



INTERNATIONAL
TRADE
ADMINISTRATION

5G

Wireless Network Technology

Enabling the 5G Ecosystem

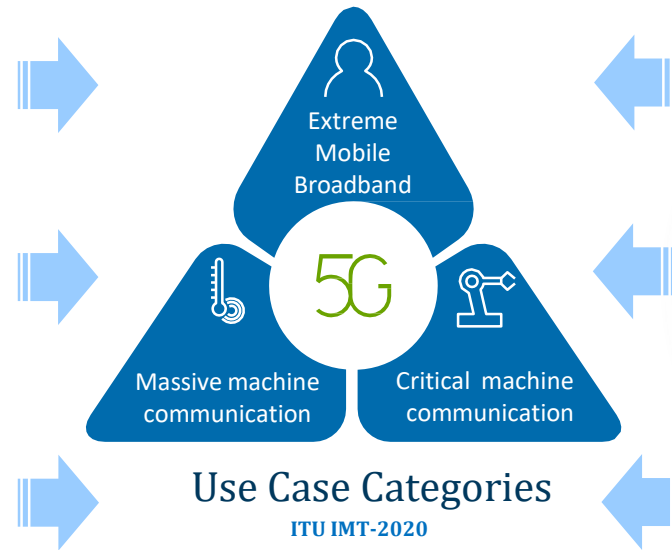
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Office of Health and Information Technologies | Industry & Analysis



KEY PERFORMANCE INDICATORS

ITU IMT-2020

- ★ **High Data Rates** 1 – 10 Gbps in User Experience (max 20 Gbps)
- ★ **Massive Connectivity:** Support for more than 1 million connections per km²
- ★ **Ultra Low Latency:** less than 1 ms
- ★ **Extreme Mobility:** movement up to 500km/h
- ★ **Uninterrupted Ubiquitous Service Coverage** of 99.9%
- ★ **Enhanced Reliability, Spectral Efficiency, Energy Efficiency**
- ★ **Expanded Data Throughput** at least 100 MHz



ENABLING THE 5G ECOSYSTEM

Mid-band Spectrum · Multi-Access Edge Computing · Network Slicing · 5G NR · 5GC · Artificial Intelligence · 4G-LTE · MU-MIMO · Carrier Aggregation · OFDMA · Spectrum · mmWave · NB-IOT · Wi-Fi · Small Cells · Het-Nets · Software Defined Networks · D2D · Machine Learning · V2X · FWA · Satellites · Network Densification · LTE-M · Unlicensed Spectrum · Virtualization · CoMP · Spread Spectrum · Multi-band · LDPC Coding · Content Distributed Architecture · 256 QAM · Optical Fiber · Beam Forming · Macro Cells · Distributed Architectures · LTE Advanced · M2M · Low-band Spectrum · Cloud RAN · NSA · SA

