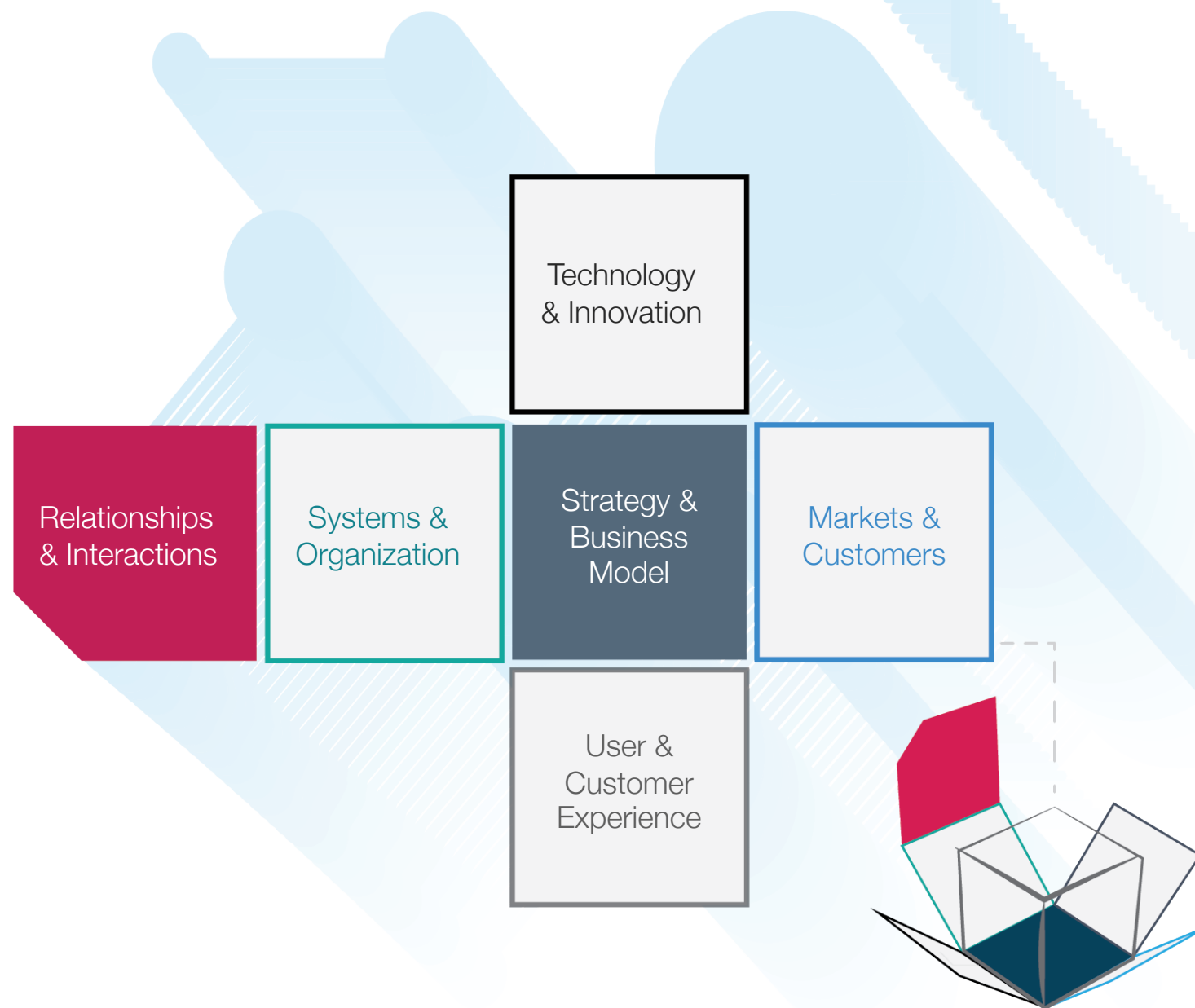


market
opportunity
overview

The Advent of Private LTE and 5G Networks

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.

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

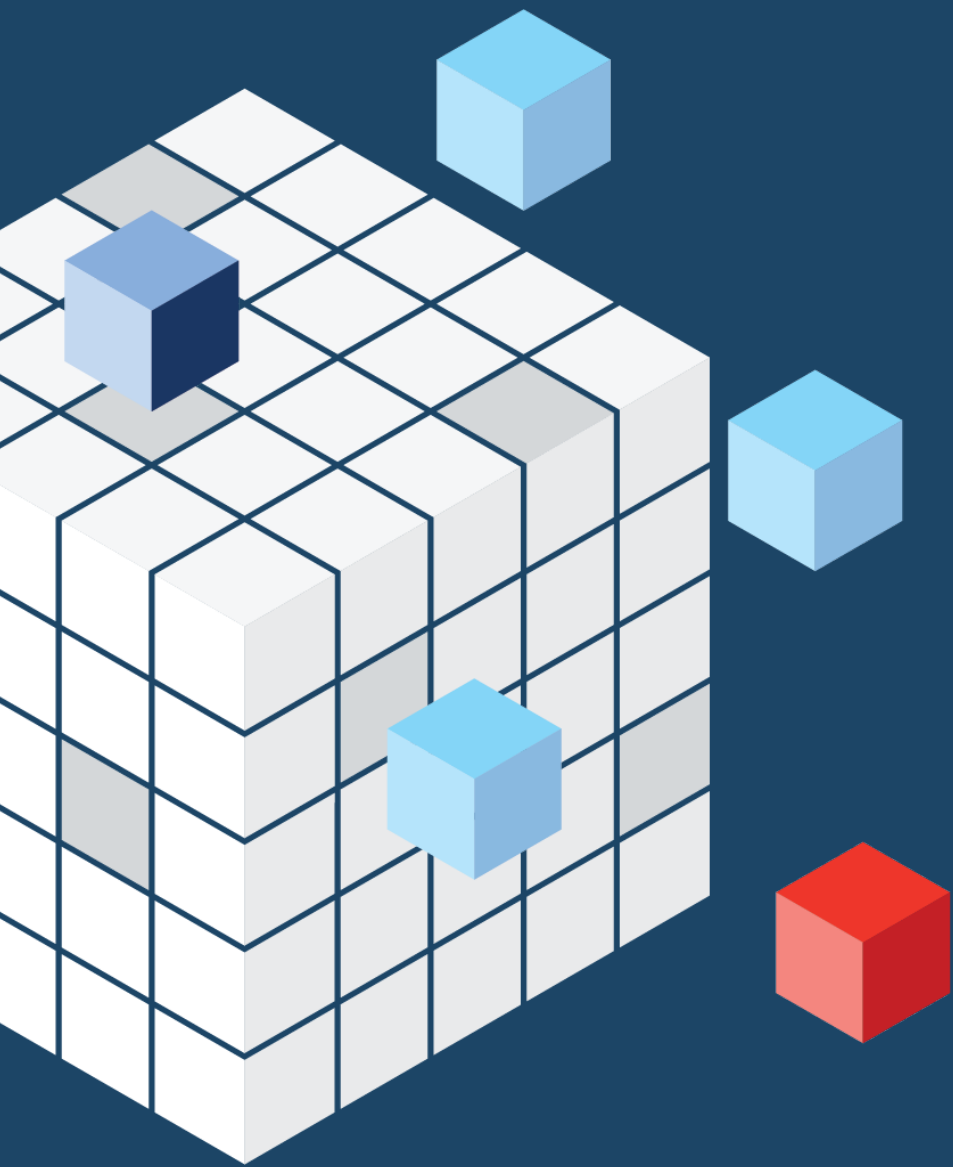
The revenue opportunity for private networks and related IoT enablement, software and services will be over \$200 billion by 2025, as they address coverage, security, latency, reliability, and cost issues associated with applying existing wired and wireless networks to IoT.

