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# Private 5G Networks: 2024 – 2030 – Opportunities, Challenges, Strategies & Forecasts

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## Abstracts

Private LTE networks are a well-established market and have been around for more than a decade, albeit as a niche segment of the wider cellular infrastructure segment – iNET's (Infrastructure Networks) 700 MHz LTE network in the Permian Basin, Tampnet's offshore 4G infrastructure in the North Sea, Rio Tinto's private LTE network for its Western Australia mining operations and other initial installations date back to the early 2010s. However, in most national markets, private cellular networks or NPNs (Non-Public Networks) based on the 3GPP-defined 5G standard are just beginning to move beyond PoC (Proof-of-Concept) trials and small-scale deployments to production-grade implementations of standalone 5G networks, which are laying the foundation for Industry 4.0 and advanced application scenarios.

Compared to LTE technology, private 5G networks – also referred to as 5G MPNs (Mobile Private Networks), 5G campus networks, local 5G or e-Um 5G systems depending on geography – can address far more demanding performance requirements in terms of throughput, latency, reliability, availability and connection density. In particular, 5G's URLLC (Ultra-Reliable, Low-Latency Communications) and mMTC (Massive Machine-Type Communications) capabilities, along with a future-proof transition path to 6G networks in the 2030s, have positioned it as a viable alternative to physically wired connections for industrial-grade communications between machines, robots and control systems. Furthermore, despite its relatively higher cost of ownership, 5G's wider coverage radius per radio node, scalability, determinism, security features and mobility support have stirred strong interest in its potential as a replacement for interference-prone unlicensed wireless technologies in IIoT (Industrial IoT) environments, where the number of connected sensors and other endpoints is expected to increase significantly over the coming years.

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It is worth noting that China is an outlier and the most mature national market thanks to state-funded directives aimed at accelerating the adoption of 5G connectivity in industrial settings such as factories, warehouses, mines, power plants, substations, oil and gas facilities and ports. To provide some context, the largest private 5G installations in China can comprise hundreds to even thousands of dedicated RAN (Radio Access Network) nodes supported by on-premise or edge cloud-based core network functions depending on specific latency, reliability and security requirements. For example, home appliance manufacturer Midea's Jingzhou industrial park hosts 2,500 indoor and outdoor 5G NR access points to connect workers, machines, robots and vehicles across an area of approximately 104 acres, steelmaker WISCO (Wuhan Iron & Steel Corporation) has installed a dual-layer private 5G network – spanning 85 multi-sector macrocells and 100 small cells – to remotely operate heavy machinery at its steel plant in Wuhan (Hubei), and Fujian-based manufacturer Wanhua Chemical has recently built a customized wireless network that will serve upwards of 8,000 5G RedCap (Reduced Capability) devices, primarily surveillance cameras and IoT sensors.

As end user organizations in the United States, Germany, France, Japan, South Korea, Taiwan and other countries ramp up their digitization and automation initiatives, private 5G networks are progressively being implemented to support use cases as diverse as wirelessly connected machinery for the rapid reconfiguration of production lines, distributed PLC (Programmable Logic Controller) environments, AMRs (Autonomous Mobile Robots) and AGVs (Automated Guided Vehicles) for intralogistics, AR (Augmented Reality)-assisted guidance and troubleshooting, machine vision-based quality control, wireless software flashing of manufactured vehicles, remote-controlled cranes, unmanned mining equipment, BVLOS (Beyond Visual Line-of-Sight) operation of drones, digital twin models of complex industrial systems, ATO (Automatic Train Operation), video analytics for railway crossing and station platform safety, remote visual inspections of aircraft engine parts, real-time collaboration for flight line maintenance operations, XR (Extended Reality)-based military training, virtual visits for parents to see their infants in NICUs (Neonatal Intensive Care Units), live broadcast production in locations not easily accessible by traditional solutions, operations-critical communications during major sporting events, and optimization of cattle fattening and breeding for Wagyu beef production.

Despite prolonged teething problems in the form of a lack of variety of non-smartphone devices, high 5G IoT module costs due to low shipment volumes, limited competence of end user organizations in cellular wireless systems and conservatism with regards to new technology, early adopters are affirming their faith in the long-term potential of private 5G by investing in networks built independently using new shared and local area

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licensed spectrum options, in collaboration with private network specialists or via traditional mobile operators. Some private 5G installations have progressed to a stage where practical and tangible benefits – particularly efficiency gains, cost savings and worker safety – are becoming increasingly evident. Notable examples include but are not limited to:

Tesla's private 5G implementation on the shop floor of its Gigafactory Berlin-Brandenburg plant in Brandenburg, Germany, has helped in overcoming up to 90 percent of the overcycle issues for a particular process in the factory's GA (General Assembly) shop. The electric automaker is integrating private 5G network infrastructure to address high-impact use cases in production, intralogistics and quality operations across its global manufacturing facilities.

John Deere is steadily progressing with its goal of reducing dependency on wired Ethernet connections from 70% to 10% over the next five years by deploying private 5G networks at its industrial facilities in the United States, South America and Europe. In a similar effort, automotive aluminum die-castings supplier IKD has replaced 6 miles of cables connecting 600 pieces of machinery with a private 5G network, thereby reducing cable maintenance costs to near zero and increasing the product yield rate by ten percent.

Lufthansa Technik’s 5G campus network at its Hamburg facility has removed the need for its civil aviation customers to physically attend servicing by providing reliable, high-resolution video access for virtual parts inspections and borescope examinations at both of its engine overhaul workshops. Previous attempts to implement virtual inspections using unlicensed Wi-Fi technology proved ineffective due to the presence of large metal structures.

The EWG (East-West Gate) Intermodal Terminal's private 5G network has increased productivity from 23-25 containers per hour to 32-35 per hour and reduced the facility's personnel-related operating expenses by 40 percent while eliminating the possibility of crane operator injury due to remote-controlled operation with a latency of less than 20 milliseconds.

The Liverpool 5G Create network in the inner city area of Kensington has demonstrated significant cost savings potential for digital health, education and social care services, including an astonishing $10,000 drop in yearly expenditure per care home resident through a 5G-connected fall prevention system and a $2,600 reduction in WAN (Wide Area Network) connectivity charges per GP

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(General Practitioner) surgery – which represents $220,000 in annual savings for the United Kingdom's NHS (National Health Service) when applied to 86 surgeries in Liverpool.

NEC Corporation has improved production efficiency by 30 percent through the introduction of a local 5G-enabled autonomous transport system for intralogistics at its new factory in Kakegawa (Shizuoka Prefecture), Japan. The manufacturing facility's on-premise 5G network has also resulted in an elevated degree of freedom in terms of the factory floor layout, thereby allowing NEC to flexibly respond to changing customer needs, market demand fluctuations and production adjustments.

A local 5G installation at Ushino Nakayama's Osumi farm in Kanoya (Kagoshima Prefecture), Japan, has enabled the Wagyu beef producer to achieve labor cost savings of more than 10 percent through reductions in accident rates, feed loss, and administrative costs. The 5G network provides wireless connectivity for AI (Artificial Intelligence)-based image analytics and autonomous patrol robots.

CJ Logistics has achieved a 20 percent productivity increase at its Ichiri center in Icheon (Gyeonggi), South Korea, following the adoption of a private 5G network to replace the 40,000 square meter warehouse facility's 300 Wi-Fi access points for Industry 4.0 applications, which experienced repeated outages and coverage issues.

Delta Electronics – which has installed private 5G networks for industrial wireless communications at its plants in Taiwan and Thailand – estimates that productivity per direct labor and output per square meter have increased by 69% and 75% respectively following the implementation of 5G-connected smart production lines.

An Open RAN-compliant standalone private 5G network in Taiwan's Pingtung County has facilitated a 30 percent reduction in pest-related agricultural losses and a 15 percent boost in the overall revenue of local farms through the use of 5G-equipped UAVs (Unmanned Aerial Vehicles), mobile robots, smart glasses and AI-enabled image recognition.

