5G SPECTRUM OPPORTUNITIES & CHALLENGES

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EVOLUTION TO A SMART AND CONNECTED WORLD

**2G**
Cellular Comms.
Few MHz < 1 GHz

**3G**
Data and the emergence of apps
10s of MHz < 2 GHz

**4G**
Faster data rates
The app revolution
Several 10s of MHz < 4 GHz

**5G**
Reactive, smart, and connected devices
Several 100s of MHz From < 1 GHz to > 70 GHz
Enabling new “5G” applications requires access to a variety of spectrum bands: low, mid, and high frequencies.

SPECTRUM NEEDS OF 5G

Access to sufficient spectrum in a variety of bands with economies of scale is key to success in 5G

5G applications drive technical requirements, including type and amount of spectrum
- < 1 GHz – for wide area applications, e.g. sensor networks, etc.
- < 6 GHz – for coverage/capacity trade-off, e.g. massive MIMO, outdoor-to-indoor
- Higher – for apps needing ultra-wide channels, e.g. 4k/8k video, VR, etc.

Continuous flow of sufficient, adequate, new spectrum is key to:
- Expansion of wireless market to 5G and beyond, and
- Building a strong and healthy eco-system

WRC-15 OUTCOMES BELOW 6 GHZ

Crucial to make sufficient spectrum sub 6 GHz available in a timely manner to enable 5G.
BANDS ABOVE 6 GHZ TO BE STUDIED TOWARDS WRC-19

ITU-R will study the above bands (yellow, orange) to prepare for WRC-19
If approved by WRC-2020, timeframe of availability ~2020+
USA and some other countries are going forward with 28 GHz in 2016-2018 timeframe

Challenge
Sharing conditions are expected to be difficult in some bands under study
**TECHNOLOGY AND SPECTRUM IN 5G ERA**

- **mMTC**
- **URLLC**
- **Enhanced Mobile Broadband (eMBB)**

**Spectrum**
- 3 GHz
- 10 GHz
- 30 GHz
- 100 GHz

**5G New Radio**

- **LTE-A Pro**

**Sub-6GHz to 100GHz with scalable bandwidth**

**Multi-band and multi-mode support**

**2.4 GHz**
- IoT (VHF)
- 600 MHz
- 700 MHz

**2.5 GHz**
- 1427 MHz
- 1518 MHz

**3.3 GHz**
- 3.3 GHz
- 3.4 GHz

**3.4 GHz**
- 3.4 GHz
- 3.5 GHz

**3.6 GHz**
- 3.6 GHz
- 3.7 GHz

**3.8 GHz**
- 3.8 GHz
- 3.9 GHz

**4.2 GHz**
- 4.2 GHz
- 4.3 GHz

**4.4 GHz**
- 4.4 GHz
- 4.5 GHz

**4.8 GHz**
- 4.8 GHz
- 4.9 GHz

**5.0 GHz**
- UNII (Wi-Fi)
- 5.1 GHz
- 5.2 GHz

**5.2 GHz**
- 5.3 GHz
- 5.4 GHz

**5.9 GHz**
- 5.9 GHz
- 6.0 GHz

**5G eMBB < 6**

**47.2-50.2 GHz**
- 47.2 GHz
- 47.3 GHz

**5.0-52.6 GHz**
- 5.0 GHz
- 5.1 GHz

**WRC-19**

**US**
- 37-40.5 GHz
- 40.5-42.5 GHz
- 42.5-43.5 GHz
- 45.5-47 GHz
- 47-50.2 GHz
- 50.4-52.6 GHz
5G AND THE INTERNET OF THINGS

By 2016...
6.4B connected things¹

By 2019...
$1.3T worldwide spending on the Internet of Things²

By 2020...
8.6B connected things in Asia Pacific³

¹ Gartner Group http://www.gartner.com/newsroom/id/3165317
³ IDC http://www.idc.com/getdoc.jsp?containerId=prHK25553415
SPECTRUM NEEDS OF IOT

How much spectrum does IoT need?

- Determined by each application’s throughput, but also latency, requirements
  - For a given spectral efficiency (b/s/Hz), the lower the latency requirements the larger the bandwidth needed to send a given amount of data

- While many IoT applications might not need high speed connections and/or have very stringent latency requirements, some might

And in what frequency bands?

- Determined by each application’s range and coverage requirements, but also bandwidth needs of the applications

- Range and coverage requirements also depend on deployment scenarios
  - Point-to-point, mesh, broadcast, multi-cast, etc.
DEDICATED “IoT” SPECTRUM?

Pros

- Global harmonization of spectrum increases economies of scale
- Dedicated spectrum might help lower spectrum management risks

Cons

- Achieving global harmonization on band(s) for IoT might prove very difficult, if not impossible
- Need for ITU-R/WRC action on dedicated spectrum could delay deployments and implementations
- Many gov’ts strongly opposed to dedicated spectrum for IoT
- Increases the risk of more dedicated spectrum – less flexibility

Variety of existing bands (cellular, unlicensed) could emerge through industry consensus in leading markets without any WRC action