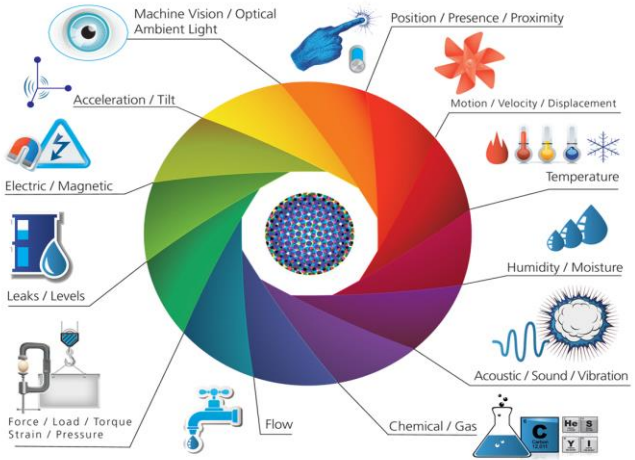
MulteFire in the Enterprise and IoT: Driving Innovation and Value Creation

smart systems design | Harbor Research

SENSORS & *ACTUATORS*

We are giving our world a digital nervous system. Location data using GPS sensors. Eyes and ears using cameras and microphones, along with sensory organs that can measure everything from temperature to pressure changes.



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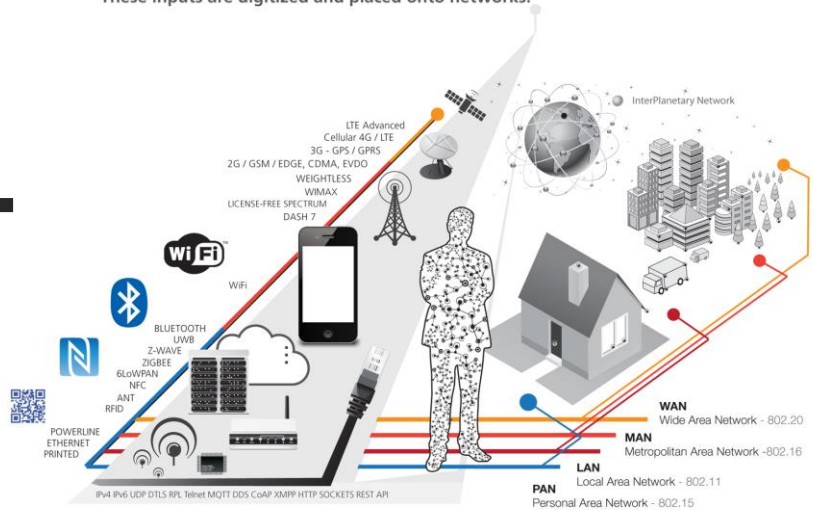
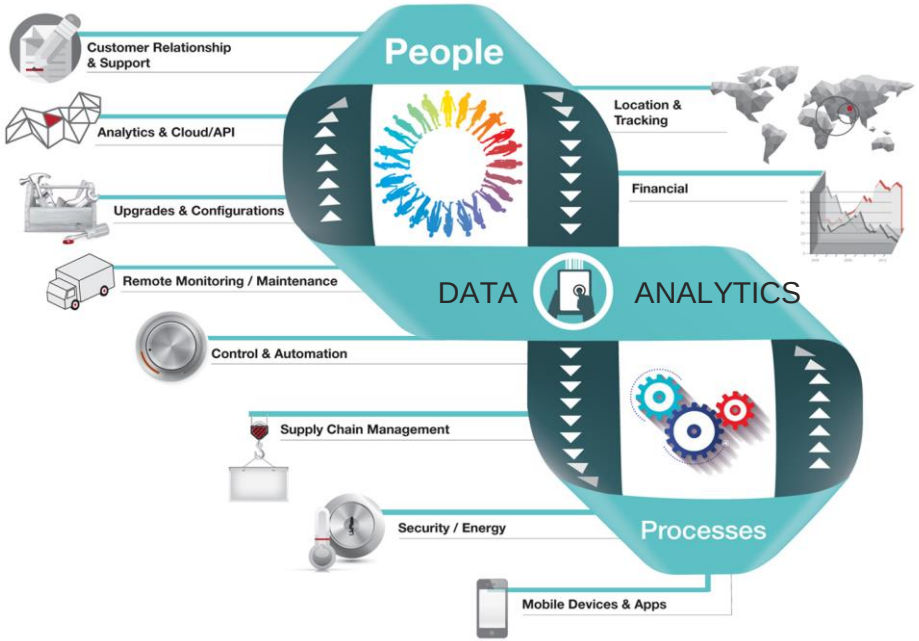
CONNECTIVITY

These inputs are digitized and placed onto networks.

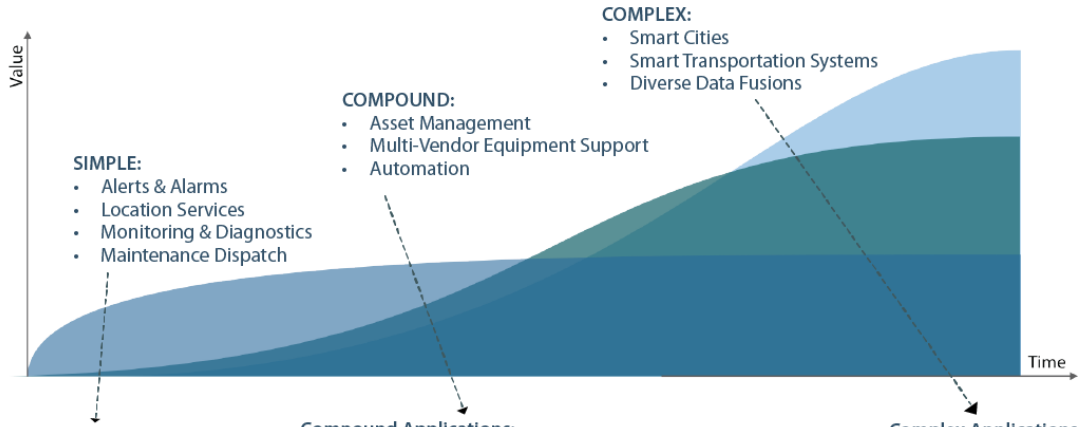


PEOPLE, **DATA** *and analytics processes*

These networked inputs can then be combined into bi-directional systems that integrate data, people, processes and systems for better decision making.