JD Logistics – the supply chain and logistics arm of online retailer JD.com – has achieved near-zero packet loss and reduced the likelihood of connection

timeouts by an impressive 70 percent since migrating AGV communications from unlicensed Wi-Fi systems to private 5G networks at its logistics parks in Beijing and Changsha (Hunan), China.

Baosteel – a business unit of the world's largest steelmaker China Baowu Steel Group – credits its 43-site private 5G deployment at two neighboring factories with reducing manual quality inspections by 50 percent and achieving a steel defect detection rate of more than 90 percent, which equates to $7 Million in annual cost savings by reducing lost production capacity from 9,000 tons to 700 tons.

Dongyi Group Coal Gasification Company ascribes a 50 percent reduction in manpower requirements and a 10 percent increase in production efficiency – which translates to more than $1 Million in annual cost savings – at its Xinyan coal mine in Lvliang (Shanxi), China, to private 5G-enabled digitization and automation of underground mining operations.

Sinopec's (China Petroleum & Chemical Corporation) explosion-proof 5G network at its Guangzhou oil refinery in Guangdong, China, has reduced accidents and harmful gas emissions by 20% and 30% respectively, resulting in an annual economic benefit of more than $4 Million. The solution is being replicated across more than 30 refineries of the energy giant.

Since adopting a hybrid public-private 5G network to enhance the safety and efficiency of urban rail transit operations, the Guangzhou Metro rapid transit system has reduced its maintenance costs by approximately 20 percent using 5G-enabled digital perception applications for the real-time identification of water logging and other hazards along railway tracks.

Some of the most technically advanced features of 5G Advanced – 5G's next evolutionarily phase – are also being trialed over private wireless installations. Among other examples, Chinese automaker Great Wall Motor is using an indoor 5G Advanced network for time-critical industrial control within a car roof production line as part of an effort to prevent wire abrasion in mobile application scenarios, which results in production interruptions with an average downtime of 60 hours a year.

In addition, against the backdrop of geopolitical trade tensions and sanctions that have restricted established telecommunications equipment suppliers from operating in

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specific countries, private 5G networks have emerged as a means to test domestically produced 5G network infrastructure products in controlled environments prior to large-scale deployments or vendor swaps across national or regional public mobile networks. For instance, Russian industrial groups are trialing private 5G networks in pilot zones within their production sites, using indigenously built 5G equipment operating in Band n79 (4.8-4.9 GHz) spectrum.

To capitalize on the long-term potential of private 5G, a number of new alternative suppliers have also developed 5G infrastructure offerings tailored to the specific needs of industrial applications. For example, satellite communications company Globalstar has launched a 3GPP Release 16-compliant multipoint terrestrial RAN system that is optimized for dense private wireless deployments in Industry 4.0 automation environments while German engineering conglomerate Siemens has developed an in-house private 5G network solution for use at its own plants as well as those of industrial customers.

SNS Telecom & IT estimates that annual investments in private 5G networks for vertical industries will grow at a CAGR of approximately 42% between 2024 and 2027, eventually accounting for nearly $3.5 Billion by the end of 2027. Although much of this growth will be driven by highly localized 5G networks covering geographically limited areas for Industry 4.0 applications in manufacturing and process industries, sub-1 GHz wide area critical communications networks for public safety, utilities and railway communications are also anticipated to begin their transition from LTE, GSM-R and other legacy narrowband technologies to 5G towards the latter half of the forecast period, as 5G Advanced becomes a commercial reality. Among other features for mission-critical networks, 3GPP Release 18 – which defines the first set of 5G Advanced specifications – adds support for 5G NR equipment operating in dedicated spectrum with less than 5 MHz of bandwidth, paving the way for private 5G networks operating in sub-500 MHz, 700 MHz, 850 MHz and 900 MHz bands for public safety broadband, smart grid modernization and FRMCS (Future Railway Mobile Communication System).

The “Private 5G Networks: 2024 – 2030 – Opportunities, Challenges, Strategies & Forecasts” report presents an in-depth assessment of the private 5G network market, including the value chain, market drivers, barriers to uptake, enabling technologies, operational and business models, vertical industries, application scenarios, key trends, future roadmap, standardization, spectrum availability and allocation, regulatory landscape, case studies, ecosystem player profiles and strategies. The report also presents global and regional market size forecasts from 2024 to 2030. The forecasts

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cover three infrastructure submarkets, 16 vertical industries and five regional markets.

The report comes with an associated Excel datasheet suite covering quantitative data from all numeric forecasts presented in the report, as well as a database of over 7,000 global private cellular engagements – including more than 2,200 private 5G installations – as of Q2'2024.

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3.7.6.2 3GPP-Defined Features for Edge Computing Support
3.7.6.3 Public vs. Private Edge Computing
3.7.7 Network Slicing
3.7.7.1 Logical Partitioning of Network Resources
3.7.7.2 3GPP Functions, Identifiers & Procedures for Slicing
3.7.7.3 RAN Slicing
3.7.7.4 Mobile Core Slicing
3.7.7.5 Transport Network Slicing
3.7.7.6 UE-Based Network Slicing Features
3.7.7.7 Management & Orchestration Aspects
3.7.8 Network Sharing
3.7.8.1 Service-Specific PLMN (Public Land Mobile Network) IDs
3.7.8.2 DNN (Data Network Name)-Based Isolation
3.7.8.3 GWCN (Gateway Core Network): Core Network Sharing
3.7.8.4 MOCN (Multi-Operator Core Network): RAN & Spectrum Sharing
3.7.8.5 MORAN (Multi-Operator RAN): RAN Sharing Without Spectrum Pooling
3.7.8.6 DECOR (Dedicated Core) & eDECOR (Enhanced DECOR)
3.7.8.7 Roaming in Non-Overlapping Service Areas
3.7.8.8 Passive Sharing of Infrastructure Resources
3.7.9 E2E (End-to-End) Security
3.7.9.1 UE Authentication Framework
3.7.9.2 Subscriber Privacy
3.7.9.3 Air Interface Confidentiality & Integrity
3.7.9.4 Resilience Against Radio Jamming
3.7.9.5 RAN, Core & Transport Network Security
3.7.9.6 Security Aspects of Network Slicing
3.7.9.7 Application Domain Protection
3.7.9.8 Other Security Considerations
3.7.10 Shared & Unlicensed Spectrum
3.7.10.1 DSS (Dynamic Spectrum Sharing): LTE & 5G NR Coexistence
3.7.10.2 CBRS (Citizens Broadband Radio Service): Three-Tiered Sharing
3.7.10.3 LSA (Licensed Shared Access) & eLSA (Evolved LSA): Two-Tiered Sharing

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3.7.10.4 AFC (Automated Frequency Coordination): License-Exempt Sharing
3.7.10.5 Local Area Licensing of Shared Spectrum
3.7.10.6 5G NR-U (NR in Unlicensed Spectrum)
3.7.11 Rapidly Deployable 5G Network Systems
3.7.11.1 NIB (Network-in-a-Box) Systems
3.7.11.2 Vehicular COWs (Cells-on-Wheels)
3.7.11.3 Aerial Cell Sites
3.7.11.4 Maritime Cellular Platforms
3.7.12 Direct Communications & Coverage Expansion
3.7.12.1 Sidelink for Direct Mode D2D Communications
3.7.12.2 UE-to-Network & UE-to-UE Relays
3.7.12.3 Indoor & Outdoor Small Cells
3.7.12.4 DAS (Distributed Antenna Systems)
3.7.12.5 IAB (Integrated Access & Backhaul)
3.7.12.6 Mobile IAB: VMRs (Vehicle-Mounted Relays)
3.7.12.7 NCRs (Network-Controlled Repeaters)
3.7.12.8 NTNs (Non-Terrestrial Networks)
3.7.12.9 ATG/A2G (Air-to-Ground) Connectivity
3.7.13 Cloud-Native, Software-Driven & Open Networking
3.7.13.1 Cloud-Native Technologies
3.7.13.2 Microservices & SBA (Service-Based Architecture)
3.7.13.3 Containerization of Network Functions
3.7.13.4 NFV (Network Functions Virtualization)
3.7.13.5 SDN (Software-Defined Networking)
3.7.13.6 Cloud Compute, Storage & Networking Infrastructure
3.7.13.7 APIs (Application Programming Interfaces)
3.7.13.8 Open RAN & Core Architectures
3.7.14 Network Intelligence & Automation
3.7.14.1 AI (Artificial Intelligence)
3.7.14.2 Machine & Deep Learning
3.7.14.3 Big Data & Advanced Analytics
3.7.14.4 SON (Self-Organizing Networks)
3.7.14.5 Intelligent Control, Management & Orchestration
3.7.14.6 Support for Network Intelligence & Automation in 3GPP Standards

