June 2019

5G WIRELESS SD-WAN

PREPARE FOR THE 5G FUTURE WITH PEPLINK | PEPWAVE



Welcome to our Webinar:
PREPARE FOR THE 5G FUTURE WITH PEPLINK | PEPWAVE

Intermission:
Live session will begin at 3 pm local Hong Kong time.

Before we begin, participants with 4G or faster mobile devices, please goto www.speedtest.net and do a speedtest 4G + WiFi. Key the max download speeds into the chat with your region for reference. Thank you.

Table of Contents

Current Status of 5G

4G, 5G and What's in Between

peplink

2010-2018

4G LTE

- **Mobile Broadband**
  - 10-50Mbps
  - ~50-100ms Latency
- One size fits(?) all

2015-2019

4G IoT

- **Cat 1**
  - 5-10Mbps
- **Cat M1**
  - 0.3-1Mbps
  - Longer range
- **NB-IoT (Cat M2)**
  - 250Kbps
  - Much Longer range

2018-2019

Gig LTE

- **Faster Broadband**
  - 50-200 Mbps
  - ~50-100ms Latency
- Incremental steps towards 5G

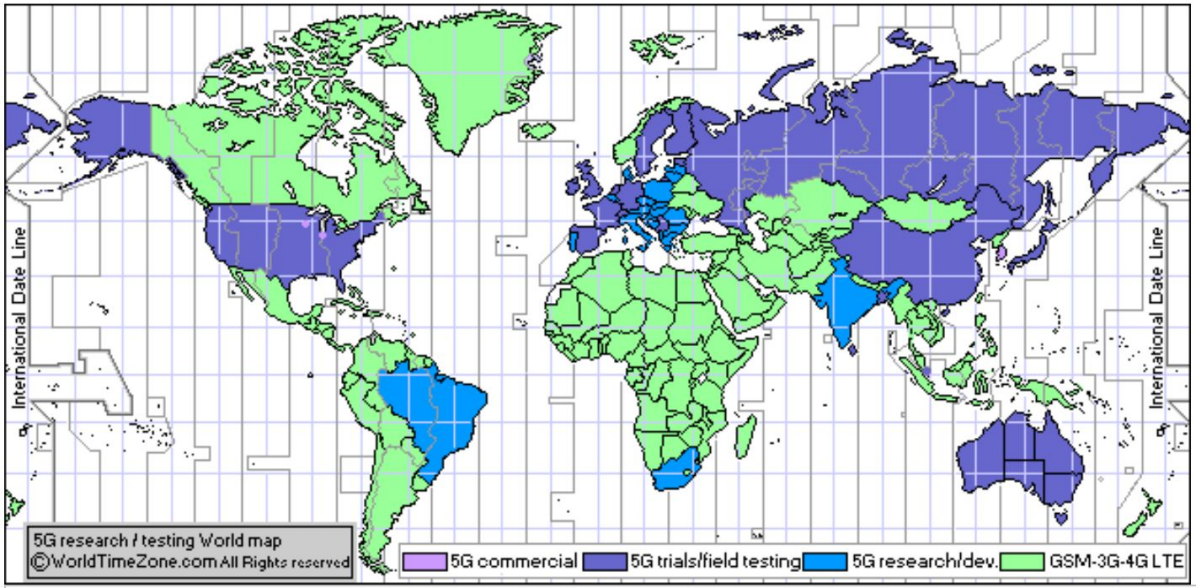
2019-2025

5G

- **Gigabit Broadband**
  - +1, +10 Gbps
  - <1-20ms Latency
- Different "waves" for different applications
  - Fixed
  - NB-IoT
  - Low Latency

Current Status of 5G

5G development world coverage map



- 5G is at its nascent phase
- Yet, over **30 5G-smartphones** have already been scheduled for **release** in 2019
- Over **20 carriers** worldwide have announced **support** for this standard

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
United States (USA)	5G Verizon; 5G AT&T ; 5G T-Mobile USA; 5G Sprint; 5G Google; 5G Facebook;	**Qualcomm** Technologies (San Diego)- first 5G mobile connection (Snapdragon X50 5G modem chipset), with a connection speed of 1 Gbit/s 5G **Verizon** (with Alcatel-Lucent, Cisco, Ericsson, Nokia, Qualcomm, Samsung) testing in "sandboxes" (small testing areas) in Waltham (MA), San Francisco (CA),Basking Ridge, Bridgewater, Piscataway (NJ), HQ New York; 5G **AT&T / Ericsson** testing in Middletown (NJ) ; 5G AT&T / Nokia testing in Austin (TX): 5G AT&T testing in Atlanta (GA) , San Ramon (CA); 5G **T-Mobile** USA testing in HQ Bellevue (WA); 5G Sprint/Nokia & Ericsson demos at Copa soccer games in Santa Clara, Philadelphia in June 2016 ; 5G Google (Skybender) testing via solar drones in NM; 5G Facebook (Terragraph / ARIES) testing in Menlo Park (CA), San Jose;	**AT&T** rolls out mobile 5G service in 12 US cities- requires Netgear hotspot (Dec 2018); **Verizon** - Disney and The New York Times are using high-speed 5G technologies; Sprint /Nokia/Qualcomm completed the world's first over-the-air 5G data transmission using 2.5 GHz on its commercial network (Jan 2019); **T-Mobile / Ericsson / Intel** - world's first 5G data call and video call on 600 MHz on a live commercial network. (Jan 2019);	**Verizon** began rolling out its 5G services in Chicago and Minneapolis on April 3, 2019, a week ahead of schedule. USA dismisses South Korea's launch of world-first 5G network; European Commission dismisses USA and South Korea 5G launches; The **Samsung Galaxy S10** 5G will be available in the USA starting in May.

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
South Korea	5G SK Telecom (SKT) 5G LG Uplus 5G Korea Telecom	5G SKT / Samsung (Nokia, Ericsson, Samsung, Intel and Rohde & Schwarz) completes 5G field trial; 5G Korea Telecom / NEC is testing at Phoenix Park Ski World in PyeongChang; KT Corporation launched 5G at Lotte World Tower in Seoul;	5G SKT and 5G Korea Telecom showcase 5G service at the 2018 Olympic Winter Games in PyeongChang Plan to have 5% of the country's mobile users on a 5G network by 2020.	South Korea (SK Telecom, KT and LG Uplus) launched the world's first nationwide 5G mobile on April 3, 2019 USA dismisses South Korea’s launch of world-first 5G network; European Commission dismisses USA and South Korea 5G launches; The Samsung Galaxy S10 5G was launched to tie into the release of South Korea's 5G network

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Japan	5G NTT DoCoMo	5G NTT DoCoMo / Huawei have demonstrated mobile internet speeds of 3.6Gbps in the world's first large-scale public network test of 5G in Chengdu, China; 5G NTT DoCoMo / Nokia trial of real-time transmission of 8K of 48Gbps video (on May 19, 2016) ; 5G NTT DoCoMo / Toyota tested controlling a humanoid robot on 5G (Nov, 2018)	5G NTT DoCoMo is planning to launch 5G service at venues of the 2020 Tokyo Olympic and Paralympic Games.	