Digital and IoT are Still Emergent; Still Evolving…



Simple Applications:

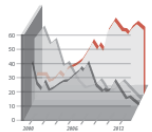
Applications involving simple remote monitoring, location services and product support for maintenance or upgrades

Compound Applications:

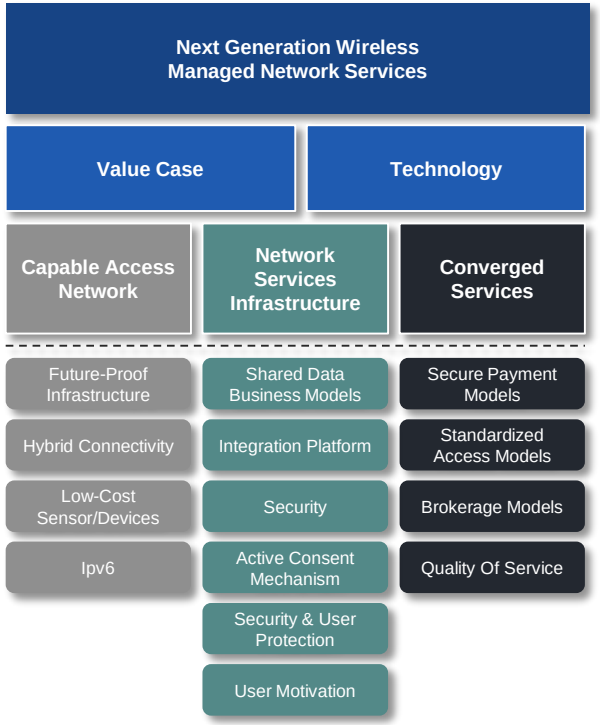
Applications that involve multiple [peer-to-peer] devices and machines with significant interactions between systems and equipment in multi-vendor environment such as factories, hospitals and related environments characterized by diverse vendors, users and stakeholders

Complex Applications:

Applications driven by diverse interactions involving sensors, actuators, machines, people and systems that enable extending/expanding values from collaboration and analytics supported by data fusion between and among disparate and diverse sources



A Confluence of Forces & Trends Impacting Wireless Opportunities



‘Always-Available’ Integrated Services Environment:

Higher bandwidth, reliable connectivity anywhere and “on-the-move” are key to many business models - networks that are “Out-of-the-Box” and enable “As-A-Service” Become The Norm

Innovation Shifts From Core Applications To The Edge:

The “center of gravity” in the Enterprise will increasingly be driven by new sensing devices, edge computing capabilities and data analytics opportunities

Wireless Infrastructure/Services Divide:

Customers are already shifting their usage patterns, from their own captive and traditional service providers to new support modes and service providers including a long tail of “specialist” OT-focused players

The Internet Of Things Business Model Impact:

As “machine-to-machine” or “machine-to-mobile” wireless communications grows, workable business models that enable diverse new players to participate in the value created – in single-service metered services; bundles structured for key usage segments; abundant (all-you-can-eat) pricing for connectivity and date services; differentiated tiered pricing based on quality/speed

Private LTE Can Address Industrial Network Requirements

Industrial & Business Critical Segments

Industrial Manufacturing
- Discrete Manufacturing
- Process Industries
- Hybrid / Converting

Utilities and Electrical Power
- Power Generation
- Power Transmission & Distribution
- Water Utilities

Public Venues
- Transport Venues
- Military Bases
- Maritime Ports

Healthcare
- Hospitals

Supply Chain
- Warehouse & Distribution

Natural Resources
- Mining
- Oil & Gas

Top Applications

Real-Time Surveillance

Operations Visibility & Optimization

Authentication & Access Control

Worker Safety Monitoring

Remote Diagnostics & Predictive Maintenance

Asset Management & Uptime Assurance

Industrial Network Requirements Addressed by Private LTE

- Reliability
- Throughput
- Mobility
- Security
- Low Latency
- Simplified Network Management

The top applications will largely address ancillary data services, with integral operations and automation applications gaining traction in the long term.

