market
opportunity
overview

The Advent of
Private LTE and
5G Networks

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Smart Systems and Internet of Things Growth Strategy
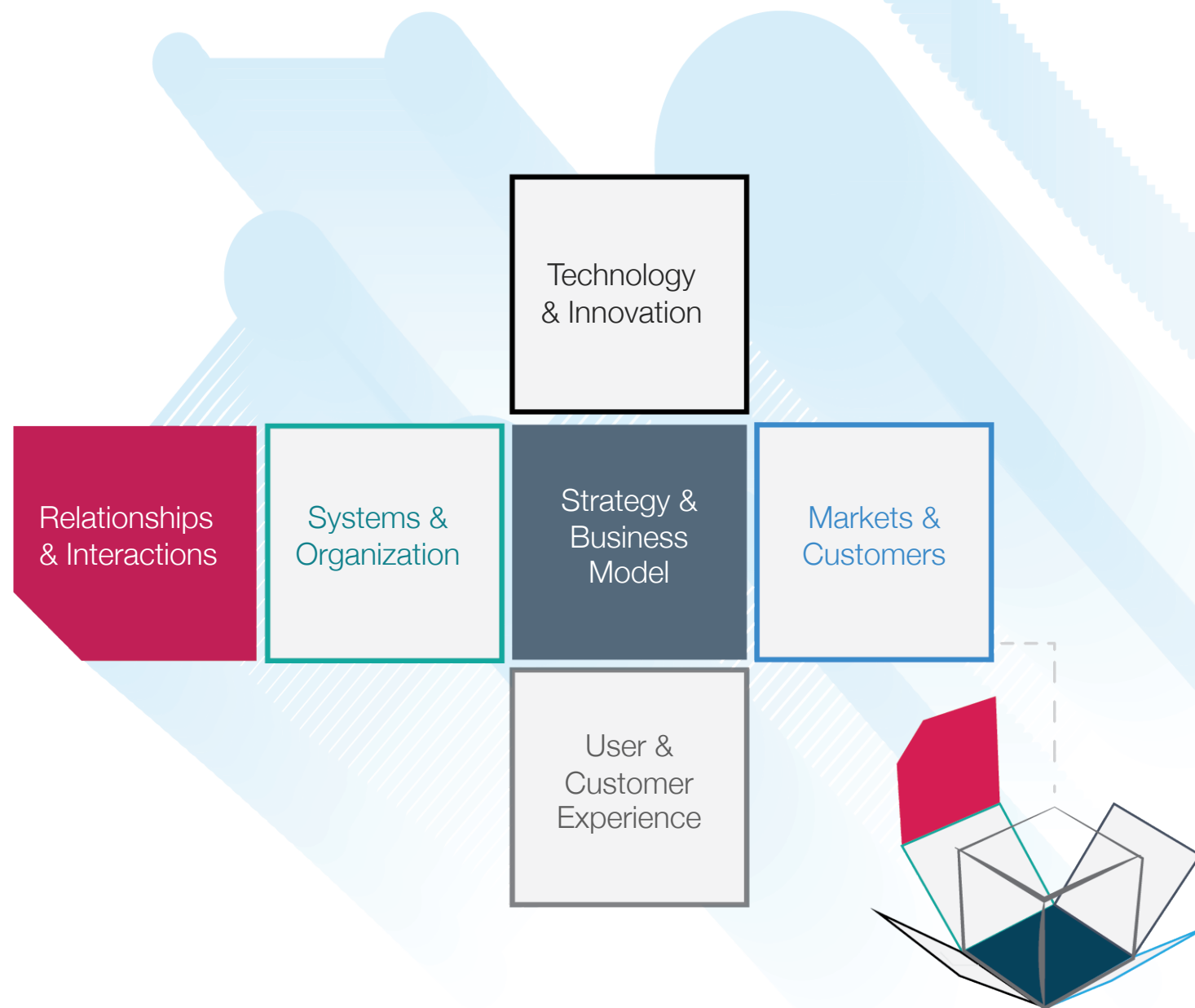
The worlds of sensors, automation, machine learning, computing and communications are each changing rapidly, while at the same time converging into an entirely new competitive arena: Smart Systems and the Internet of Things.

The forces at work in these sectors make strategic decision-making extremely difficult. The velocity of change conspires with the number of variables in play to overtax many managers' ability to make confident and informed decisions.

This has two crucial effects on strategists: First, they need better analytic methods and frameworks for decision-making. Second, while they are more likely to consult with outside advisors, they also need more effective modes of interaction with them.

Smart Systems technologies are creating significant discontinuities in the marketplace. Knowing which applications and use cases to focus on, which business model to pursue, and which market relationships to create are critical in today's rapidly evolving marketplace.

Harbor's services combine research, strategy and design with collaborative facilitation processes to provide clients with unparalleled perspective and applied methods for developing new business opportunities.

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Summary of Key Takeaways for the Private Network Opportunity

1 **High Performance Networks are a Key Enabler of Smart Systems and Mission Critical IoT Deployments**

Whereas today's network environment is a patchwork of dedicated and siloed systems to support specific device types and use cases, future networks will be seamlessly integrated and managed to achieve the complete value of Smart Systems for enterprises.

2 **Private LTE Networks Solve Key Technical & Operational Challenges, and Set the Stage for Future 5G Deployments**

New technical and business model innovations are enabling 4G LTE to be deployed as a private WLAN network. Soon, private 5G networks will be able to offer even higher performance, achieving similar latency, bandwidth, reliability and security as traditional wired networks.

**3** **The Opportunity for Private Networks in IoT is Massive, Driven by New Levels of Operational Performance**

The revenue opportunity for private networks and related IoT enablement, software and services will be over $200 billion by 2025, as they address coverage, security, latency, reliability, and cost issues associated with applying existing wired and wireless networks to IoT.

4 **The Networks Ecosystem is Rapidly Evolving, as Many Suppliers Jockey for a Controlling Position in Private Networks**

Providing a complete private network solution requires hardware, software, service and support. Mobile Network Operators are well-positioned to offer private networks; however, they are threatened by DIY enterprises and peers expanding into managed services.

5 **To Successfully Capture the Opportunity, Suppliers Must Consider Technical & Business Model Adjustments**

While some players are expanding their capabilities with software-enabled service innovations, many are opting for partnerships to build out an end-to-end offering. Beyond new capabilities, successful strategies require engaging different channels with new business models.

