T-MOBILE FOR BUSINESS

WHITEPAPER

T-MOBILE 5G STANDALONE
THE INTELLIGENT CONNECTIVITY PLATFROM FOR THE FUTURE.

T-Mobile 5G Standalone delivers ultra-fast, low-latency connectivity to power next-generation business applications seamlessly.

Executive Summary

> With the only nationwide 5G SA network in the US, we are uniquely positioned to bring the dream of network slicing to life, delivering 5G benefits across the country. It's time we fulfill the promise of 5G. And I'm so incredibly proud to say T-Mobile is leading the charge.

-John Saw, Executive Vice President & Chief Technology Officer, T-Mobile

5G Standalone (SA) marks a turning point in wireless connectivity-not just for the industry, but for the customers and businesses it serves. By removing dependence on legacy 4G infrastructure, 5G SA unlocks the full capabilities of 5G, enabling real-time experiences, consistent high-speed performance, and enterprise grade reliability that were previously out of reach.

T-Mobile's nationwide 5G SA network empowers customers with ultra-low latency for applications like autonomous vehicles, immersive AR/VR, robust throughput for seamless streaming, remote collaboration, and a powerful security framework that protects users from evolving threats.

Intelligent automation, powered by AI-native orchestration, dynamically tunes the network for performance and efficiency. With T-Mobile's unmatched multi-band layer cake spectrum strategy customers benefit from enhanced coverage, Massive MIMO, beamforming, and high-order modulation, all at national scale.

T-Mobile's 5G Standalone (SA) network also lays the groundwork for rapid innovation by providing developers and enterprises with a programmable, cloud-native platform. This enables network slicing and edge computing capabilities that tailor connectivity to specific use cases—whether it's ultra-reliable low-latency communication for healthcare or high-bandwidth support for media production. As industries evolve, T-Mobile's 5G SA ensures they have the agility and scale to adapt, innovate, and lead in an increasingly connected world.

From smart cities and connected manufacturing to mission-critical communications and next-generation media, T-Mobile's 5G Standalone infrastructure is already delivering tangible value, unmatched performance, and breakthrough innovation today.

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Introduction

The 5G era is no longer a distant promise—it's a present-day reality, and T-Mobile is at the forefront of its evolution. As the first and only U.S. operator to deploy a nationwide 5G Standalone network, T-Mobile has set a new benchmark for what mobile connectivity can achieve.

Unlike Non-Standalone (NSA) 5G, which depends on legacy 4G infrastructure, 5G SA is purpose built from the ground up, delivering a transformational leap in speed, latency, efficiency, and intelligence.

This shift isn't just technical—it's foundational. By eliminating 4G core dependencies, T-Mobile's SA network creates a flexible, cloud-native architecture capable of supporting real-time applications, enterprise-grade reliability, and differentiated services through advanced capabilities like network slicing, edge computing, and AI-native orchestration.

These innovations enable the network to dynamically adapt to the demands of smart cities, connected industries, autonomous systems, and immersive experiences—all while optimizing resource use and enhancing security.

What sets T-Mobile apart isn't just the early deployment of 5G SA—it's the scale, intelligence, and integration of technologies that make this network a true platform for innovation. With unmatched mid-band spectrum holdings, real-world slicing deployments, and deep partnerships with AI leaders like NVIDIA, T-Mobile has created a programmable, responsive infrastructure ready for the next decade of digital transformation.

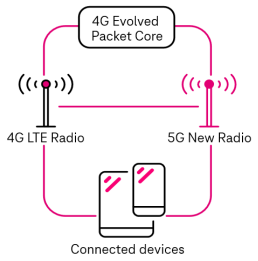
This whitepaper explores how T-Mobile's 5G network architecture delivers on the full potential of 5G. From ultra-low latency and massive throughput to zero-trust security and energy-efficient design. T-Mobile's 5G Standalone network is powering the future of connectivity turning theoretical potential into an operational advantage, nationwide.