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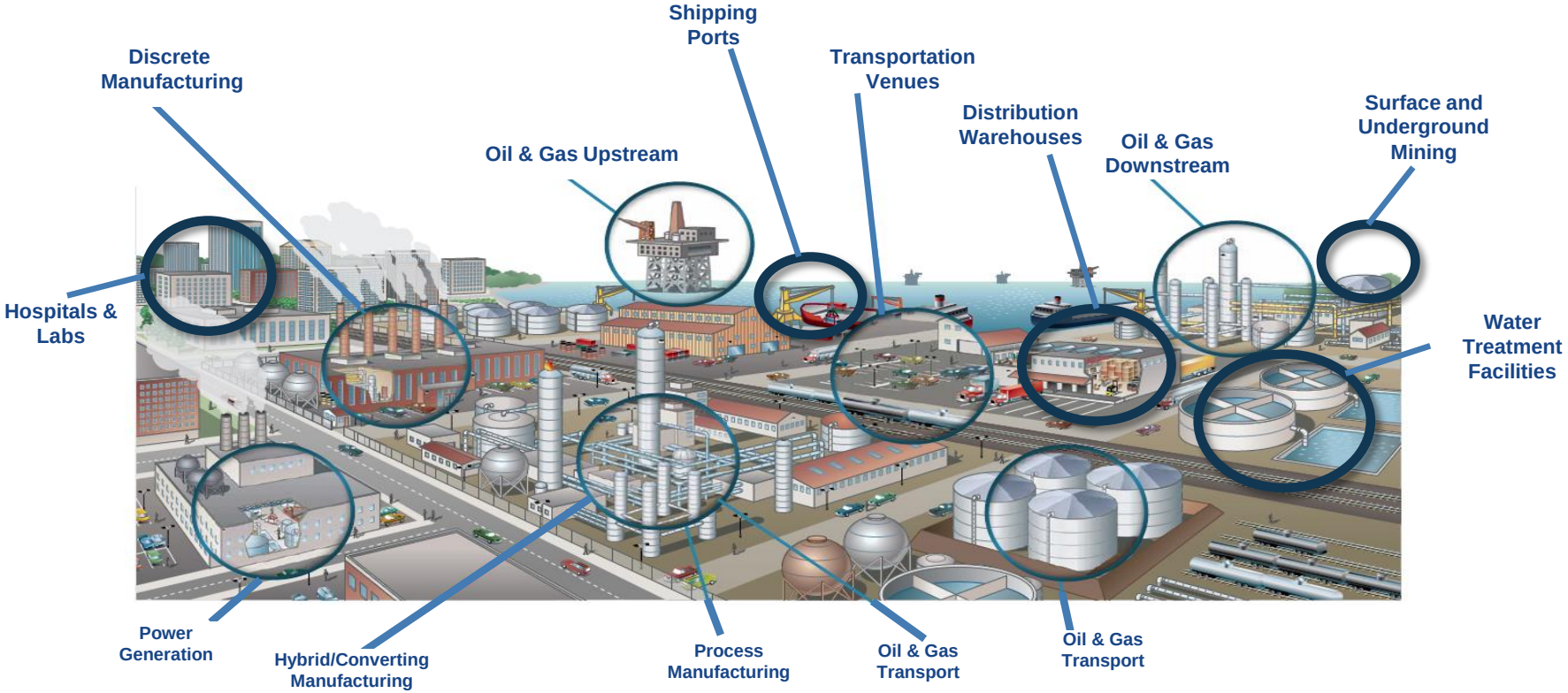
Industrial & Business Critical Segments Addressed by Private LTE



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Top Apps and Devices Addressable by Private LTE

Real-Time Surveillance

Key devices: IP cameras (thermal and regular), drones, radar and security equipment (touch pads, keyless entry)

Asset Management & Uptime Assurance

Key devices: motors and drives, power transmission equipment, machine controllers, AGV's & forklifts, robots & handling equipment

Authentication & Access Control

Key devices: Biometric Systems, Card Readers / Smartcards, Door Sensors / Actuators, Speech Recognition Devices

Remote Diagnostics & Predictive Maintenance

Key devices: motors and drives, power transmission equipment, machine controllers, AGV's & forklifts, robots & handling equipment, generators, re-combiners and power conversion, co-generation engines, and combined heat & power systems.

Operations Visibility & Optimization

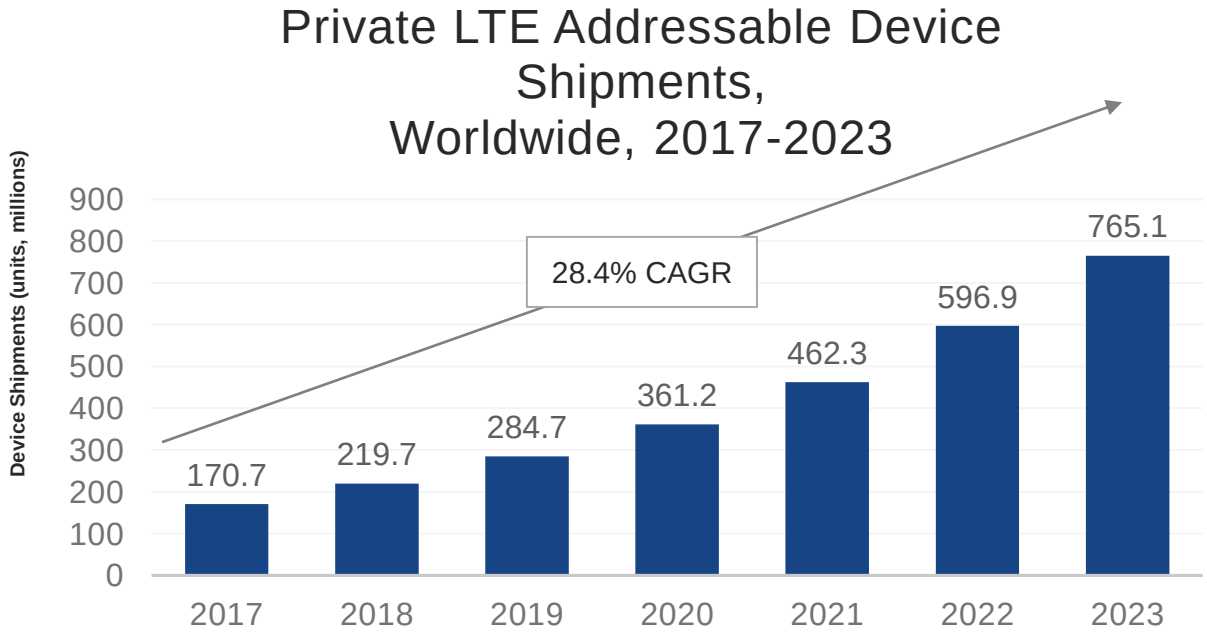
Key devices: motors and drives, power transmission equipment, HMI's, machine controllers, AGV's & forklifts, robots & handling equipment, generators, re-combiners and power conversion, co-generation engines, and combined heat & power systems.