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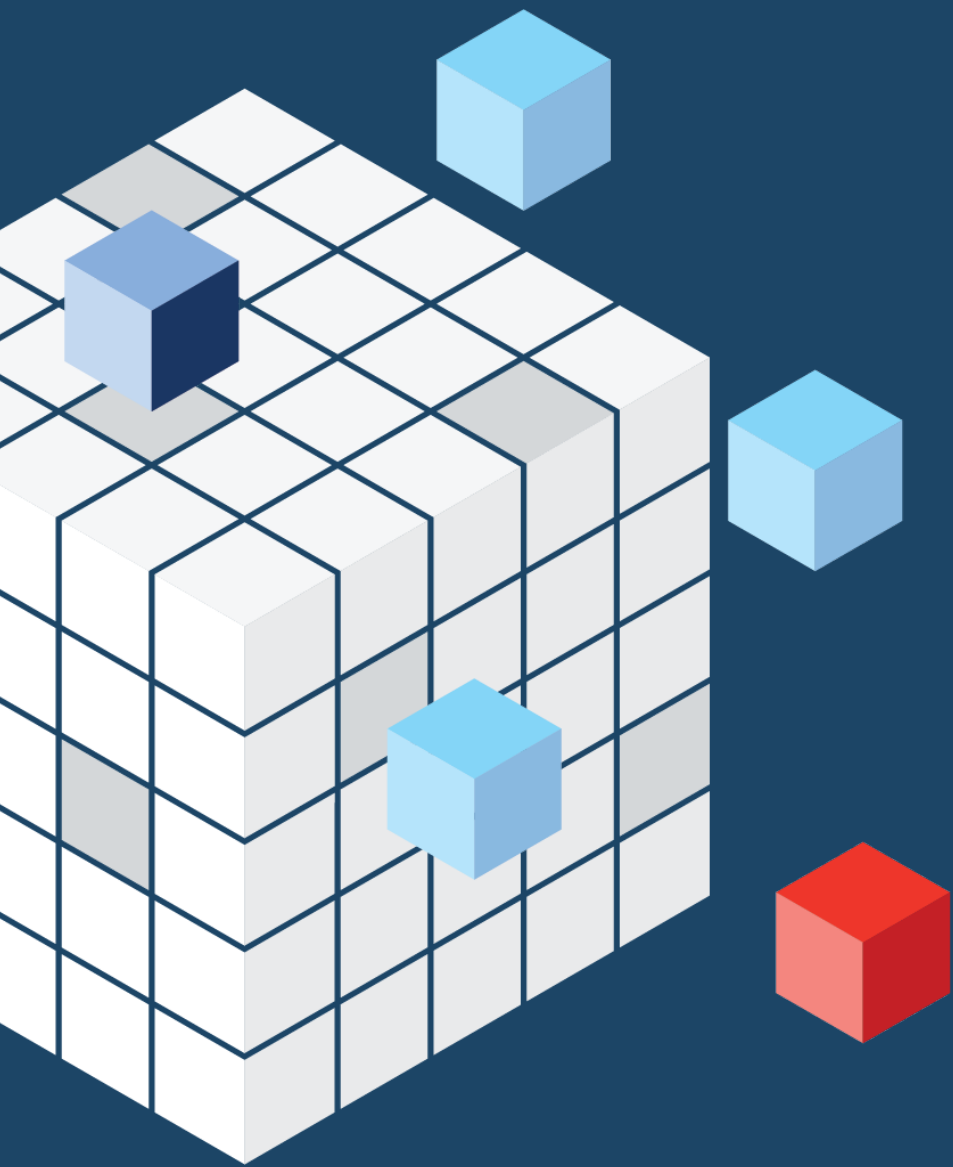
Framing the Private LTE and 5G Networks Market Opportunity

Networks Must Evolve to Address Increasingly Complex Applications

Higher performance networks are required enable a new generation of applications, giving rise to an increasingly complex set of interactions of data between device, machine and human processes

The Evolution of Use Cases & Related Networking Requirements

Increasing Value-Add

Complex
Process & System Integration

High Performance & Integrated Hybrid Networks

Multi-system Coordination

Safety, Control & Automation

Compound
Aggregation of Things

Multiple Overlapping Networks

Location & Tracking

Simple
Thing

Single/Dual Network

Diagnostics & Prognostics

Status & Monitoring

Increasing Network Requirements

Device Management & Connectivity

Connect and Monitor   **Manage, Integrate and Analyze**   **Predict, Optimize and Interact**

Increasing Solution Complexity

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The Current Network Landscape is Fragmented & Uncoordinated

Today's fragmented landscape creates barriers to adoption riddled with proprietary device networks, cautious users and buyers, and broken promises about the potential of wireless technologies

Range (vertical axis)
- 1,000+ Meters
- 100 Meters
- 10 Meters
- 1 Meter

Data Rate (horizontal axis)
- 0.0 Mbps
- 1 Mbps
- 10 Mbps
- 100 Mbps
- 1G Gbps +

Diagram labels:
- NB-IoT/ LTE CatM1
- LPWAN (SigFox, Weightless, LoRa)
- Unlicensed 900MHz
- Satellite
- Cellular, 5G and Private LTE
- 802.15.4 (Zigbee, Z-Wave, ISA 100-11a, WirelessHart, Thread, Proprietary)
- Unlicensed 2.4 GHz
- Bluetooth LE
- Bluetooth (802.15.1)
- Industrial Ethernet (EtherCAT, EtherNet/IP, PROFINET, POWERLINK, SERCOS III, CC-Link IE, and Modbus TCP)
- 802.11 (b/g/n, proprietary)

Remote Assets / High Coverage
- Substation Monitoring
- Oil Rig Monitoring
- Electricity Metering
- Weather/soil Monitoring

High Bandwidth / Mobile Assets
- Agriculture Vehicles
- Off-Road Construction
- Surface and Sub-terrain Mining
- Streaming Video

Mission-Critical / Control
- Automation / Process Control
- Machine and Equipment Monitoring

Short-Range, Lower Data Rate
- Environment Monitoring
- Wireless Sensor Monitoring
- Mesh Network Diagnostics

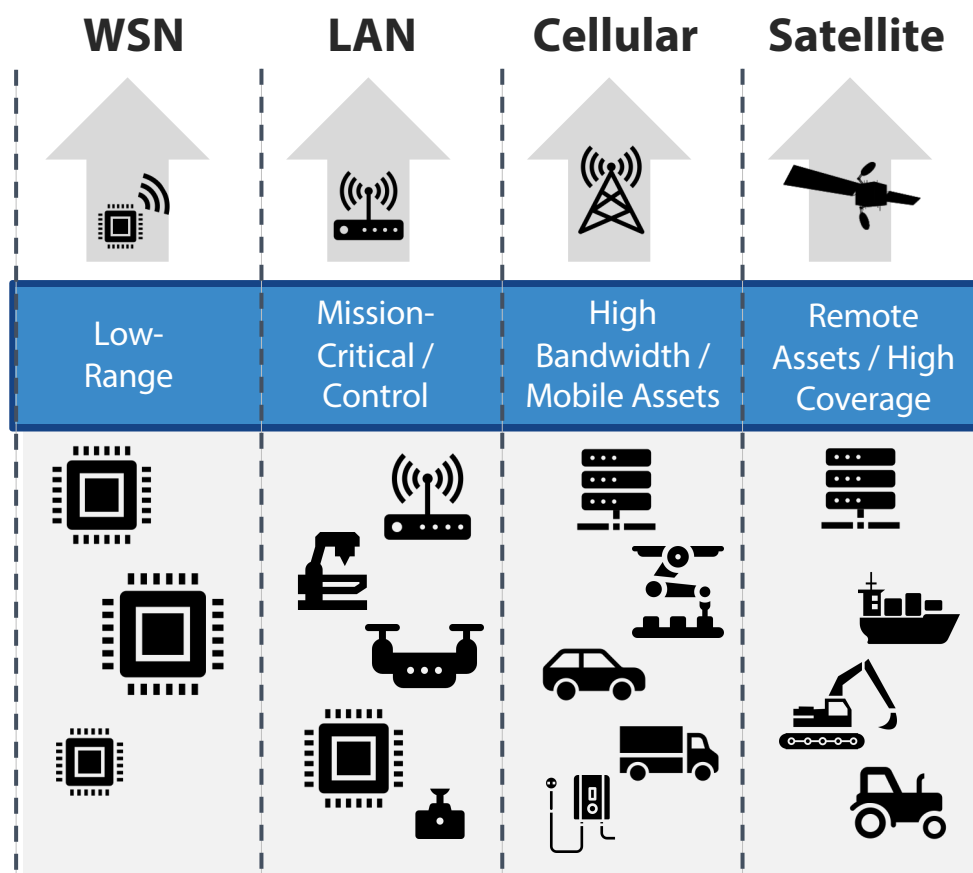smart
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Integrated, Hybrid Network Services Enable Seamless Orchestration