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
China	5G China Mobile	5G China Mobile / ZTE completed testing the world's first pre-5G massive MIMO base station.	Chinese ZTE Gigabit Phone- the world's first phone capable of using 5G connectivity was unveiled at the Mobile World Congress (MWC)- Feb 28, 2017. ZTE GM 5G standalone architecture functionality test (Sep 2018). ZTE plans to launch its first 5G phone in the first half of 2019 Huawei to launch 5G at Africa Cup of Nations in Egypt (June 21- July 19, 2019) Huawei claims world first 5G hardware for automotive industry (April 22, 2019) China plans to commercialize 5G mobile networks as early as 2020.	

Current Status of 5G

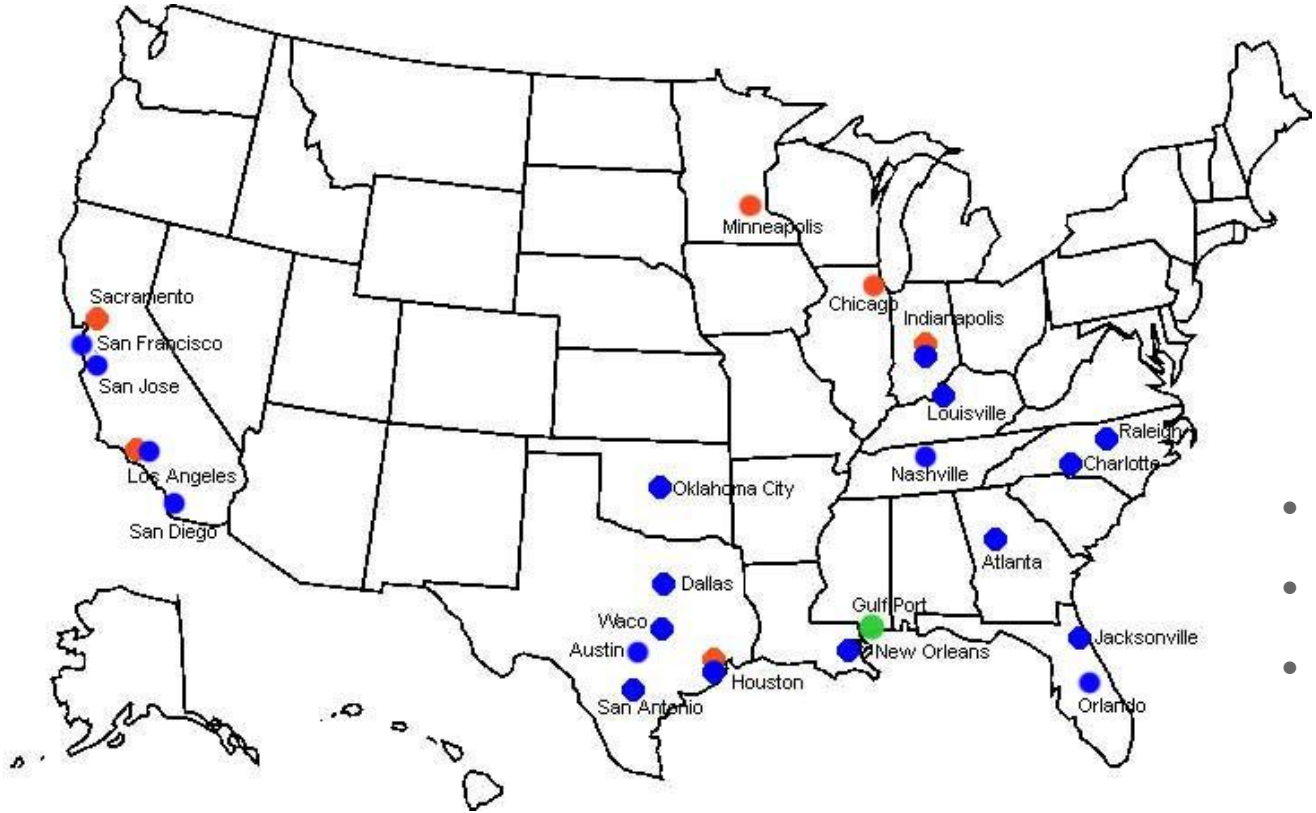
5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Russia	5G MegaFon; 5G Rostelecom; 5G MTS ; 5G VimpelCom (Beeline) ;	5G MegaFon / Huawei testing fifth-generation cellular networks via TV channel "Russia 24" 5G MTS / Nokia & Ericsson tested at the World Cup soccer games in Russia in 2018. 5G trial Rostelecom / Ericsson in St. Petersburg and 5G trial Rostelecom / Nokia in Skolkovo	5G MegaFon tested in Russia World Cup 2018 Russian mobile operators are set to launch commercial 5G networks in 2020; MTS, Megafon, Beeline and Tele2 to create a single 5G operator.	

