

smart
systems
research

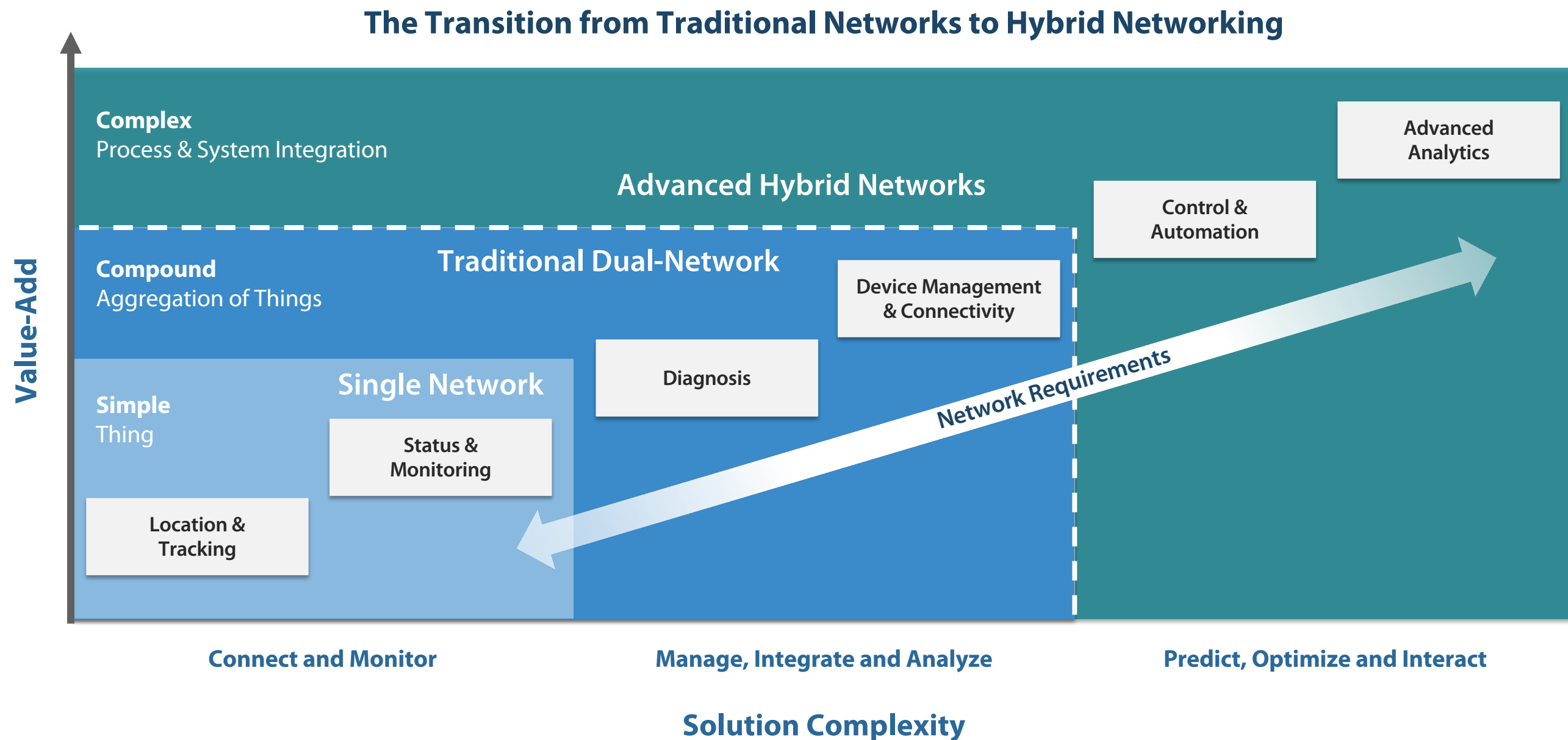
The Advent of Hybrid Networks

Executive Summary

- 1 With the advent of Smart Systems and the Internet of Things, new applications require higher-performance networks. Traditional network service providers are not delivering to customers all their connectivity needs
- 2 Given the installed base of legacy networks, upgrading these systems presents many challenges, therefore, we believe that no one network will win, and each must be interoperable
- 3 Network determinism, throughput, security and latency are all features of networking driving the transition from traditional networks to advanced technologies like Private LTE, 5G, and LEO- and MEO-based satellite networks
- 4 While customer needs advance, traditional network solution providers are simply focusing on their traditional businesses, creating an environment ripe for disruption for those who can integrate networks and drive easy-to-deploy solutions
- 5 Several player groups are positioned to deliver a software-defined network platform to serve market demands, including Telco providers, Automation and Control OEMs and silicon/network communications providers
- 6 The winners in this market will learn from other's failures, build out and develop an ecosystem and platform that supports the network of networks

