Myth vs. Reality

Can Cellular Support a Mission-Critical FAN?

Exploring Reduced-Capability 5G Within Distribution Automation Use Cases

White Paper | 5G RedCap for Field Area Networks

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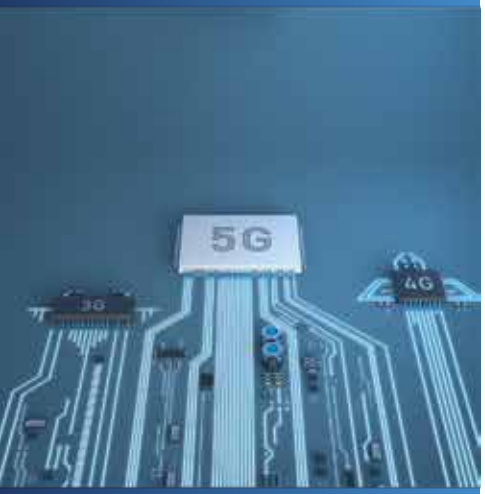
Executive Summary

For years, the utility sector has viewed cellular networks with a degree of skepticism, especially for mission-critical applications. The prevailing myth suggests that cellular technology is too unreliable for the demanding environment of a Distribution Field Area Network (FAN). However, the reality of modern cellular—*specifically with the advent of 5G RedCap (Reduced-Capability 5G)*—paints a very different picture. When engineered with the right architecture, today's cellular networks deliver the throughput, latency, and priority Quality of Service (QoS) required for complex grid operations.

This article provides an educational deep dive into the evolution of cellular technology, demystifies 5G RedCap, and presents a clear blueprint for how utilities can confidently integrate it into their FAN strategy. We will explore how to leverage its capabilities for supervisory control, telemetry, and operational support, while clarifying why the most time-critical functions are still best reserved for fiber.

Reduced-Capability 5G gives utilities a low-cost, low-power path to reliable, priority-managed connectivity—without sacrificing core network performance.



Unlike legacy networks, 5G Standalone guarantees high-priority utility data gets through—even during peak congestion—thanks to bearer-level QoS, preemption, and slicing.

A Fast History of "Why Cellular Got a Bad Rap"

To appreciate the advancements of 5G, it is essential to understand why older cellular generations developed a reputation for unreliability in industrial settings.

The 1G/2G/3G Era: Voice-First Networks

Initial cellular networks were designed primarily for voice communication, with data capabilities added as an afterthought. This resulted in best-effort data transmission characterized by limited QoS controls, narrow channels, and unpredictable performance. For utilities requiring consistent and timely data for SCADA systems, the jittery performance and variable latency of these early networks were significant barriers to adoption.

The 4G/LTE Leap: A Step Forward, But Still Shared

LTE (4G) represented a major technological jump, introducing Orthogonal Frequency-Division Multiplexing (OFDM), MIMO antennas, and wider channels. This brought significant improvements in speed and capacity. Yet, public LTE networks largely operated on a shared, best-effort basis. During periods of high network traffic—such as rush hour or large public events—congestion could sideline critical utility data like telemetry and SCADA commands. The core issue remained: without dedicated mechanisms to prioritize traffic, essential operational data had to compete with consumer video streams and social media updates.

The Game Changer: 5G Standalone (SA)

The introduction of the 5G Standalone (SA) core fundamentally changes this dynamic. Unlike previous generations that upgraded the radio network over an older core, 5G SA provides an entirely new network core architected for diverse use cases. It introduces critical features for industrial applications, including:

- **Bearer-Level QoS:** The ability to assign specific QoS characteristics to different data flows.
- **Priority and Preemption:** Mechanisms to ensure high-priority traffic gets network resources ahead of lower-priority data.
- **Network Slicing Readiness:** The capability to create virtual, end-to-end networks with guaranteed performance characteristics for specific applications.

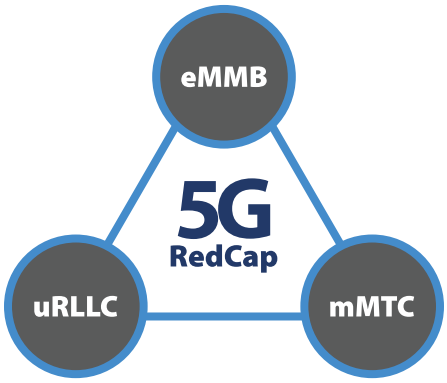
These features mean that critical utility traffic can be admitted, scheduled, and protected from congestion, ensuring deterministic performance even when the network is busy.