Private network services will will act as an abstraction and orchestration layer to link existing networks and optimize the way data moves between systems

Current State of Wireless Networks

- Limited device and data interactions
- Simple use cases
- Inefficient bandwidth usage
- Complex, uncoordinated management

WSN	LAN	Cellular	Satellite
Low-Range	Mission-Critical / Control	High Bandwidth / Mobile Assets	Remote Assets / High Coverage

Key Enablers

- Network Slicing
- Multi-Access Edge Computing
- Dynamic Spectrum Access
- License-assisted Access
- Listen before talk
- Traffic Prioritization
- Open, Virtualize RAN
- Automated Orchestration

Future State of Hybrid Network Services

- Greater visibility of network usage
- Autonomous, distributed use cases
- Optimized bandwidth usage and computing limits
- Increased control over connected devices

LAN	Cellular	Satellite

Hybrid Network Services Platform
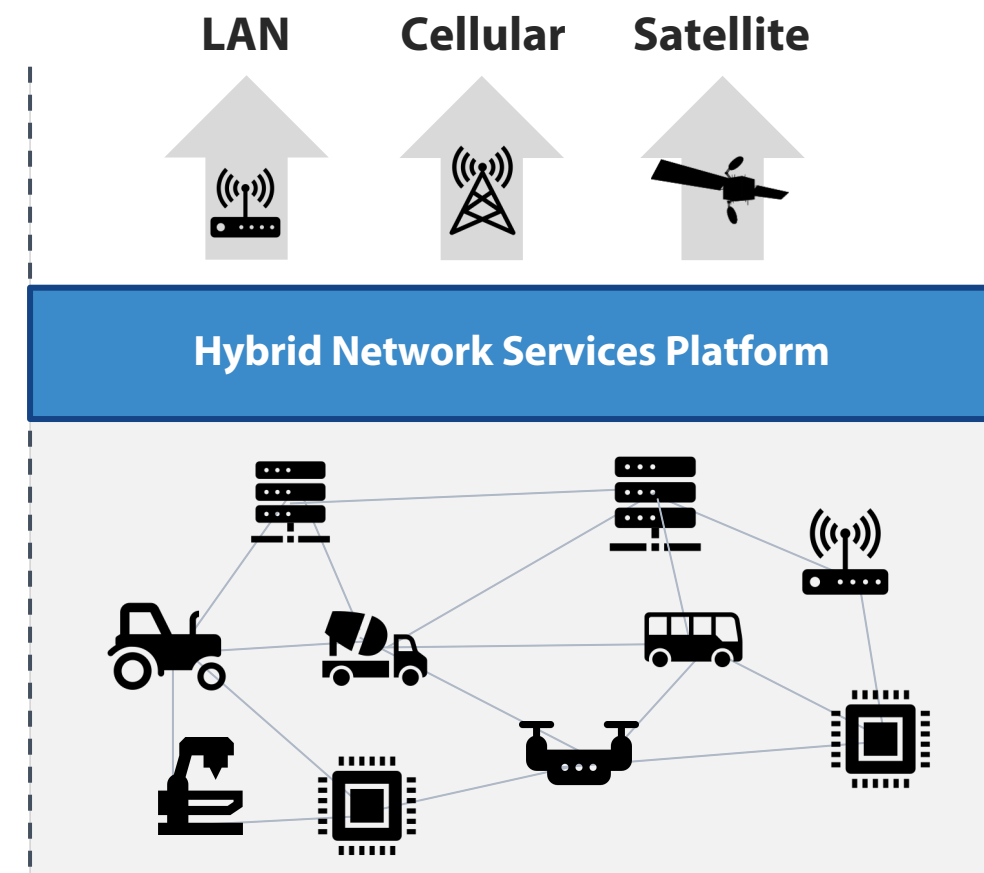
Emergence of 5G Promises to Solve Wireless Performance Issues

Technologies like 5G introduce new services capabilities to extend wireless into previously untapped industries and operations, enabled by networking innovations such as network slicing and dynamic spectrum access technologies

Network Requirements

Complexity of Applications

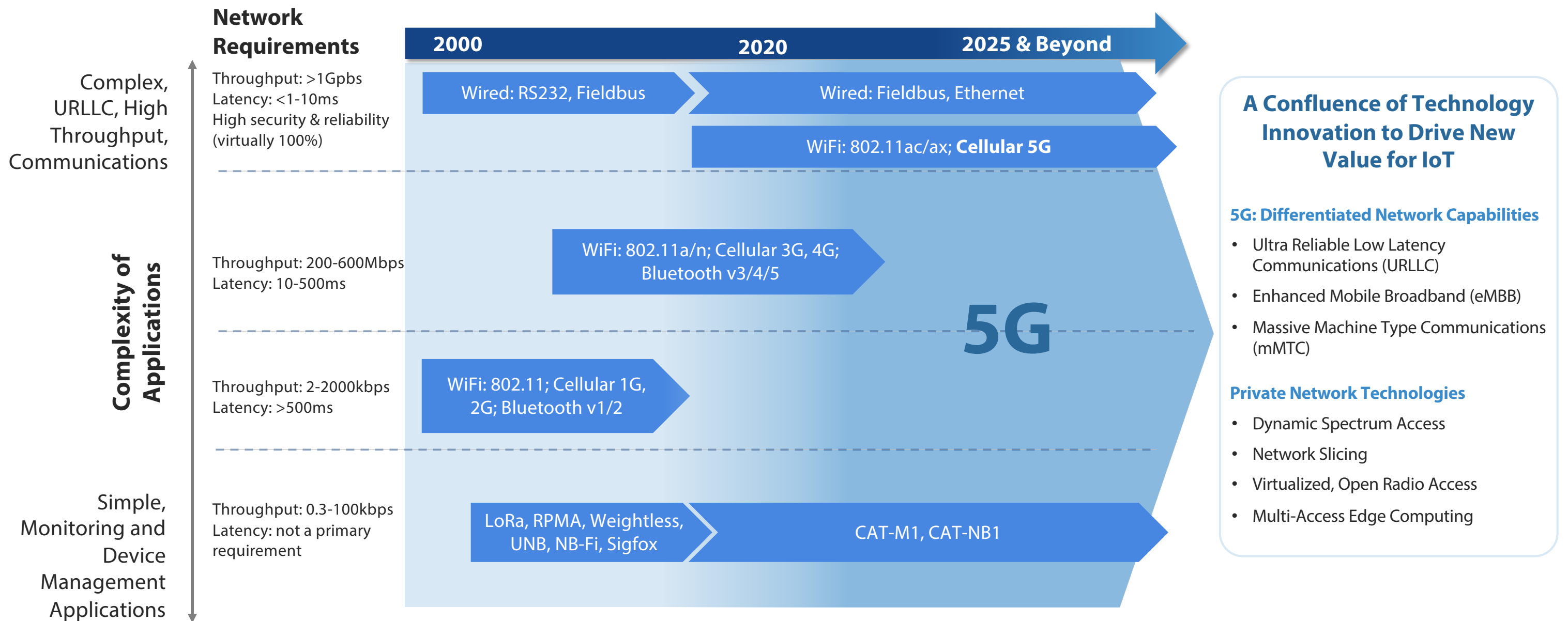|	2000	2020	2025 & Beyond

Complex, URLLC, High Throughput, Communications
Throughput: >1Gpbs
Latency: <1-10ms
High security & reliability (virtually 100%)