Current Status of 5G

5G development world coverage map

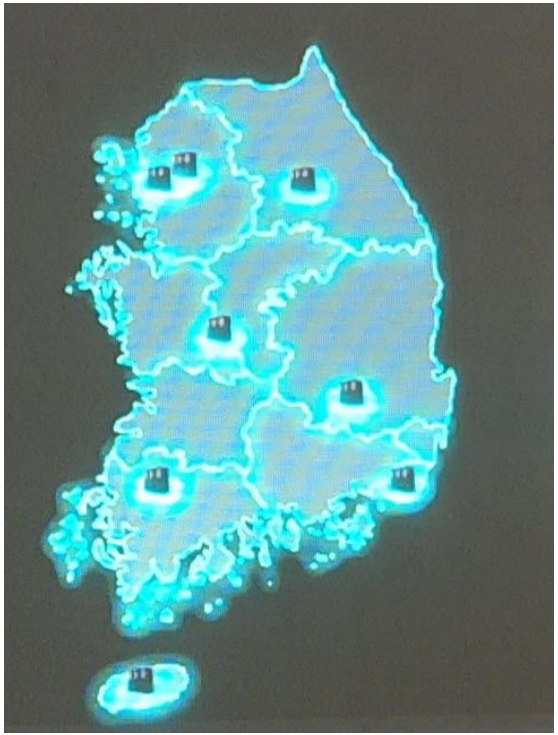
Current Coverage in the US



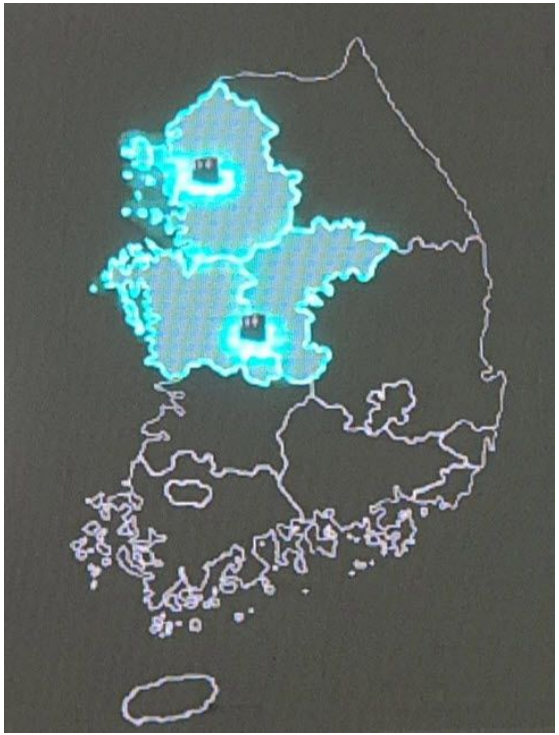
Key:
- AT&T
- Sprint
- T-Mobile
- Verizon
- C Spire

- Coverage is in *parts* of the indicated cities.
- AT&T currently only offers a 5G hotspot.
- Verizon *Mobile* 5G is only available in Minneapolis & Chicago.