What is 5G RedCap and Why Does It Help?

RedCap, or "Reduced-Capability" 5G, is a device profile that trims radio complexity (using narrower bandwidth and fewer MIMO layers) to cut cost and power. Critically, it does this while retaining the advanced 5G Standalone core features that utilities need. It provides a managed lane on the cellular freeway— reserved bandwidth and priority—without paying for a race car you don't need.

Key Advantages of 5G RedCap

- **Deterministic QoS:** It fully supports 5G SA features like 5QI mapping, Guaranteed Bit Rate (GBR) and non-GBR bearers, and ARP priority. This lets control and telemetry traffic stay predictable even under load.
- **Longevity:** 5G SA + RedCap is on a long-term support path, aligning with the 10-15 year asset lifecycles common in utility rate cases and avoiding the "end-of-life whiplash" seen with older modules.
- **Right-Sized Cost:** RedCap modules are cheaper than full eMBB (enhanced Mobile Broadband) modems but far more capable than NB-IoT or LTE-M for utility operations.



Class	Intended Traffic	Throughput	Latency / Jitter Targets	QoS on 5G/RedCap + IP/MPLS
Class-P	Protection coordination, µPMU fast streams, R-GOOSE visibility (not primary trip)	50 kbps–2 Mbps per site	≤ 8 ms one-way (metro fiber); jitter ≤ 2 ms; FRR < 50 ms on fiber; LTE used only as tertiary/visibility	Highest priority; GBR bearer; preemption-capable; mapped to strict-priority queue end-to-end; PTP/SyncE at edge
Class-S	SCADA, FLISR supervisory, DERMS setpoints	10–500 kbps steady; short bursts higher	≤ 50 ms one-way; jitter ≤ 10 ms; failover < 150 ms (fiber); 0.3–0.7 s to LTE tertiary	High-priority GBR; reserved bandwidth; preemption allowed over Class-M; QoS markings preserved (bearer→MPLS queue)
Class-M	O&M, sensors/video (moderate), patches, OOB	0.1–5+ Mbps (use shaping for video)	≤ 500 ms typical; tolerant of higher jitter; LTE tertiary acceptable	Non-GBR or low-GBR; preemptible; rate-limited/shaped; lowest queue; best-effort when congested

5G RedCap Longevity: Why It Will Last 10+ Years

A key concern for any utility investment is asset lifecycle. RedCap is engineered for longevity, making it a safe, long-term choice.

- **Near-Shannon Waveform:** 5G New Radio (NR) uses scalable OFDM, high-order QAM, and modern Forward Error Correction (FEC), operating near the theoretical limits of channel capacity. This means no major modulation leap is looming that would make today's RedCap radios obsolete.
- **Stable 3GPP Profile:** RedCap (defined in 3GPP Release 17) and eRedCap (Release 18) are standard UE categories on 5G Standalone. 3GPP evolves additively (e.g., 5G-Advanced) with backward compatibility, so existing RedCap devices remain supported as networks upgrade.
- **Aligned Operator Economics:** Carriers are consolidating on 5G SA for both high-speed mobile broadband and enterprise/IoT services. RedCap fills the crucial mid-tier for Mbps-level performance at a lower cost and power profile, matching utility needs.
- **Determinism by Policy, Not Tricks:** The predictable performance of RedCap comes from policy-based features like 5QI/GBR and priority/preemption within the 5G core. This reliability is preserved through network policy and scaling, not frequent device replacement.

Architectural Blueprint: Making Cellular Mission-Critical

Integrating cellular successfully into a mission-critical FAN requires a deliberate architectural approach. The goal is to keep fiber/MPLS for protection-grade paths and use 5G RedCap for supervisory control and telemetry with engineered priority.

1. **Traffic Classes & QoS:**
   - Class-P (Protection/µPMU fast telemetry): Primary on fiber/MPLS. RedCap should only be used for visibility or backup.
   - Class-S (SCADA/FLISR supervisory, DERMS setpoints): Use a GBR bearer on RedCap with high ARP and preemption, mapped to high-priority queues end-to-end.
   - Class-M (O&M/video/patching): Use non-GBR or rate-limited GBR; this traffic should be preemptible.
2. **Core Integrations:**
   - Establish a private APN or enterprise slice with clearly defined 5QI/GBR policies per traffic class.
   - Use URSP (User-level Radio Service Profile) policies so devices automatically select the right bearer for the right application.
3. **Edge & Security:**
   - An edge router (e.g., substation PE) should enforce VRFs/HQoS.
   - RedCap CPE must establish IPsec tunnels to the headend for security.
   - Implement continuous OAM/SLA monitoring (TWAMP/Y.1731) to establish baselines and set latency/jitter alarms.
4. **Resilience:**
   - Design for dual access options (e.g., private + public 5G) or dual carriers where critical.
   - Implement a fiber-primary / RedCap-tertiary policy with automatic revert and pre-built tunnels.