Worker Safety Monitoring

Key devices: CCTV / IP cameras, safety controllers & devices, mobile tracking devices

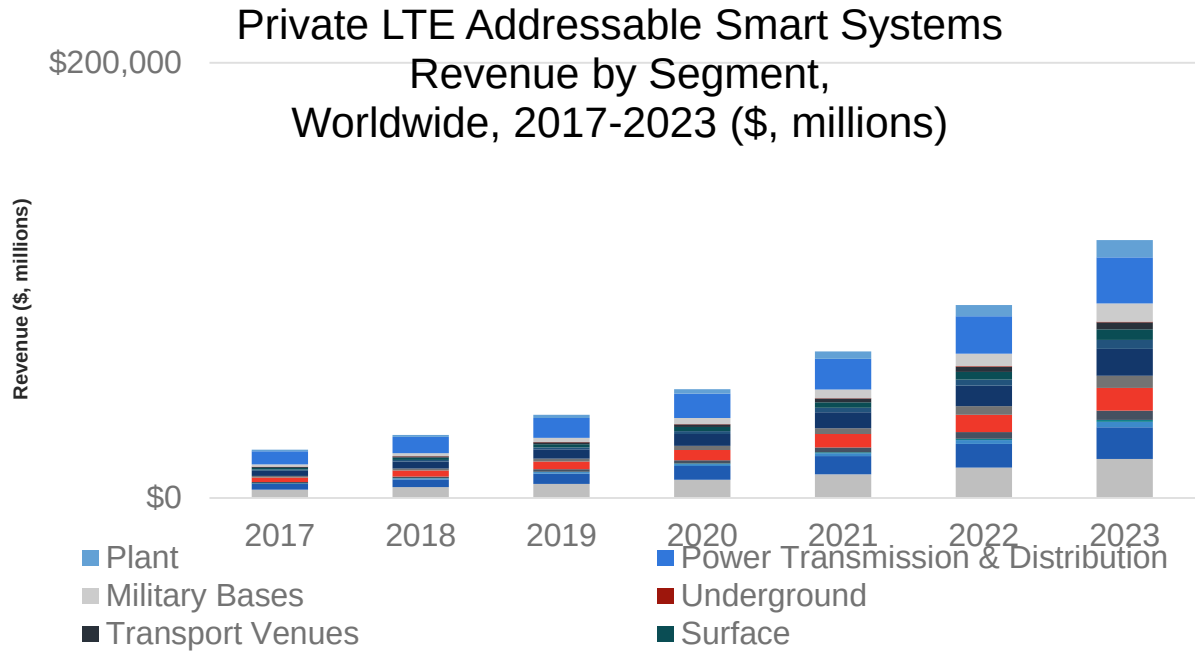
The Dollars and Devices Behind the Private LTE Opportunity

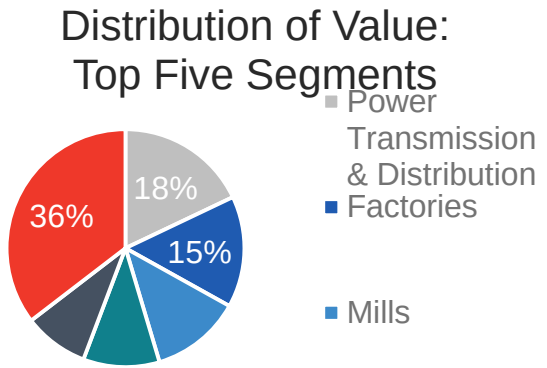
The global opportunity for Private LTE in industrial and business critical environments will be significant, with device shipments volumes growing from 170.7 million in 2017 to 765.1 million in 2023 at a 28.4% CAGR.



The Greatest Opportunity Exists in Industrial, Supply Chain and Energy

The top five markets are expected to make up roughly 65% of the value created from Private LTE enabled devices/equipment





Target Enterprise Markets for Private and Neutral Host LTE

MulteFire addressable Enterprise markets are characterized as indoor and outdoor environments with network requirements to support data-intensive, hyper-dense mobile and traditional applications

Enterprise Markets

Buildings
- Commercial Office Buildings (Financial, Corporate, etc.)