Understanding 5G Standalone (SA) vs Non-Standalone (NSA)

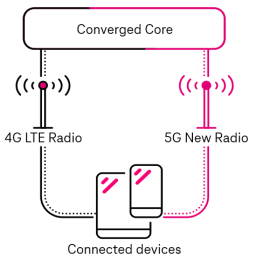
5G Non-Standalone (NSA) networks, while leveraging 5G radios, remain dependent on 4G LTE core infrastructure for key functions such as signaling and control.

Designed as a transitional step, NSA offered early access to improved speeds, but its hybrid architecture limits the ability to deliver the full promise of 5G including ultra-low latency, advanced security, and true network customization.

5G Non-standalone (5G NSA)
Our competitors' 5G networks are still tied to legacy 4G LTE standards.



5G Standalone (5G SA)
5G SA enables new capabilities like slicing the network to offer first responders prioritized access for data.



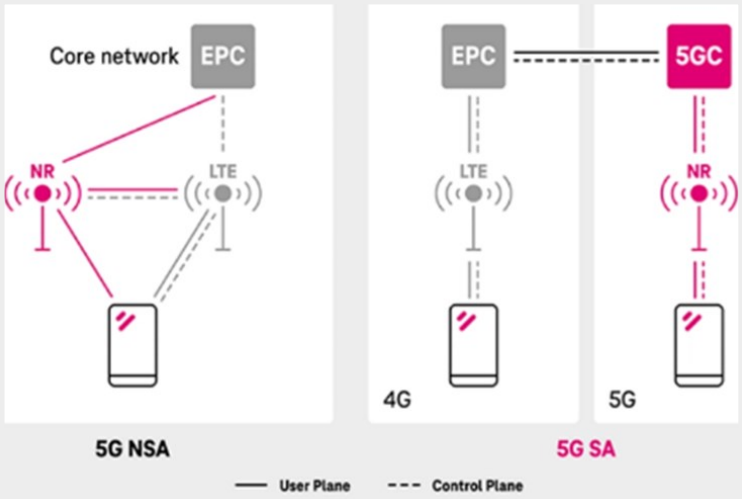
In contrast, 5G Standalone (SA) operates on a dedicated, cloud-native 5G core, enabling a full suite of next-generation capabilities such as dynamic network slicing, service-based routing, edge computing, and end-to-end quality of service management. This allows operators like T-Mobile to prioritize traffic for mission-critical applications—like first responder communications—while delivering consistent, high-performance connectivity across diverse environments.

NSA introduces inherent limitations, including higher latency, less efficient spectrum use, constrained coverage, and increased architectural complexity. It also lacks the scalability and flexibility needed to support emerging use cases and future innovation. SA however overcomes these challenges with a virtualized, software-defined architecture that delivers significantly greater efficiency, deployment agility, and network intelligence.

By fully decoupling from legacy LTE, 5G SA delivers the speed, adaptability, and reliability that define true 5G. More than a generational shift in wireless technology, 5G SA lays the foundation for long-term digital transformation—empowering enterprises, developers, and industries with a programmable platform built to evolve.

5G NON-STANDALONE A transitional technology	5G STANDALONE Supports long-term growth and digital transformation
▪ Limited 5G capabilities ▪ Limited coverage ▪ Higher latency ▪ Less efficient use ▪ Complexity and cost ▪ Limited future-proofing	▪ Full utilization of 5G capabilities ▪ Virtualized 5G core delivers ultimate deployment flexibility ▪ Advanced feature sets such as network slicing ▪ Improved coverage and capacity ▪ Enables edge computing ▪ Greater efficiency and flexibility ▪ Future-proofing and scalability

5G Standalone Key Benefits



5G Standalone (SA), uses a new, cloud-native 5G Core designed for transformational capabilities. The architecture introduces a Service-Based Architecture (SBA) that enables dynamic and efficient routing of control and user plane traffic.

Combined with network slicing, SA can guarantee ultra-low latency for specific services or enterprise verticals, enabling deterministic behavior crucial for mission-critical use cases.

With the User Plane Function (UPF) deployed at or near the network edge, latency reductions of 40% or more compared to Non-Standalone (NSA) deployments have been documented in trials and early commercial rollouts.