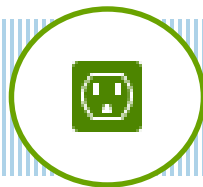
Automotive



Healthcare



Utilities



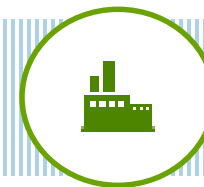
Transportation



Energy



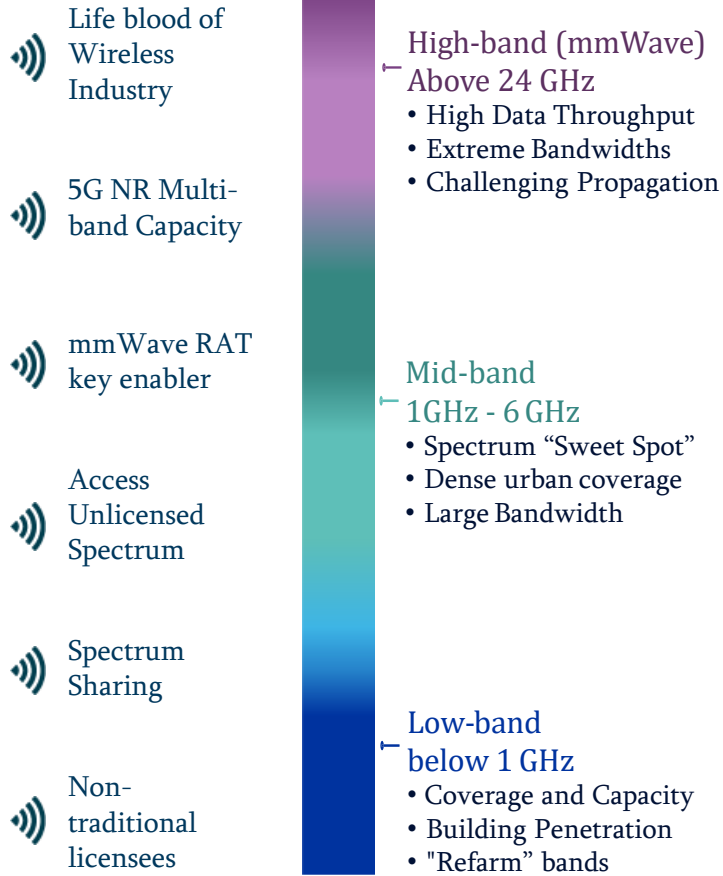
Manufacturing



Entertainment



SPECTRUM



KEY STANDARDS

5G NR

- ↻ 5G New Radio
- ↻ Spectral Efficiency
- ↻ Multi-band
- ↻ SA and NSA

5GC

- ↻ Core Network
- ↻ SDN/NFV Capabilities
- ↻ Artificial Intelligence
- ↻ Opex/Capex Savings