## 4 CHAPTER 4: KEY VERTICAL INDUSTRIES & APPLICATIONS

4.1 Cross-Sector & Enterprise Application Capabilities
4.1.1 Mobile Broadband

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4.1.2 FWA (Fixed Wireless Access)
4.1.3 Voice & Messaging Services
4.1.4 High-Definition Video Transmission
4.1.5 Telepresence & Video Conferencing
4.1.6 Multimedia Broadcasting & Multicasting
4.1.7 IoT (Internet of Things) Networking
4.1.8 Wireless Connectivity for Wearables
4.1.9 Untethered AR/VR/MR (Augmented, Virtual & Mixed Reality)
4.1.10 Real-Time Holographic Projections
4.1.11 Tactile Internet & Haptic Feedback
4.1.12 Precise Positioning & Tracking
4.1.13 Industrial Automation
4.1.14 Remote Control of Machines
4.1.15 Connected Mobile Robotics
4.1.16 Unmanned & Autonomous Vehicles
4.1.17 BVLOS (Beyond Visual Line-of-Sight) Operation of Drones
4.1.18 Data-Driven Analytics & Insights
4.1.19 Sensor-Equipped Digital Twins
4.1.20 Predictive Maintenance of Assets
4.2 Vertical Industries & Specific Application Scenarios
4.2.1 Agriculture
4.2.1.1 Intelligent Monitoring of Crop, Soil & Weather Conditions
4.2.1.2 IoT & Advanced Analytics-Driven Yield Optimization
4.2.1.3 Sensor-Based Smart Irrigation Control Systems
4.2.1.4 Real-Time Tracking & Geofencing in Farms
4.2.1.5 Livestock & Aquaculture Health Management
4.2.1.6 Video-Based Remote Veterinary Inspections
4.2.1.7 Unmanned Autonomous Tractors & Farm Vehicles
4.2.1.8 Robots for Planting, Weeding & Harvesting
4.2.1.9 5G-Equipped Agricultural Drones
4.2.1.10 Connected Greenhouses & Vertical Farms
4.2.2 Aviation
4.2.2.1 Inflight Connectivity for Passengers & Cabin Crew
4.2.2.2 Connected Airports for Enhanced Traveler & Visitor Experience
4.2.2.3 Coordination of Ground Support Equipment, Vehicles & Personnel
4.2.2.4 ATM (Air Traffic Management) for Drones & Urban Air Mobility Vehicles
4.2.2.5 Wireless Upload of EFB (Electronic Flight Bag) & IFE (In-Flight Entertainment) Updates
4.2.2.6 Aircraft Data Offload for Operational & Maintenance Purposes

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4.2.2.7 Video Surveillance of Airport Surface & Terminal Areas
4.2.2.8 5G-Enabled Remote Inspection & Repair of Aircraft
4.2.2.9 Navigation, Weather & Other IoT Sensors
4.2.2.10 Smart Baggage Handling
4.2.2.11 Asset Awareness & Tracking
4.2.2.12 Passenger Flow & Resource Management
4.2.2.13 Automation of Check-In & Boarding Procedures
4.2.2.14 Intelligent Airport Service Robots
4.2.3 Broadcasting
4.2.3.1 3GPP-Based PMSE (Program Making & Special Events)
4.2.3.2 Live AV (Audio-Visual) Media Production Using NPNs
4.2.3.3 Private 5G-Enabled Production in Remote Locations
4.2.3.4 Network Slicing for Contribution Feeds
4.2.3.5 Wire-Free Cameras & Microphones
4.2.3.6 Multicast & Broadcast Content Distribution
4.2.4 Construction
4.2.4.1 Wireless Connectivity for Construction Sites & Field Offices
4.2.4.2 Instantaneous Access to Business-Critical Applications
4.2.4.3 5G-Based Remote Control of Heavy Machinery
4.2.4.4 Autonomous Mobile Robots for Construction
4.2.4.5 IoT Sensor-Driven Maintenance of Equipment
4.2.4.6 Video Surveillance & Analytics for Site Security
4.2.4.7 Real-Time Visibility of Personnel, Assets & Materials
4.2.4.8 Aerial Surveying & Monitoring of Construction Sites
4.2.5 Education
4.2.5.1 Remote & Distance Learning Services
4.2.5.2 Mobile Access to Academic Resources
4.2.5.3 5G-Connected Smart Classrooms
4.2.5.4 Automation of Administrative Tasks
4.2.5.5 Personalized & Engaging Learning
4.2.5.6 AR/VR-Based Immersive Lessons
4.2.5.7 5G-Enabled Virtual Field Trips
4.2.5.8 Educational Telepresence Robots
4.2.6 Forestry
4.2.6.1 Wireless Connectivity for Forestry Operations & Recreation
4.2.6.2 5G-Facilitated Teleoperation of Forestry Equipment
4.2.6.3 Autonomous Harvesting & Milling Machinery
4.2.6.4 Real-Time Tracking of Equipment, Vehicles & Personnel
4.2.6.5 Cellular IoT Sensors for Biological & Environmental Monitoring

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4.2.6.6 Wireless Cameras for Wildlife Observation, Conservation & Security
4.2.6.7 Early Wildfire Detection & Containment Systems
4.2.6.8 Drones for Search & Rescue Operations
4.2.7 Healthcare
4.2.7.1 5G-Connected Smart Hospitals & Healthcare Facilities
4.2.7.2 Wireless Transmission of Medical Imagery & Rich Datasets
4.2.7.3 Real-Time Monitoring of Patients in Acute & Intensive Care
4.2.7.4 Telehealth Video Consultations for Visual Assessment
4.2.7.5 Connectivity for AI-Based Healthcare Applications
4.2.7.6 AR Systems for Complex Medical Procedures
4.2.7.7 Remote-Controlled Surgery & Examination
4.2.7.8 Assisted Living & Rehabilitation Robotics
4.2.7.9 Immersive VR-Based Medical & Surgical Training
4.2.7.10 Connected Ambulances for EMS (Emergency Medical Services)
4.2.8 Manufacturing
4.2.8.1 Untethered Connectivity for Production & Process Automation
4.2.8.2 Wireless Motion Control & C2C (Control-to-Control) Communications
4.2.8.3 Cellular-Equipped Mobile Control Panels
4.2.8.4 Mobile Robots & AGVs (Automated Guided Vehicles)
4.2.8.5 Autonomous Forklifts & Warehouse Robotics
4.2.8.6 AR-Facilitated Factory Floor Operations
4.2.8.7 Machine Vision-Based Quality Inspection
4.2.8.8 Closed-Loop Process Control
4.2.8.9 Process & Environmental Monitoring
4.2.8.10 Precise Indoor Positioning for Asset Management
4.2.8.11 Remote Access & Maintenance of Equipment
4.2.9 Military
4.2.9.1 5G-Based Tactical Battlefield Communications
4.2.9.2 Smart Military Bases & Command Posts
4.2.9.3 ISR (Intelligence, Surveillance & Reconnaissance)
4.2.9.4 Command & Control of Weapon Systems
4.2.9.5 Remote Operation of Robotics & Unmanned Assets
4.2.9.6 AR HUD (Heads-Up Display) Systems
4.2.9.7 Wireless VR/MR-Based Military Training
4.2.9.8 Perimeter Security & Force Protection
4.2.10 Mining
4.2.10.1 Safety-Critical Communications in Remote Mining Environments
4.2.10.2 Wireless Control of Drilling, Excavation & Related Equipment
4.2.10.3 Automated Loading, Haulage & Train Operations