Current Coverage in South Korea

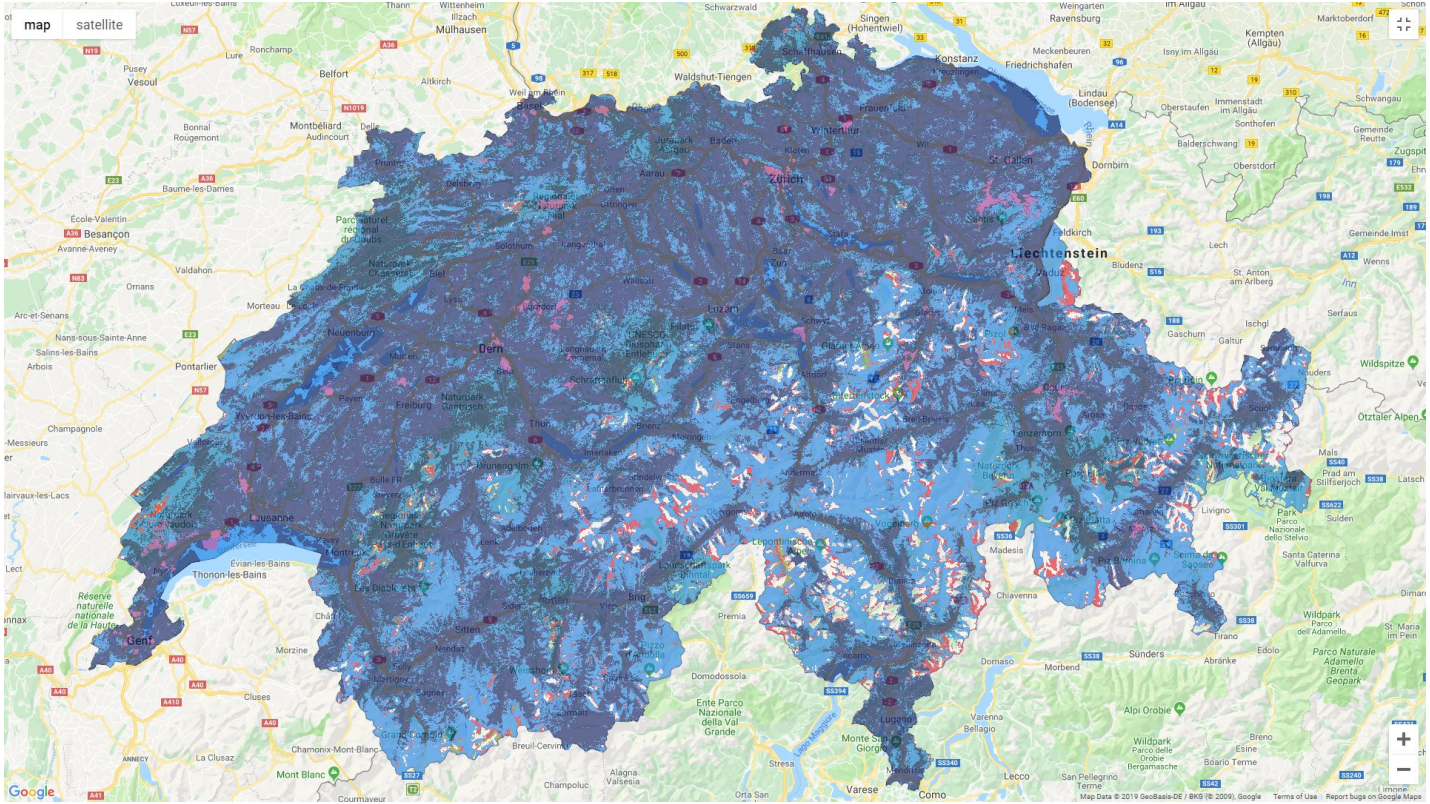


KT - 8 Cities: Guro, Hyehwa, Daejeon, Daegu, Gwangju, Busan, Jeju and Wonju



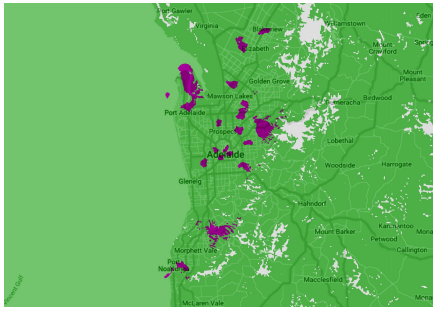
SK Telecom - 2 Cities: Sungsoo, Dusan

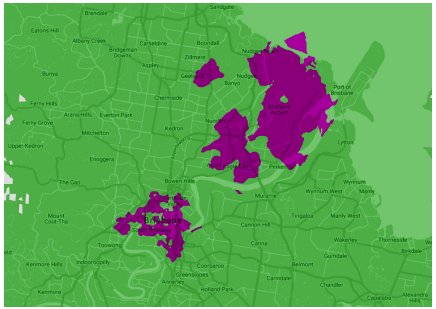
Current Coverage in Switzerland

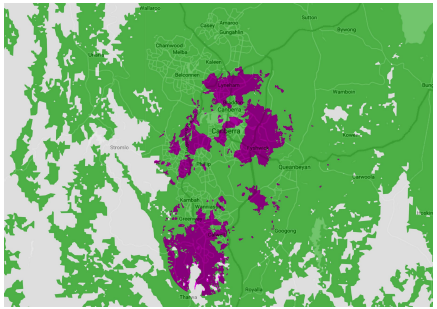


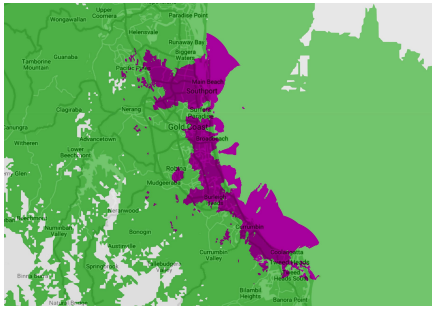
- April 10th, 2019 - 102 Locations with multiple cellular mobile devices from multiple major brands

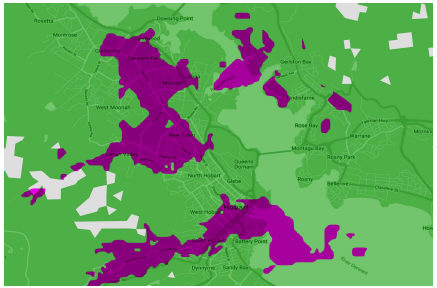
Current Status in Australia

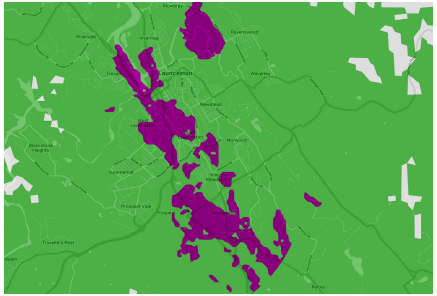


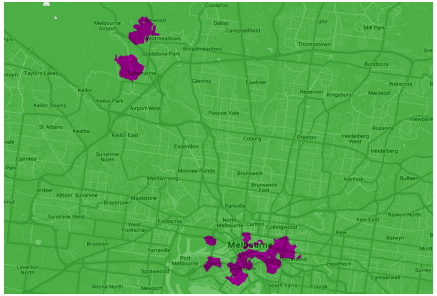


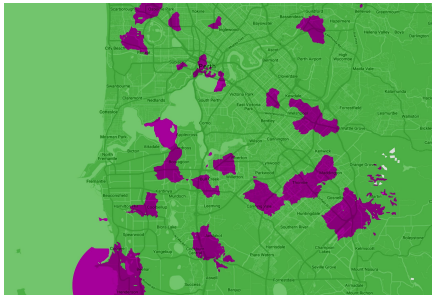






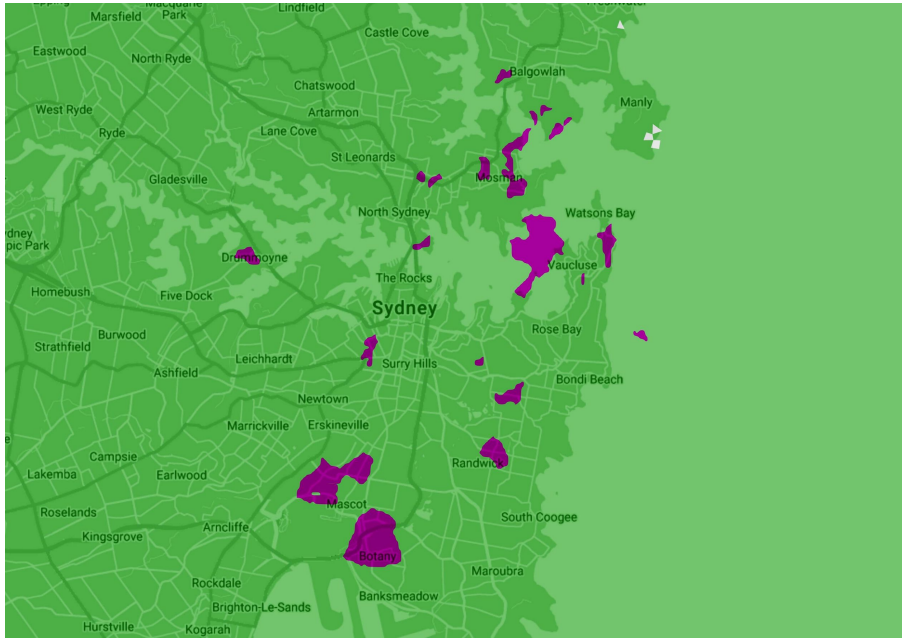


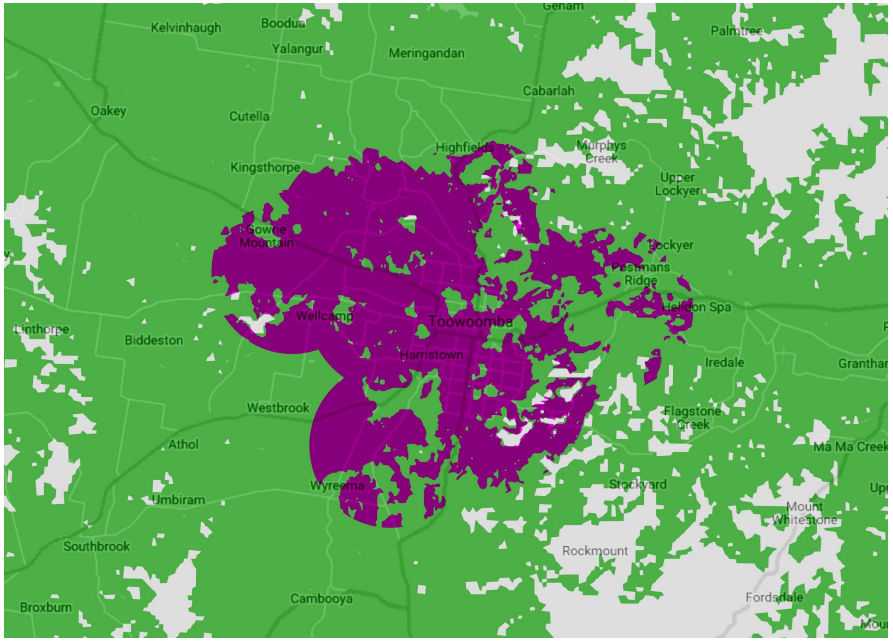




Telstra - 10 Cities Adelaide, Brisbane, Canberra, Gold Coast, Hobart, Launceston, Melbourne, Perth, Sydney, Toowoomba