Wired: RS232, Fieldbus → Wired: Fieldbus, Ethernet

WiFi: 802.11ac/ax; **Cellular 5G**

Throughput: 200-600Mbps
Latency: 10-500ms

WiFi: 802.11a/n; Cellular 3G, 4G; Bluetooth v3/4/5

5G

Throughput: 2-2000kbps
Latency: >500ms

WiFi: 802.11; Cellular 1G, 2G; Bluetooth v1/2

Simple, Monitoring and Device Management Applications
Throughput: 0.3-100kbps
Latency: not a primary requirement

LoRa, RPMA, Weightless, UNB, NB-Fi, Sigfox → CAT-M1, CAT-NB1

A Confluence of Technology Innovation to Drive New Value for IoT

5G: Differentiated Network Capabilities
- Ultra Reliable Low Latency Communications (URLLC)
- Enhanced Mobile Broadband (eMBB)
- Massive Machine Type Communications (mMTC)

Private Network Technologies
- Dynamic Spectrum Access
- Network Slicing
- Virtualized, Open Radio Access
- Multi-Access Edge Computing

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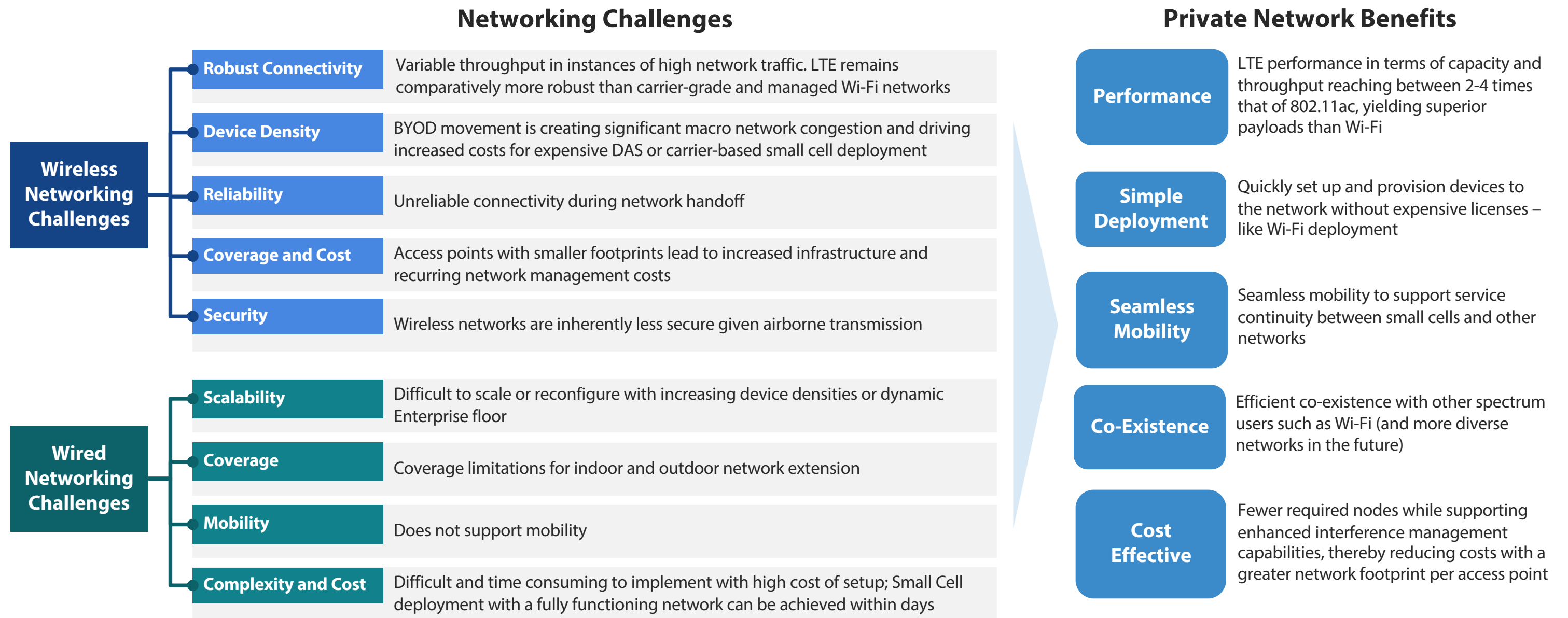# Private LTE Networks Play a Key Role in Future IoT & 5G Adoption

Private wireless networks are cellular networks **dedicated to a specific enterprise, venue or geographic area**, leveraging flexible spectrum access technologies with the ability to operate over unlicensed, shared and licensed spectrum