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.

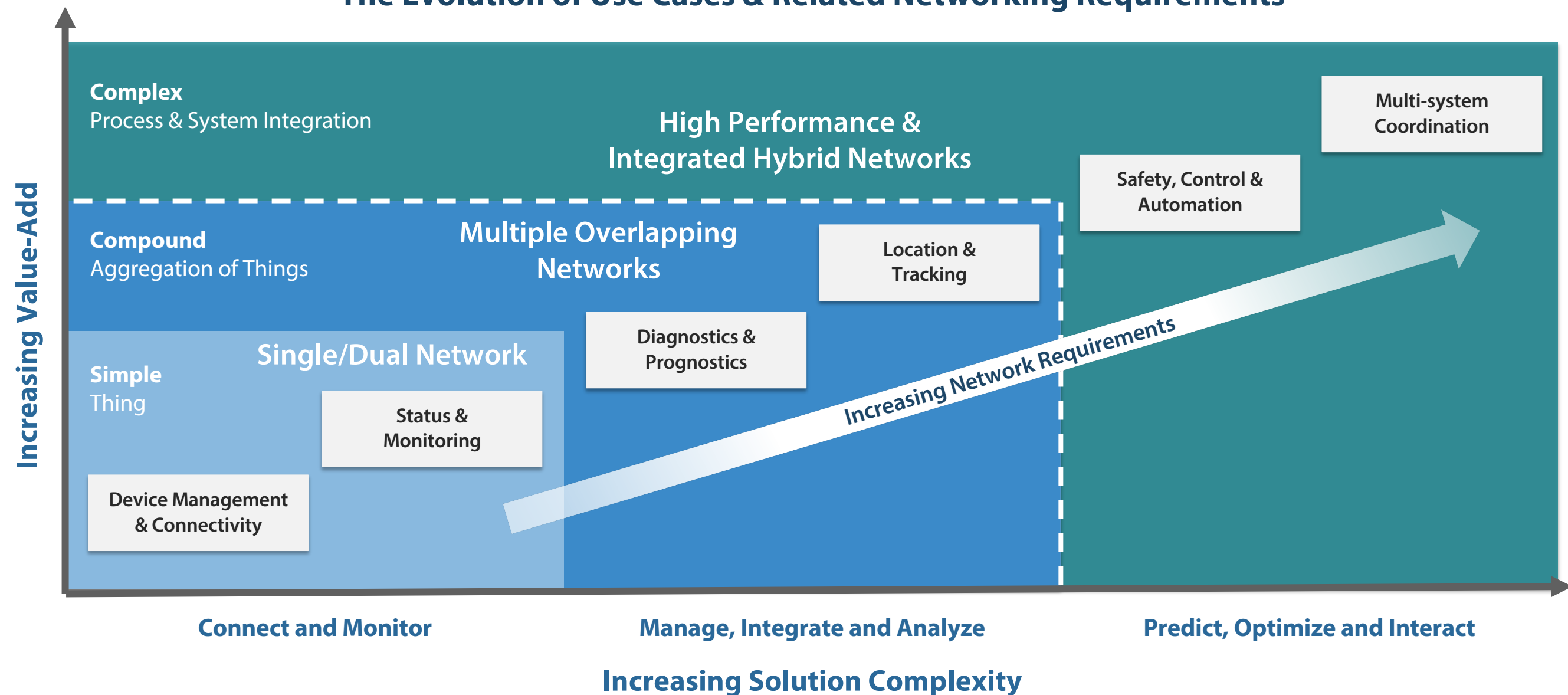


Framing the Private LTE and 5G Networks Market Opportunity

Networks Must Evolve to Address Increasingly Complex Applications

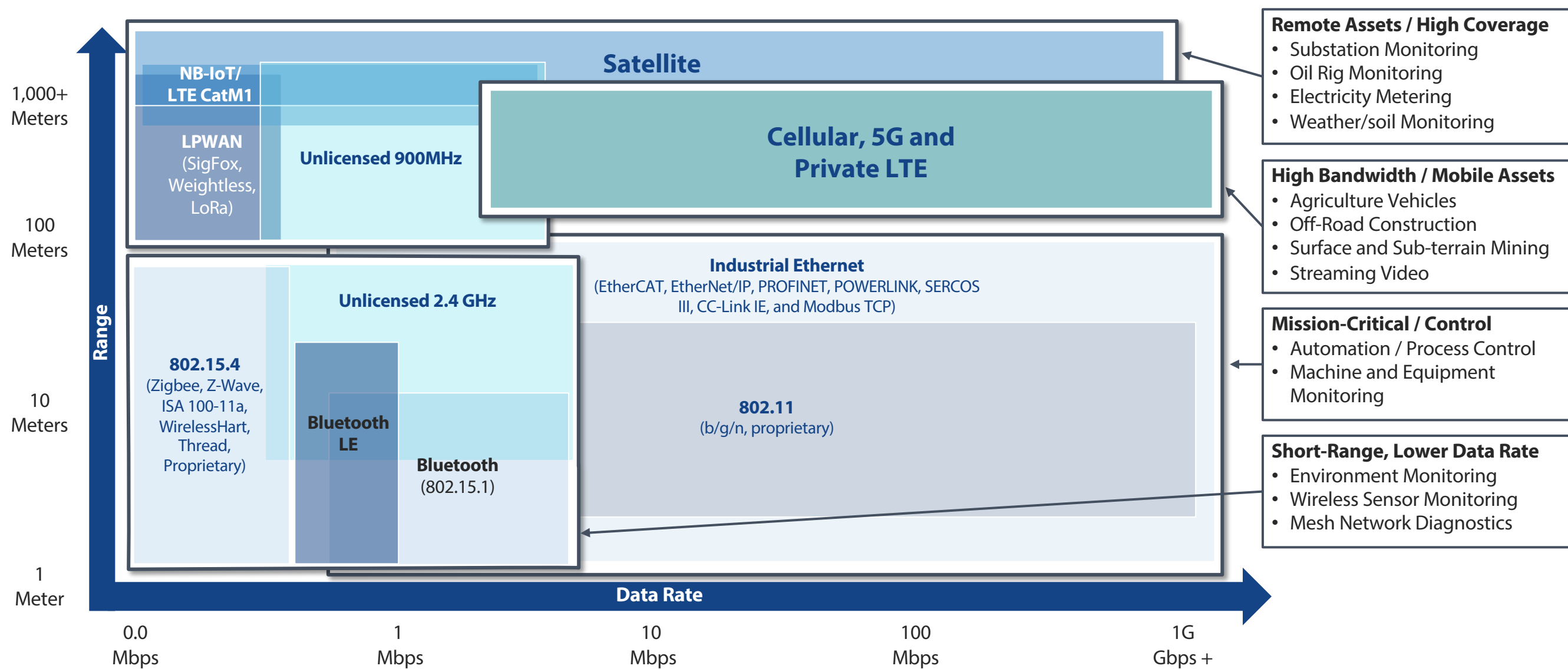
Higher performance networks are required enable a new generation of applications, giving rise to an increasingly complex set of interactions of data between device, machine and human processes