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4.2.10.4 Video-Based Monitoring of Personnel & Assets
4.2.10.5 Underground Positioning & Geofencing
4.2.10.6 Smart Ventilation & Water Management
4.2.10.7 Real-Time Operational Intelligence
4.2.10.8 AR & VR for Mining Operations
4.2.11 Oil & Gas
4.2.11.1 Wireless Connectivity for Remote Exploration & Production Sites
4.2.11.2 Critical Voice & Data-Based Mobile Workforce Communications
4.2.11.3 Push-to-Video & Telepresence Conferencing for Field Operations
4.2.11.4 Cellular-Equipped Surveillance Cameras for Situational Awareness
4.2.11.5 IoT Sensor-Enabled Remote Monitoring & Automation of Processes
4.2.11.6 SCADA (Supervisory Control & Data Acquisition) Communications
4.2.11.7 Location Services for Worker Safety & Asset Tracking
4.2.11.8 AR Smart Helmets for Hands-Free Remote Assistance
4.2.11.9 Predictive Maintenance of Oil & Gas Facilities
4.2.11.10 Mobile Robots for Safety Hazard Inspections
4.2.12 Ports & Maritime Transport
4.2.12.1 Critical Communications for Port Workers
4.2.12.2 Automation of Port & Terminal Operations
4.2.12.3 5G-Connected AGVs for Container Transport
4.2.12.4 Remote-Controlled Cranes & Terminal Tractors
4.2.12.5 Video Analytics for Operational Purposes
4.2.12.6 Environmental & Condition Monitoring
4.2.12.7 Port Traffic Management & Control
4.2.12.8 AR & VR Applications for Port Digitization
4.2.12.9 Unmanned Aerial Inspections of Port Facilities
4.2.12.10 Private Cellular-Enabled Maritime Communications
4.2.12.11 Wireless Ship-to-Shore Connectivity in Nearshore Waters
4.2.12.12 5G-Facilitated Remote Steering of Unmanned Vessels
4.2.13 Public Safety
4.2.13.1 Mission-Critical PTT Voice Communications
4.2.13.2 Real-Time Video & High-Resolution Imagery
4.2.13.3 Messaging, File Transfer & Presence Services
4.2.13.4 Secure & Seamless Mobile Broadband Access
4.2.13.5 Location-Based Services & Enhanced Mapping
4.2.13.6 Multimedia CAD (Computer-Aided Dispatch)
4.2.13.7 Massive-Scale Video Surveillance & Analytics
4.2.13.8 Smart Glasses & AR Headgear for First Responders
4.2.13.9 5G-Equipped Police, Firefighting & Rescue Robots

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4.2.13.10 5G MBS/5MBS in High-Density Environments
4.2.13.11 Sidelink-Based Direct Mode Communications
4.2.14 Railways
4.2.14.1 FRMCS (Future Railway Mobile Communication System)
4.2.14.2 Train-to-Ground & Train-to-Train Connectivity
4.2.14.3 Wireless Intra-Train Communications
4.2.14.4 Rail Operations-Critical Voice, Data & Video Services
4.2.14.5 ATO (Automatic Train Operation) & Traffic Management
4.2.14.6 Video Surveillance for Operational Safety & Security
4.2.14.7 Smart Maintenance of Railway Infrastructure
4.2.14.8 Intelligent Management of Logistics Facilities
4.2.14.9 Onboard Broadband Internet Access
4.2.14.10 PIS (Passenger Information Systems)
4.2.14.11 Smart Rail & Metro Station Services
4.2.15 Utilities
4.2.15.1 Multi-Service FANs (Field Area Networks)
4.2.15.2 Critical Applications for Field Workforce Communications
4.2.15.3 AMI (Advanced Metering Infrastructure)
4.2.15.4 DA (Distribution Automation) Systems
4.2.15.5 Microgrid & DER (Distributed Energy Resource) Integration
4.2.15.6 5G-Enabled VPPs (Virtual Power Plants)
4.2.15.7 Low-Latency SCADA Applications for Utilities
4.2.15.8 Teleprotection of Transmission & Distribution Grids
4.2.15.9 Video Monitoring for Critical Infrastructure Protection
4.2.15.10 Sensor-Based Detection of Water & Gas Leaks
4.2.15.11 AR Information Overlays for Repairs & Maintenance
4.2.15.12 Drone & Robot-Assisted Inspections of Utility Assets
4.2.15.13 Local Wireless Connectivity for Remote & Offshore Facilities
4.2.16 Warehousing & Other Verticals

**5 CHAPTER 5: SPECTRUM AVAILABILITY, ALLOCATION & USAGE**

5.1 National & Local Area Licensed Spectrum
5.1.1 Low-Band (Sub-1 GHz)
5.1.1.1 200 400 MHz
5.1.1.2 410 & 450 MHz
5.1.1.3 600 MHz
5.1.1.4 700 MHz
5.1.1.5 800 MHz

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5.1.1.6 900 MHz
5.1.2 Mid-Band (1 6 GHz)
5.1.2.1 1.4 GHz
5.1.2.2 1.6 GHz
5.1.2.3 1.8 GHz
5.1.2.4 1.9 GHz
5.1.2.5 2.1 GHz
5.1.2.6 2.3 GHz
5.1.2.7 2.4 GHz
5.1.2.8 2.5 GHz
5.1.2.9 2.6 GHz
5.1.2.10 3.4 GHz
5.1.2.11 3.5 GHz CBRS PAL Tier
5.1.2.12 3.7 3.8 GHz
5.1.2.13 3.8 4.2 GHz
5.1.2.14 4.6 4.9 GHz
5.1.2.15 Other Bands
5.1.3 High-Band mmWave (Millimeter Wave)
5.1.3.1 26 GHz
5.1.3.2 28 GHz
5.1.3.3 37 GHz
5.1.3.4 Other Bands
5.2 License-Exempt (Unlicensed) Spectrum
5.2.1 Sub-1 GHz Bands (470 790/800/900 MHz)
5.2.2 1.8 GHz DECT Guard Band
5.2.3 1.9 GHz sXGP Band
5.2.4 2.4 GHz (2,400 2,483.5 MHz)
5.2.5 3.5 GHz CBRS GAA Tier
5.2.6 5 GHz (5,150 5,925 MHz)
5.2.7 6 GHz (5,925 7,125 MHz)
5.2.8 60 GHz (57 71 GHz)
5.2.9 Other Bands
5.3 North America
5.3.1 United States
5.3.2 Canada
5.4 Asia Pacific
5.4.1 Australia
5.4.2 New Zealand
5.4.3 China

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5.4.4 Hong Kong
5.4.5 Taiwan
5.4.6 Japan
5.4.7 South Korea
5.4.8 Singapore
5.4.9 Malaysia
5.4.10 Indonesia
5.4.11 Philippines
5.4.12 Thailand
5.4.13 Vietnam
5.4.14 Laos
5.4.15 Myanmar
5.4.16 India
5.4.17 Pakistan
5.4.18 Rest of Asia Pacific
5.5 Europe
5.5.1 United Kingdom
5.5.1.1 Great Britain
5.5.1.2 Northern Ireland
5.5.2 Republic of Ireland
5.5.3 France
5.5.4 Germany
5.5.5 Belgium
5.5.6 Netherlands
5.5.7 Switzerland
5.5.8 Austria
5.5.9 Italy
5.5.10 Spain
5.5.11 Portugal
5.5.12 Sweden
5.5.13 Norway
5.5.14 Denmark
5.5.15 Finland
5.5.16 Estonia
5.5.17 Czech Republic
5.5.18 Poland
5.5.19 Ukraine
5.5.20 Turkiye
5.5.21 Cyprus