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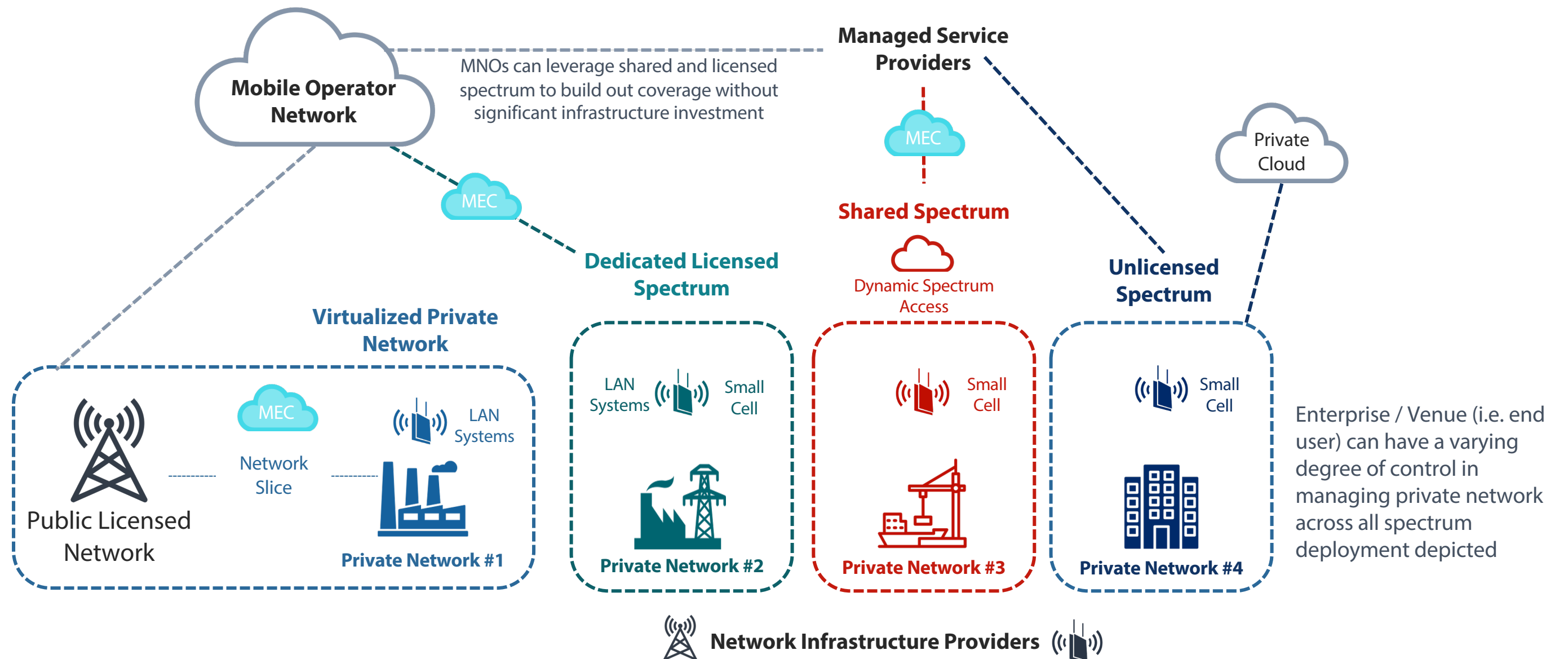
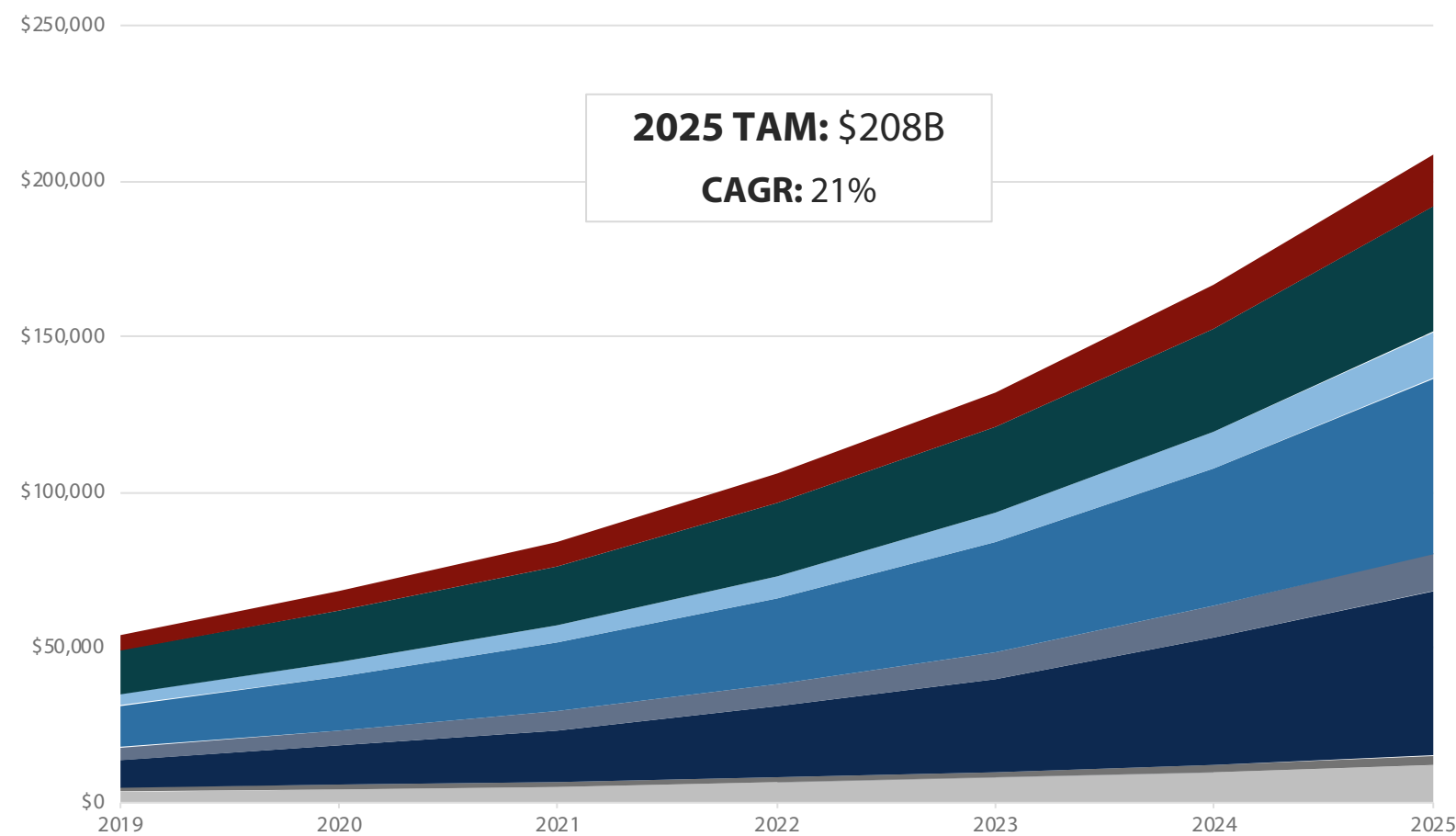# Private Networks Harness Untapped Value, Addressing Key Challenges

The benefits of Private and Neutral Host networks directly address challenges such as device density, user mobility, infrastructure and ongoing management costs, and network security

Networking Challenges

Wireless Networking Challenges

Robust Connectivity	Variable throughput in instances of high network traffic. LTE remains comparatively more robust than carrier-grade and managed Wi-Fi networks
Device Density	BYOD movement is creating significant macro network congestion and driving increased costs for expensive DAS or carrier-based small cell deployment
Reliability	Unreliable connectivity during network handoff
Coverage and Cost	Access points with smaller footprints lead to increased infrastructure and recurring network management costs
Security	Wireless networks are inherently less secure given airborne transmission

Wired Networking Challenges

Scalability	Difficult to scale or reconfigure with increasing device densities or dynamic Enterprise floor
Coverage	Coverage limitations for indoor and outdoor network extension
Mobility	Does not support mobility
Complexity and Cost	Difficult and time consuming to implement with high cost of setup; Small Cell deployment with a fully functioning network can be achieved within days

Private Network Benefits

Performance	LTE performance in terms of capacity and throughput reaching between 2-4 times that of 802.11ac, yielding superior payloads than Wi-Fi
Simple Deployment	Quickly set up and provision devices to the network without expensive licenses – like Wi-Fi deployment
Seamless Mobility	Seamless mobility to support service continuity between small cells and other networks
Co-Existence	Efficient co-existence with other spectrum users such as Wi-Fi (and more diverse networks in the future)
Cost Effective	Fewer required nodes while supporting enhanced interference management capabilities, thereby reducing costs with a greater network footprint per access point