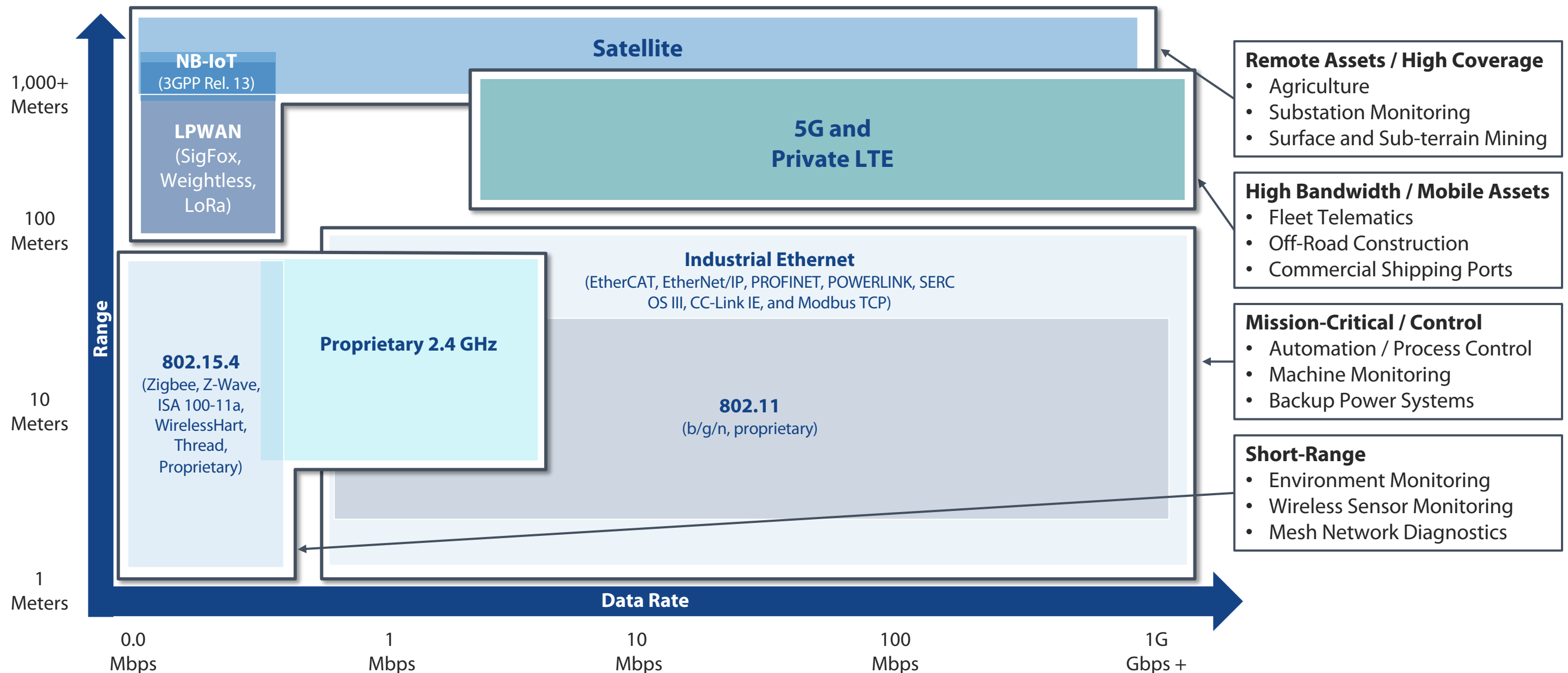
Digital & Smart Systems are Driving a Need for 'Hybrid Networks'

More advanced networks will enable a new generation of applications, giving rise to an increasingly complex set of interactions of data between device, machine and human processes



Increasingly Complex Applications Have Created a Mess of Networks

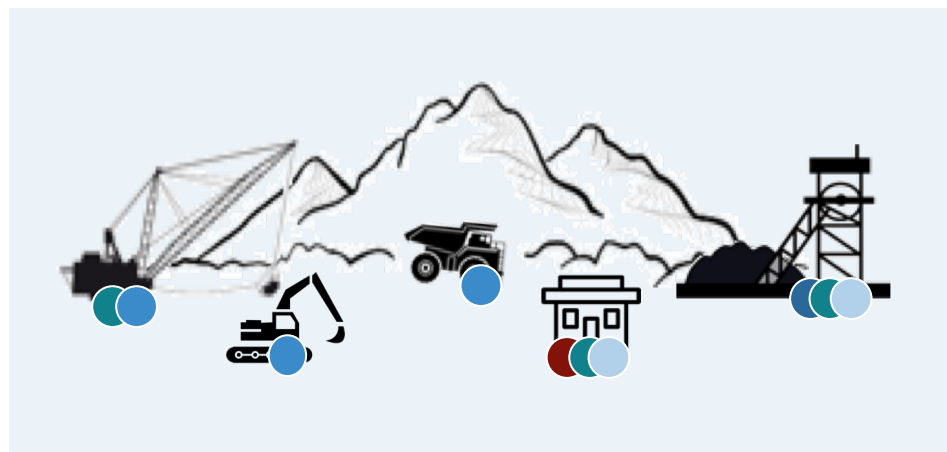
Today's fragmented landscape is full of proprietary device networks, cautious users and buyers, and broken promises about the potential of wireless technologies



Increasingly Connected Environments Require Network Support

As more connected devices enter customers' lives, new services are needed to manage networks

Industrial: Mining Site



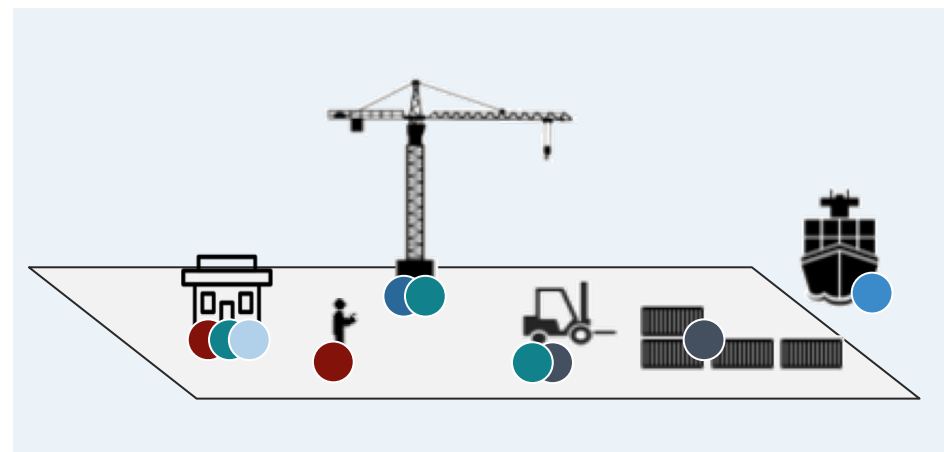
Applications and Use Cases

- Mobile & Temporary Office responsible for: Operational Visibility & Productivity; and Security, Safety & Compliance
- Heavy Mobile Production Equipment responsible for: Fleet/Asset Management; Autonomous or Remote Vehicle Control; Security Safety & Compliance