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5.5.22 Greece
5.5.23 Bulgaria
5.5.24 Romania
5.5.25 Hungary
5.5.26 Slovenia
5.5.27 Croatia
5.5.28 Russia
5.5.29 Belarus
5.5.30 Rest of Europe
5.6 Middle East & Africa
5.6.1 Saudi Arabia
5.6.2 United Arab Emirates
5.6.3 Qatar
5.6.4 Oman
5.6.5 Bahrain
5.6.6 Kuwait
5.6.7 Iraq
5.6.8 Jordan
5.6.9 Israel
5.6.10 Egypt
5.6.11 Algeria
5.6.12 Morocco
5.6.13 Tunisia
5.6.14 South Africa
5.6.15 Botswana
5.6.16 Zambia
5.6.17 Kenya
5.6.18 Ethiopia
5.6.19 Angola
5.6.20 Republic of the Congo
5.6.21 Gabon
5.6.22 Nigeria
5.6.23 Uganda
5.6.24 Ghana
5.6.25 Senegal
5.6.26 Rest of the Middle East & Africa
5.7 Latin & Central America
5.7.1 Brazil
5.7.2 Mexico

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5.7.3 Argentina
5.7.4 Colombia
5.7.5 Chile
5.7.6 Peru
5.7.7 Ecuador
5.7.8 Bolivia
5.7.9 Dominican Republic
5.7.10 Bardados
5.7.11 Trinidad & Tobago
5.7.12 Suriname
5.7.13 Rest of Latin & Central America

**6 CHAPTER 6: STANDARDIZATION, REGULATORY & COLLABORATIVE INITIATIVES**

6.1 3GPP (Third Generation Partnership Project)
6.1.1 Release 15: 5G eMBB Capabilities, Introduction of Network Slicing & New Operating Bands
6.1.2 Release 16: 3GPP Support for NPNs, 5G URLLC, TSN, NR-U & Vertical Application Enablers
6.1.3 Release 17: NPN Enhancements, Edge Computing, TSC, Expansion of IIoT Features, RedCap & NTN Connectivity
6.1.4 Release 18: 5G Advanced, Further NPN Refinements, DetNet, Intelligent Automation, Spectrum Flexibility & XR Services
6.1.5 Releases 19, 20, 21 & Beyond: Succession From 5G Advanced to the 6G Evolution
6.2 450 MHz Alliance
6.2.1 Promoting 3GPP Technologies in the 380 470 MHz Frequency Range
6.3 5G-ACIA (5G Alliance for Connected Industries and Automation)
6.3.1 Maximizing the Applicability of 5G Technology in the Industrial Domain
6.4 5GAIA (5G Applications Industry Array)
6.4.1 Advancing the Development of China's 5G Applications Industry
6.5 5G Campus Network Alliance
6.5.1 Supporting the Market Development of 5G Campus Networks in Germany
6.6 5GDNA (5G Deterministic Networking Alliance)
6.6.1 Industry Collaboration & Promotion of 5GDN (5G Deterministic Networking)
6.7 5GFF (5G Future Forum)
6.7.1 Accelerating the Delivery of 5G MEC (Multi-Access Edge Computing) Solutions
6.8 5G Forum (South Korea)

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6.8.1 Expanding Convergence Between 5G Technology & Vertical Industries
6.9 5G Health Association
6.9.1 Interfacing 5G-Based Connectivity & Healthcare Applications
6.10 5G-MAG (5G Media Action Group)
6.10.1 5G-Based NPNs in Media Production
6.11 5GMF (Fifth Generation Mobile Communication Promotion Forum, Japan)
6.11.1 Initiatives Related to Local 5G Networks in Japan
6.12 5GSA (5G Slicing Association)
6.12.1 Addressing Vertical Industry Requirements for 5G Network Slicing
6.13 6G-IA (6G Smart Networks and Services Industry Association)
6.13.1 Private 5G-Related Projects & Activities
6.14 AGURRE (Association of Major Users of Operational Radio Networks, France)
6.14.1 Spectrum Access, Regulatory Framework & Industrial Ecosystem for Private Mobile Networks
6.15 APCO (Association of Public-Safety Communications Officials) International
6.15.1 Public Safety 5G-Related Advocacy Efforts
6.16 ATIS (Alliance for Telecommunications Industry Solutions)
6.16.1 Deployment & Operational Requirements of 5G-Based NPNs
6.16.2 Shared HNI & IBN Administration for CBRS Spectrum
6.16.3 Other Private 5G-Related Initiatives
6.17 BTG (Dutch Association of Large-Scale ICT & Telecommunications Users)
6.17.1 KMBG (Dutch Critical Mobile Broadband Users) Expert Group
6.18 B-TrunC (Broadband Trunking Communication) Industry Alliance
6.18.1 B-TrunC Standard for 3GPP-Based Critical Communications
6.19 CAMET (China Association of Metros)
6.19.1 Adoption of 3GPP Networks for Urban Rail Transit Systems
6.20 CEPT (European Conference of Postal and Telecommunications Administrations)
6.20.1 Common Spectrum Policies for Local 5G, PPDR Broadband & FRMCS
6.21 DSA (Dynamic Spectrum Alliance)
6.21.1 Promoting Unlicensed & Dynamic Access to Spectrum
6.22 Electricity Canada (Canadian Electricity Association)
6.22.1 PVNO & Dedicated Spectrum for Smart Grid Communications
6.23 ENTELEC (Energy Telecommunications and Electrical Association)
6.23.1 Policy Advocacy & Other Private 5G-Related Activities
6.24 EPRI (Electric Power Research Institute)
6.24.1 Research & Guidelines in Support of 3GPP-Based Utility Communications
6.25 ERA (European Union Agency for Railways)
6.25.1 Evolution of Railway Radio Communication Project
6.26 ETSI (European Telecommunications Standards Institute)

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6.26.1 Technical Specifications for FRMCS, PPDR Broadband, MCX & TETRA-3GPP Interworking
6.26.2 Other Work Relevant to Private 5G Networks
6.27 EU-Rail (Europe s Rail Joint Undertaking)
6.27.1 FRMCS-Related Research & Innovation Activities
6.28 EUTC (European Utilities Telecom Council)
6.28.1 Addressing 5G-Related Requirements for European Utilities
6.29 EUWENA (European Users of Enterprise Wireless Networks Association)
6.29.1 Catalyzing the Wider Adoption of 3GPP-Based Private Networks
6.30 EWA (Enterprise Wireless Alliance)
6.30.1 Supporting the Private Wireless Industry in the United States
6.31 free5GC
6.31.1 Open-Source 5GC Software
6.32 GSA (Global Mobile Suppliers Association)
6.32.1 Advocacy for Private Mobile Networks
6.33 GSMA (GSM Association)
6.33.1 Guidelines for 5G Private & Dedicated Networks
6.34 GUTMA (Global UTM Association)
6.34.1 ACJA (Aerial Connectivity Joint Activity) Initiative
6.35 ITU (International Telecommunication Union)
6.35.1 International & Regional Harmonization of 5G Spectrum
6.35.2 Defining the Role of IMT-2020 to Support Vertical Applications
6.36 JOTS (Joint Operators Technical Specification) Forum
6.36.1 NHIB (Neutral Host In-Building) Specification
6.37 JRC (Joint Radio Company)
6.37.1 Supporting 5G-Based Smart Grid Initiatives
6.38 KRRI (Korea Railroad Research Institute)
6.38.1 Functional Testing & Certification of 3GPP-Based Railway Communications Systems
6.39 LF (Linux Foundation)
6.39.1 Magma Mobile Core Software Platform
6.39.2 LF Networking's 5G Super Blueprint
6.39.3 LF Edge's Akraino Private 5G ICN (Integrated Cloud-Native) Blueprint
6.39.4 Other Projects Relevant to Private 5G Networks
6.40 MFA (Alliance for Private Networks)
6.40.1 Uni5G Technology Blueprints for Private 5G Networks
6.40.2 Network Identifier Program Supporting Private & Neutral Host Networks
6.41 MSSA (Mobile Satellite Services Association)
6.41.1 Advancing the Global Direct-to-Device NTN Ecosystem