Health Delivery
- Hospitals / Labs
- Clinics

Retail
- Big Box / Malls
- Specialty / Boutique

Hospitality
- Hotels
- Restaurants

Residential
- Multi Tenant
- Single Tenant

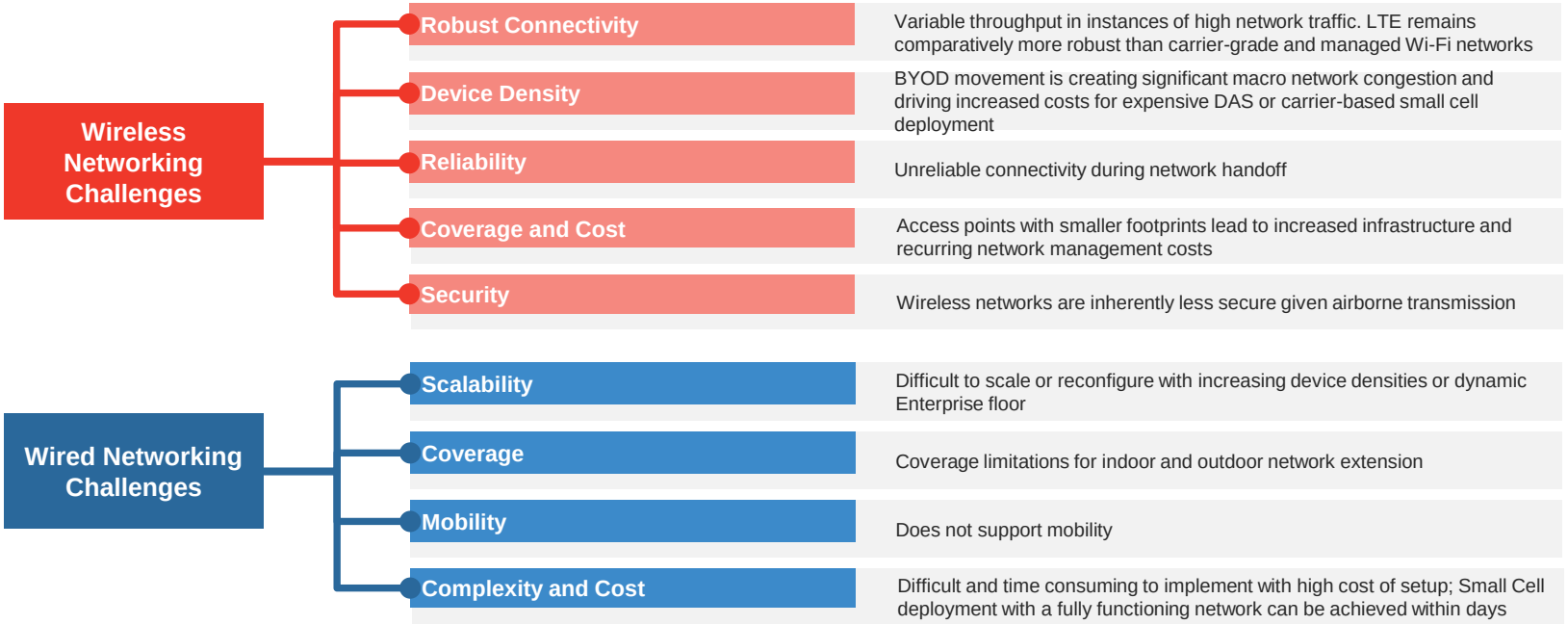
Public Venues
- Airports
- Military Bases
- Stadiums

Supply Chain & Distribution
- Warehouses
- Retail Distribution

*This analysis excludes all IoT, industrial or operational technology applications for Private and Neutral Host LTE

Network Challenges Addressed by MulteFire

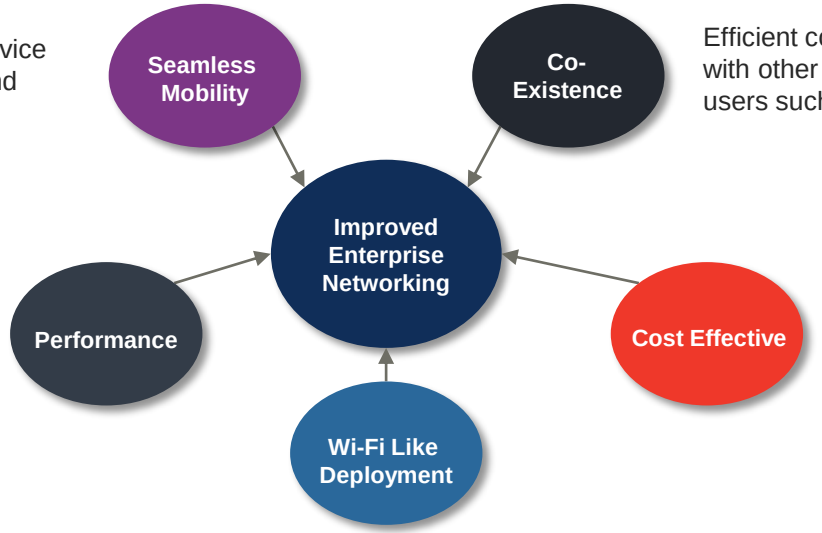
The benefits of Private and Neutral Host LTE directly address challenges such as device density, user mobility, infrastructure and ongoing management costs, and network security



Key Features of MulteFire that Will Benefit the Digital Enterprise

MulteFire will generate significant value by ensuring increasingly complex interactions can occur with a level of service continuity that a digital Enterprise requires

Seamless mobility to support service continuity between small cells and other networks



Efficient co-existence with other spectrum users such as Wi-Fi

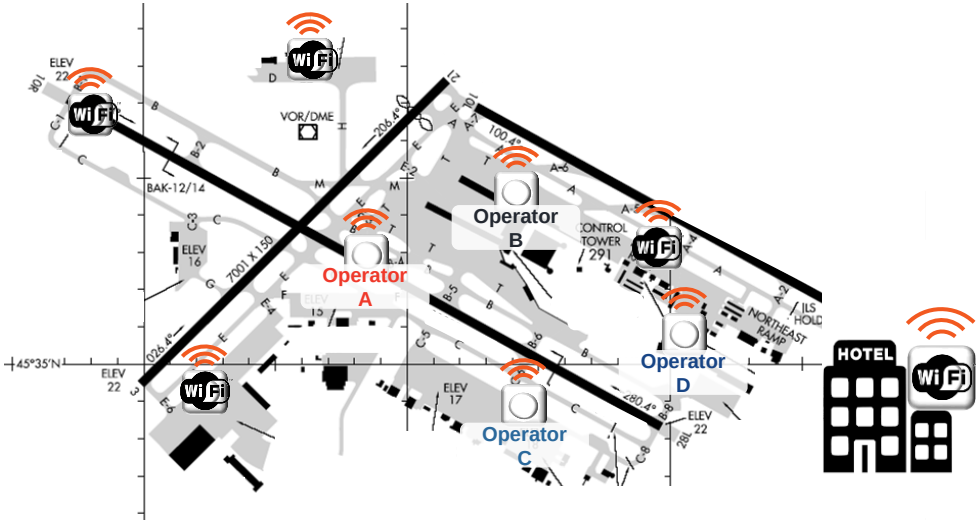
LTE performance in terms of capacity and throughput reaching between 2-4 times that of 802.11ac, yielding superior payloads than Wi-Fi