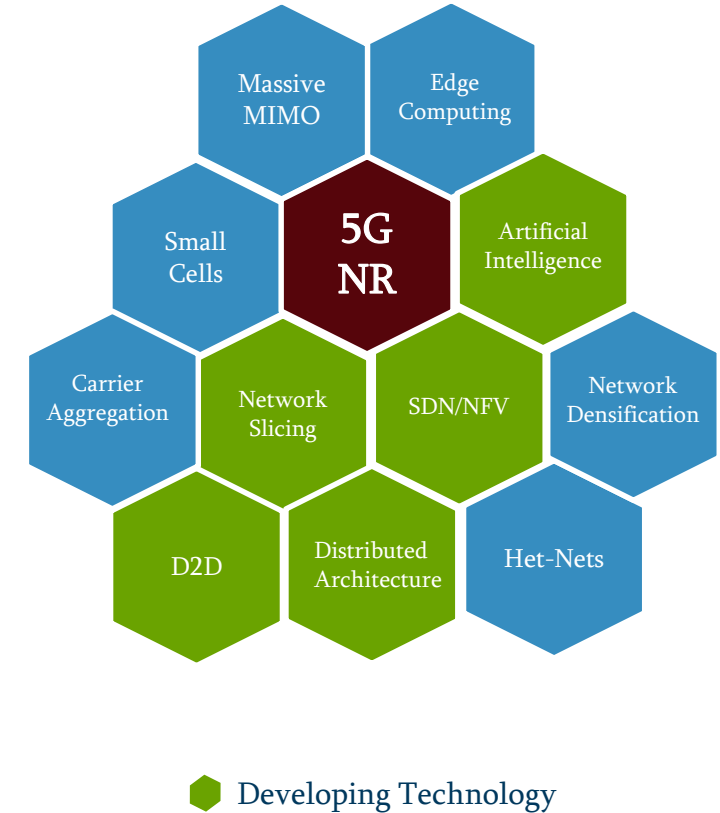
NB-IOT LTE-M

- ↻ Utilize LTE Hardware
- ↻ Narrow band
- ↻ IoT over licensed spectrum

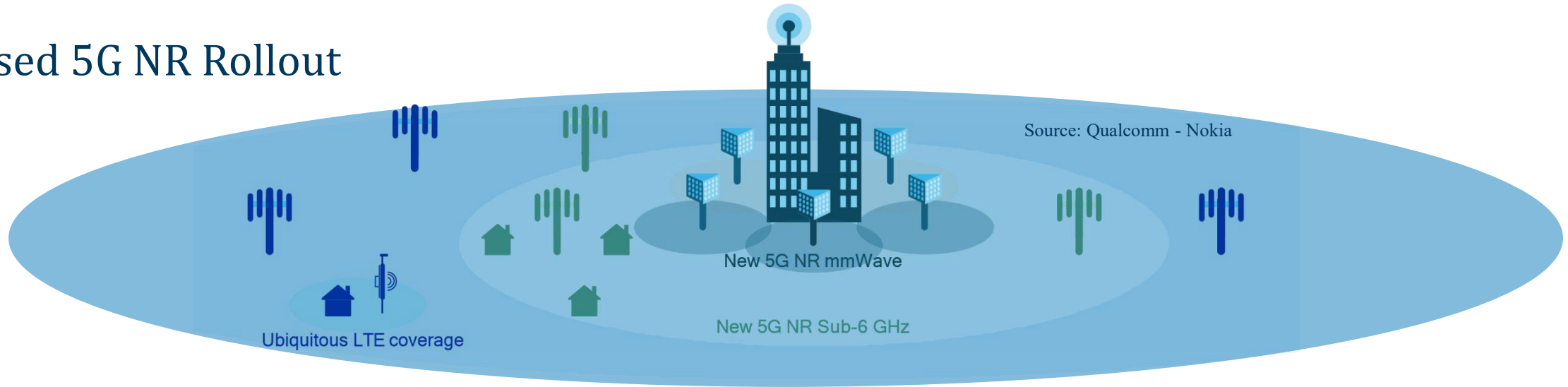
V2X

- ↻ Wireless Vehicle to X Communication
- ↻ Licensed Spectrum

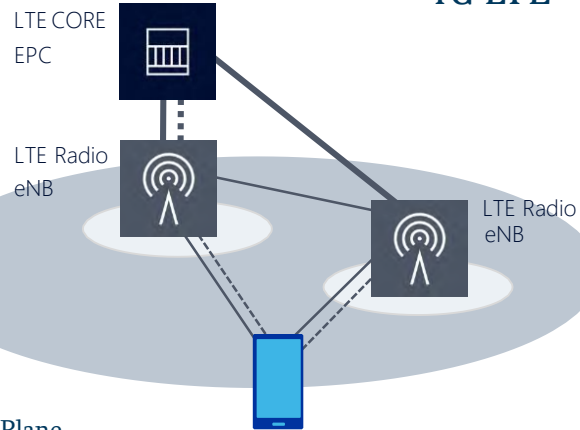
ENABLING TECHNOLOGIES & APPS



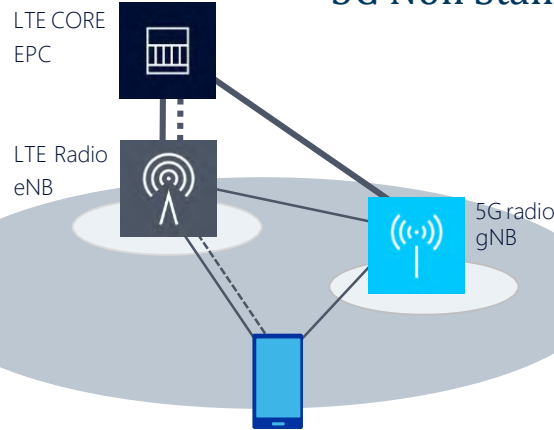
Phased 5G NR Rollout



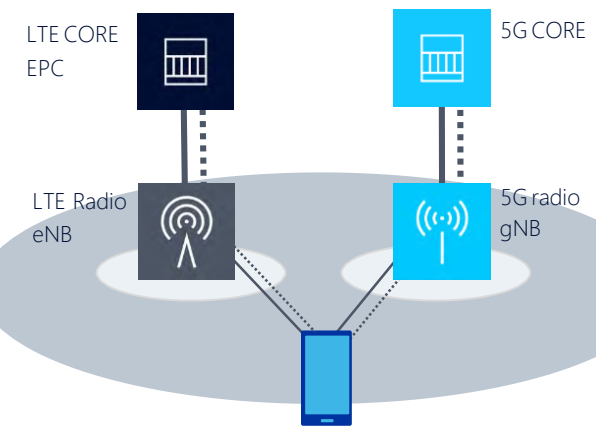
4G LTE



5G Non Standalone



5G Standalone



— Data Plane
- - - Control Plane

Continue to Leverage Existing 4G-LTE Infrastructure