This reduction is critical for latency-sensitive applications such as autonomous driving, industrial automation, remote surgery, and real-time AR/VR experiences, where even a few milliseconds of delay can compromise performance or safety.

Higher Throughput

The 5G NR (New Radio) interface, especially when deployed with mid-band spectrum such as 2.5 GHz, provides a significant boost in throughput over legacy LTE systems. Mid-band 5G offers a compelling balance of capacity and coverage, with spectrum allocations ranging from 80 MHz to as much as 190 MHz. This enables high-speed, low-latency connectivity across broad geographic areas, making it ideal for both urban and suburban environments.

The 5G Standalone (SA) Core plays a pivotal role in realizing these gains by streamlining traffic flow through a cloud-native, service-based architecture. This approach minimizes signaling overhead, supports advanced features like dynamic spectrum sharing, intelligent load balancing, and allows for more efficient use of radio and core resources. T-Mobile has reported throughput improvements of 20–30% over NSA deployments by migrating traffic to its SA core, with further performance gains enabled by combining large mid-band channels with massive MIMO and network slicing capabilities.

Greater Energy Efficiency

5G SA introduces advanced power-saving mechanisms that significantly reduce network signaling and device energy consumption. For instance, the RRC (Radio Resource Control) Inactive state allows devices to maintain context with the network while remaining in a low-power state, enabling faster transitions to Active mode without the need for full reconnection (3GPP TS 38.331). This leads to reduced signaling overhead and improves energy efficiency for both the network and end-user devices.

Another enhancement is the Power Saving Mode (PSM) and extended Discontinuous Reception (eDRX), which allows IoT and mobile devices to "sleep" for longer intervals without losing connectivity. This is especially important for IoT deployments where sensors and endpoints may need to operate for years on a single battery. T-Mobile has actively promoted SA 5G as foundational for low-power, large-scale IoT networks using these mechanisms.

Security

Authentication in 4G and 5G NSA

Authentication Mechanism
Both 4G and 5G NSA use the 3GPP AAA server located within the Home Public Land Mobile Network (HPLMN) for authentication, authorization, policy enforcement, and routing information. The authentication is typically performed using EAP-SIM/AKA/AKA' via the SIM card.

Encryption
In 4G, the user's identity and location are not encrypted during the initial connection to the base station, making them vulnerable to attacks. Subsequent communications are encrypted, but the initial vulnerability remains.

This means that while users can experience some benefits of 5G, the control plane still operates on the 4G infrastructure, which can impact overall performance and latency.

Authentication in 5G SA

Authentication Mechanism
5G SA uses mutual authentication with 5G AKA or EAP -AKA' and AKMA, providing replay protection and enhanced key management.

Infrastructure Independence
The 5G SA architecture is built from the ground up with a dedicated 5G core network. This allows for ultra-reliable low-latency communications (URLLC) and massive machine-type communication (mMTC), fully leveraging the capabilities of 5G technology.

Encryption
Additionally, the user's identity and location are encrypted from the moment they connect to the network, making it impossible to identify or locate them. This ensures that both the user and the network authenticate each other, reducing the risk of fake base stations and replay attacks.

User Plane Integrity Protection:

Preventing over-the-air replay attack and injections

4G and 5G NSA	5G STANDALONE
User plane integrity protection is **optional** and not commonly implemented, leaving the network vulnerable to attacks.	User plane integrity protection is **mandatory** starting from 3GPP Release 16, significantly enhancing security by protecting user plane data against tampering and replay attacks.

Secure Core Network Data Flows:

Preventing network attacks

4G and 5G NSA	5G STANDALONE
Core network data flows are vulnerable due to reliance on older security protocols and optional user plane integrity protection. Mitigations are in place but are not as robust as in 5G SA.	Offers enhanced security with mandatory user plane integrity protection, secure APIs, end-to-end encryption, and network slicing. Advanced encryption mechanisms and SBA provide a higher level of security. **Service-Based Architecture (SBA):** 5G SA networks use SBA, which mitigates long-standing 4G vulnerabilities and enables stronger security. This architecture allows for secure communication between different parts of the network using secure APIs. **End-to-End Encryption:** Future 5G SA networks will provide end-to-end encryption between services with mutual TLS 1.3 versus TLS 1.2, ensuring that data is protected throughout its journey across the network. **Network Slicing:** The ability to create isolated virtual networks with tailored security configurations further enhances the security of 5G SA networks.