The Evolution of Use Cases & Related Networking Requirements



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

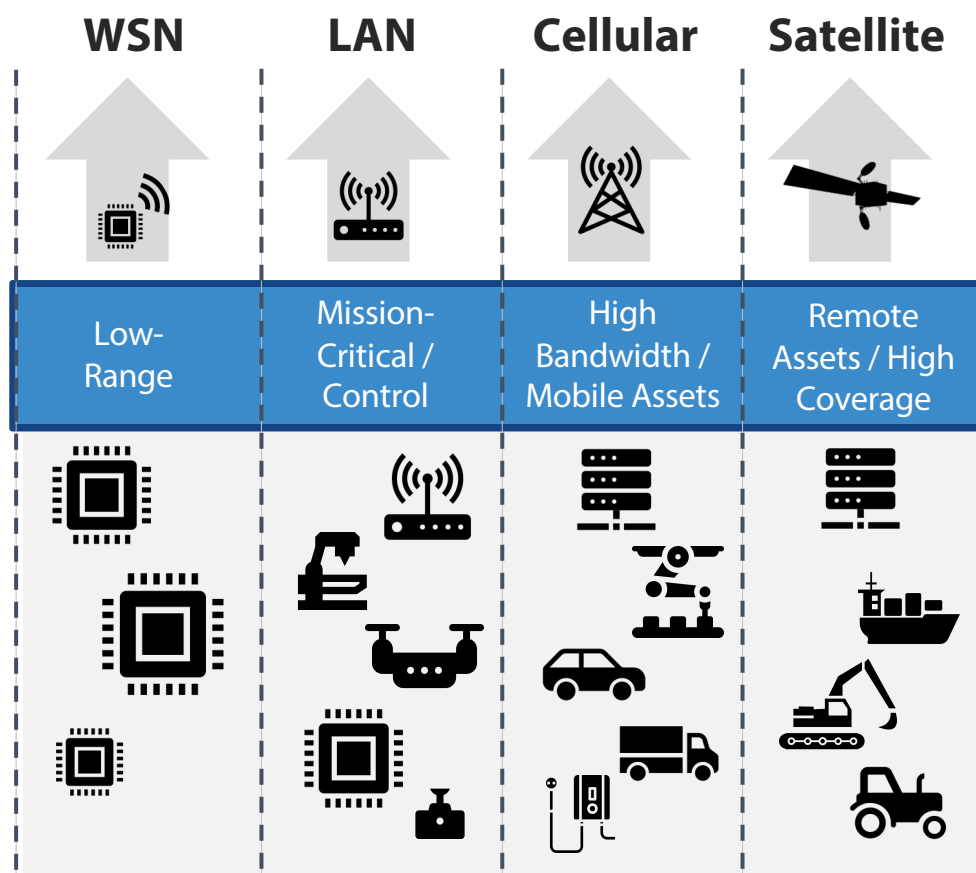


Integrated, Hybrid Network Services Enable Seamless Orchestration

Private network services 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

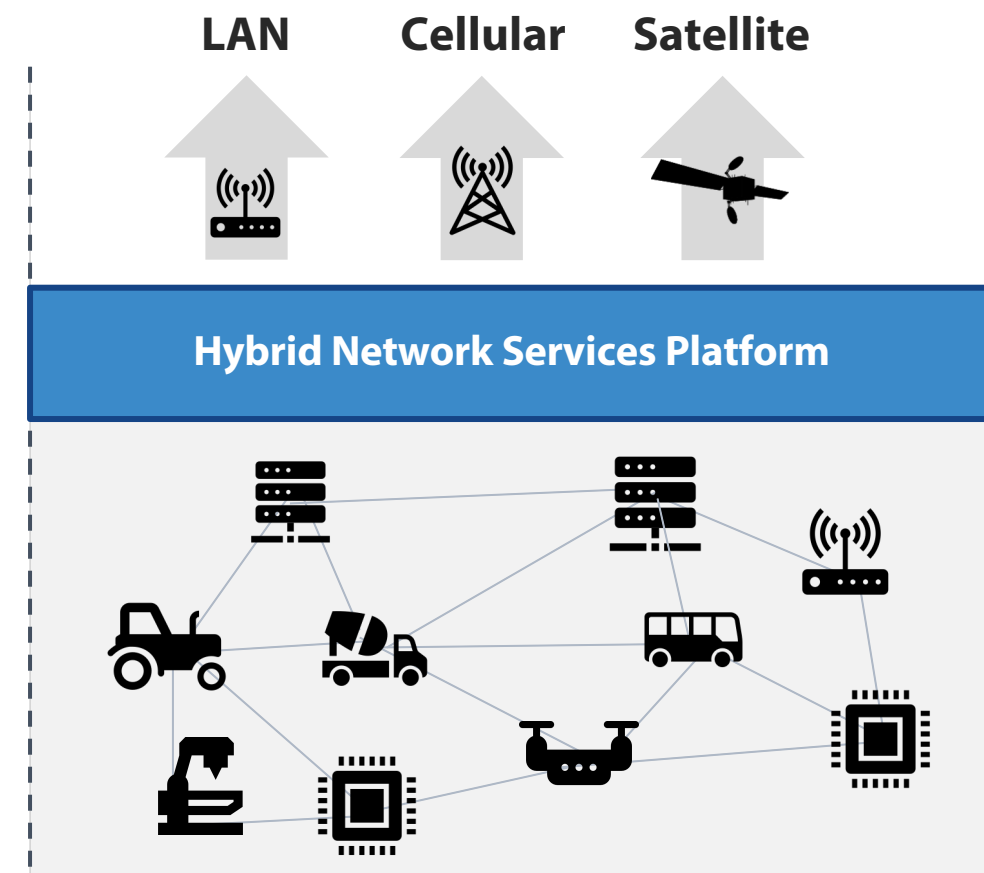


Key Enablers

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

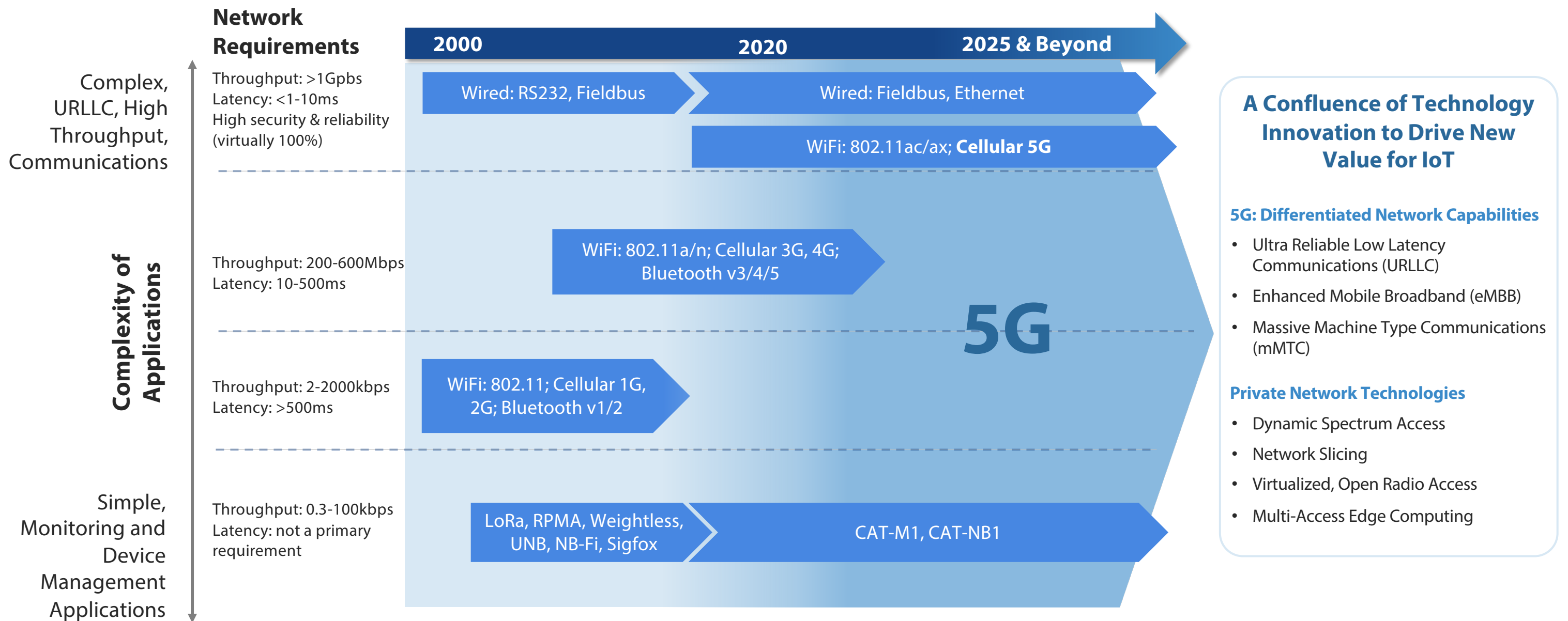
Future State of Hybrid Network Services

