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.

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