate telemetry to a mesh gateway. **Caution:** wellheads and gas/liquid pipeline taps usually sit within classified hazardous (explosive-atmosphere) zones and require intrinsically-safe certified hardware - consumer LoRa boards do not qualify and must not be mounted there. Gas pipelines are PHMSA-regulated (49 CFR Parts 192/195) with reliability and monitoring requirements; a best-effort LoRa pressure tap is **not a SCADA substitute** and cannot replace regulated leak detection or safety-

instrumented systems. Treat any such telemetry as supplementary, non-safety, and latency-tolerant only.
- **Tank level reporting** - Production and storage tank levels monitored without requiring individual cellular modems at each tank (subject to the same hazardous-area certification limits where tanks are in classified zones)
- **Compressor status** - Run/stop status and basic telemetry from remote compressor stations
- **Leak detection correlation** - Pressure-drop events can be reviewed across multiple sensors to help flag suspected leaks. Note that LoRa mesh is best-effort and **not time-synchronized**: it does not provide the tightly timestamped, guaranteed real-time delivery true correlation requires, so this must never be relied on as a primary leak-detection or safety system.

Mining Operations

Underground mining presents extreme communication challenges. While LoRa does not penetrate deep into rock (signal attenuates rapidly in solid material), it is effective for:

- **Surface and portal coverage** - Mesh covering the mine surface, haul roads, and portal entrance where most activity occurs (in non-classified, non-explosive-atmosphere areas only)
- **Equipment tracking on surface** - GPS-equipped haul trucks, loaders, and support vehicles visible on operations map
- **Environmental monitoring** - Acid mine drainage sensors, tailings pond level monitoring, dust monitors (sited in non-classified areas)

Do NOT use mesh for blast clearance. Best-effort LoRa mesh must never be used for blast perimeter clear-zone verification or any blasting clearance. Blasting clearance is a regulated life-safety procedure (MSHA / ATF) that requires positive, fail-safe, interlocked confirmation. Best-effort mesh provides no guaranteed delivery or acknowledgment and cannot meet that requirement.

Regulatory Considerations

Industrial mesh deployments for safety-critical applications should understand the regulatory landscape:

- FCC Part 15 operation is unlicensed but carries no interference protection; industrial operators in RF-congested areas may want to consider licensed alternatives for safety-critical links

- In classified hazardous (explosive-atmosphere) locations, electronics must hold intrinsic-safety or explosion-proof certification under the applicable scheme - ATEX/IECEx internationally, or in the US under NEC Article 500 (Class I Division 1/2) and NEC Article 505 (zone system), with intrinsic safety per UL 913 / IECEx. Consumer LoRa boards are **not** intrinsically safe and cannot be deployed in these areas without certified, purpose-built equipment - not merely "additional engineering." Uncertified electronics in an explosive atmosphere are an ignition source. Confirm the governing standards and equipment certification with a qualified hazardous-area engineer (see also OSHA 29 CFR 1910.307).
- NERC CIP cybersecurity requirements may apply to utilities using mesh for grid monitoring, but applicability depends on whether the deployment touches Bulk Electric System (BES) cyber assets and on their categorization. Confirm BES asset classification and CIP scope with your compliance team before deploying in regulated environments.