Current Status in Australia





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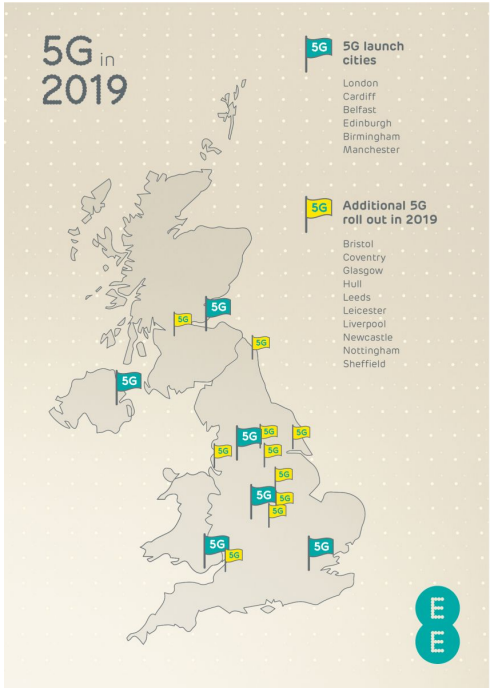
Current Status in the UK



EE - 6 Cities London, Cardiff, Belfast, Edinburgh, Birmingham and Manchester

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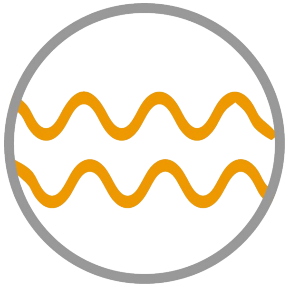
Check [Appendix I] for the status of other countries

Current Status of 5G

5G technologies



Millimeter Waves

- broadcast at frequencies between 30 to 300 GHz
- **vary in length from 1-10mm**
- connect mobile users with a nearby base station

Small Cells

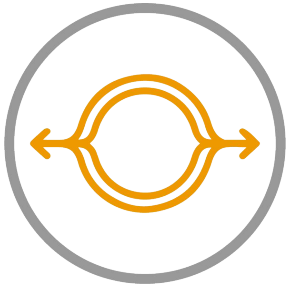
- **portable miniature base stations**
- require minimal power to operate
- can be placed every 250 meters or so throughout cities

Massive MIMO

- MIMO = multiple-input multiple-output
- support about a hundred ports
- **featuring dozens of antennas on a single array**

Beamforming

- a **traffic-signaling system** for cellular base stations
- identifies the most efficient data-delivery route to a particular user

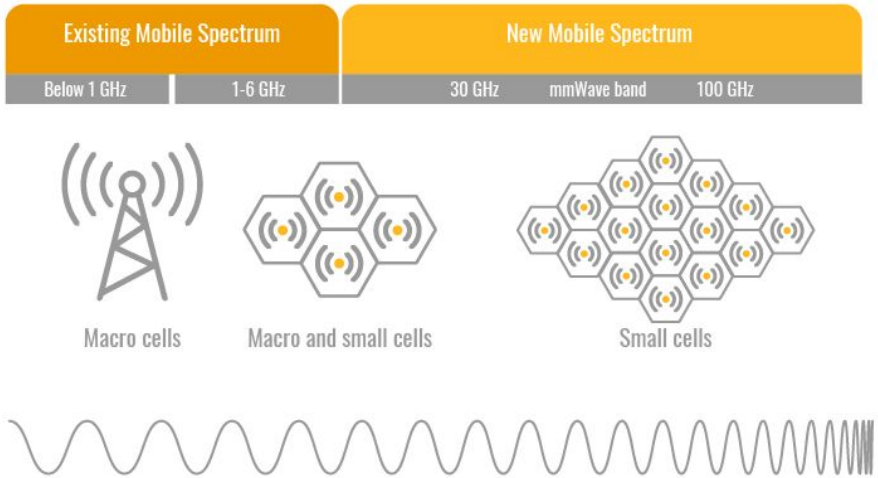


Full Duplex

- able to **transmit and receive data at the same time**, on the same frequency
- drawback to full duplex is that it also creates more signal interference

The Promise of 5G

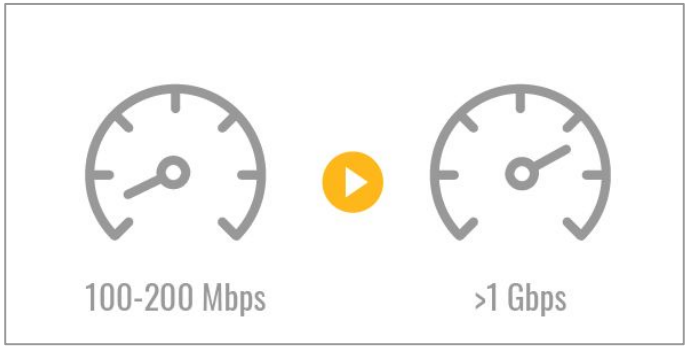
New wave Spectrum

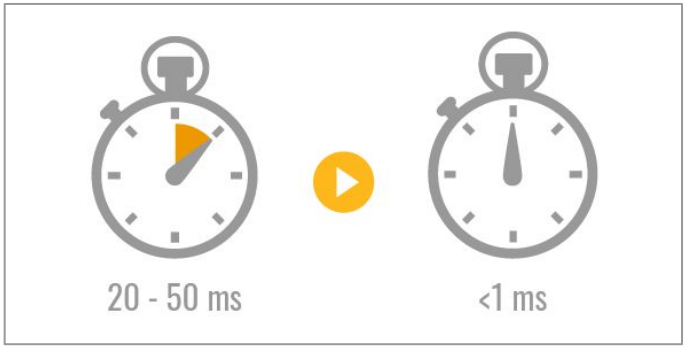


- 5G Adds a lot of new frequencies
  - mmWave
  - Sub 6 GHz
  - Sub 1GHz
- Low band 5G **trades speed for reliability**
- **Densification**
  - Much greater tower density
  - Requires ubiquitous fiber for backhaul

The Promise of 5G

Speed and Latency





Speed:

- 5G promises **download speeds over 1Gbps**.
- At least 10x faster than the typical 4G-LTE speeds of 100-200Mbps.
- Faster than dedicated broadband services.

