Private Wireless Market Briefing for Mavenir

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MOBILE EXPERTS

Agenda

- Our forecast methodology and key assumptions
- CBRS network outlook
- Spectrum for private wireless
- Open RAN outlook for private wireless
- Enterprise radios – ASP outlook
- Millimeter wave and massive MIMO for private wireless
- 4G vs. 5G for private wireless
- On-prem vs. cloud mix for Core networking
- 5G Core for private wireless

Our Methodology

- Primary research via input from industry stakeholders, including mobile operators, industrial automation companies, infrastructure vendors, and system integrators
- Our *Cellular IoT* research for the device market forecast
- Secondary research on macro trends in specific industry sectors (e.g., oil & gas, mining, transportation, etc.)

Key Assumptions in Our Forecast (1/4)

Oil & Gas

- Capex decline near-term
- Capex returning to 5% in 2023
- Steady new oil field projects
- Steadily increasing upgrade projects on existing onshore and offshore fields

Mining

- 50k estimated mines globally
- 15-30 radio sites per large ‘surface’ mines
- 4 radio sites per smaller ‘underground’ mines
- Increasing adoption of private LTE/5G for safety-driven digital transformation

Key Assumptions in Our Forecast (2/4)

Utility

- ~$120B industry CAPEX (EEI)
- Less than 30% on Distribution
- 10% of Distribution on automation/networking
- Increasing private wireless for automation of new generation sites (e.g.., solar, wind farms)

Transportation

- Railway moderization from GSM-R to LTE-R, FRMCS
- Digital modernization projects at airports and shipping ports

Key Assumptions in Our Forecast (3/4)

Government

- LTE-based Public Safety projects in Korea, China, N.Am.
- Bulk of opportunity in user terminals
- Steady 7% growth assumed (based on Motorola Solutions trends)
- 15-20% of market opportunity from military tactical radios