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



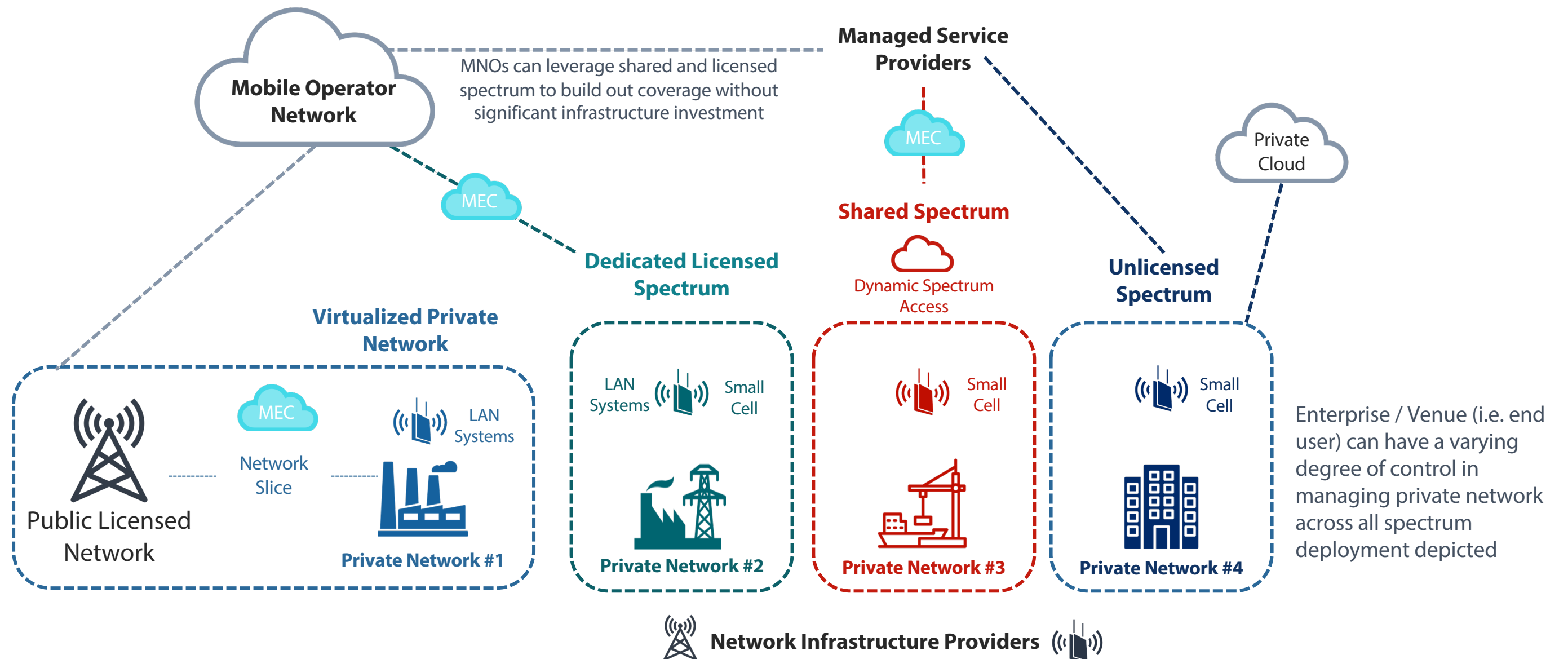
Emergence of 5G Promises to Solve Wireless Performance Issues

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



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

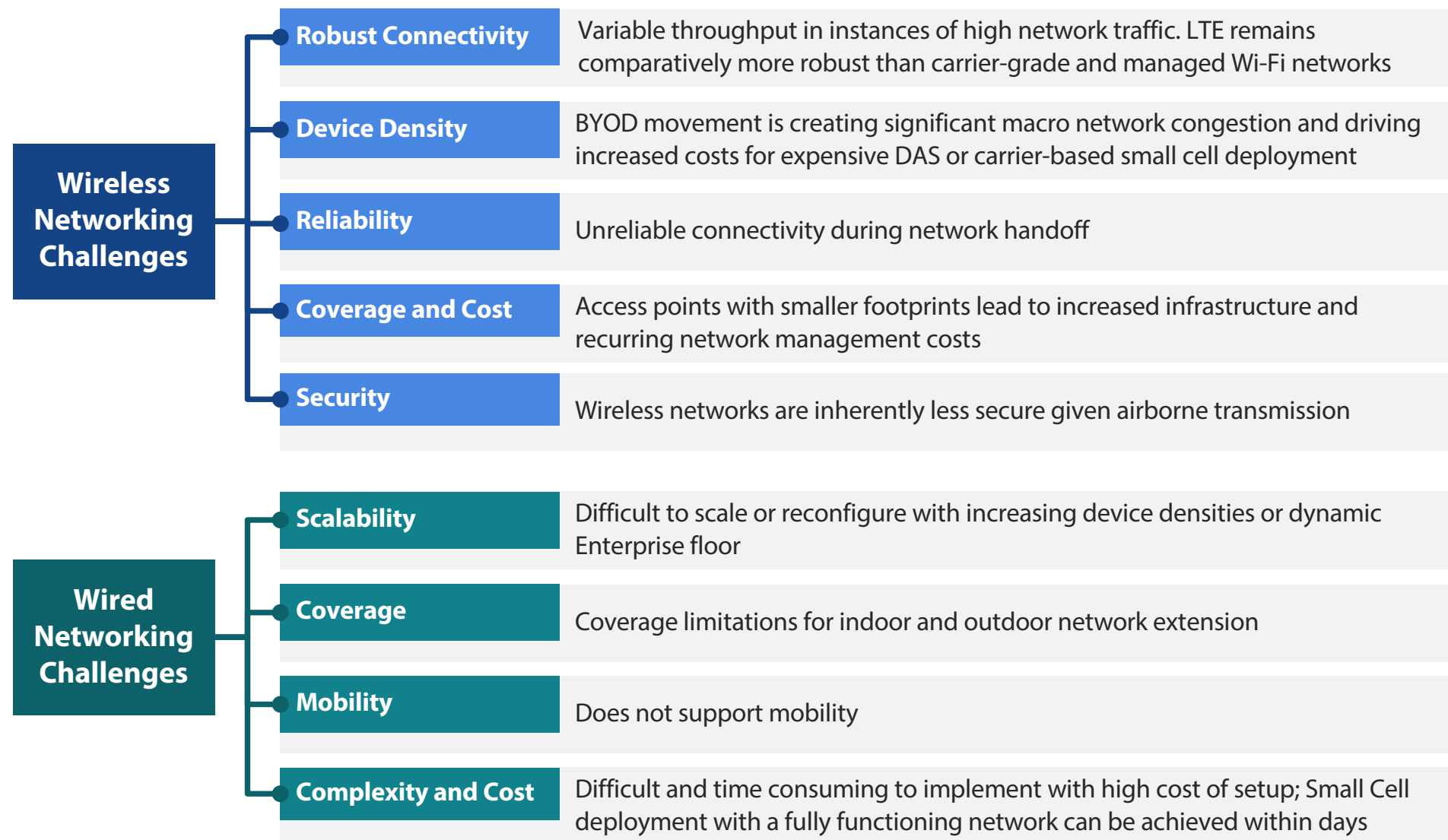
Private wireless networks are cellular networks **dedicated to a specific enterprise, venue or geographic area**, leveraging flexible spectrum access technologies with the ability to operate over unlicensed, shared and licensed spectrum