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6.42 NGA (Next G Alliance)
6.42.1 Building the Foundation for North American Leadership in 6G
6.43 NGMN (Next-Generation Mobile Networks) Alliance
6.43.1 Work Related to Private 5G & Network Slicing
6.44 NSC (National Spectrum Consortium)
6.44.1 Enhancing Spectrum Superiority & 5G Capabilities for Federal Users
6.45 OCP (Open Compute Project) Foundation
6.45.1 Initiatives Aimed at Open Designs for Telco Hardware
6.46 one6G Association
6.46.1 Driving 6G Innovation & Development Across Vertical Industries
6.47 ONF (Open Networking Foundation)
6.47.1 Aether Private 5G Connected Edge Platform
6.47.2 SD-RAN, SD-Core, OMEC & Other Relevant Projects
6.48 OnGo Alliance
6.48.1 Promoting 5G OnGo Wireless Network Technology
6.48.2 Technical Specifications & Guidelines for 5G NR-Based CBRS Networks
6.48.3 Product Certification Program Supporting Multi-Vendor Interoperability
6.49 OPC Foundation
6.49.1 OPC UA (Unified Architecture) Over 5G for Industry 4.0 Applications
6.50 Open RAN Policy Coalition
6.50.1 Promoting Policies to Drive the Adoption of Open RAN
6.51 Open5GCore
6.51.1 Vendor-Independent 5GC Implementation
6.52 Open5GS & NextEPC
6.52.1 Open-Source 5GC & EPC Software
6.53 OpenInfra (Open Infrastructure) Foundation
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6.57 PMeV (German Professional Mobile Radio Association)
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6.59 PSCE (Public Safety Communication Europe)
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6.66 TCCA (The Critical Communications Association)
6.66.1 CCBG (Critical Communications Broadband Group)
6.66.2 BIG (Broadband Industry Group)
6.66.3 SCADA, Smart Grid & IoT Group
6.66.4 Future Technologies Group
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6.67.1 SPF (Spectrum Policy Forum)
6.68 TIA (Telecommunications Industry Association)
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6.75 UIC (International Union of Railways)
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6.78 UTC (Utilities Technology Council)
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## 8 CHAPTER 8: KEY ECOSYSTEM PLAYERS

8.1 10T Tech
8.2 1NCE
8.3 1oT
8.4 2TEST (Alkor-Communication)
8.5 3D-P (Epiroc)
8.6 450connect
8.7 4K Solutions
8.8 4RF
8.9 6Harmonics/6WiLInk
8.10 6WIND
8.11 7P (Seven Principles)

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8.12 A Beep/Diga-Talk+
8.13 A1 Telekom Austria Group
8.14 A10 Networks
8.15 A5G Networks
8.16 AAEON Technology (ASUS ASUSTeK Computer)
8.17 Aarna Networks
8.18 ABB
8.19 ABEL Mobilfunk
8.20 ABiT Corporation
8.21 ABS
8.22 Abside Networks
8.23 Accedian
8.24 AccelerComm
8.25 Accelink Technologies
8.26 Accelleran
8.27 Accenture
8.28 Access Spectrum
8.29 Accton Technology Corporation
8.30 Accuver (InnoWireless)
8.31 ACE Technologies
8.32 AceTel (Ace Solutions)
8.33 Achronix Semiconductor Corporation
8.34 ACOME
8.35 Actelis Networks
8.36 Action Technologies (Shenzhen Action Technologies)
8.37 Actiontec Electronics
8.38 Active911
8.39 Actus Networks
8.40 Adax
8.41 Adcor Magnet Systems
8.42 ADI (Analog Devices, Inc.)
8.43 ADLINK Technology
8.44 ADRF (Advanced RF Technologies)
8.45 ADT
8.46 Adtran
8.47 Advanced Energy Industries
8.48 AdvanceTec Industries
8.49 Advantech
8.50 Advantech Wireless Technologies (Baylin Technologies)

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8.52 Aerial Applications
8.53 Aeris
8.54 Aerostar International
8.55 Aethertek
8.56 Affarii Technologies
8.57 Affirmed Networks (Microsoft Corporation)
8.58 AFL Global
8.59 AFRY
8.60 Agile (Agile Interoperable Solutions)
8.61 AGIS (Advanced Ground Information Systems)
8.62 AGM Mobile
8.63 AH NET (MVM NET)
8.64 AI-LINK
8.65 AINA Wireless
8.66 Airbus/SLC (Secure Land Communications)
8.67 Airfide Networks
8.68 Airgain
8.69 AirHop Communications
8.70 Airlinq
8.71 Airspan Networks
8.72 Airtower Networks
8.73 Airwavz Solutions
8.74 AIS (Advanced Info Service)
8.75 AiVader
8.76 Akamai Technologies
8.77 Akoustis Technologies
8.78 Alaxala Networks Corporation (Fortinet)
8.79 ALBEDO Telecom
8.80 albis-elcon (UET United Electronic Technology)
8.81 Alcadis
8.82 Alea (Leonardo)
8.83 Alef (Alef Edge)
8.84 Alepo
8.85 Alibaba Group
8.86 Aliniant
8.87 Allbesmart
8.88 Allen Vanguard Wireless
8.89 Allerio

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8.91 Allot
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8.93 Alpha Wireless
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8.96 Altaeros
8.97 Altair Semiconductor (Sony Semiconductor Israel)
8.98 ALTAN Redes
8.99 Altice Group
8.100 ALVIS (Argentina)
8.101 AM Telecom
8.102 Amantya Technologies
8.103 Amarisoft
8.104 Amazon/AWS (Amazon Web Services)
8.105 Ambra Solutions-ECOTEL
8.106 AMD (Advanced Micro Devices)
8.107 Amdocs
8.108 America Movil
8.109 American Tower Corporation
8.110 AMI (American Megatrends International)
8.111 AMIT Wireless
8.112 Ampere Computing
8.113 Amphenol Corporation
8.114 Ampleon
8.115 Amtele Communication
8.116 Andesat
8.117 ANDRO Computational Solutions
8.118 Anktion (Fujian) Technology
8.119 Anokiwave
8.120 Anritsu
8.121 ANS Advanced Network Services (Charge Enterprises)
8.122 Antenna Company
8.123 Anterix
8.124 Antevia Networks
8.125 Antna Antenna Technology
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8.127 Apple
8.128 APRESIA Systems

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8.134 Arabsat
8.135 Arcadyan Technology Corporation (Compal Electronics)
8.136 Archos
8.137 Arctic Semiconductor (Formerly SiTune Corporation)
8.138 Arete M
8.139 Argela
8.140 ArgoNET
8.141 Aria Networks
8.142 Arista Networks
8.143 Arkessa (Wireless Logic Group)
8.144 Arm
8.145 Armour Communications
8.146 Arqit Quantum
8.147 ArrayComm (Chengdu ArrayComm Wireless Technologies)
8.148 Arrcus
8.149 Artemis Networks
8.150 Artiza Networks
8.151 Aruba (HPE Hewlett Packard Enterprise)
8.152 Arukona
8.153 Asavie
8.154 ASELSAN
8.155 AsiaInfo Technologies
8.156 AsiaSat (Asia Satellite Telecommunications Company)
8.157 Askey Computer Corporation (ASUS ASUSTeK Computer)
8.158 ASOCS
8.159 Aspire Technology (NEC Corporation)
8.160 ASR Microelectronics
8.161 AST SpaceMobile
8.162 ASTELLA (Astella Technologies)
8.163 ASTRI (Hong Kong Applied Science and Technology Research Institute)
8.164 ASUS (ASUSTeK Computer)
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8.167 Ataya

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8.174 Atlas Telecom
8.175 AtlasEdge (Liberty Global/DigitalBridge Group)
8.176 ATN International
8.177 Atos
8.178 Atrinet
8.179 Attabotics
8.180 AttoCore
8.181 Auden Techno
8.182 Auray Technology (Auden Techno)
8.183 Avanti Communications
8.184 Avari Wireless
8.185 AVI
8.186 Aviat Networks
8.187 Avidyne Corporation
8.188 AVIWEST (Haivision)
8.189 AVM
8.190 AW2S Advanced Wireless Solutions and Services (SERMA Group)
8.191 AWTG
8.192 AXESS Networks (HISPASAT)
8.193 Axians (VINCI Energies)
8.194 Axiata Group
8.195 Axione
8.196 Axis Communications
8.197 Axon
8.198 Axtel
8.199 Axxcelera Broadband Wireless (Axxcss Wireless Solutions)
8.200 Axxcss Wireless Solutions
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8.205 Baicells
8.206 Ball Aerospace