Downgrade Attacks:

Bidding-down attacks exploit the backward compatibility of mobile networks, forcing user endpoint devices to connect to earlier, less secure generations of 3GPP.

This can lead to weaker encryption algorithms and increased vulnerability to various attack vectors.

4G and 5G NSA	5G STANDALONE
Vulnerable to downgrade attacks due to reliance on older security protocols and partial mitigation measures.	Offers enhanced security with anti-bidding measures requiring cryptographic proof of protocol level, preventing forced downgrades, and robust encryption and authentication mechanisms.

Advanced Security

5G Standalone (SA) networks are built on a **Zero Trust Architecture (ZTA),** which assumes no implicit trust for users, devices, or services-even within the network boundary. This security model requires rigorous identity verification, access control, and continuous monitoring across all network functions.

At the core of this framework is the **5G Authentication Server Function (AUSF),** which collaborates with the **Unified Data Management (UDM)** responsible for storing and managing subscriber data-and the **Access and Mobility Management Function (AMF),** which handles connection and mobility management. Together, these components authenticate users and maintain secure communication contexts, in accordance with (3GPP's TR 33.894) recommendations for implementing Zero Trust in mobile networks.

The **5G Service-Based Architecture (SBA)** further strengthens this model by using hardened APIs, OAuth 2.0, and mutual TLS for secure inter-service communication. As noted by Ericsson, this enables native Zero Trust compliance within the 5G Core, enhancing protection for network slices, multi-tenant environments, and enterprise deployments. Continuous security monitoring and dynamic policy enforcement provide a layered, defense-in-depth strategy tailored for today's complex threat landscape.

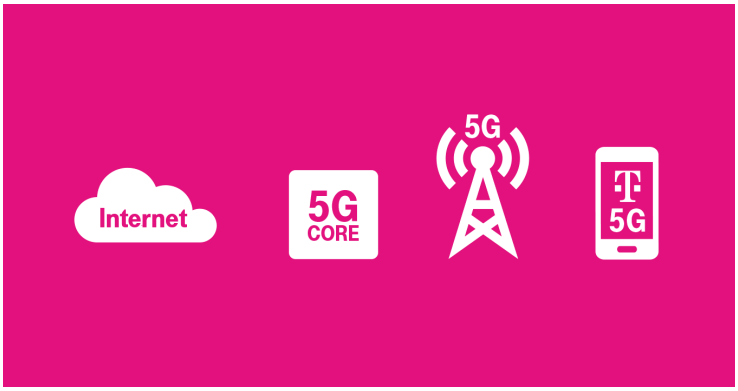
5G Security Enhancements Table			
Known Security Control Gaps	**4G and 5G NSA**	**5G Standalone (SA)**	
Subscriber privacy - IMSI tracking (Over-the-air location tracking)	Vulnerable	Mitigated	via IMSI ciphering (SUPI/SUCI)
Secure signaling UE / Core flows (Non-access stratum messages)	Vulnerable (uses en-capsulation)	Partially Mitigated	encryption after key distribution
User plane integrity protection (Prevents over-the-air replay attack and injections)	Vulnerable (optional feature)	Mitigated	starting in Release 16. (mandatory feature but optional for implementation)
Secured core network data flows	Vulnerable	Mitigated	via SBA and Secure APIs
End-to-end customer traffic isolation	Vulnerable	Mitigated	via End-to-End Network Slicing (e.g., UE to the Cloud)
Downgrade attacks (Force the UE to use earlier 3GPP re-leases)	Vulnerable	Mitigated	via anti-bidding down between architecture
Supply chain security	Vulnerable	In progress	e.g., NESAS / SCAS

5G Standalone (SA) delivers significantly stronger security than 4G and 5G Non-Standalone by implementing a Zero Trust Architecture with end-to-end encryption, mutual authentication, and continuous monitoring. It mitigates common vulnerabilities like IMSI tracking, replay attacks, and downgrade exploits through advanced identity protection and secure core data flows.