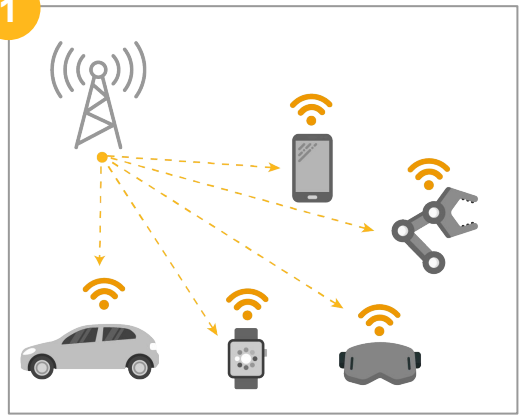
Latency:

- The 5G network also promises significantly lower latency
- Potentially down to an **imperceptible 1ms delay** compared to around 20-50ms delay typical of 3G and 4G networks.

Limitations of 5G

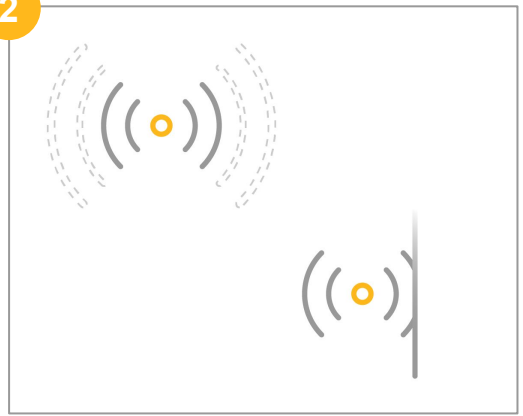
Network Congestion and Short Range

1



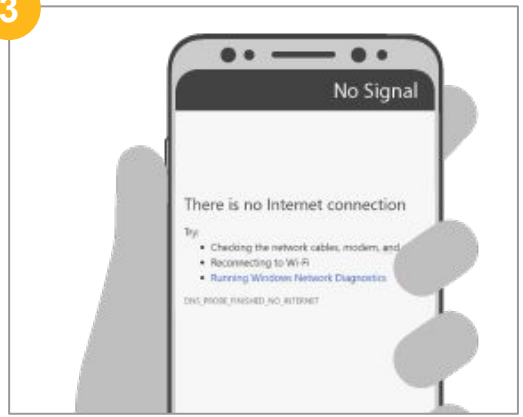
Billions of connected devices causes potential **network congestion**

2



Unstable network signal due to **short range & low penetration** of millimeter wave

3



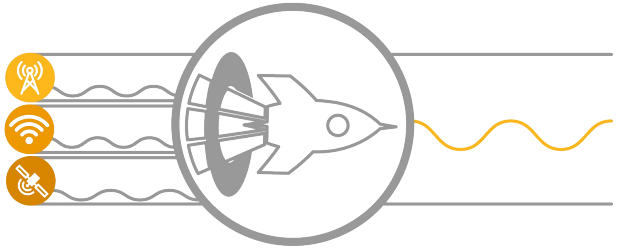
Cellular dead spots will lead to packet loss and dropped connections

- 5G network and user requirements pose **significant engineering challenges**.

Peplink's
5G Wireless SD-WAN

Applying SD-WAN Technology to 5G

Untethered from fixed line



❶ Support multiple connectivity technologies (e.g. cellular, Wi-Fi, satellite)

❷ Combined to form one logical WAN connection

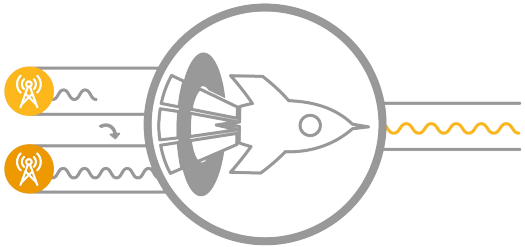
❸ Establish unbreakable high-bandwidth SD-WAN connections

Untethered from fixed line

- *Features:* **Combine the bandwidth** of several mobile connections to form an ultra-fast data link
- *Applications:* rolling workplace with full access to multi-cloud and security services, HD video streaming and mobile clinic.

Applying SD-WAN Technology to 5G

Unbreakable connectivity



❶ When a WAN link fails, SpeedFusion Hot Failover technology seamlessly routes traffic to a working tunnel

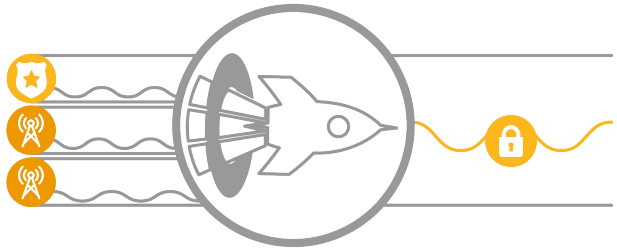
❷ Enables an uninterrupted connection while keeping your session intact

Unbreakable connectivity

- *Features:* **SpeedFusion Hot Failover** maintains secure tunnels over all available WAN links to keep the network up and running when a connection drops out
- *Applications:* uninterrupted VoIP sessions

Applying SD-WAN Technology to 5G

Unrivaled coverage



Public Safety applications

❶ Use Commercial LTE as backup to Public Safety LTE

❷ Combined networks for the best possible coverage

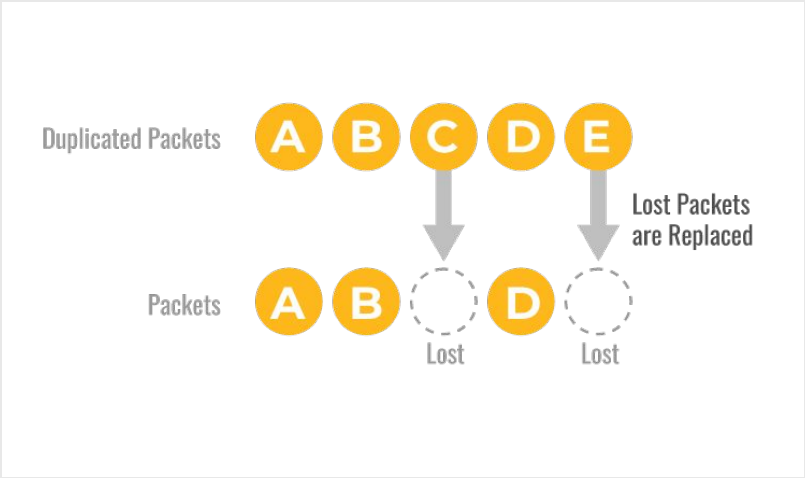
❸ Establish packet-level VPN security

Unrivaled coverage

- *Features:* By **combining the coverage network** of several mobile carriers, chances of running into a network blindspot or congestion is minimized.
- *Applications:* Use Commercial LTE as backup to Public Safety LTE