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8.212 BAYFU (Bayerische Funknetz)
8.213 Baylin Technologies
8.214 BBB (BB Backbone Corporation)
8.215 BBK Electronics
8.216 BCDVideo
8.217 Beam Semiconductor
8.218 Beamlink
8.219 BearCom
8.220 BEC Technologies (Billion Electric)
8.221 becon
8.222 Beeper Communications
8.223 Beijer Electronics Group
8.224 Belden
8.225 BelFone
8.226 Bell Canada
8.227 Bellantenna
8.228 Benetel
8.229 BesoVideo
8.230 Betacom
8.231 Bharti Airtel
8.232 BHE (Bonn Hungary Electronics)
8.233 BICS (Proximus)
8.234 BinnenBereik (NOVEC)
8.235 Bird Technologies
8.236 BISDN (Berlin Institute for Software Defined Networks)
8.237 Bittium
8.238 BK Technologies
8.239 Black & Veatch
8.240 Black Box
8.241 BlackBerry
8.242 Blackned
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8.245 Blue Arcus Technologies

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8.252 Boingo Wireless (DigitalBridge Group)
8.253 Boldyn Networks (Formerly BAI Communications)
8.254 Bombardier
8.255 Booz Allen Hamilton
8.256 Boston Dynamics
8.257 Bouygues Telecom
8.258 Boxchip
8.259 Branch Communications
8.260 BravoCom
8.261 Bredengen
8.262 Broadcom
8.263 BroadForward
8.264 Broadmobi Shanghai Broadmobi Communication Technology (Wutong Group)
8.265 Broadpeak
8.266 Broadtech
8.267 BSNL (Bharat Sanchar Nigam Limited)
8.268 BT Group
8.269 BTI Wireless
8.270 BubbleRAN
8.271 Bullitt Mobile
8.272 Bumicom Telecommunicatie
8.273 Bureau Veritas/7Layers
8.274 BVSystems (Berkeley Varitronics Systems)
8.275 BWT (BlueWaveTel)
8.276 BYD
8.277 B-Yond
8.278 C Spire
8.279 C Squared Systems
8.280 C3Spectra
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8.282 CableLabs
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8.284 Cadence Design Systems

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8.293 CampusGenius
8.294 Canoga Perkins
8.295 Canonical
8.296 Capgemini Engineering
8.297 CapX Nederland
8.298 Carbyne
8.299 Casa Systems (Axyom & NetComm Portfolio)
8.300 CASIC (China Aerospace Science and Industry Corporation)
8.301 Casio Computer Company
8.302 Castor Marine
8.303 Catalyst Communications Technologies
8.304 Cavli Wireless
8.305 CBNG (Cambridge Broadband Networks Group)
8.306 CCI (Communication Components Inc.)
8.307 CCN (Cirrus Core Networks)
8.308 CCww (Communications Consultants Worldwide)
8.309 Cegeka
8.310 CeLa Link Corporation
8.311 Celfinet (Cyient)
8.312 CellAntenna Corporation
8.313 Cellcomm Solutions
8.314 Cellient
8.315 Celling 5G
8.316 CellMax Technologies (Rosenberger)
8.317 Cellnex Telecom
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8.319 cellXica
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8.330 CETIN Group
8.331 CEVA
8.332 CGI
8.333 Challenge Networks (Vocus)
8.334 Charter Communications
8.335 Cheerzing (Xiamen Cheerzing IoT Technology)
8.336 Chelton
8.337 Chemring Technology Solutions
8.338 Chengdu NTS
8.339 China All Access
8.340 China Mobile
8.341 China Satcom (China Satellite Communications)
8.342 China Telecom
8.343 China Unicom
8.344 Chunghwa Telecom
8.345 Cibicom
8.346 CICT China Information and Communication Technology Group (China Xinke Group)
8.347 Ciena Corporation
8.348 CIG (Cambridge Industries Group)
8.349 CIO (Connected IO)
8.350 Cirpack
8.351 Cisco Systems
8.352 Citymesh (Cegeka/DIGI Communications)
8.353 CitySwitch
8.354 CKH IOD (CK Hutchison)
8.355 Clavister
8.356 Clever Logic
8.357 CloudMinds
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8.371 Colt Technology Services
8.372 Com4 (Wireless Logic Group)
8.373 Comander (ANDRA)
8.374 Comarch
8.375 Comba Telecom
8.376 Combain Mobile
8.377 Comcast Corporation
8.378 Comcores
8.379 Comfone
8.380 COMLAB
8.381 CommAgility (E-Space)
8.382 CommandWear Systems
8.383 Commnet Wireless (ATN International)
8.384 Comms365
8.385 CommScope
8.386 Compal Electronics
8.387 Comprod
8.388 Comptek Technologies (Aero Wireless Group)
8.389 Comrod Communication Group
8.390 COMSovereign
8.391 Comtech Telecommunications Corporation
8.392 Comtest Wireless
8.393 Comtrend Corporation
8.394 Comviva (Tech Mahindra)
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8.396 CONEXIO Corporation
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8.409 Cortina Access
8.410 Cosemi Technologies
8.411 COSMOTE (OTE Group)
8.412 Council Rock
8.413 Coweaver
8.414 Cox Communications
8.415 Cradlepoint (Ericsson)
8.416 Creanord
8.417 CrisisGo
8.418 CROSSCALL
8.419 Crown Castle International Corporation
8.420 CRSC (China Railway Signal & Communication Corporation)/CASCO Signal
8.421 CS Corporation
8.422 CSG Systems International
8.423 CTG (Celestia Technologies Group)
8.424 CTL
8.425 CTS (Communication Technology Services)
8.426 CTS Corporation
8.427 Cubic Corporation
8.428 Cubic Telecom
8.429 Cumucore
8.430 Custom MMIC
8.431 CybertelBridge 1000
8.432 Cyient 1001
8.433 Cyrus Technology 1002
8.434 D2 Technologies 1003
8.435 DAEL Group 1004
8.436 Daeyoun System Company 1005
8.437 Dahua Technology 1006
8.438 Dali Wireless 1007
8.439 DAMM Cellular Systems 1008