Heterogenous Wireless Access Technologies

25 billion Connected Devices by 2025

107 EB (exabytes) data per month by the end of 2023

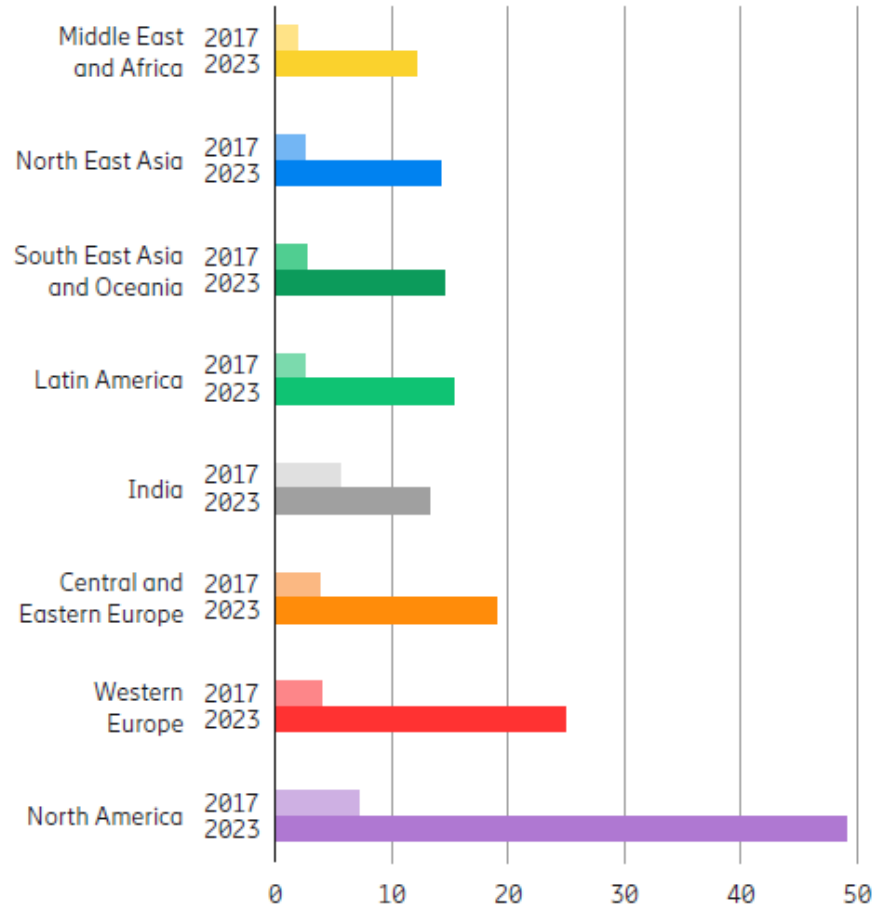
43% CAGR in mobile data traffic by 2023

77% Smartphone penetration by 2025

Capacity/Usage Constraints emerging apps and use cases

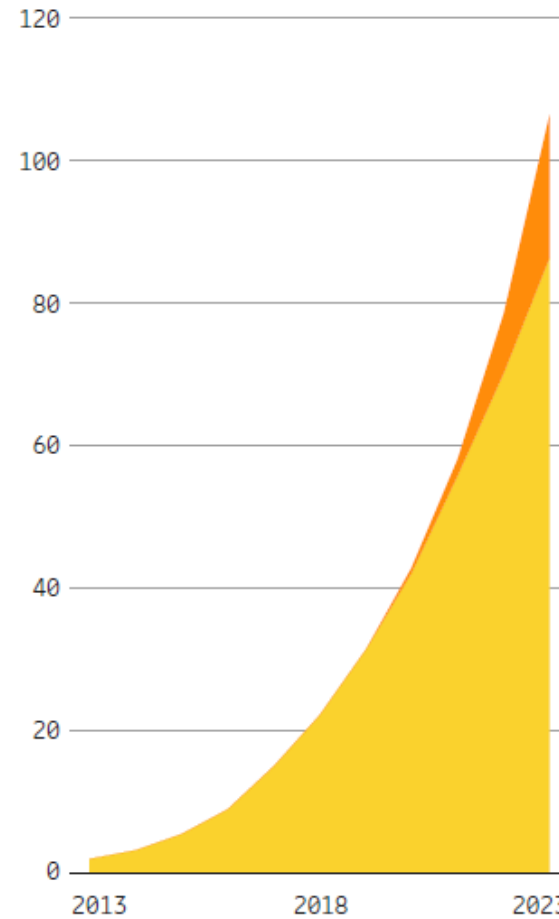


Mobile data traffic per active smartphone (gigabytes per month)



Ericsson Mobility Report | 2018

Global mobile data traffic (exabytes per month)