Applying SD-WAN Technology to 5G

Connection Reliability vs Consistency

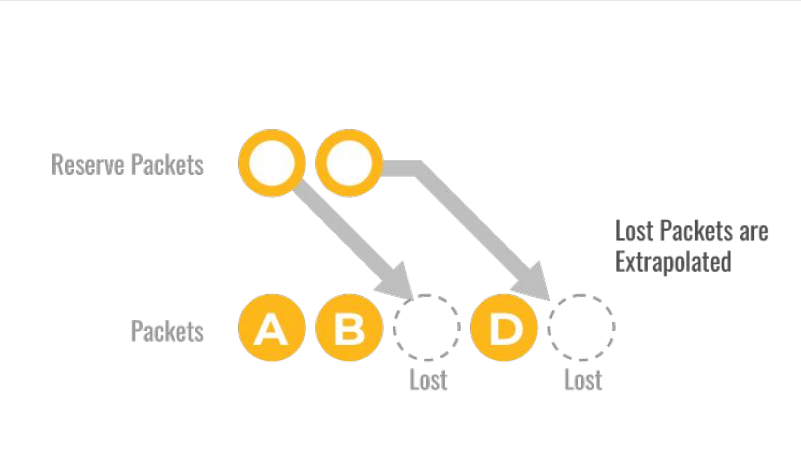


WAN Smoothing

- This Peplink technology **duplicates packets**
- When packet loss occurs, the duplicated packets replace the lost packets
- Best suited to **two-way communications** such as VoIP or video conferencing

Applying SD-WAN Technology to 5G

Connection Reliability vs Consistency

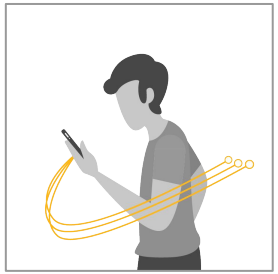


Forward Error Correction (FEC)

- This Peplink technology **generates reserve packets**
- When packet loss occurs, FEC uses the information within the reserve packets to extrapolate the lost data
- This technology is best suited to **one-way video streaming**

Current Status of 5G

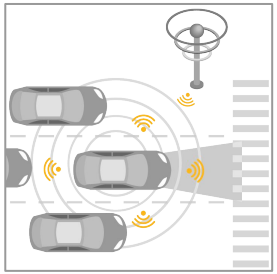
5G Use cases



Broadband access everywhere

Augmented / Virtual reality (AR/VR)

Internet of Thing (IoT)



Autonomous vehicles

Healthcare Industry

Next-gen real-time communication

- **The upgrade from 4G to 5G does not only promise faster speed**.
- The 5G standard is meant to enable the **next killer app** or something entirely new.
- **These new applications** will change the way enterprises and organizations connect with the outside world.

Peplink's
5G Ready Devices

Get Started on 5G with Peplink

5G ready, modular models

E

EPX

Extreme Performance SD-WAN Platform

E

SDX

Modular Enterprise Grade Router

I T

HD4 MBX

Quad Cellular Gigabit LTE Mobile Powerhouse

I

PDX

Portable, Rapid Deployable SD-WAN

Focus markets:

- E Enterprise
- I Industrial
- T Transportation

EPX

Extreme Performance SD-WAN Platform

Get Started on 5G with Peplink

EPX | Extreme Performance SD-WAN Platform

Enterprise

Get Started on 5G with Peplink

EPX | Extreme Performance SD-WAN Platform

Enterprise

> Learn more <

- **rapidly deployable**, powerful, and versatile SD-WAN router
- connects a **wide range of WAN options** from LTE-A, satellite modems, to fixed line networks.
- 19" **2U rack** mountable form factor
- can combine **up to 18x LTE-A** connections for absolute connection reliability

Get Started on 5G with Peplink

Expandable modules for **EPX**

3x LTE-A Module

Interface:

- 3x Embedded LTE-A Cellular Modems with Redundant SIM Slots

Antenna Connectors:

- 6x SMA Cellular Antenna Connectors
- 1x SMA GPS Antenna Connector

8x GE PoE Module

Interface:

- 8x 10/100/1000M Ethernet Ports* Capable of PoE

4x SFP+ Module

Interface:

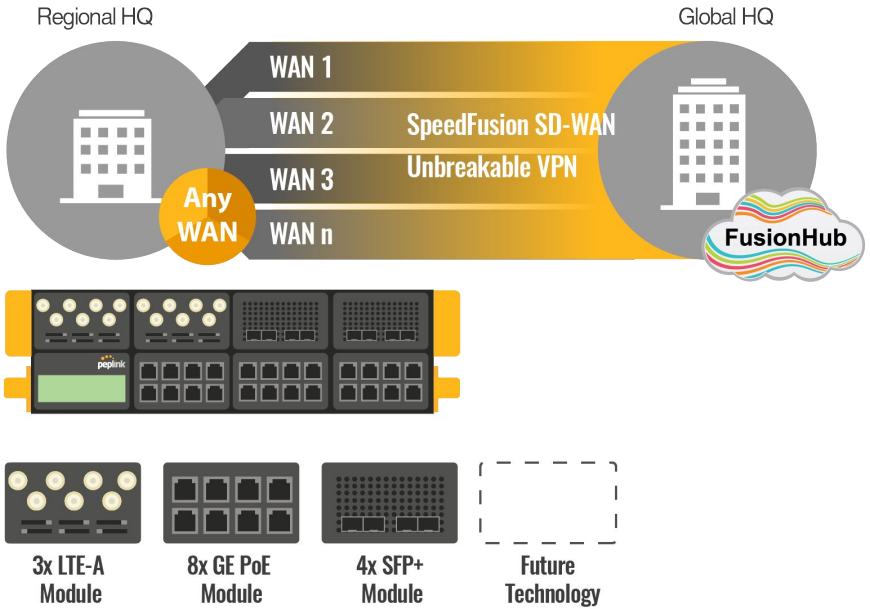
- 4x SFP+ Ports*

* Module can be configured with LAN or WAN ports as needed.