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Private Networks Create New Revenue Opportunities

Near-term addition in environments with high network performance needs catalyze market growth and create demand for new network services

Private Wireless Networks TAM ($USD Millions)

2025 TAM: $208B

CAGR: 21%

Legend (TAM chart):
- Buildings & Facilities
- Consumer IT
- Healthcare
- Industrial Manufacturing
- Infrastructure
- Resources
- Retail, Commercial & Institutional Services
- Professional IT
- Transportation

Private Wireless Network Services by Revenue Category
(Percentage of Network Services Revenues)

2025 (outer ring): 17%, 18%, 36%, 5%, 9%, 17%, 12%, 8%, 4%
2019 (inner ring): 40%, 28%, 6%
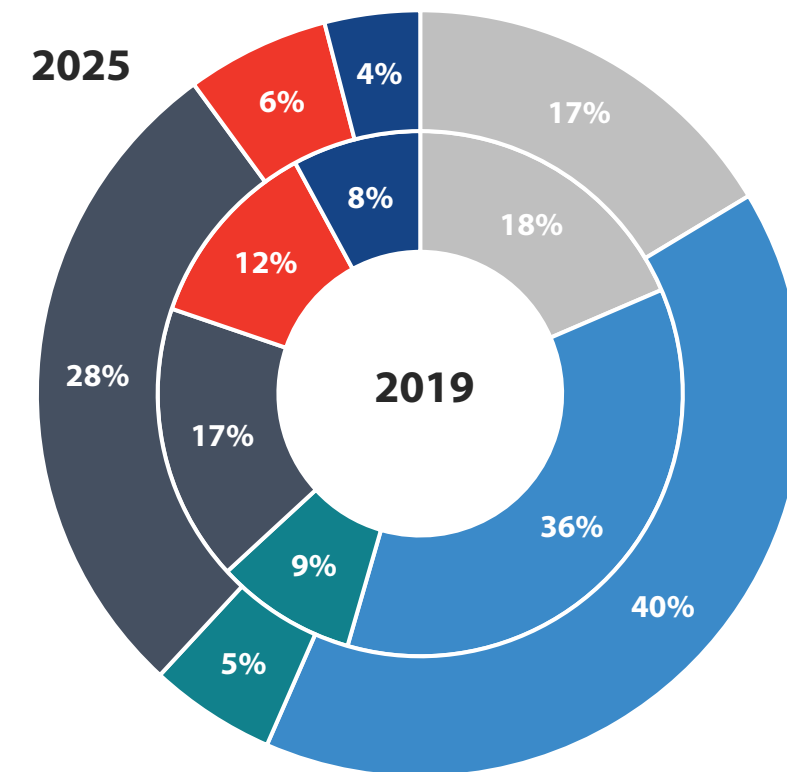
Legend (donut chart):
- Data Service
- Network Management
- Provisioning & Commissioning
- Network Security
- Network Service Orchestration
- Other Network Services

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Players are Organizing To Capture Value of High-Performance Networks

While some operators are taking initiatives to expand into adjacent network services, only a short-list of players are addressing the need to fully manage and operate high performance, wide area networks & emerging private LAN

- **Satellite:** New terminal technologies enable operators to access new markets
- **WWAN:** Significant investment in 5G for complex applications and LPWAN for simple IoT applications

- **Platform & Data Management:** Solutions for private network to enable distributed edge-cloud deployments
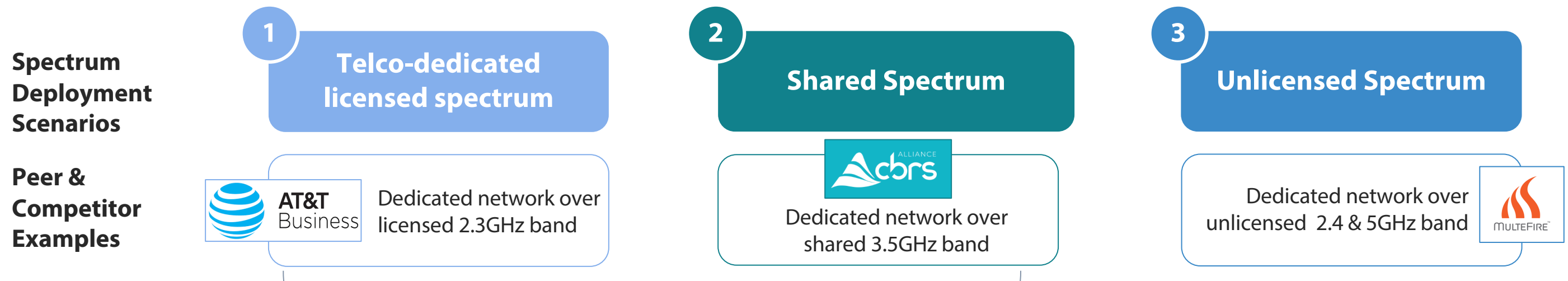- **Applications:** Analytics and machine learning tools to optimize combinations of networks for specific assets
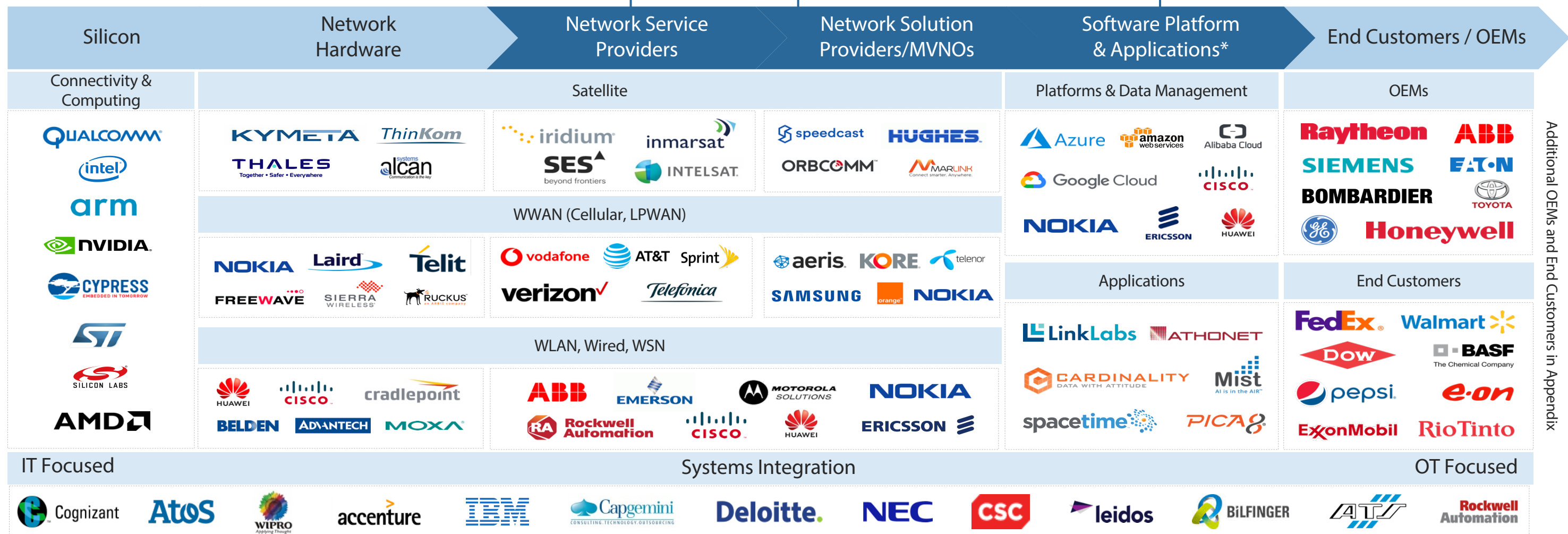
*When mapping to revenue categories, Platforms & Data Mgmt. largely falls in System Applications, and Applications largely falls in Value-Added Applications. One notable exception to this is CSPs (i.e. Google Cloud) which is segmented into Value-Added Applications given their proximity to AI, ML and other apps