Solution Requirements

- Autonomous equipment and remote control necessitate significant throughput and reliable, low-latency communications for associated sensor suites and video feeds
- Temporary mining offices require a reliable WWAN and progressively higher throughput connection for backhaul
- Simple devices that likely leverage sensor networks or LPWAN technologies will require data aggregation and backhaul capabilities

Commercial & Enterprise: Commercial Port Facility



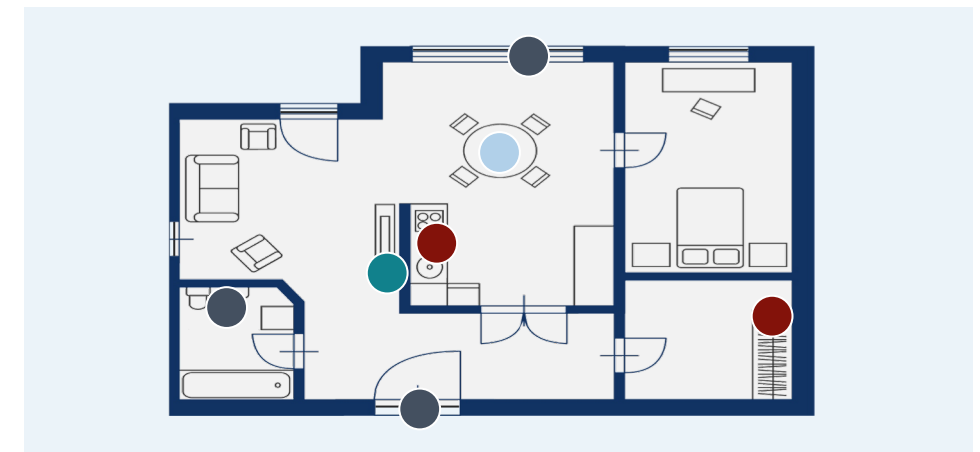
Applications and Use Cases

- Enhanced mobile broadband to support data intensive AGV/Forklift and video surveillance applications
- Mobile and fixed material handling equipment operates outside of core system processes, and requires further network integration

Solution Requirements

- High volume, low latency applications require advanced cellular networks such as for automated guided vehicles
- Software-defined terminals for automatic network switching based on application and network needs
- Interoperable communications for site control points including: offloading site, remote operator, control center, and warehouse

Consumer: Smart Home



Applications and Use Cases

- Support for media and entertainment services as well as home and residential security
- Fixed and mobile wireless broadband for gaming and entertainment over a dedicated consumer network

Solution Requirements

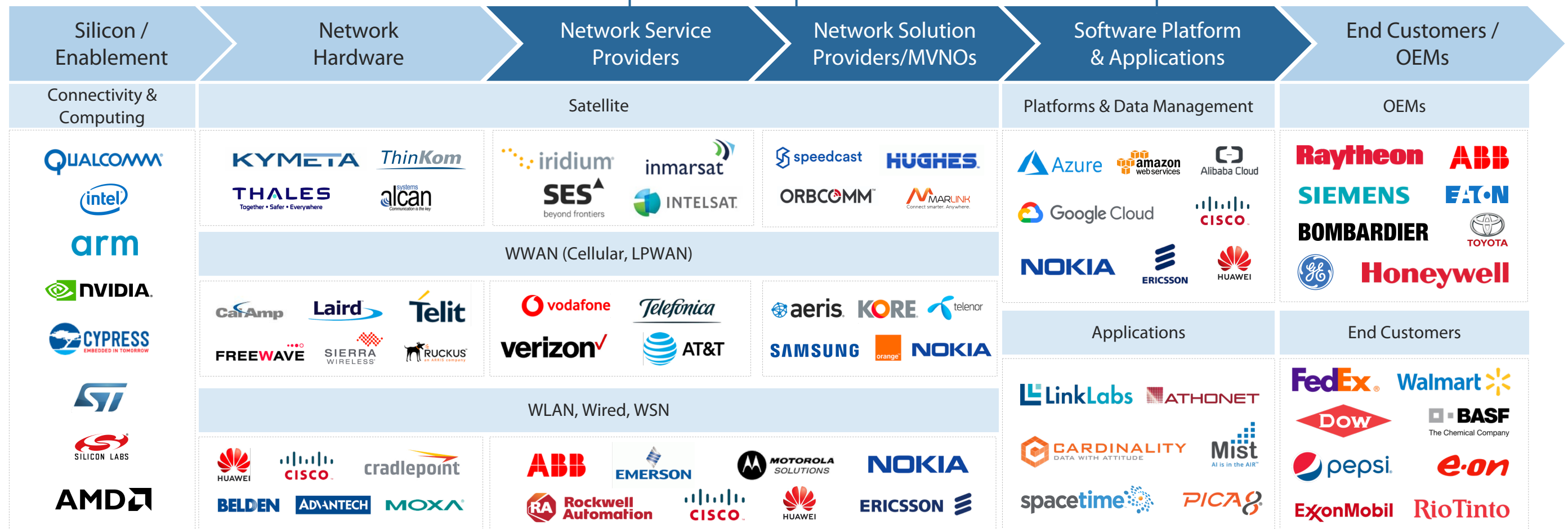
- Fixed wireless access supporting gigabit data rates for consumer devices provides a Wi-Fi alternative that takes fiber-to-the-home out of the equation, simplifying deployment
- Cost-effective solution for extending enhanced capacity and coverage across consumer device networks
- Support for media and entertainment services as well as home and residential security