5G Ecosystem: Demand and Supply

- Drivers
- 5G capabilities

5G USE CASES AND APPLICATIONS

Waiting for Killer Application

<h3>Autonomous Vehicles</h3> <ul style="list-style-type: none"> Collision Avoidance Intelligent Transportation Mobility/Low Latency 	<h3>Fixed Wireless Access</h3> <ul style="list-style-type: none"> Fiber Replacement Broadband Access Throughput/Cost Efficiency 	<h3>IoT Applications</h3> <ul style="list-style-type: none"> Remote Monitoring/Mgmt. Networked Devices Coverage/Power Efficiency 	<h3>Smart Cities Applications</h3> <ul style="list-style-type: none"> Connected utilities, transport, etc. Data Analytics Density/Cost Efficiency
<h3>AR/VR Applications</h3> <ul style="list-style-type: none"> Personal Entertainment Industrial Applications Low Latency/Throughput 	<h3>Healthcare</h3> <ul style="list-style-type: none"> Long-term Monitoring Remote Care and Diagnosis Throughput/Low Latency 	<h3>Tactile Internet</h3> <ul style="list-style-type: none"> Industrial Applications Augmented Reality Data Speeds/Low Latency 	<h3>Advanced Manufacturing</h3> <ul style="list-style-type: none"> Automation Remote Monitoring/Mgmt. Reliability/Density

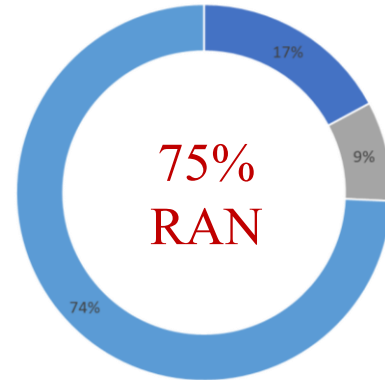


Logos include: Ruckus Wireless, Hewlett Packard Enterprise, COMMSCOPE, Dell, Red Hat, Juniper Networks, Ciena, Intel, Ribbon Communications, Netscout, Arista, VMware, Polaris Networks, Tellabs, Extreme Networks, Google, Keysight Technologies, Globalstar, American Tower, Oracle, Texas Instruments, VMware, Dialogic, Cirrus, Netgear, 5 Networks, Starry, T-Mobile, AT&T, CrowdStrike, InterDigital, Broadcom, Linksys, Skyworks, Microwave Networks, Apple, IBM, Netgear, Silicon Labs, Tecore Networks, Airspan, BridgeWave Communications, AltioStar, Blue Danube, Qualcomm, Verizon, Xilinx, SpiderCloud Wireless, Mojo Networks, Corning, Infinera, Viasat, Cloudstreet, and Industry & Analysis.

KEY CHALLENGES TO 5G ECOSYSTEM

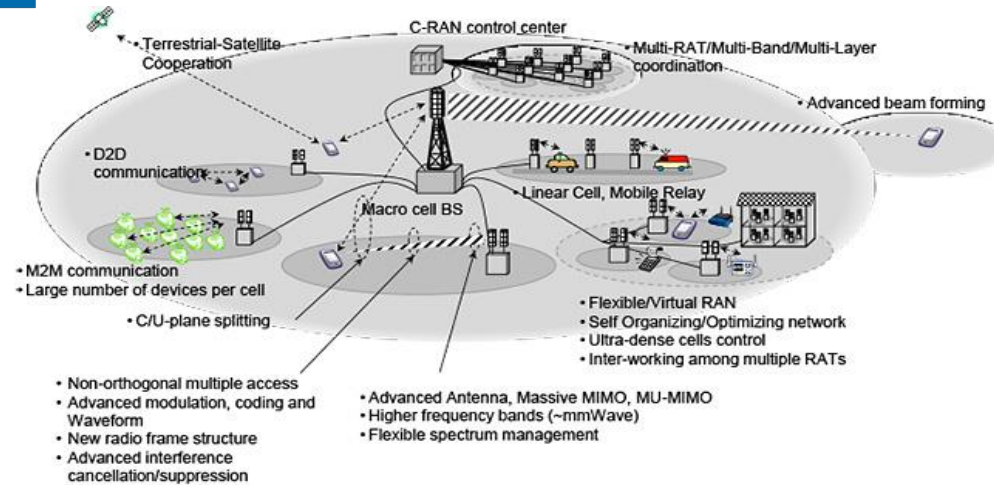
- 1 Effective RF spectrum capacity management
- 2 Cost of network deployment and upgrades
- 3 Permitting and site approvals to deploy radios and network infrastructure
- 4 Killer applications and business cases yet to emerge...why 5G?
- 5 Trade and Regulatory policies disrupting globalized industry
- 6 Continuing evolution of the network architecture
- 7 Emerging technologies still under development
- 8 Increased security vulnerabilities
- 9 Standards and Interoperability