Manufacturing

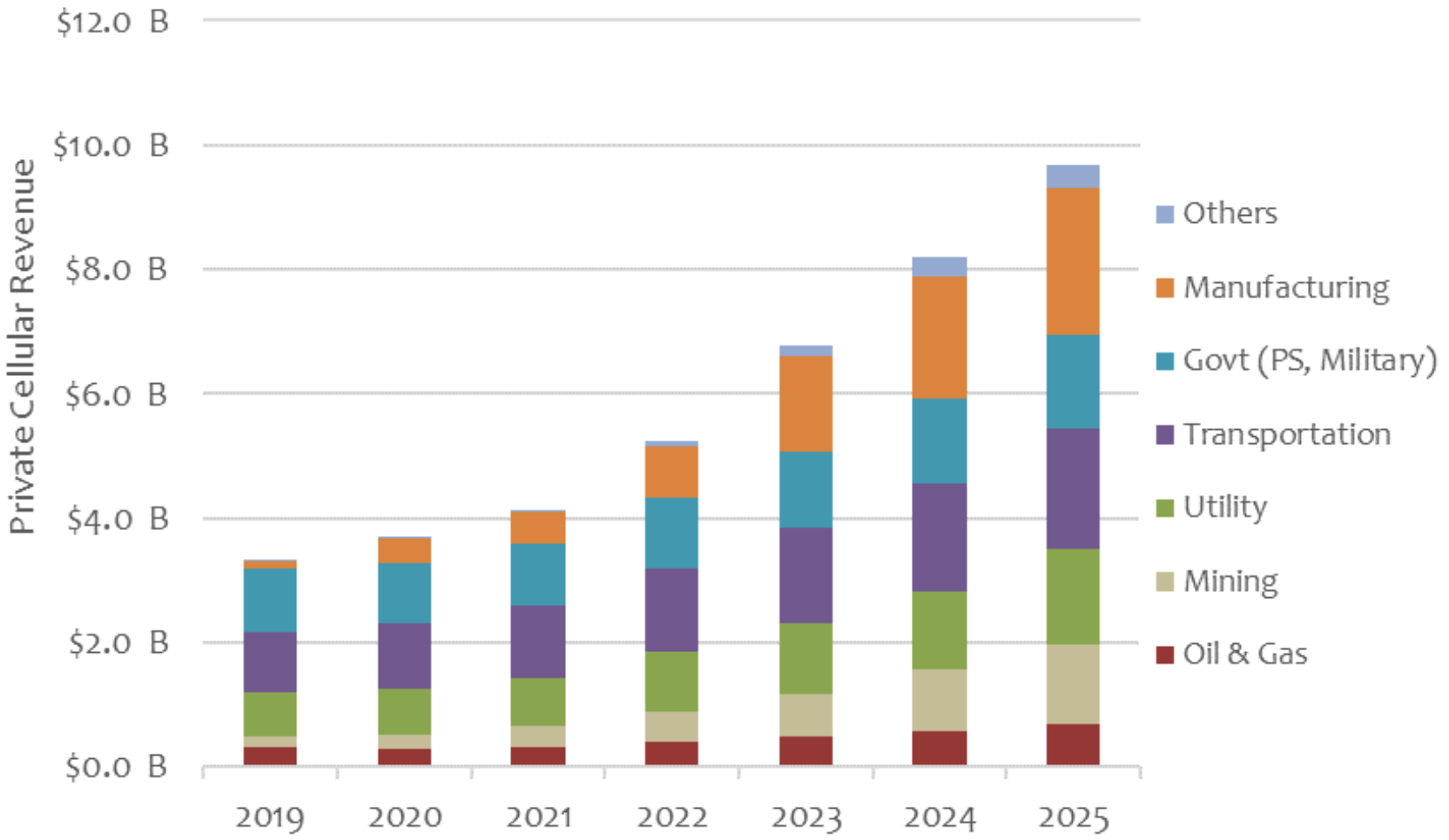
- ~10M manufacturing sites globally (McKinsey, Manufacturing Institute)
- Only large (~1%) manufacturers will adopt private LTE/5G
- EU will lead, followed by APAC and N. Am. manufacturers
- Release 16 and 17 features will be key drivers

Key Assumptions in Our Forecast (4/4)