In the Early Stages, a Few Players Flirt with Hybrid Networks

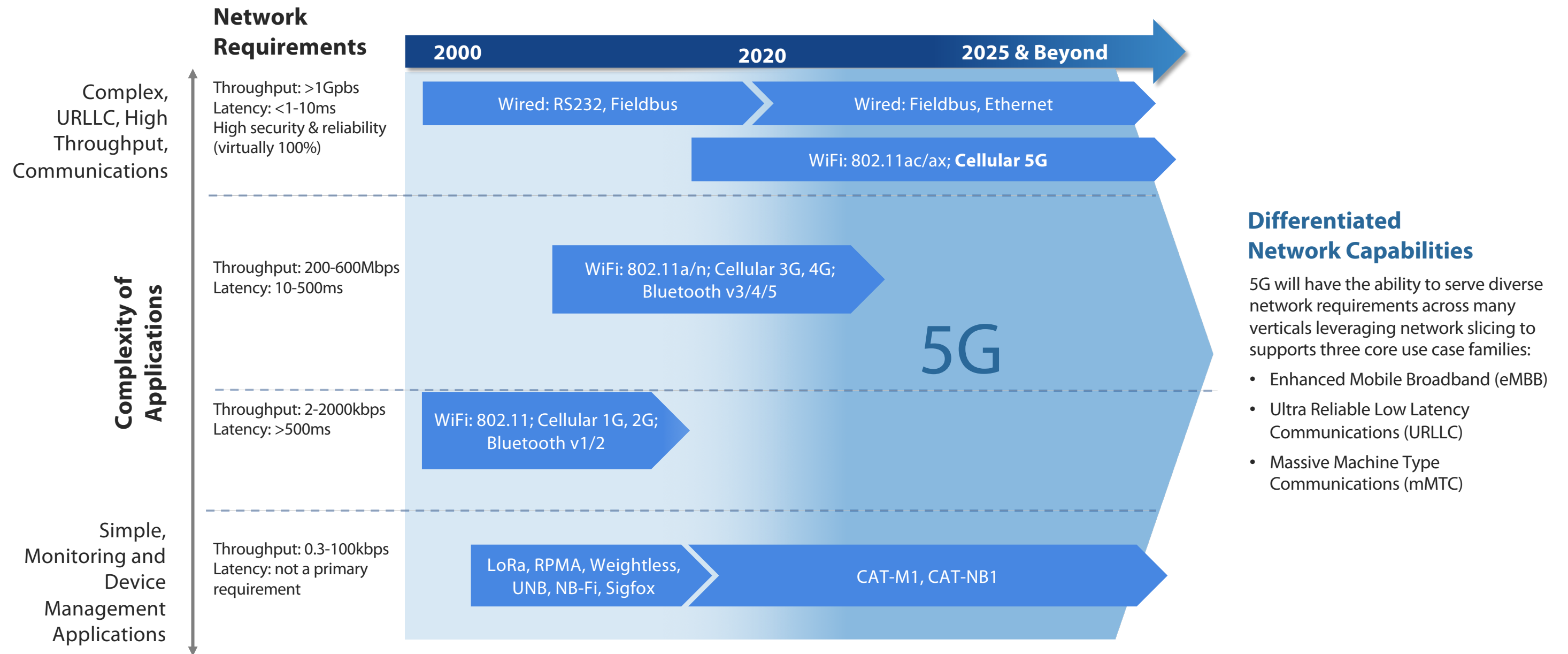
While some operators are taking initiatives to expand into adjacent wide area networks, only a short-list of players are addressing the need to fully manage and operate hybrid networks