SA also enables traffic isolation via network slicing and hardened inter-service communication. These capabilities make 5G SA a future-ready platform for secure, resilient connectivity across critical applications.

AI-Optimized, Spectrum-Powered 5G

T-Mobile's 5G Standalone (SA) network is built for more than speed, it's designed for intelligence. By combining a fully virtualized, cloud-native infrastructure with deep AI integration and unmatched mid-band spectrum holdings, T-Mobile delivers a uniquely capable and adaptive wireless platform. This next-generation network supports real-time orchestration, predictive analytics, and autonomous performance tuning-making it one of the most advanced mobile networks in the world.



AI-Native Orchestration, From Core to Edge

5G SA introduces closed-loop automation, allowing the network to optimize itself in real time using continuous telemetry. Leveraging the 3GPP-defined **Network Data Analytics Function (NWDAF),** T-Mobile integrates AI and machine learning directly into the control plane to proactively manage resources, forecast demand, and detect anomalies. Through intent-based networking, T-Mobile translates service-level goals like low latency for gaming or high throughput for video-into automated, network-wide actions. This model has been validated by Telenor and Nokia, brought to life through cloud-native platforms operated by Google Cloud and T-Mobile itself.

Real-Time Optimization with Built-In Intelligence

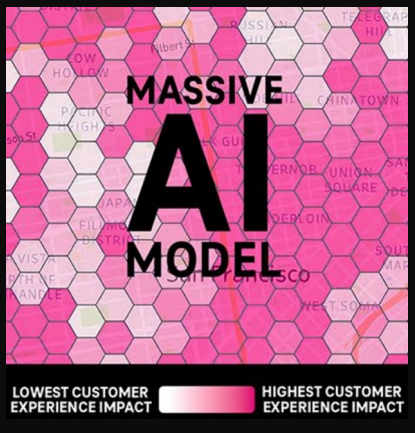
AI enables T-Mobile to dynamically and autonomously optimize critical network functions at scale.

- **Dynamic RAN Tuning:** AI models adjust Massive MIMO configurations, beamforming angles, and handover timing in real time to optimize user experience.
- **Predictive Congestion Mitigation:** ML anticipates traffic surges and proactively reroutes flows to maintain service quality.
- **Energy Optimization:** AI-powered orchestration activates or deactivates RAN components based on real time demand, reducing energy usage without sacrificing coverage.
- **Service-Aware Orchestration:** The network detects application needs-such as video conferencing versus IoT -and adapts slices and prioritization on the fly.

Partnership with NVIDIA: Accelerating the AI Core

In 2024, T-Mobile partnered with NVIDIA to deploy NVIDIA AI Enterprise software and accelerated computing platforms across its nationwide network. This laid the foundation for AI-native operations at scale. In 2025, the partnership expanded to drive 6G R&D, including:

- AI-based spectrum optimization across ultra-high frequency bands
- Self-healing network cores and predictive maintenance



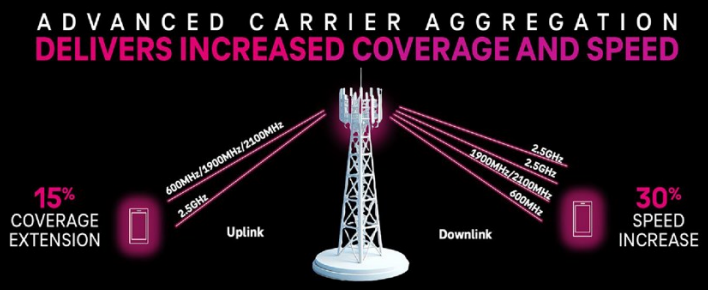
Autonomous network slicing and real-time QoS adjustments

While competitors pilot automation in isolated domains, T-Mobile has integrated AI into the heart of its network-creating a programmable, responsive platform ready for the future of applications, services, and developer innovation.