Fewer required nodes while supporting enhanced interference management capabilities, thereby reducing costs with a greater network footprint per access point

The simplicity of deployment, analogous to Wi-Fi, in unlicensed spectrum allows MulteFire to support any device without an operator or SIM card

Multi-carrier Private and Neutral Host LTE Airport Case Study

Phase I

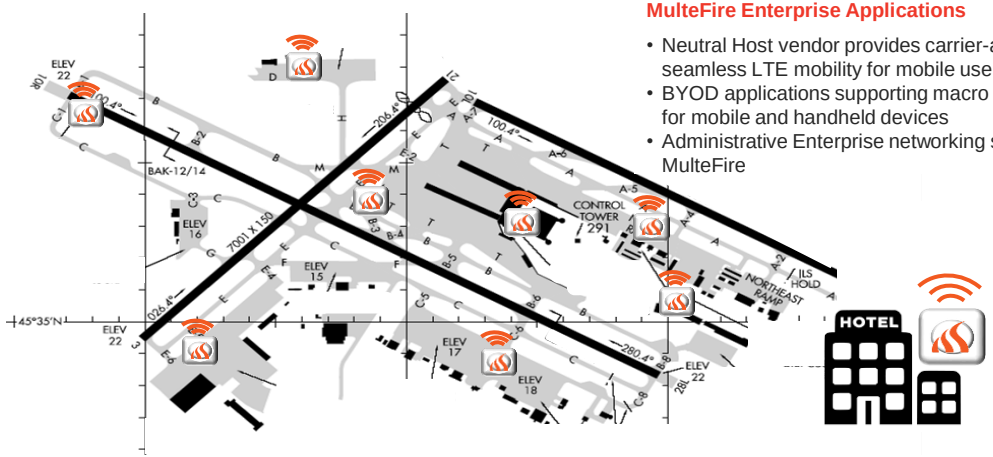


Carriers Deploy DAS and Small Cell Network with Operator Managed Switch

- Carrier has its own small cell and controller, deploying network over licensed spectrum
- Given the significant allocation of CapEx to build a robust DAS or Small Cell network, carriers face a challenging cost-benefit analysis to identify strategic deployment
- Venue owners have little control and visibility into network services
- Distinct Wi-Fi and carrier-managed networks create fragmented quality of service and little user mobility

Multi-carrier Private and Neutral Host LTE Airport Case Study

Phase II



Note: Illustrative deployment locations

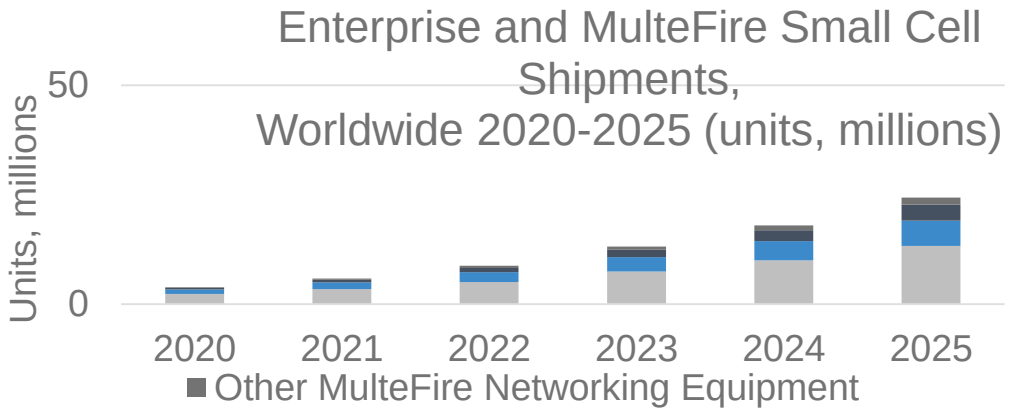
MulteFire Enterprise Applications

- Neutral Host vendor provides carrier-agnostic, seamless LTE mobility for mobile users
- BYOD applications supporting macro data offloading for mobile and handheld devices
- Administrative Enterprise networking supported by MulteFire

	Main Terminal & Administrative Main Offices	Gate Areas	Hotel & Transit Center
Floor area (sq. ft) (number of rooms)	1,500,000	4,043,000	332,170 (519)
User per Day (annual users)	1,644.2	164,424 (5,100,000)	359 (131,000)
Area per user / day	912.3	24.6	0.69
Number of MulteFire Small Cells (illustrative configuration)	132 Pico; 23 Micro	410 Pico; 38 Micro; 54 Femto	48 Pico, 105 Femto
Supporting Neutral Host Network Equipment	Switch / Router	Small Cell Controller	Dedicated Backhaul