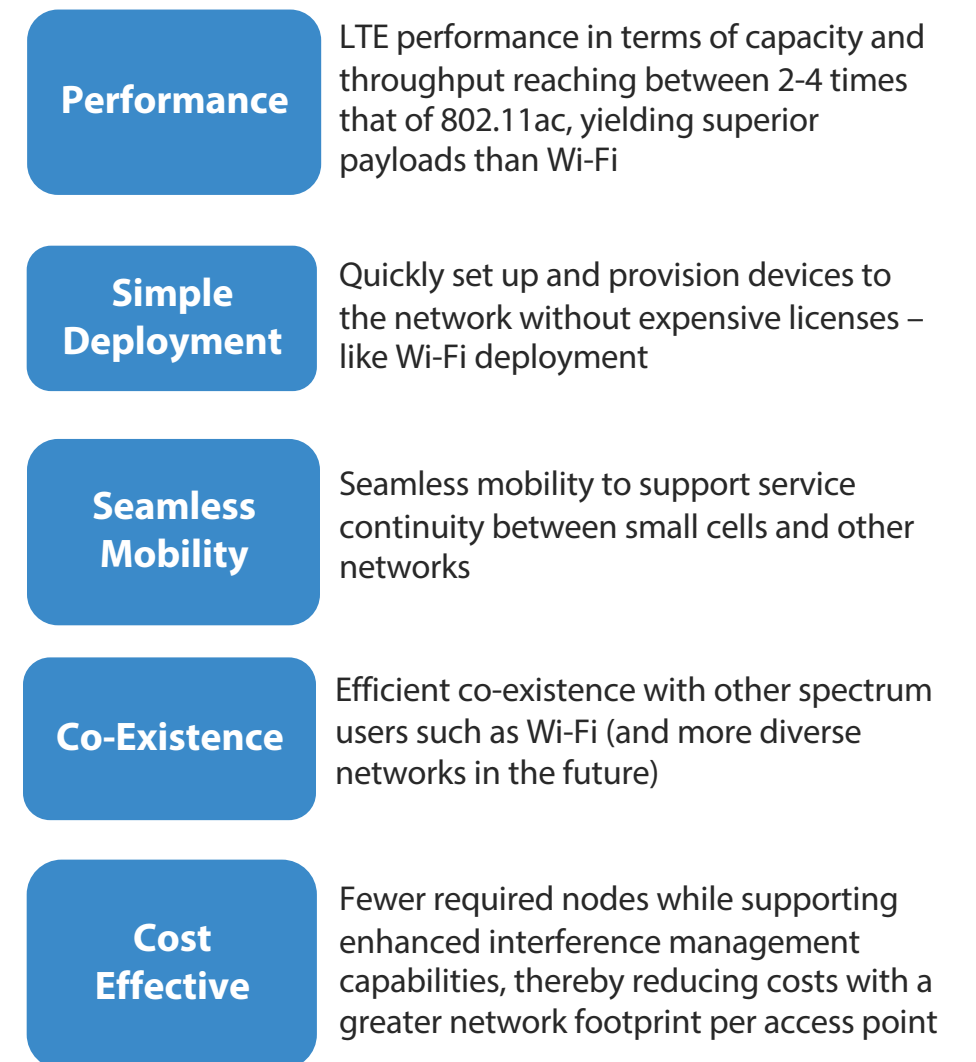
Private Networks Harness Untapped Value, Addressing Key Challenges