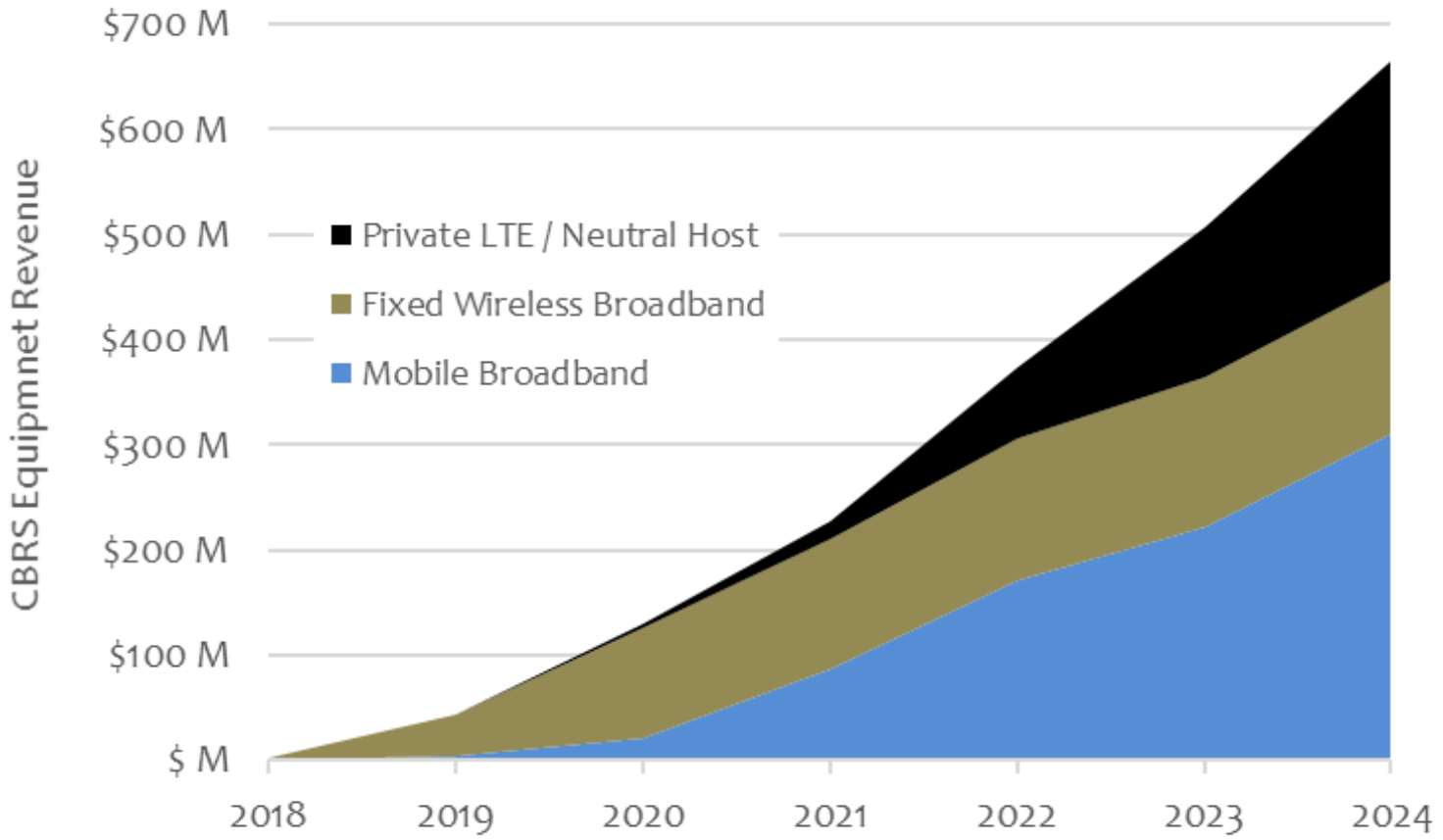
BUT, our 2020 Private LTE and 5G forecast did not account for COVID-19… Qualitatively, our projections will be:

- Oil & Gas – more negative (near-term) but remain intact (longer term)
- Mining – negative (near-term) but remain intact (longer term)
- Utility – same
- Transportation – negative (near-term) and ??? (longer term)
- Government – negative
- Manufacturing – negative (very near-term) but remain intact (longer term)