2 Cost Structure for 5G Deployment



- Uncertain cost structure
- 5 - 200 Billion USD Capex
- 30 - 60 USD per User
- 5X cost for Standalone
- High-band radios
- Urban vs. rural densification
- Phased Deployment
- CAPEX vs. OPEX

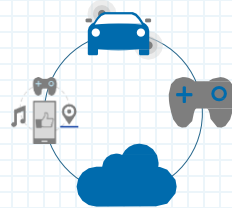
6 Architectures with Heterogenous RAT



9 Ecosystem of Tech Standards



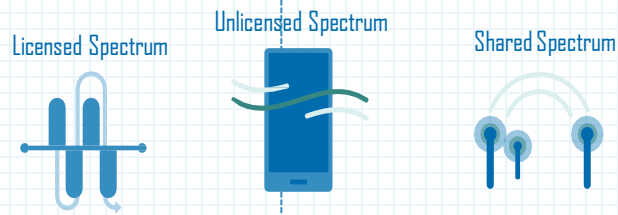
Policy Environment for 5G Ecosystem



POLICY BLUEPRINT FOR 5G DEVELOPMENT & DEPLOYMENT

SPECTRUM ALLOCATION

- Clear and Transparent access across all 3 band segments
- Licensed spectrum, unlicensed, and shared spectrum mgmt.
- Consistent with international harmonization



SPECTRUM FLEXIBLE-USE AND TECHNOLOGY NEUTRALITY

- Service licenses not tied to specific technology
- Ease of wireless technology platform development

EASE OF SITING AND PERMITTING FOR RADIOS AND INFRASTRUCTURE

- Cost-effective and open access to urban "furniture"
- Efficient and timely site permitting
- Infrastructure Sharing



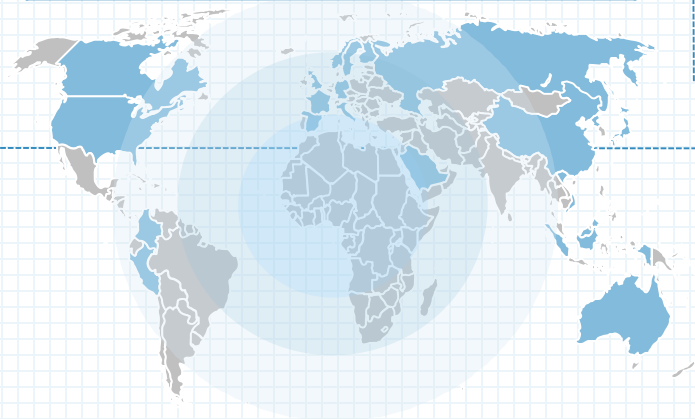
Areas of Cooperation

ACCESS TO GLOBAL TECHNOLOGY MARKET

- Duty-free access to international goods and services
- Full life-cycle cost analysis of procurement
- No place for forced localized production or local content requirements

FREE MOVEMENT OF CROSS-BORDER DATA

- Data localization requirements harm innovation and business use cases



SECURE SUPPLY-CHAINS & CYBERSECURITY

- Trusted suppliers in all layers of the network and architecture
- Employ risk-based security regime
- Cyber workforce development

INDUSTRY-DRIVEN STANDARDS

- Continued Development of 5G standards
- Ecosystem of enabling technologies
- 5G applications
- Integration of ICT across vertical industries

SUPPORT FOR INNOVATION & TECHNOLOGY DEVELOPMENT

- Strong incentives for technology R&D
- Enabling environment for startups and entrepreneurs
- Efficient test-beds and "sand-box" trials

NOTES ON STARTUP MODEL AND INNOVATION:

- Unconstrained by Geography
Aggressively pursue growth regardless of national boundaries
- Focused on Growth
Achieving rapid scale is main strategic focus
- Changing Business Model
Iterate multiple times to find model that is repeatable and scalable.
- Additional Measures
Indicators include firm age, number of employees, ownership, revenue levels, etc



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