Where Cellular Is Not An Optimal Solution

It is vital to recognize the limitations. Wide-area wireless technologies, including 5G, are not suitable for primary trip/transfer-trip protection. These microsecond-grade actions require the determinism of local fiber or dedicated MPLS. WAN links are ideal for coordination, visibility, and supervisory control, not instantaneous protective actions.

Use Cases vs. RedCap Fit

It is crucial to match the right technology to the right application. This table provides a quick mapping of common utility use cases to their suitability for 5G RedCap.

Use Case	5G-RedCap Fit	Notes / Requirements
FLISR supervisory & switch/recloser coordination	✅ Strong fit	Use GBR bearers; design for sub-second control loops.
DERMS setpoints / telemetry	✅ Strong fit	Seconds to sub-second actions; modest bandwidth needs.
µPMU visibility (30–120 sps)	✅ Feasible	Prioritize to avoid congestion jitter; verify uplink headroom.
Video sensors / situational awareness	✅ Conditional	Works at moderate bitrates with rate shaping.
Primary teleprotection	❌ Not suitable	Keep on fiber/MPLS; RedCap only for backup visibility.

Getting Started: A Four-Step Path to Deployment

Utilities can initiate their cellular FAN modernization with a stepwise, metrics-driven approach:

1. **Define Classes and Service Level Objectives (SLOs):**
   - Establish latency and jitter targets and map 5QI/GBR requirements to each traffic class, creating a clear basis for both vendor selection and network configuration.
2. **Provision Carrier Services:**
   - Enable Standalone (SA) operation with private APN. Confirm the availability of prioritized and preemption-enabled RedCap device SKUs, and ensure bulk device ordering adheres to project scope.
3. **Field Test Under Load Conditions:**
   - Simulate "cell busy hour" conditions to assess bearer performance. Validate that control bearers consistently meet SLOs even during periods of heavy network activity.
4. **Operationalize and Monitor:**
   - Develop templates and implement monitoring protocols. Configure alarms and generate monthly SLA reports to provide transparency and evidence of compliance for rate-case justification and regulatory reporting.

Conclusion: A New Era of Cellular Reliability

The narrative that cellular is unsuitable for mission-critical utility networks is outdated. While past generations had genuine limitations, the combination of a 5G Standalone core and the 5G RedCap device class marks a turning point.

By enabling bearer-level QoS, priority, and preemption, 5G allows utilities to carve out a reliable, high-performance lane for essential operational data. This modern approach enables a pragmatic FAN architecture: use fiber for protection-grade communication and leverage 5G RedCap for a cost-effective, future-proof wireless network for supervisory control and extensive grid visibility.

As a trusted advisor in mission-critical communications, MCA wrote this paper to educate our customers on navigating these technological shifts. We partner with utilities to design, implement, and manage robust communication networks that blend the best of wired and wireless technologies.

Determining whether 5G RedCap or another solution from our portfolio is the right fit requires a collaborative consultation. Our team is ready to help you build a FAN architecture that is not only practical and fundable but also ready for the future of the grid.

5G RedCap unlocks reliable wireless control for utilities, combining QoS, preemption, and low-latency delivery to support scalable SCADA and grid visibility.

MCA helps utilities blend fiber and 5G RedCap into a fundable, future-proof FAN architecture—tested, operationalized, and monitored for long-term performance.

About MCA

We believe every workplace should be safe, secure, and efficient. As trusted advisors, we deliver integrated communication, connectivity, and security solutions with a **Service First mindset** – *driven by a team that cares deeply about our customers and each other.*

Why MCA? At MCA, we help solve critical communication, connectivity, and security challenges with turnkey, integrated system solutions—*from two-way radios and in-building wireless to video surveillance, access control, and more*. MCA is built from **over 50 companies** with deep technical expertise and strong local roots. **And we're still growing**—*expanding our capabilities, our reach, and our team.*

Our **100+ Solution Centers** bring together sales, installation, service, and customer operations teams to deliver seamless, nationwide support. **Guided by our Service First value**, we don't just connect the wires and walk away—*we provide customized solutions backed by deep expertise and lifecycle support.*

About The Author

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