Spectrum: The Silent Enabler

Behind this intelligence lies a foundation of powerful spectrum assets. T-Mobile's mid-band holdings especially its extensive 2.5 GHz footprint—enable performance-critical features to scale nationwide, not just in dense urban pockets:

Massive MIMO: Mid-band spectrum supports high-capacity, multi-user connections through advanced MIMO configurations. Today, this includes widespread 4x4 MIMO deployments, with the foundation in place to evolve toward 8x8 and multi-user MIMO (MU-MIMO) as devices and networks mature. These capabilities improve throughput and user experience even under high traffic loads.



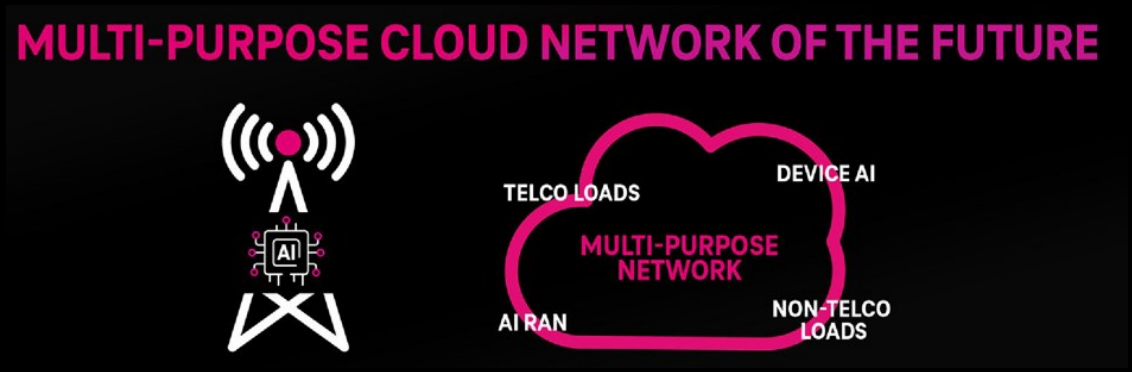
Uplink MIMO: Standalone 5G unlocks uplink MIMO configurations such as 2x2 and 4x4—especially in TDD-based mid-band deployments—delivering balanced performance for data-heavy use cases like video upload, augmented reality, and industrial IoT. NSA deployments typically fall short here, as uplink is often anchored to LTE and limited to 1x1 or 2x2 configurations.

Beamforming: Mid-band provides the clean, consistent radio environment beamforming algorithms thrive in, outperforming more interference-prone or range-limited bands like mmWave or C-band.

256QAM Modulation: Requires high signal-to-noise ratios that T-Mobile's spectrum portfolio delivers consistently, boosting spectral efficiency by up to 33%.

Where competitors struggle to scale these technologies beyond ideal lab or urban conditions, T-Mobile's integrated spectrum holdings enable real-world deployment of advanced 5G capabilities across urban, suburban, and rural areas alike.

Bottom line: AI drives the intelligence. Spectrum makes it real. Together, they define T-Mobile's advantage in delivering the first truly autonomous, nationwide 5G network—ready to power the AI-native, always-optimized future.



Network Slicing

Precision Connectivity Tailored to the Use Case
Network slicing is one of the most powerful innovations enabled by T-Mobile's 5G Standalone (SA) core. It allows the network to be segmented into virtualized, isolated slices-each optimized for distinct application needs such as latency, bandwidth, reliability, and security. Unlike shared, best-effort networks of the past, slicing delivers dedicated performance for mission-critical, real-time, or resource-sensitive applications across industries.