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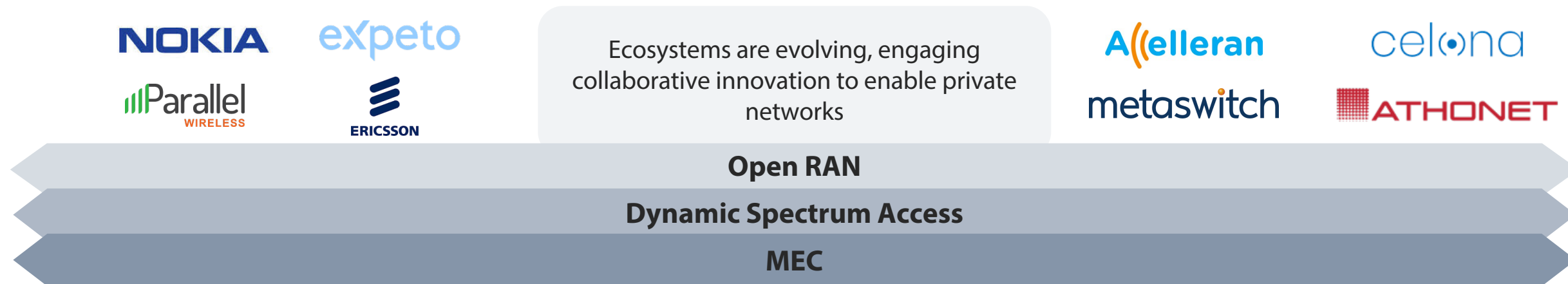# Stakeholders are Innovating Around New Spectrum Access Technologies

Network ownership and management varies across the three spectrum deployment scenarios with ownership shifting towards the enterprise and managed service providers (e.g. Neutral host vendor)

Private Cellular Network Deployments

Spectrum Deployment Scenarios

1	2	3
Telco-dedicated licensed spectrum	**Shared Spectrum**	**Unlicensed Spectrum**

Peer & Competitor Examples

AT&T Business — Dedicated network over licensed 2.3GHz band

cbrs ALLIANCE — Dedicated network over shared 3.5GHz band

Dedicated network over unlicensed 2.4 & 5GHz band — MULTEFIRE

Many players, particularly telcos, are focused on expanding capabilities around licensed and shared spectrum as unlicensed spectrum access technologies mature

Ecosystem Readiness

NOKIA   eXpeto   Acelleran   celona

Parallel WIRELESS   ERICSSON   metaswitch   ATHONET

Ecosystems are evolving, engaging collaborative innovation to enable private networks

Open RAN

Dynamic Spectrum Access

MEC

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Collaboration With Ecosystem is Critical to Network Innovation

Critical partnerships spanning the value chain are driving the R&D needed to actualize end-to-end, holistic wireless solutions

Hardware		Software & Platforms		Operational Device
Silicon & Modules	**Network Equipment & Infrastructure**	**Connectivity Services**	**Software & Platform Services**	**Machinery & Equipment**
• Key enabling components for smart devices and machinery • Integrated processing to support distributed intelligence	• Backbone for connected services, driving robust connectivity platforms within and across operational sites	• Pipeline to facilitate the exchange of data • Managed services ensuring network uptime and performance optimization	• Data transformation and value added services driving the monetization of distributed, smart device and equipment networks	• Operational devices and equipment integrating every element of the value chain • Key value chain segment that defines adoption & smart system propagation

Ericsson's initiative to drive partnerships and alliance with OEMs illustrative the strategic development of network and equipment integration to drive the next generation of smart value added applications.

While challenges around proprietary functionality, the orchestration of GE's Predix platform services with emerging Private LTE and 5G technologies will drive adoption with easy, simple integration with industrial systems.

The partnership with Ericsson and alliance surrounding the 5G Industrial Innovation Lab will support ecosystem collaboration to identify and specify connectivity solutions for haptic feedback and cloud robotics.

Connectivity hardware specified for data intensive, mission critical robotics applications will help evolve cloud based solutions for machine control and automation over flexible wireless networks.

Ericsson struck a deal to acquire CENX, a service orchestration provider, to bolster its automation capabilities as operators move ahead with virtualization with aims to automate 5G networks.

Pivotel implemented Expeto's Nextworking solution to allow trucks to roam between a private mobile network at the mine site and public mobile networks, providing continuous monitoring of asset location and telemetry.

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Private LTE & 5G Networks Market Model Elements

Devices & Sites	Regions	Years	Revenue Opportunity Categories	Market Segments

• **Devices Shipped** (New & Retrofitted Equipment)
 	
• **Devices Installed** (Existing Equipment)
 	
• **Sites**
	• **North America**
	• **Europe**
	• **Asia Pacific**
	• **ROW**
		• 2019
		• 2020
		• 2021
		• 2022
		• 2023
		• 2024
		• 2025
			• **Enablement/Connectivity**
			  ○ Wired
			  ○ WWAN
			    ○ CBRS (North America only)
			    ○ LTE
			    ○ Private 5G
			    ○ Multefire
			  ○ WPAN
			  ○ WLAN
			  ○ Computing
			
			• **Professional Services (Design/Installation, Maintenance/Upgrades)**
			
			• **Network Services**
			  ○ Wired
			  ○ WWAN
			    ○ CBRS (North America only)
			    ○ LTE
			    ○ Private 5G
			    ○ Multefire
			  ○ WPAN
			  ○ WLAN
			
			• **System Applications & Value-Added Applications**
				• **Consumer**
				  ○ Consumer IT Devices
				• **Healthcare**
				  ○ Health Delivery (Hospitals, Labs & Clinics)
				  ○ Mobile/Personal Healthcare
				• **Retail**
				  ○ Warehousing
				  ○ Distribution & Logistics
				• **Industrial Manufacturing**
				  ○ Discrete
				  ○ Hybrid/Converting
				  ○ Process
				• **Smart Cities**
				  ○ Transportation & Pedestrian Infrastructure
				• **Resources**
				  ○ Mining
				  ○ Oil & Gas
				  ○ Agriculture
				  ○ Water Utilities
				  ○ Power Utilities
				• **Transportation**
				