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8.448 Delta Electronics 1017
8.449 DENGYO (Nihon Dengyo Kosaku) 1018
8.450 Dense Air (SIP Sidewalk Infrastructure Partners) 1019
8.451 Deutsche Funkturm 1020
8.452 DGS (Digital Global Systems) 1021
8.453 Dialogic 1022
8.454 Diamond Communications 1023
8.455 Digi International 1024
8.456 Digicert 1025
8.457 Digis Squared 1026
8.458 Digita (DigitalBridge Group) 1027
8.459 Digital Ally 1028
8.460 Digital Enhancement 1029
8.461 DigitalBridge Group 1030
8.462 DigitalRoute 1031
8.463 Digitata 1032
8.464 DigitGate (Nanjing DigitGate Communication Technology) 1033
8.465 Dimetor 1034
8.466 DISH Network Corporation 1035
8.467 DKK (Denki Kogyo) 1036
8.468 D-Link Corporation 1037
8.469 DMI 1038
8.470 Doodle Labs 1039
8.471 Doogee 1040
8.472 Doosan Corporation 1041
8.473 DragonWave-X (COMSovereign) 1042
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8.483 Duons 1052
8.484 Durabook (Twinhead International Corporation) 1053
8.485 Duubee 1054
8.486 DZS 1055
8.487 Eahison Communication 1056
8.488 EANTC 1057
8.489 Eastcom (Eastern Communications) 1058
8.490 Easycom (Shenzhen Easycom Electronics) 1059
8.491 E-Band Communications (Axxcss Wireless Solutions) 1060
8.492 e-BO Enterprises 1061
8.493 ECE (European Communications Engineering) 1062
8.494 EchoStar Corporation 1063
8.495 Ecom Instruments (Pepperl+Fuchs) 1064
8.496 Ecrio 1065
8.497 Edgecore Networks (Accton Technology Corporation) 1066
8.498 EdgeQ 1067
8.499 Edgybees 1068
8.500 edotco Group (Axiata Group) 1069
8.501 EDX Wireless 1070
8.502 Effnet 1071
8.503 Eigencomm 1072
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8.505 EION Wireless 1074
8.506 Eir (Eircom) 1075
8.507 Ekinops 1076
8.508 Elbit Systems 1077
8.509 Elefante Group 1078
8.510 Element Materials Technology 1079
8.511 E-Lins Technology 1080
8.512 Elisa 1081
8.513 Elisa Polystar 1082
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8.515 Elsight 1084
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8.524 EMnify 1093
8.525 EMS (Electronic Media Services) 1094
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8.527 Endress+Hauser 1096
8.528 Enea 1097
8.529 ENENSYS Technologies 1098
8.530 Energizer Mobile (Avenir Telecom) 1099
8.531 EnerSys 1100
8.532 Entel (United Kingdom) 1101
8.533 Entropia 1102
8.534 Entropy Solution 1103
8.535 Eoptolink Technology 1104
8.536 Epiroc 1105
8.537 Equiendo 1106
8.538 Eravant (SAGE Millimeter) 1107
8.539 Ericsson 1108
8.540 Errigal 1110
8.541 ErvoCom 1111
8.542 Eseye 1112
8.543 Esharah Etisalat Security Solutions 1113
8.544 E-Space 1114
8.545 Estalky (K-Mobile Technology) 1115
8.546 ETELM 1116
8.547 eTera (Sinotech R&D Group) 1117
8.548 Ethernity Networks 1118
8.549 Etherstack 1119
8.550 Etisalat Group (e&) 1120
8.551 ETRI (Electronics & Telecommunications Research Institute, South Korea) 1121
8.552 Etteplan 1122
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8.564 Expandium 1134
8.565 Expeto 1135
8.566 Extenet (DigitalBridge Group) 1136
8.567 Extreme Networks 1137
8.568 EY (Ernst & Young) 1138
8.569 Eyecom Telecommunications Group 1139
8.570 EZcon Network 1140
8.571 F2G (Far-Together) Solutions 1141
8.572 F5 1142
8.573 Fairspectrum 1143
8.574 Fairwaves 1144
8.575 Faraday Technology Corporation 1145
8.576 Fastback Networks (COMSovereign) 1146
8.577 FCNT (Fujitsu Connected Technologies)-JEMS (Japan EM Solutions) 1147
8.578 Federal Engineering 1148
8.579 Federated Wireless 1149
8.580 Fenix Group (Nokia) 1150
8.581 Festo 1151
8.582 FET (Far EasTone Telecommunications) 1152
8.583 FIBERSTAMP 1153
8.584 Fibocom 1154
8.585 Fibrolan 1155
8.586 Filtronic 1156
8.587 Fingu (Wuhan Fingu Electronic Technology) 1157
8.588 Fiplex Communications (Honeywell International) 1158
8.589 Firecell 1159
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8.603 Fortinet 1173
8.604 Fortress Solutions 1174
8.605 Four-Faith Communication Technology 1175
8.606 Foxconn (Hon Hai Technology Group) 1176
8.607 Franklin Wireless 1177
8.608 Fraunhofer FOKUS (Institute for Open Communication Systems) 1178
8.609 Fraunhofer HHI (Heinrich Hertz Institute) 1179
8.610 Fraunhofer IIS (Institute for Integrated Circuits) 1180
8.611 Fraunhofer IPT (Institute for Production Technology) 1181
8.612 FreedomFi 1182
8.613 Freeeway 1183
8.614 Frequentis 1184
8.615 Freshwave Group (DigitalBridge Group) 1185
8.616 Frog Cellsat 1186
8.617 FRTek 1187
8.618 FSG (Field Solutions Group) 1188
8.619 FTS Formula Telecom Solutions (Magic Software Group) 1189
8.620 Fujikura 1190
8.621 Fujitsu 1191
8.622 Funk-Electronic Piciorgros 1192
8.623 Funkwerk 1193
8.624 Furukawa Electric 1194
8.625 Furuno Electric 1195
8.626 Future Technologies Venture 1196
8.627 G REIGNS (HTC Corporation) 1197
8.628 G+D (Giesecke+Devrient) 1198
8.629 G3 Global 1199
8.630 Galtronics (Baylin Technologies) 1200
8.631 Gamma Nu 1201
8.632 Gapwaves 1202
8.633 Garderos 1203
8.634 Gazprom Space Systems 1204

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8.641 GENEViSiO (QNAP Systems) 1211
8.642 Genew Technologies 1212
8.643 Genmix Technology 1213
8.644 Geotab 1214
8.645 GeoTraq 1215
8.646 Getac Technology Corporation 1216
8.647 Gewei (Wuhan Gewei Electronic Technology) 1217
8.648 GF (GlobalFoundries) 1218
8.649 GIGABYTE Technology 1219
8.650 Gigalane 1220
8.651 GIGALIGHT 1221
8.652 Gigamon 1222
8.653 GigaTera Communications (KMW) 1223
8.654 GigSky 1224
8.655 Gilat Satellite Networks 1225
8.656 GL Communications 1226
8.657 Global Telecom 1227
8.658 Globalgig 1228
8.659 Globalstar 1229
8.660 Globe Telecom 1231
8.661 Gogo Business Aviation 1232
8.662 Goodman Telecom Services 1233
8.663 Goodmill Systems 1234
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8.665 Goosetown Communications 1236
8.666 Gore (W. L. Gore & Associates) 1237
8.667 GosuncnWelink Technology (Gosuncn Group) 1238
8.668 Granite Telecommunications 1239
8.669 Grape One (Sumitomo Corporation) 1240
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8.672 Greenet (Netherlands) 1243
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8.680 Guavus (Thales) 1251
8.681 Guerrilla RF 1252
8.682 GXC (Formerly GenXComm) 1253
8.683 HAAS Alert 1254
8.684 Haier 1255
8.685 Haivision 1256
8.686 Halys 1257
8.687 Hancom MDS 1258
8.688 Handheld Group 1259
8.689 Handsfree Group 1260
8.690 Hansen Technologies 1261
8.691 Hanswell 1262
8.692 Hanwha Techwin 1263
8.693 HAPSMobile 1264
8.694 Harbor Max 1265
8.695 HARMAN DTS (Digital Transformation Solutions) 1266
8.696 HARTING 1267
8.697 Harvilon (Shenzhen Harvilon Technology) 1268
8.698 Hawk Networks (Althea) 1269
8.699 Haystax Technology (Fishtech Group/Cyderes) 1270
8.700 HBFEC (Hebei Far East Communication System Engineering) 1271
8.701 HCL Technologies 1272
8.702 Helios (Fujian Helios Technologies) 1273
8.703 Hengxin (Jiangsu Hengxin Technology) 1274
8.704 Henkel 1275
8.705 Herystorm (Guangzhou Herystorm Technology) 1276
8.706 Hexagon 1277
8.707 Hexagon Communication (Suzhou Hexagon Communication Technologies) 1278
8.708 HFCL 1279
8.709 HFR Networks 1280
8.710 HG Genuine (HGTECH Huagong Technology) 1281
8.711 Highstreet Technologies 1282
8.712 Hikvision (Hangzhou Hikvision Digital Technology) 1283

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8.718 Hitachi 1289
8.719 HKT (PCCW) 1290
8.720 HKTech (Howking Tech) 1291
8.721 HLS (HARD-LINE Solutions) 1292
8.722 HMD Global 1293
8.723 HMF Smart Solutions 1294
8.724 HMS Networks 1295
8.725 Hoimyung ICT 1296
8.726 Hologram 1297
8.727 Honeywell International 1298
8.728 Hongdian Corporation 1299
8.729 HONOR 1300
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