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



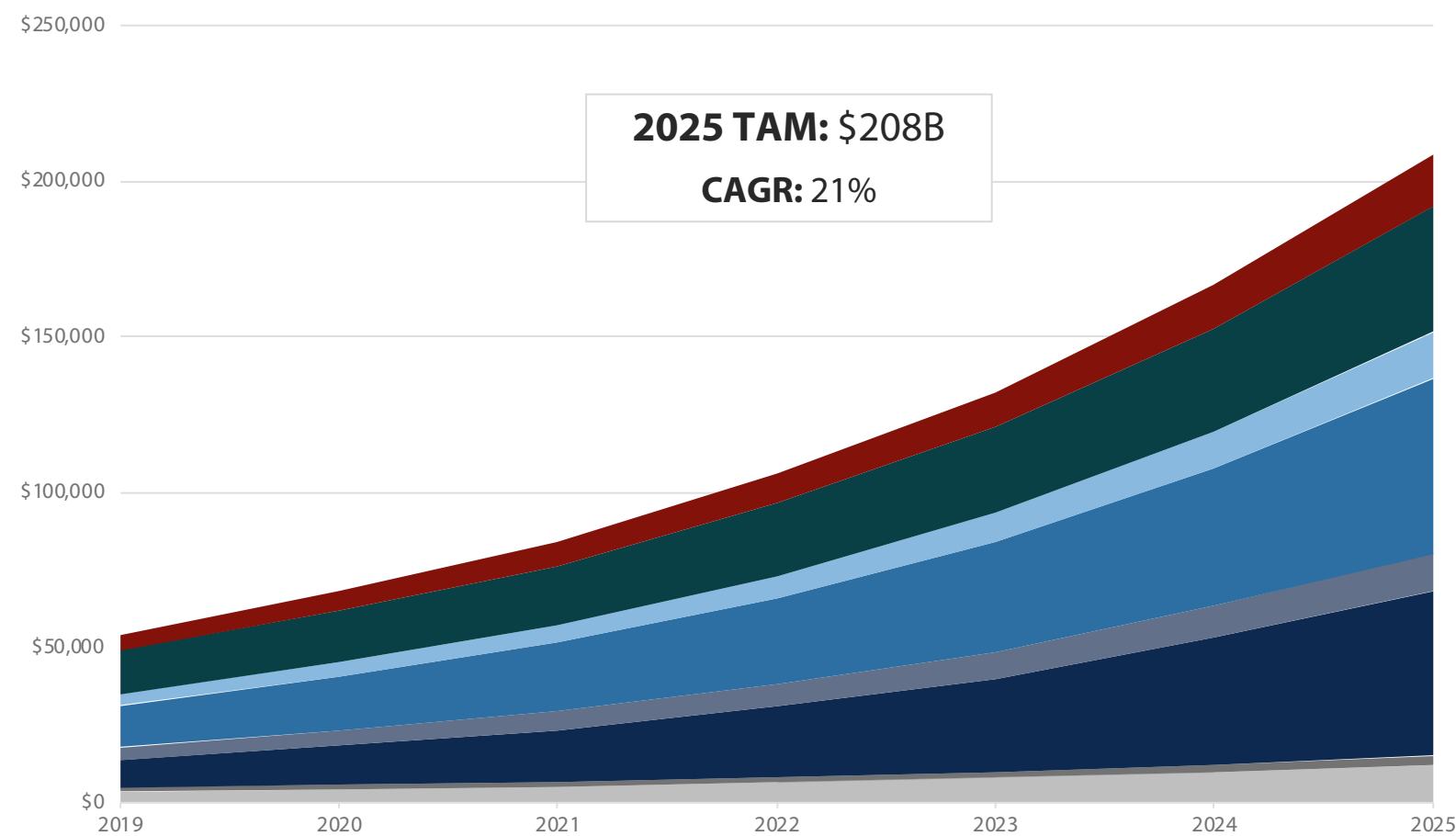
Private Network Benefits



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

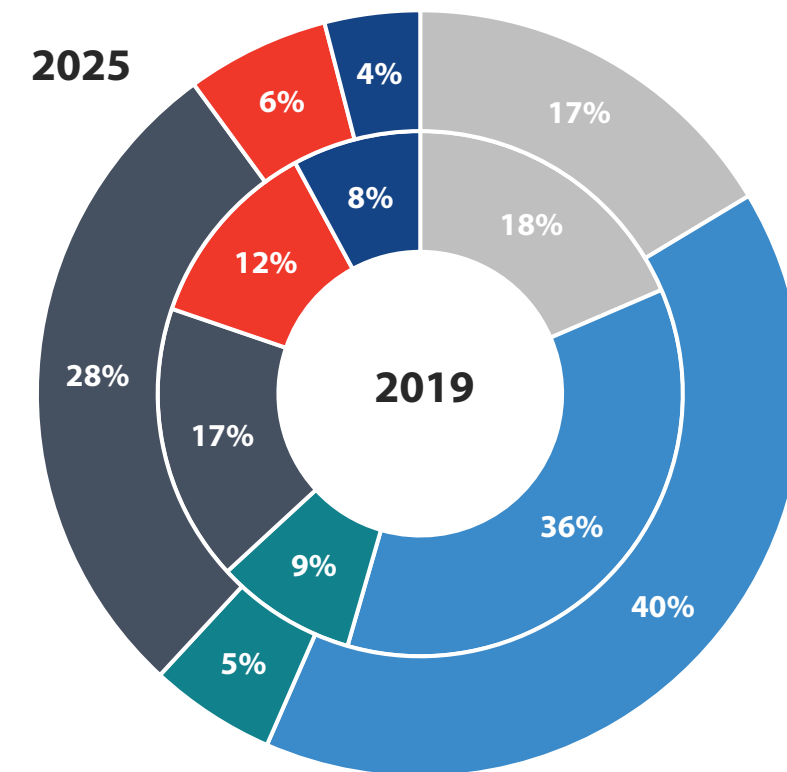
Private Wireless Networks TAM (\$USD Millions)



- 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)



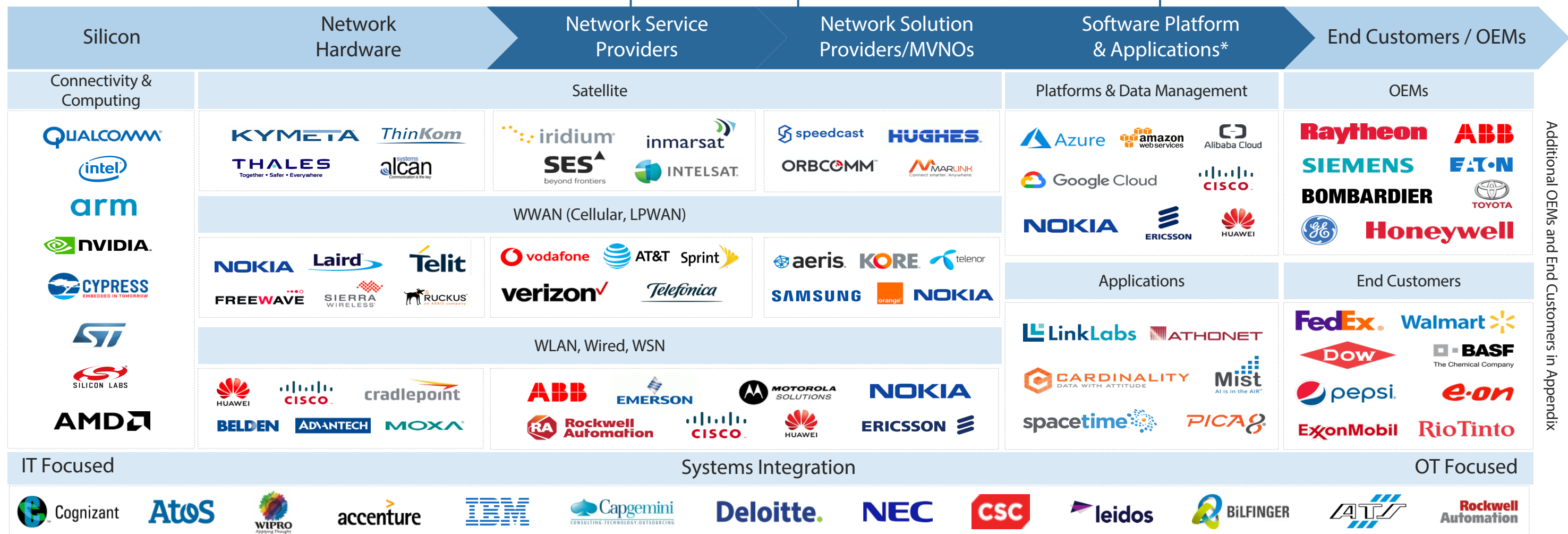
- Data Service
- Network Management
- Provisioning & Commissioning
- Network Security
- Network Service Orchestration
- Other Network Services

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



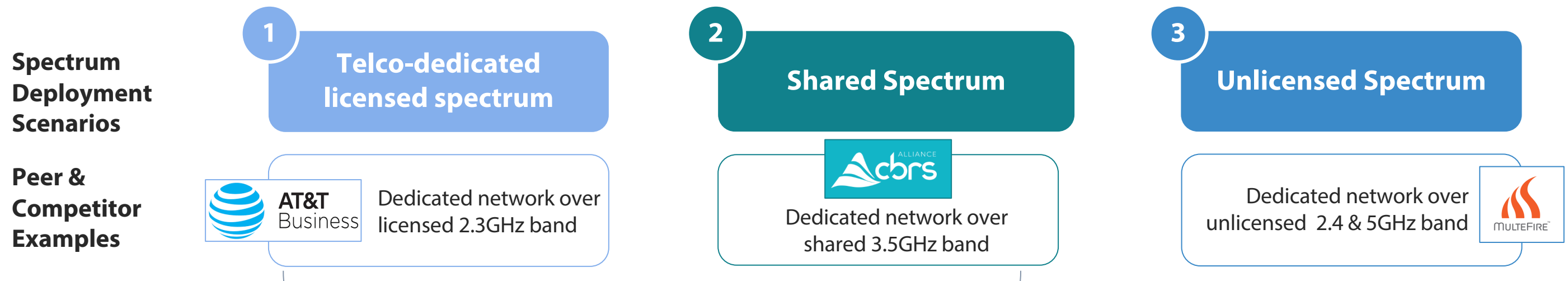
Additional OEMs and End Customers in Appendix