(3GPP) private wireless adoption varies by industry



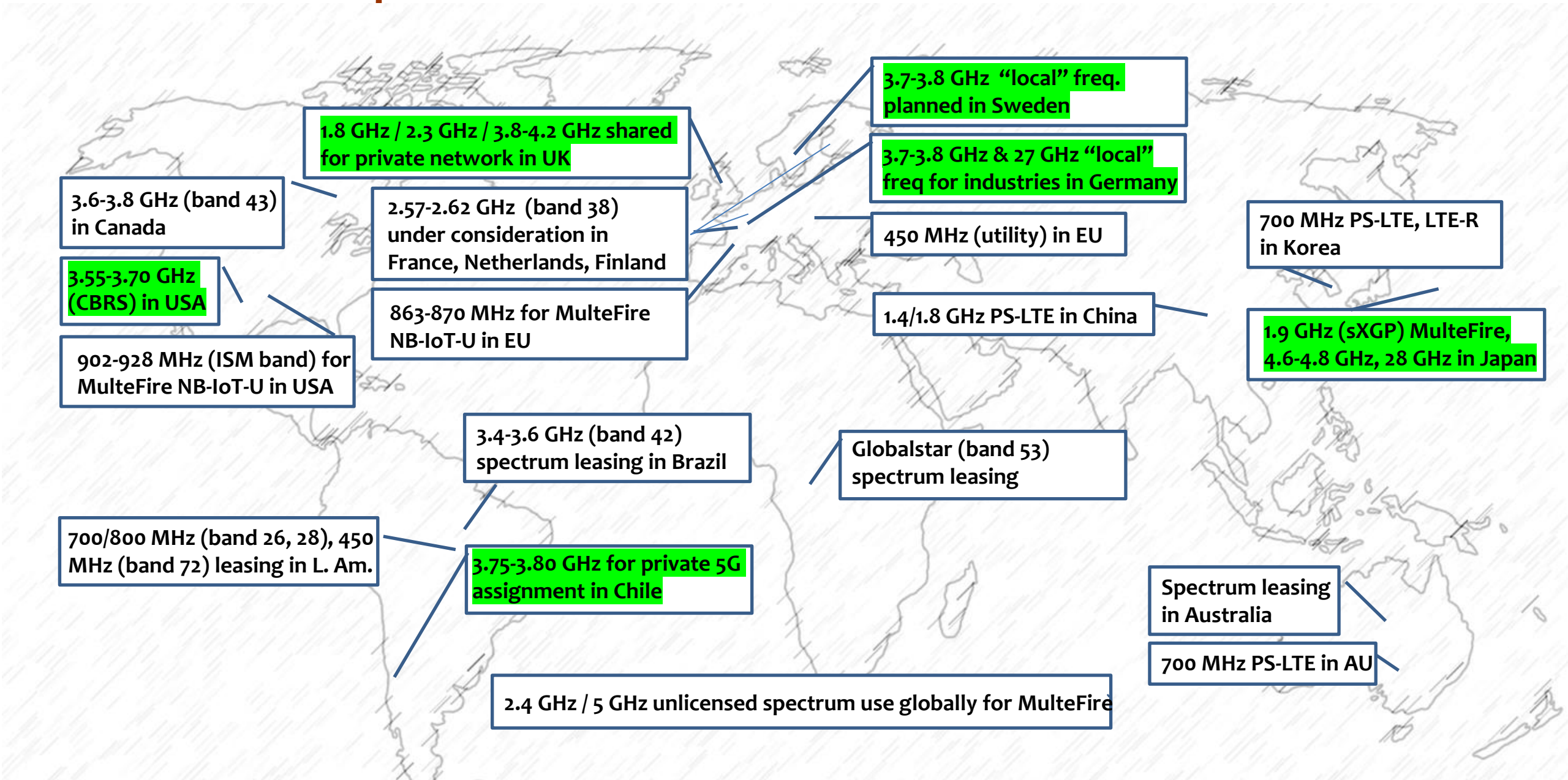
CBRS outlook for private wireless



Source: MEXP-CBRS-19-FU1 (April 2020)

- FWA and mobility will drive the near-term market adoption
- COVID-19 challenges in private wireless, enterprise
- Neutral-host in-building wireless growth outlook longer term