- **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



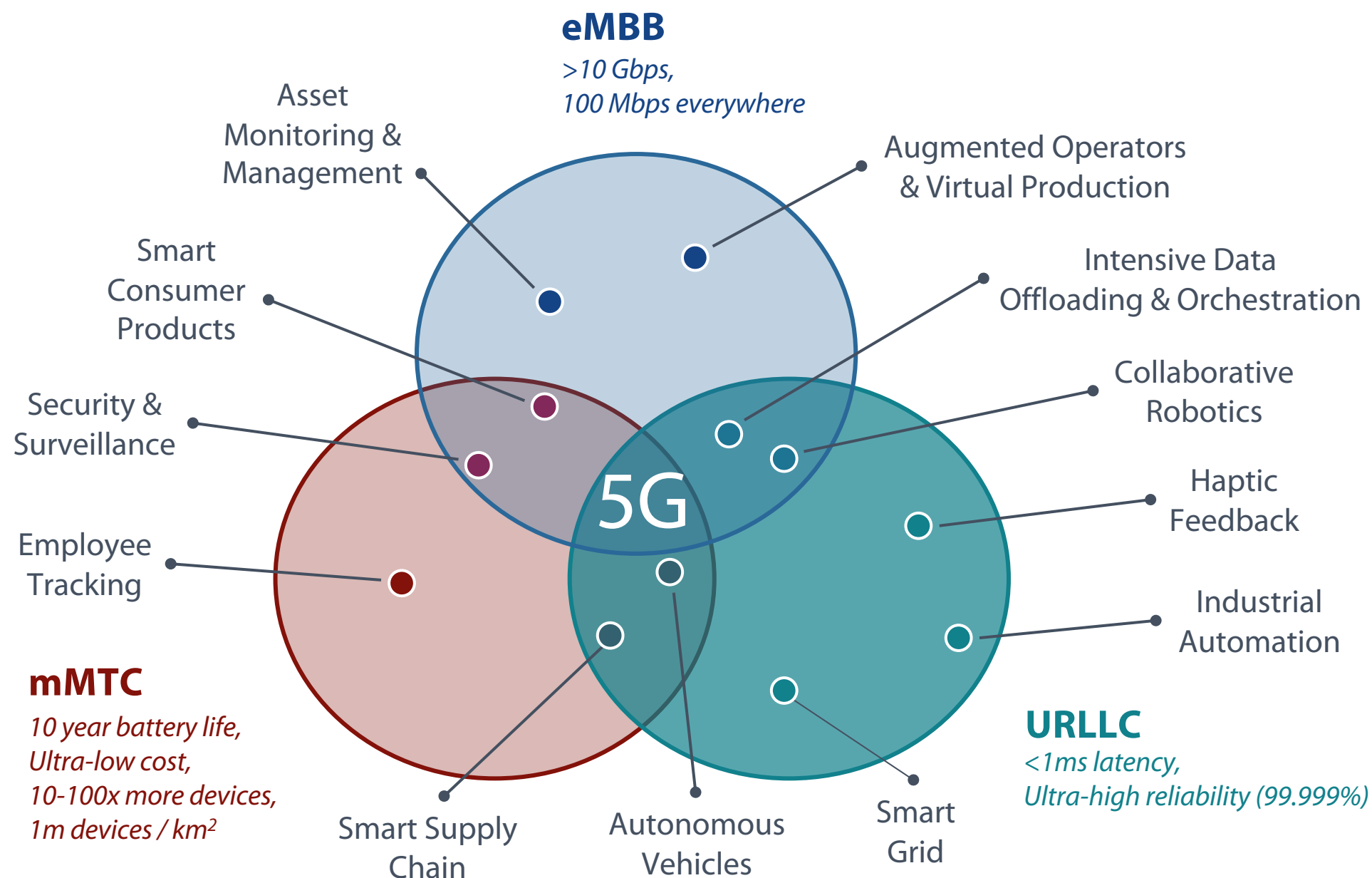
5G Disrupts Existing Network Evolution

Network slicing and cloud-native approaches will allow for 5G to support everything from data intensive short range communications to low power, distributed sensor networks



5G Networks Are Enabling High-Value Applications

The prospective capabilities of 5G including eMBB, URLLC and mMTC, will be able to address high value applications in heterogeneous device environments within and across many verticals



eMBB

(Enhanced Mobile Broadband)

- **Applications:** speeds comparable to wired networks
- **Functionality:** high network performance

mMTC

(Massive Machine Type Communications)

- **Applications:** high-scale IoT, WSN
- **Functionality:** low power connectivity, on-demand consumption, sleep-mode switching

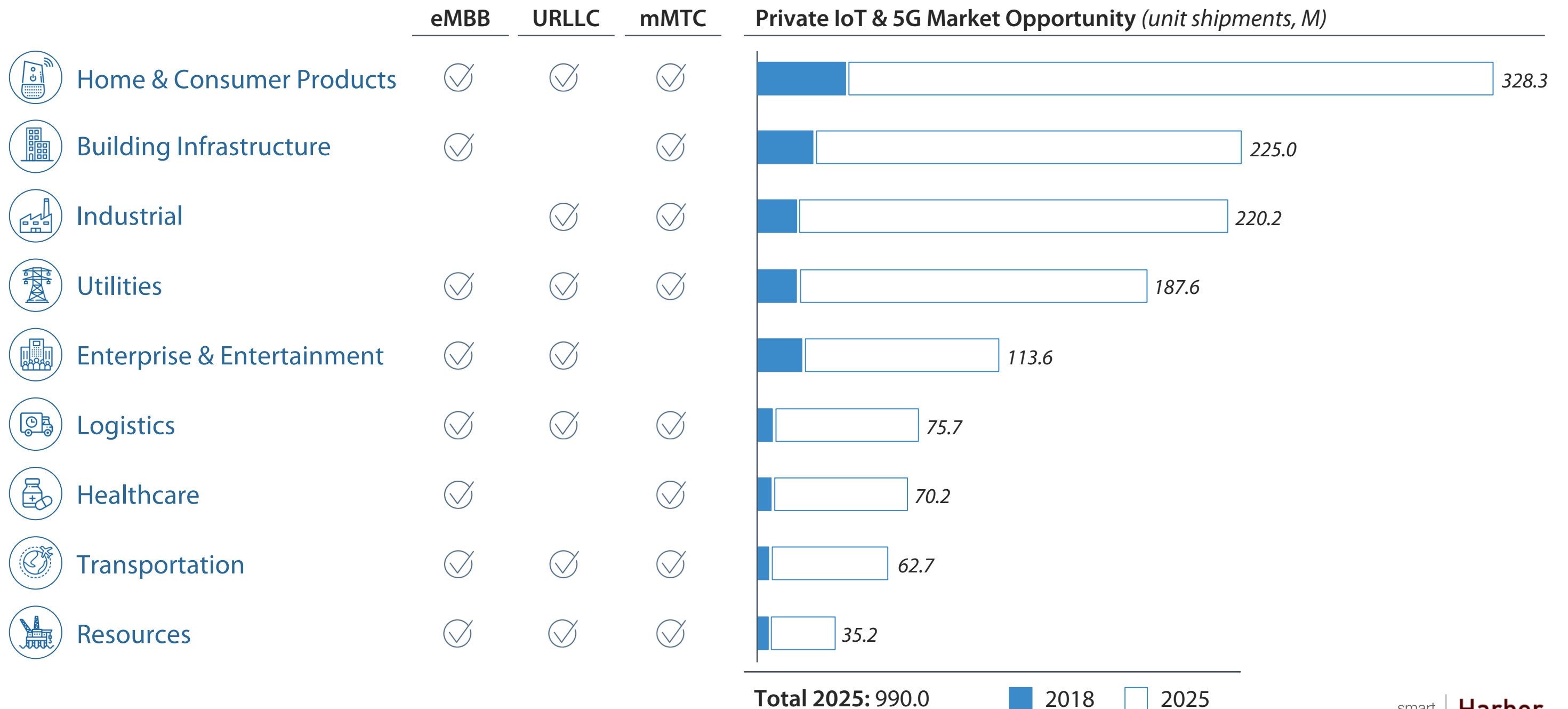
URLLC

(Ultra-reliable and Low Latency Communications)

- **Applications:** control, safety
- **Functionality:** mobile-edge computing, software-defined networks and network determinism

While Customer Needs Advance, 5G Market Opportunities Grow

There are similarities in device environment characteristics and network requirements across the top markets, ultimately informing product specification and channel strategy