				• **Professional IT**

TAM

Public 5G TAM

Private 5G TAM

Private IoT TAM
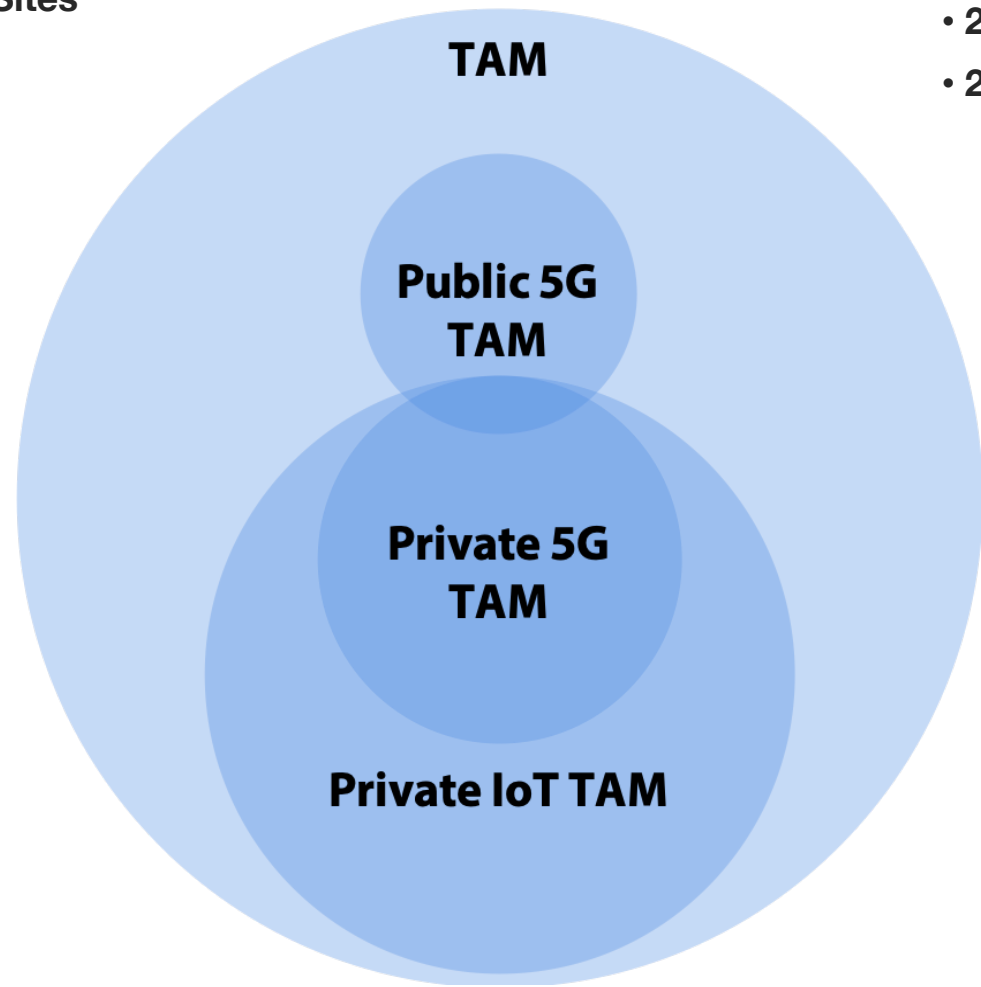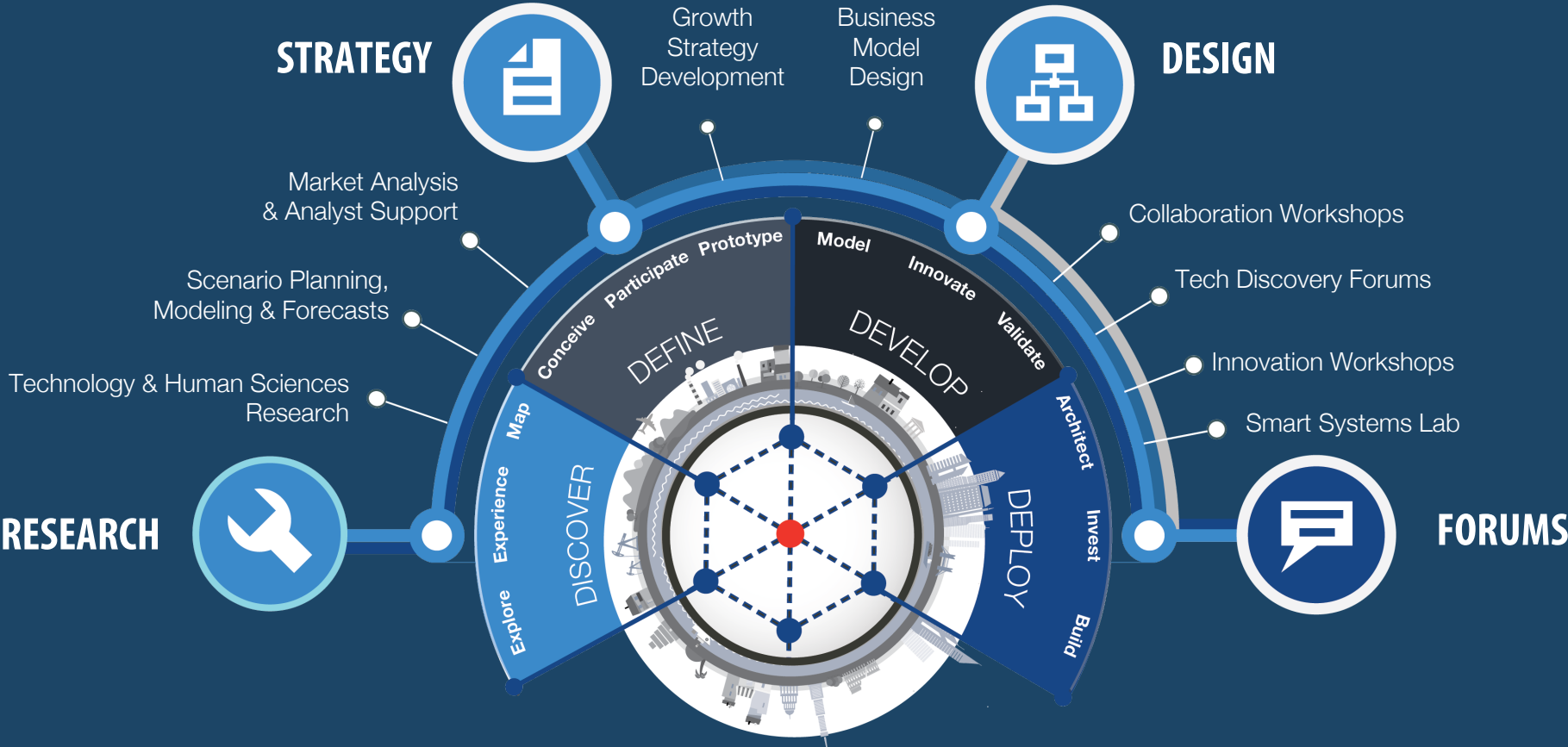
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Harbor Research has over thirty years of experience working with clients on growth strategy and new business creation. At the core of Harbor's approach is a deep understanding of the core technologies, markets and business characteristics as well as the management and organizational challenges companies face adopting and developing digital and smart systems technologies. We strive to generate deep insight into how emergent technologies drive value creation and competitive advantage in our clients' businesses and the economy as a whole.

CONTACT

info@harborresearch.com

p: +1 303.786.9000 x22

www.harborresearch.com