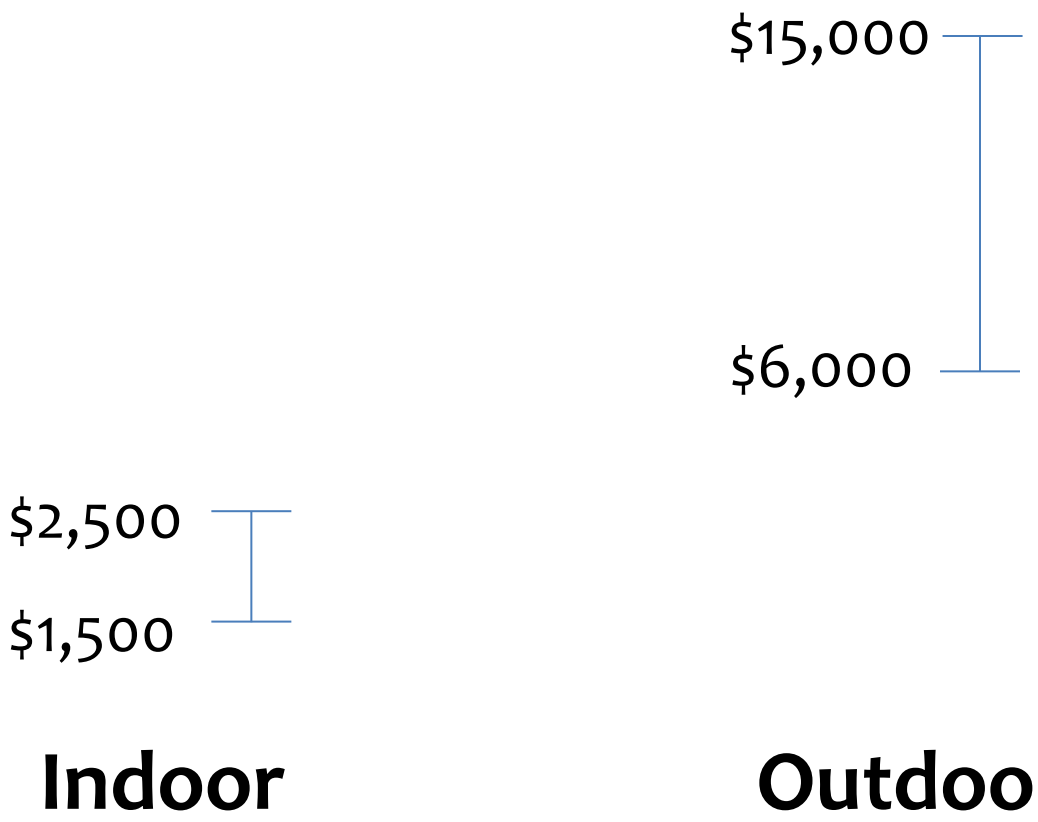
Spectrum for Private Wireless



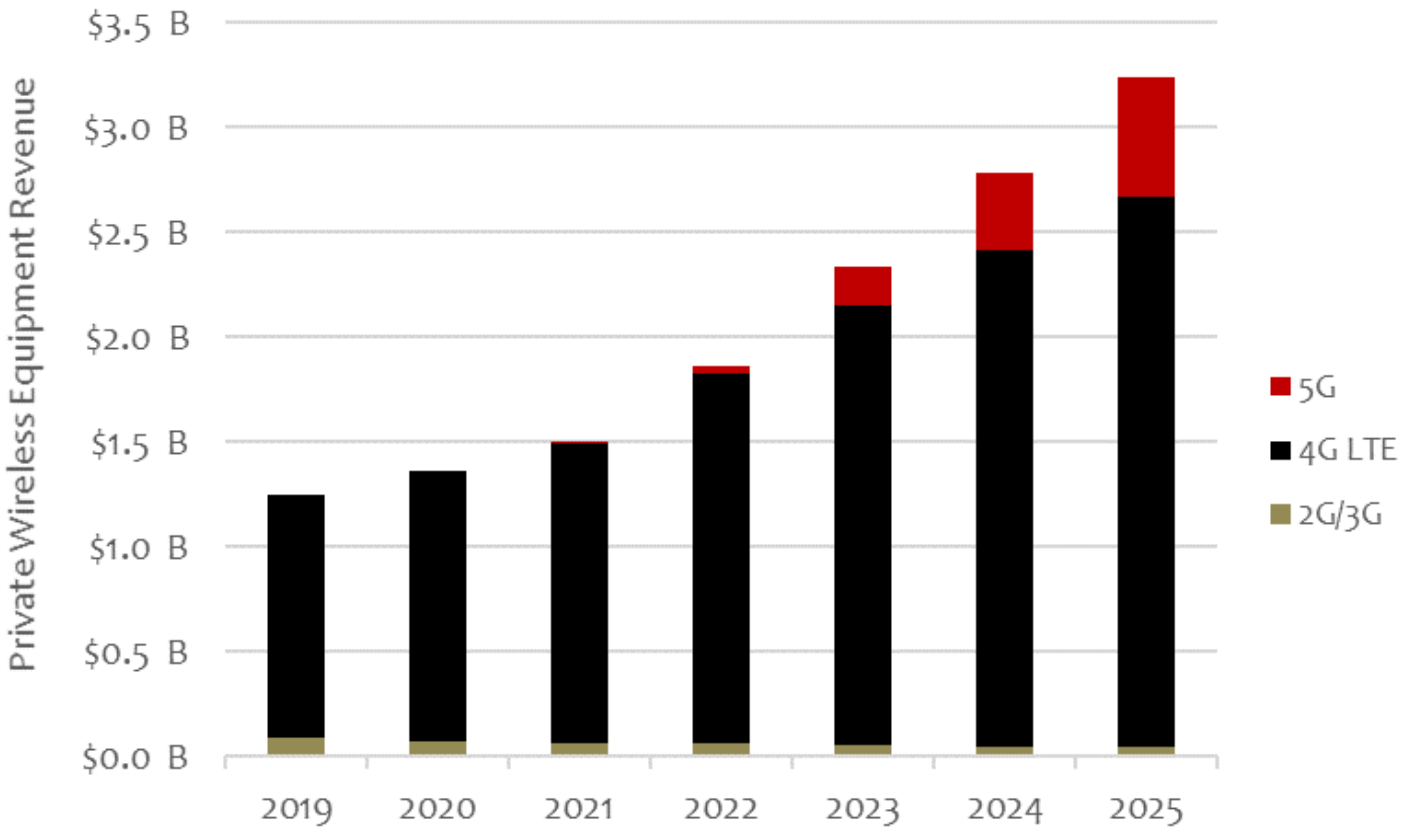
Open RAN Outlook for Private Wireless

- Solution-driven market demand in private wireless (vs. potential cost-savings benefits of open RAN)
- End-to-end solution features (e.g, along w/ MEC) may offer market opportunity
- “Greenfield” market opportunities for Open RAN

Hefty margins built in Enterprise small cell ASPs



4G vs. 5G in Private Wireless



- Expect 2 years for "hardening" of Release 16 infrastructure and device ecosystem for industry
- General broadband connectivity services can be satisfied w/ 4G and 5G Release 15
- Latency-sensitive private 5G will depend on SA Core maturity and adoption

mmW and Massive MIMO

- 5G mmW likely based on "local" frequency allocation in the millimeter wave bands (e.g., 28 GHz)
- Benefits of Massive MIMO for indoor not certain
  - -e.g., 64-antenna elements translating to 2TR/4TR streams

5G Core in the cloud will be prevalent – longer term

Deployment Architecture	Enterprise Direct	Managed Private Wireless-as-a-Service	Operator Private Wireless-as-a-Service
Fully On-Premise	Enterprise owned and managed(1)		MNO owned private RAN (no sharing)
Hybrid		MSP owned and managed	MNO owned shared RAN and Core(2)
Full Cloud Service			Network Slicing(3)

(1) Large enterprises may opt for this deployment/business model for full control
(2) Small enterprises with limited budget/staff may opt for this model
(3) Operators would prefer this model to address private wireless market opportunity with maximal shared economics with existing consumer MBB services

5G Core for Private Wireless

- SA Core is preferred over NSA -- for demanding 5G use cases (e.g., URLLC)
- Key asks in 5G SA Core
  - Dynamic Slicing to meet SLA requirements
  - Local Area Data Networks (local breakout for MEC)
- Dynamic slicing and LADN not available in NSA