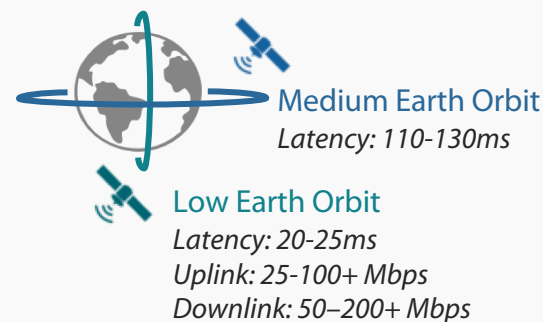
New Technologies & Investments Expand Role of Satellite

The deployment of low latency MEO & GEO satellite constellations in combination with innovative terminal technologies allow satellite networks to penetrate new markets at affordable prices

New Constellations

Impacts

- Lower latencies
- Increased capacity
- Reduced pricing



Internet of Things



High Throughput



Innovative Terminal Technology

What's Needed: Current & Future Features

- Mobile satellite connectivity
- Ease of set-up and use
- Ability to be mass produced
- Ability to handoff between networks

Who's Aiming For It



New Opportunities

New Opportunities

- High Throughput Mobile Connectivity
- Backhaul for IoT Devices
- Community Wi-Fi












Illustrative Partnerships



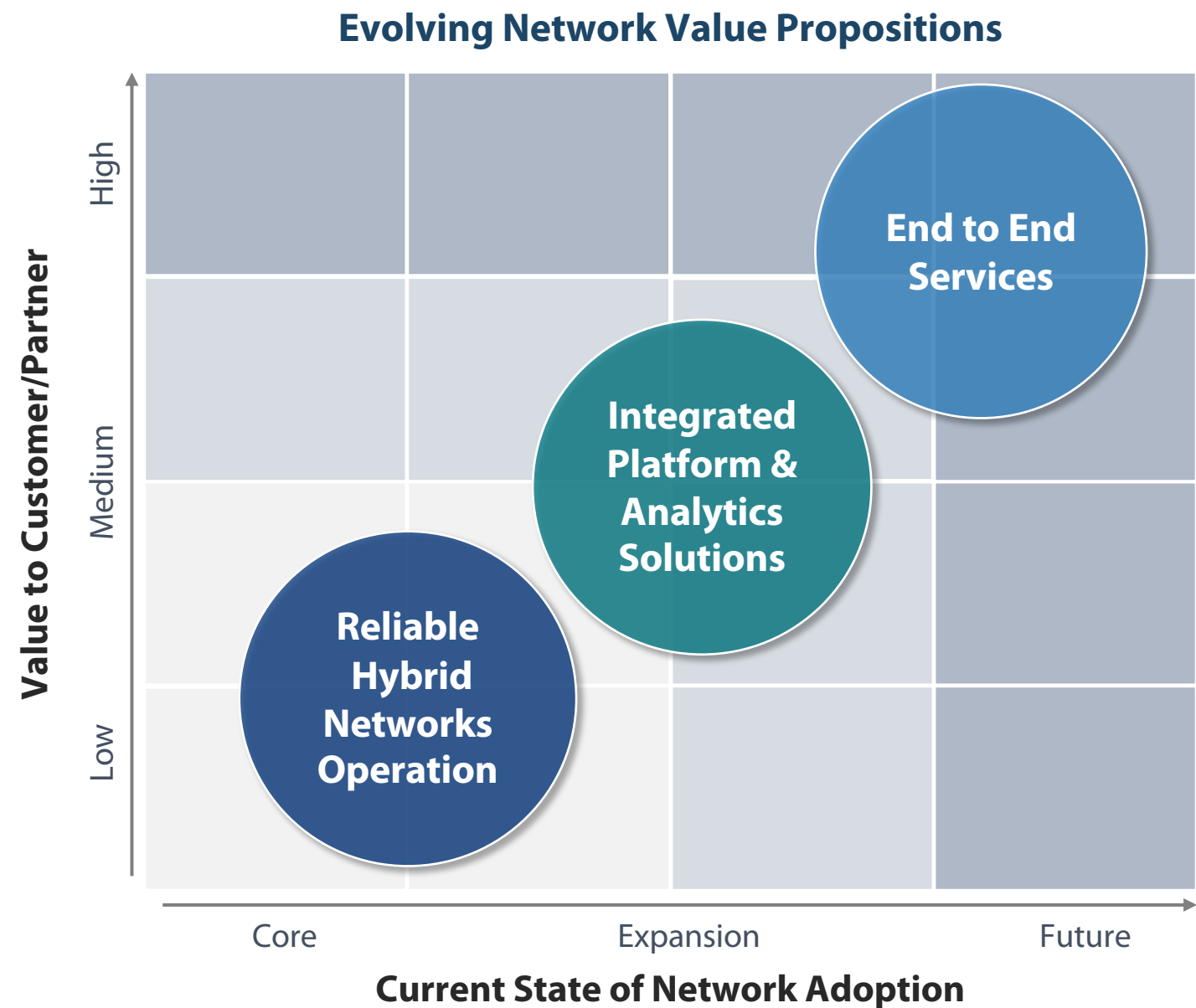
Network Suppliers Must Consider Customer Environments

The introduction of 5G will catalyze advancements such as network virtualization and automated orchestration and management that are required for hybrid networks