Enterprise MulteFire Small Cell Shipments To Reach 3.7M Units

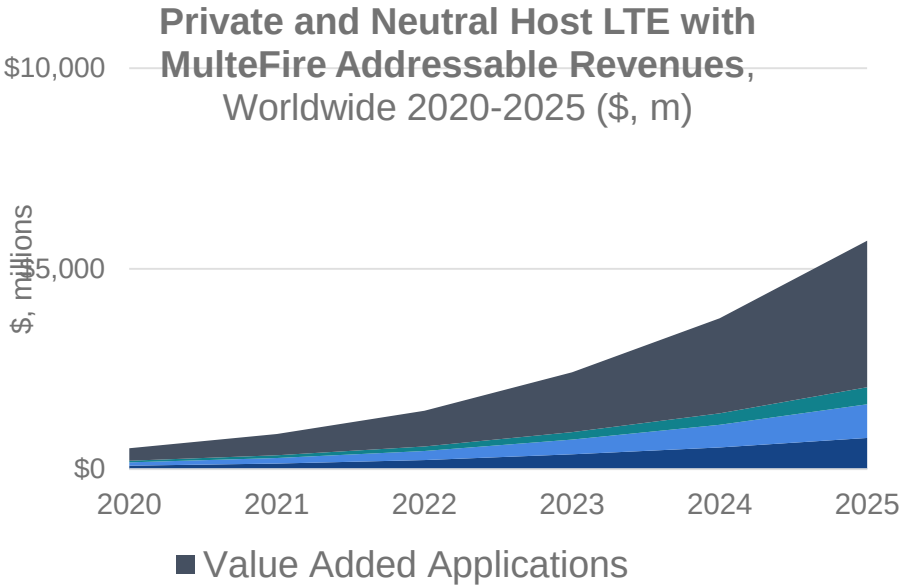
MulteFire small cells will reach 3.7 million small cell deployments in 2025 with roughly 1.6 million shipments of supporting network equipment

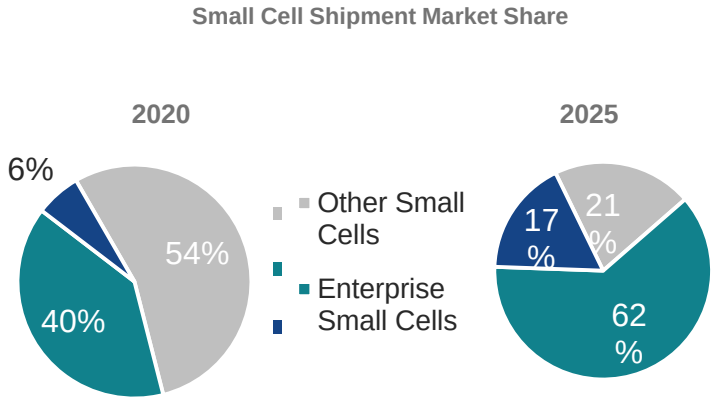


Enterprise Private and Neutral Host LTE with MulteFire: Shipments, Worldwide (units, millions)							
	2020	2021	2022	2023	2024	2025	2020-2025 CAGR
MulteFire Small Cells	0.38	0.62	1.01	1.67	2.50	3.70	**57.7%**
MF Related Switches	0.12	0.19	0.31	0.52	0.77	1.12	**57.5%**
MF Related Controllers	0.05	0.08	0.13	0.21	0.32	0.46	**56.7%**
MF Total	**0.54**	**0.89**	**1.46**	**2.41**	**3.59**	**5.28**	**57.6%**

Enterprise MulteFire Small Cell Revenue Will Reach $5.8B In 2023

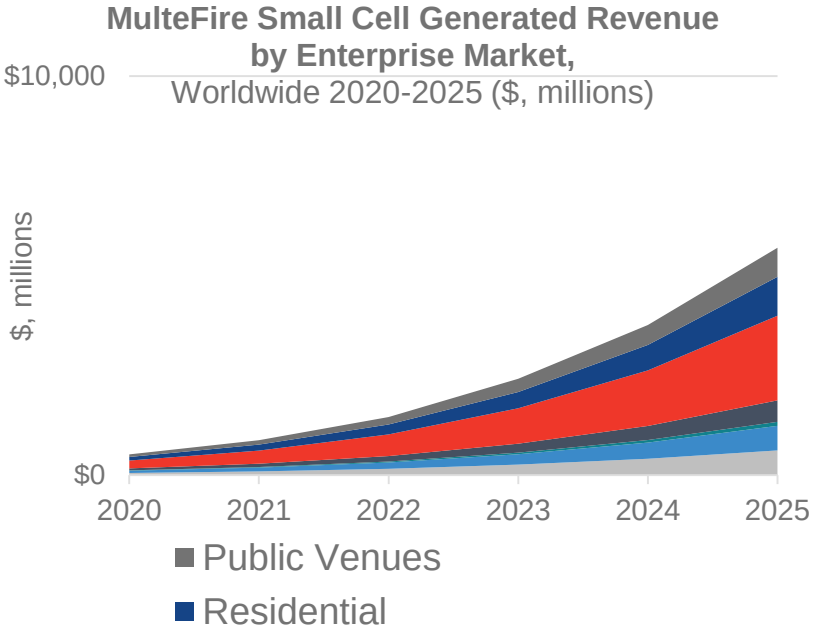
MulteFire small cells will represent 17% of the total small cell market, growing from 6% in 2020. Relative to the Enterprise small cell market, MulteFire is expected to make up 22% of deployments in 2025





Commercial Office Buildings Represent A $2.1B Opportunity In 2025

MulteFire Small Cells deployed in Commercial and Institutional Buildings are expected to reach 1.4M shipments in 2025, representing the largest Enterprise unit volumes



Enterprise Private and Neutral Host LTE with MulteFire: Small Cell Shipments, Worldwide (units, thousands)