*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

Stakeholders are Innovating Around New Spectrum Access Technologies

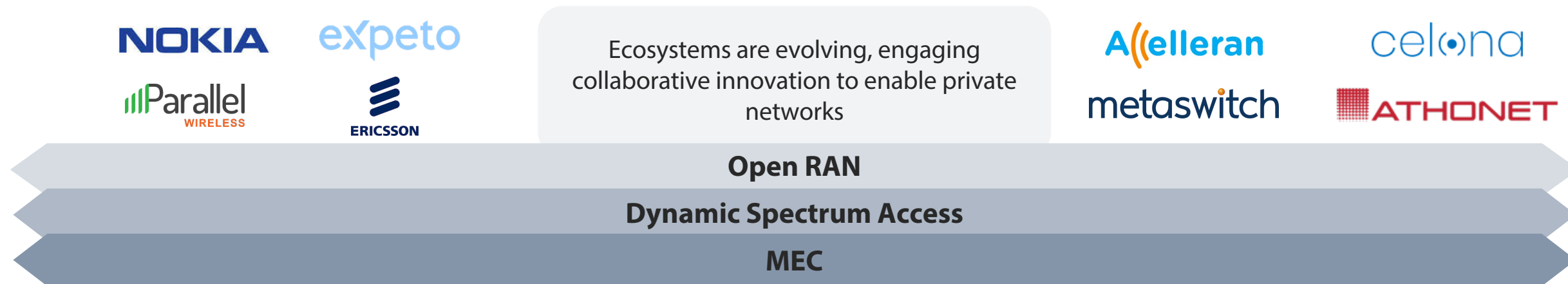
Network ownership and management varies across the three spectrum deployment scenarios with ownership shifting towards the enterprise and managed service providers (e.g. Neutral host vendor)

Private Cellular Network Deployments



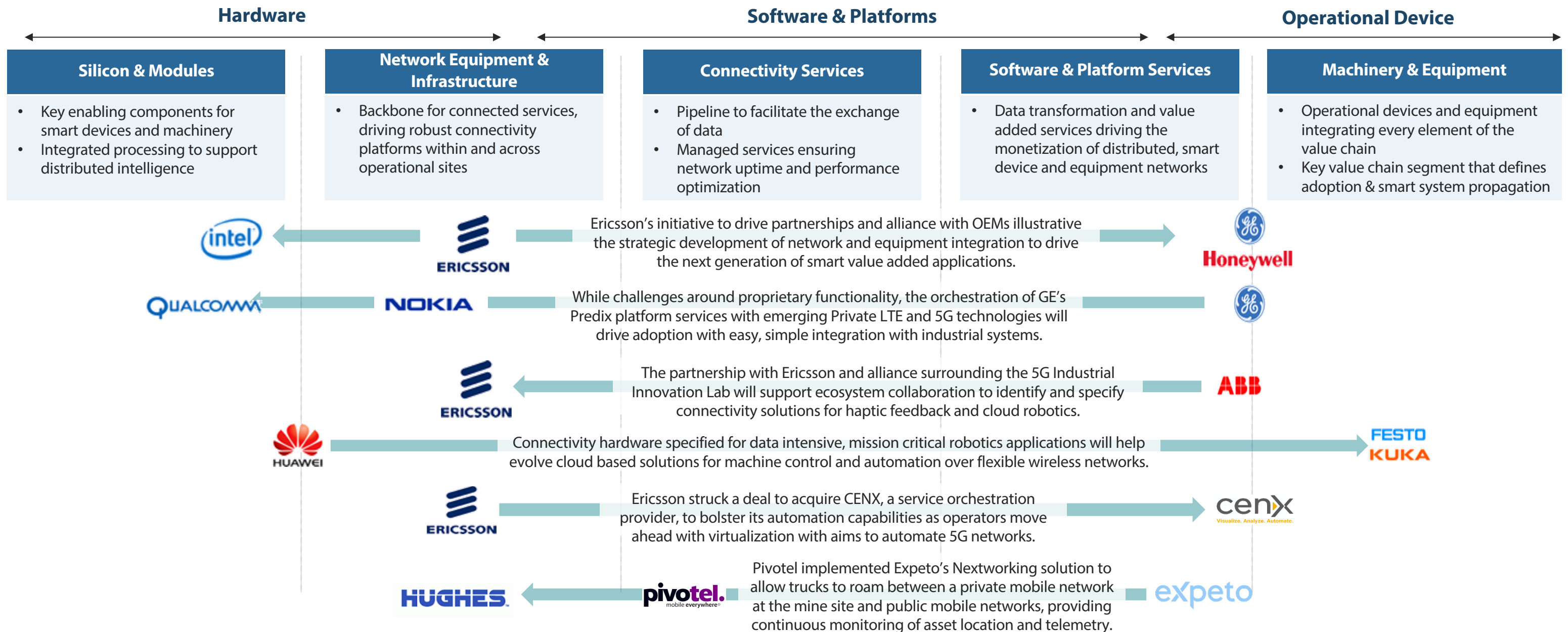
Many players, particularly telcos, are focused on expanding capabilities around licensed and shared spectrum as unlicensed spectrum access technologies mature