		Network Challenges	Wireless Networks	Wireline Networks
Consumer	 Home & Consumer Products	<ul style="list-style-type: none"> Dense infrastructure creating interference Efficient bandwidth allocation Security 	<ul style="list-style-type: none"> Cellular GSM/GPRS 802.11a/b/g/n/ac Bluetooth 	<ul style="list-style-type: none"> Ethernet / DSL
Commercial & Enterprise	 Enterprise & Entertainment	<ul style="list-style-type: none"> Efficient scalability without loss of performance Multi-protocol orchestration / interoperability for complex applications Efficient bandwidth allocation Current wireless solutions are constrained by VPN level security Constrained wireless access point coverage and costly wired installation drive up costs and limit flexible reconfiguration inside buildings 	<ul style="list-style-type: none"> Wimax 802.16; 802.11a/b/g/n/ac Cellular GSM/GPRS 3 kHz to 300 GHz Radio Proprietary Mesh 802.2.15.4/ZigBee LEO/MEO/GEO-Based Satellite RFID 	<ul style="list-style-type: none"> SDH/SONET/PDH/GPON /EPON/ONU Ethernet
	 Building Infrastructure			
	 Logistics			
	 Healthcare			
	 Transportation			
Industrial	 Industrial	<ul style="list-style-type: none"> Dense infrastructure creating interference Both IT & OT concerns of wireless security have limited the uptake of site wireless integration Current wireless solutions are limited to remote monitoring and basic control functions Power consumption / battery life for wireless devices in harsh environments 	<ul style="list-style-type: none"> Wimax 802.16 d/e/n 802.11a/b/g/n/ac Cellular GSM/GPRS WirelessHART Modbus/ISA 100.3 ISA SP100.11a TCP/IP over Satellite 	<ul style="list-style-type: none"> SDH/SONET/PDH/GPON /EPON/ONU FTTP/FTTH/Ethernet
	 Utilities			
	 Resources			

Post-Hybrid Development Leads to New Service Delivery

5G networks will enable a new generation of applications, giving rise to an increasingly complex set of interactions of data between device, machine and human processes



“End to End Services”

Drive End to End Services to Create Real Value – Hybrid Networks

Maneuvers that could create significant value for customers by providing them access to important applications & necessary network types, but would require significant additions to current offerings

“Integrated Platform & Analytics Solutions”

Advanced Wireless for “Point Solutions – WWAN + WLAN + WPAN

Edge platform and data transformation capabilities to enhance performance for both LTE and 5G networks and support for applications such as remote predictive analytics and motion control

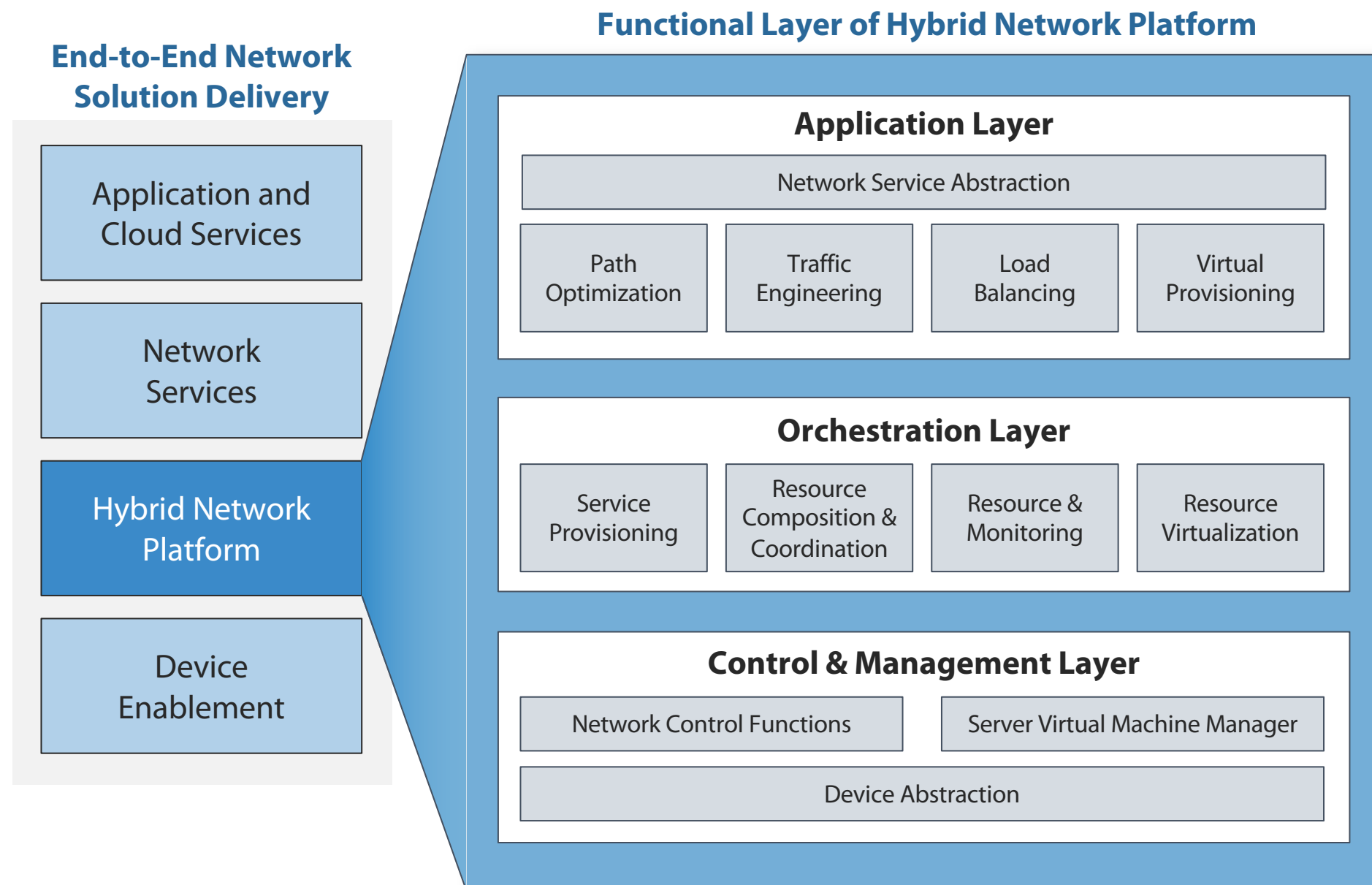
“Reliable Hybrid Network Operation”