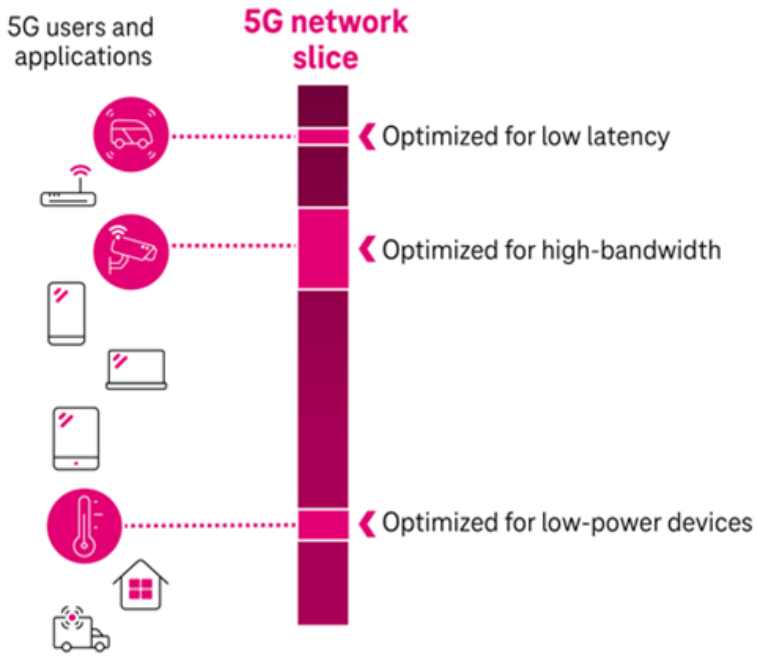
Slicing Applications in Operation
5G networking supports a range of specialized slices designed to meet the needs of priority users, industrial devices, and bandwidth-intensive applications.

T-Priority (Public Safety Slice): Delivers preemptive access, low latency, and high reliability for first responders and emergency services-ensuring seamless communication even in congested or degraded network conditions.

T-Security (SASE Slice): The industry's first network slice dedicated to secure access integrates directly with leading SASE platforms from Palo Alto Networks and Versa Networks. Purpose-built for enterprises, this slice delivers consistent, policy driven connectivity with embedded Zero Trust Security and Sim based authentication.

High-Performance Media Slice: Supports low-latency, high-throughput delivery of video and broadcast content for live events, remote production, and mobile media workflows-ensuring smooth, uninterruped transmission under demanding conditions.

Low Power IoT Slice: Optimized for reduced signaling, low bandwidth, and long battery life, this slice supports large-scale industrial IoT deployments across sectors like agriculture, logistics, and utilities.



Architecture for Enterprise-Grade Performance
Full End-to-End Isolation: From RAN to Core to user plane, each slice operates independently to ensure performance and security.

AI-Driven Orchestration: Real-time automation adapts slice behavior based on location, usage, or priority optimizing resources dynamically.

Custom SLAs and QoS: Slices can be configured for guaranteed throughput, latency, or resiliency, supporting use cases that demand predictable service.

Developer-Ready Architecture: T-Mobile's platform supports programmable control, with APIs in development to enable slice provisioning, monitoring, and integration with enterprise systems.

T-Mobile is leading the U.S. market in operationalizing 5G slicing-delivering flexible, application-specific connectivity that unlocks new business models, smarter infrastructure, and responsive digital experiences.

Competitive Differentiation: T-Mobile Delivers Real 5G

In an industry full of 5G claims, only T-Mobile delivers a fully operational, end-to-end 5G Standalone (SA) Experience "Real 5G." While other U.S. carriers remain anchored to transitional NSA architectures, T-Mobile has built a future-ready platform from the ground up, delivering what others still promise.

Key advantages that set T-Mobile apart:

- **Nationwide 5G Standalone Core:** The only U.S. operator with a fully deployed 5G SA core and RAN (no LTE dependencies).
- **Most balanced spectrum portfolio in the U.S.** from low-band 600 MHz for reach and indoor coverage to mid-band 2.5 GHz enabling scalable Massive MIMO and 256QAM across geographies.
- **Live Network Slicing:** Purpose-built slices for public safety, IOT, and SASE were delivering real slicing today.
- **AI-Native Optimization with NVIDIA:** Real-time orchestration across RAN and Core for responsive, efficient, and adaptive network performance.
- **Security by Design:** Zero Trust architecture, encrypted slices, and isolated network functions.
- This isn't an upgrade. It's a transformation. T-Mobile is the **only operator offering true, standalone 5G across the U.S. today.**

T-Mobile 5G Standalone is Real 5G. Everything else is still catching up. Backed by a uniquely structured spectrum portfolio, T-Mobile's SA network brings real 5G capabilities to more places, more consistently-making theoretical performance a nationwide reality.

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