Ecosystem Readiness



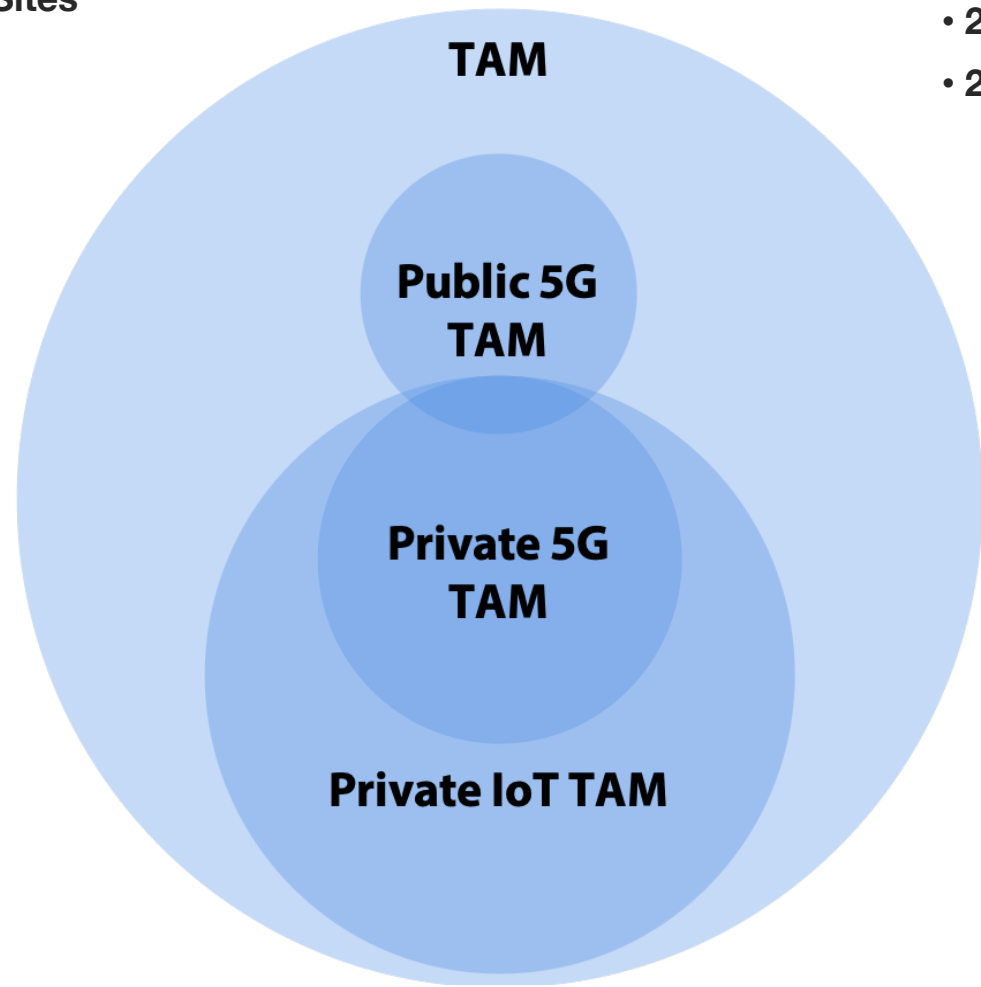
Collaboration With Ecosystem is Critical to Network Innovation

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

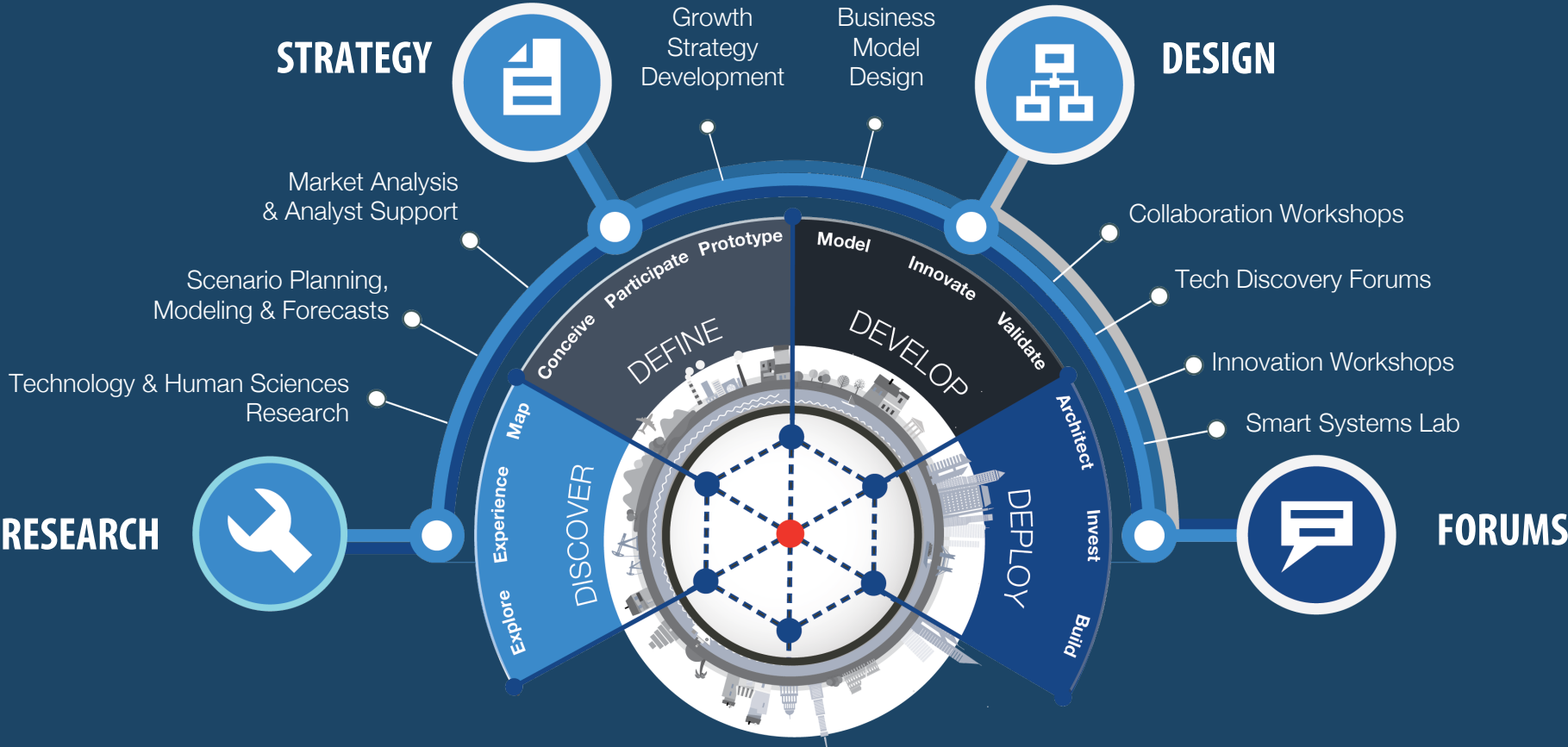


Private LTE & 5G Networks Market Model Elements

Devices & Sites	Regions	Years	Revenue Opportunity Categories	Market Segments
<ul style="list-style-type: none"> • Devices Shipped (New & Retrofitted Equipment) • Devices Installed (Existing Equipment) • Sites 	<ul style="list-style-type: none"> • North America • Europe • Asia Pacific • ROW 	<ul style="list-style-type: none"> • 2019 • 2020 • 2021 • 2022 • 2023 • 2024 • 2025 	<ul style="list-style-type: none"> • Enablement/Connectivity <ul style="list-style-type: none"> ○ Wired ○ WWAN <ul style="list-style-type: none"> ○ CBRS (North America only) ○ LTE ○ Private 5G ○ Multefire ○ WPAN ○ WLAN ○ Computing • Professional Services (Design/Installation, Maintenance/Upgrades) • Network Services <ul style="list-style-type: none"> ○ Wired ○ WWAN <ul style="list-style-type: none"> ○ CBRS (North America only) ○ LTE ○ Private 5G ○ Multefire ○ WPAN ○ WLAN • System Applications & Value-Added Applications 	<ul style="list-style-type: none"> • Consumer <ul style="list-style-type: none"> ○ Consumer IT Devices • Healthcare <ul style="list-style-type: none"> ○ Health Delivery (Hospitals, Labs & Clinics) ○ Mobile/Personal Healthcare • Retail <ul style="list-style-type: none"> ○ Warehousing ○ Distribution & Logistics • Industrial Manufacturing <ul style="list-style-type: none"> ○ Discrete ○ Hybrid/Converting ○ Process • Smart Cities <ul style="list-style-type: none"> ○ Transportation & Pedestrian Infrastructure • Resources <ul style="list-style-type: none"> ○ Mining ○ Oil & Gas ○ Agriculture ○ Water Utilities ○ Power Utilities • Transportation • Professional IT



HarborResearch



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.

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