Make Sure The System Works

Maneuvers that would establish network services companies as a Managed Service provider and allow customers/partners more control over their own connectivity needs

Leading Hybrid Networks Must Address Fundamental Functions

Each of the layers and underlying functions of a hybrid network platform empower customers to control, manage and optimize increasingly distributed IoT devices and systems

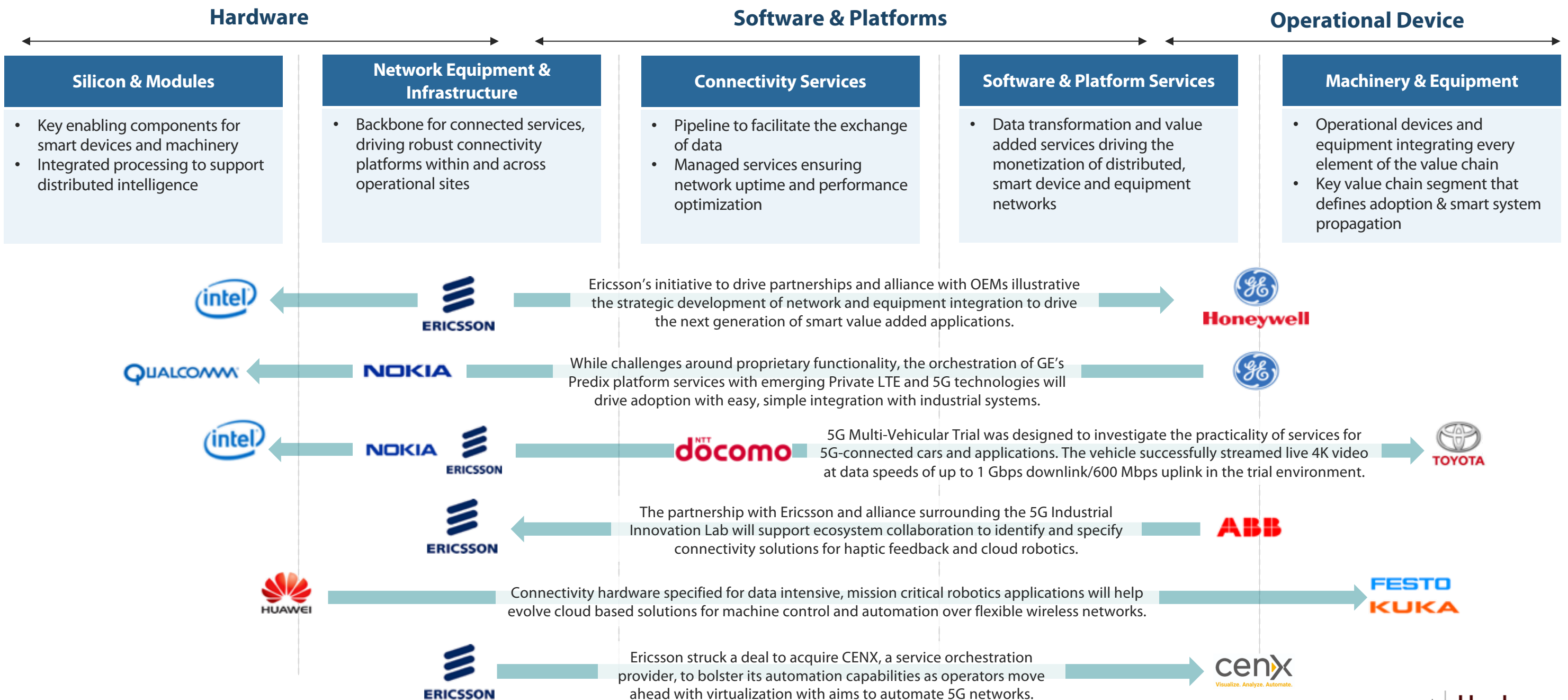


Network Architecture Considerations

1. Embrace open-source technologies and development
2. Support open API access for delivery through easy to access 3rd party OSS/BSS applications
3. Consider taking a platform and device agnostic approach throughout the design stages
4. Test using software development kits in target consumer, commercial, or industrial environment with software development kit (development runtime, tooling, documentation, and reference applications)
5. Repository of reusable, deployable, and runnable network applications for further integration and/or extension for additional products and services

Collaboration is Enabling Wireless Industrial Connectivity

Critical partnerships spanning the value chain are driving the R&D needed to actualize end-to-end, holistic 5G solutions – OEM partnerships will support optimized product specification



ABOUT HARBOR RESEARCH

An internationally recognized strategy consulting, design and technology research firm, Harbor Research has predicted, tracked, and driven the development of Smart Systems, Services and the Internet of Things since our inception in 1984. While our history is long, our strategy is simple: create value for our clients by combining creative facilitation with rigorous analysis and systems-focused thinking. It is this mindset that has given us the privilege of working with leaders in some of the greatest companies in the world. In the same way that the market has flexed and grown over the years, our services and experience have evolved to better serve our clients. We work with clients in a variety of ways including strategy consulting, business model development, solution design services, advisory, research and content development and collaborative facilitation.

THOUGHT LEADERSHIP

We provide our clients with rigorous analysis and unique insights to support the development of new growth strategies and solutions. Our research, content and modeling work provides an ideal context for discovery and ideation. We combine market intelligence with creative decision making forums in a mutually supportive mode.

UNIQUE PROCESSES

There is no simple “linear” process to drive new smart systems innovation. Iterative, nonlinear methods are important because design innovation is a process of exploration and discovery. Our methods facilitate new thinking and unexpected concepts and ideas that drive tangible customer and market impact.

VIBRANT COMMUNITY

Building new smart systems and digital growth ventures requires new and different modes of design, development and collaboration. We tap our community of innovators and thought leaders to help organizations push the boundaries of collaboration to include new and unfamiliar participants that help foster new insights and creative perspectives.