Venue	Market	2020	2021	2022	2023	2024	2025	2020-2025 CAGR
Health Delivery	Clinics	16.0	26.4	43.6	68.4	103.4	154.3	57.3%
	Hospitals / Labs	25.2	41.6	68.5	116.3	171.4	249.2	58.1%
Supply Chain & Distribution	Retail Distribution	30.3	49.3	81.1	133.7	200.0	295.2	57.7%
	Warehouses	10.8	17.6	28.8	46.0	69.6	104.0	57.3%
Hospitality	Hotels	0.8	1.3	2.1	4.5	7.2	11.4	70.2%
	Restaurants	5.6	9.1	14.9	23.2	35.4	53.4	57.0%
Retail	Big Box	27.1	44.1	71.7	116.6	175.9	261.8	57.4%
	Specialty	9.0	14.7	23.9	38.9	58.6	87.1	57.5%
Buildings	Commercial & Institutional	142.1	231.5	377.3	614.9	926.0	1,375.6	57.5%
Residential	Multi Tenant	53.8	87.5	142.5	231.9	349.7	520.1	57.4%
	Single Tenant	11.6	18.8	30.6	49.9	75.3	112.1	57.4%
Public Venues	Transport Venues	4.6	7.5	12.3	20.2	30.3	44.7	57.6%
	Military Bases	14.4	23.8	39.4	65.3	82.7	103.3	48.3%
	Stadiums	28.0	46.4	78.1	144.7	219.2	323.7	63.2%
	Total	**379.3**	**620.0**	**1,014.8**	**1,674.5**	**2,504.7**	**3,696.0**	**57.7%**

Neutral Host Business Models and Monetization

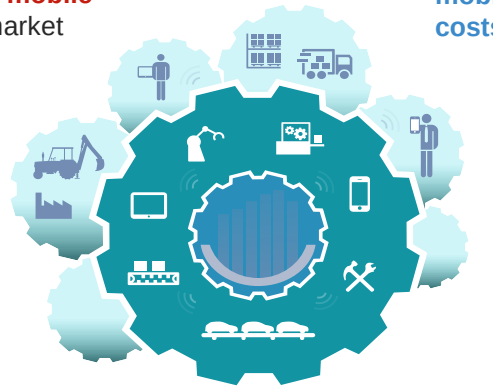
The introduction of MulteFire into these environments will drive the transformation of business models for Enterprise networking

Neutral Host Ownership Model	Neutral Host Monetization
Carrier Ownership	
Carrier deploys and operates DAS or small cell network supporting a single or multi-carrier network, as part of a partnership with DAS or small cell vendor.	• Revenue opportunities revolve around Carrier deployment of the neutral host network, extending service to other MNOs.
Venue Ownership	• Carriers benefit from reduced investment in costly infrastructure deployments.
Enterprise itself invests in multi-carrier DAS and small cell deployments in partnership with DAS or small cell vendor, generating revenue from leasing space and MNO service contracts.	• Neutral host vendors are contracted out by venue to build distributed neutral host network. • The venue benefits in this scenario by controlling the infrastructure and services associated with the neutral host networked. The venue will generate revenues from charging the carrier for extended multi-carrier services within the enterprise.
Neutral Host Ownership	• Carriers benefit from reduced investment in costly infrastructure deployments.
Neutral Host vendor controls and manages the carrier agnostic network, creating contracts by which carriers will pay for access to the neutral host network. Venue owner has little control over or insight into network services.	• Neutral host monetizes network via SLA's in which the carrier pays a membership fee, recurring subscription or by usage ($/Gb). • Venue owners can generate additional revenue from leasing space for the network as well as charging MNO for the cost of utilities to support the network. Furthermore, the venue owner will drive new forms of revenue generation with improved Quality of Experience for end users.

Conclusions From Our Research

Attractive applications for Private IoT networks include **worker safety monitoring, security and surveillance, maintenance and service orchestration, and mobile equipment automation** across the identified market segments

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



The adoption of private IoT networks will grow substantially beyond the estimates for 4G/LTE with the introduction of 5G networks to **765+ million device shipments in 2023.**

The adoption of MulteFire in Enterprise environments will grow substantially, introducing disruptive business models that will drive MulteFire Enterprise small cell shipments to **3.7 million units in 2025**

The market for wireless managed networks within mission critical segments including applications in **transportation, supply chain, energy and industrial** is expected to experience steady and attractive growth

The market for Private and Neutral Host LTE with MulteFire within Enterprise segments including **Commercial Buildings, Stadiums, Airports and Retail** is expected to experience steady and attractive growth

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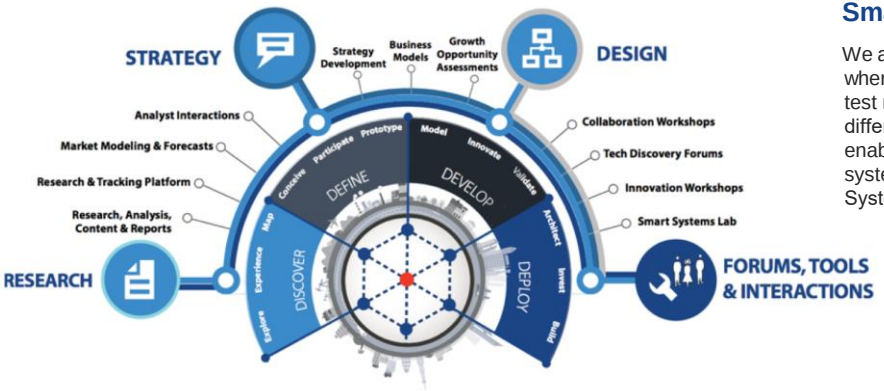
Our strategy and business development consulting services deliver creative innovation tools, practical methods and applied problem solving

Research & Content

Our research, tracking, and decision support tools provide an accessible learning environment for those who are trying to wrap their arms and minds around emerging disruptive opportunities

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Four Strategies for the Age of Smart Services

Harbor Has Been a Pioneer and Thought Leader In Smart Connected Products, Systems and Services

Smart Systems Lab

We are creating a real-world laboratory where organizations design, prototype and test new models for delivering value and differentiation. The Lab's mission is to enable business model, technology, and system-level innovation enabled by "Smart Systems" and the Internet of Things

thank you

Alex Glaser

aglaser@harborresearch.com

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