Get Started on 5G with Peplink

EPX | Extreme Performance SD-WAN Platform

Enterprise



Futureproof, Scalable, Unbreakable Cellular Backup for Regional Offices

- modular construction enables regional offices to **add WAN connections of any type**
- cellular modules provide **network resilience** to landlines network
- **5G modules** available in future

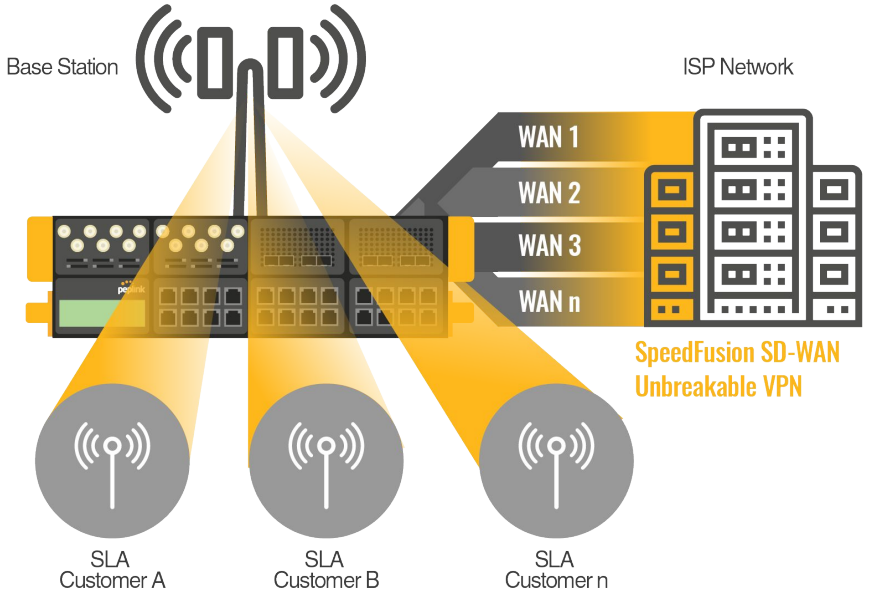
Get Started on 5G with Peplink

EPX | Extreme Performance SD-WAN Platform

Enterprise

Mobile Broadband by ISP

- enables **service providers** to build a flexible SD-WAN backhaul to the main network
- incorporate as many Ethernet, Fiber, and cellular links as needed
- **cloud-based management** software for complete visibility and control of WAN usage



Case Study:

Wireless SD-WAN for a large scale event

- **Project**
  - Using Peplink routers to support network infrastructure in a large scale technological event
- **Project highlights**
  - 3x Key nodes: EPX + SDX +UPS
  - 7x Sub-nodes in large building (connected by SFP fiber): HD4 MBX + AirProbe
  - 8x Sub-nodes in smaller building (connected by SFP fiber): HD4 MBX
  - 7x Sub-nodes outside building structure (using SIM): Transit Duo
- **Winning Factors**
  - “Cellular was super nice to have because it allowed us to deploy early and configure everything before our fiber was rolled out.” the project manager
  - InControl2 allows managing multiple groups at one time

Case Study:

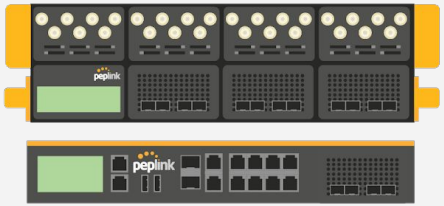
Wireless SD-WAN for a large scale event

7x Sub-nodes (in larger building)

- Connected with key nodes by SFP fibers
- HD4 MBX + AirProbe

3x Key nodes

- SFP fiber as WAN
- 2x EPX + 2x SDX +UPS



8x Sub-nodes (in smaller building)

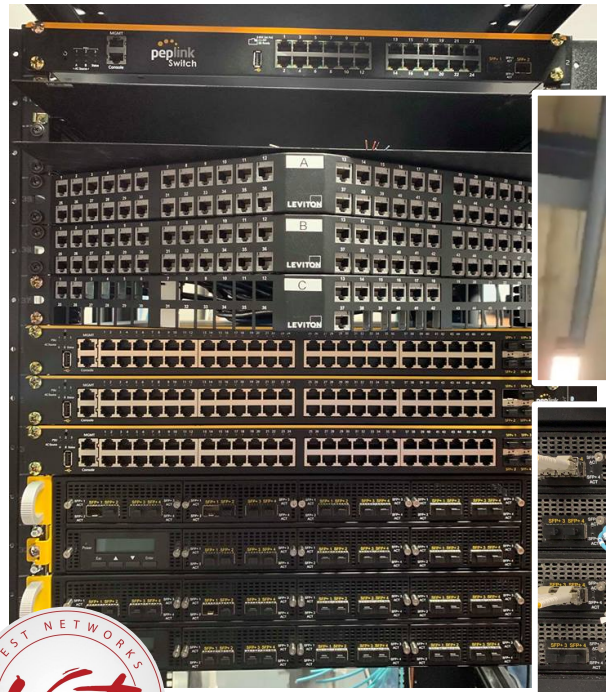
- Connected with key nodes by SFP fiber
- HD4 MBX

7x Sub-nodes (outside building)

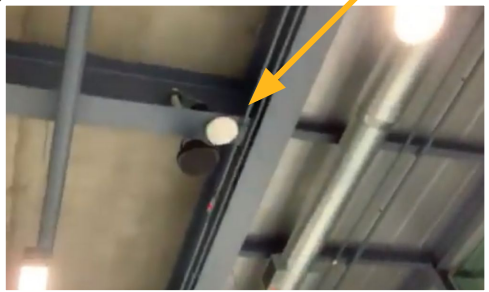
- Cellular as WAN
- Transit Duo

Case Study:

EPX | Extreme Performance SD-WAN Platform



AirProbes



- **Company**
  - Corporate headquarters in Sarasota, Florida
  - Installed by West Networks LLC
- **Project highlights**
  - Dual Peplink EPX as fiber cores
  - Full stack of Peplink accessories, including 48 port switches, AP One Enterprise, and AirProbes
- **Winning Factors**
  - Speed - 40Gb EPX routers
  - Future proof, allow future upgrade
  - Unbreakable network with dual 10GB redundant connection from 48 port Switch to EPX
  - Manageable network (AirProbes for network performance monitoring)

SDX

Modular Enterprise Grade Router

Get Started on 5G with Peplink

SDX | Modular Enterprise Grade Router

Enterprise

Get Started on 5G with Peplink

SDX | Modular Enterprise Grade Router

Enterprise

- **2x integrated SFP+ WAN Ports**, as well as **8x PoE-enabled LAN Ports**
- includes popular features such as **SpeedFusion SD-WAN** and **InControl** centralized management
- **expansion module** that can be changed for future needs

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Expandable modules for SDX

3x LTE-A Module

Interface:

- 3x Embedded LTE-A Cellular Modems with Redundant SIM Slots

Antenna Connectors:

- 6x SMA Cellular Antenna Connectors
- 1x SMA GPS Antenna Connector

8x GE PoE Module

Interface:

- 8x 10/100/1000M Ethernet Ports* Capable of PoE

4x SFP+ Module

Interface:

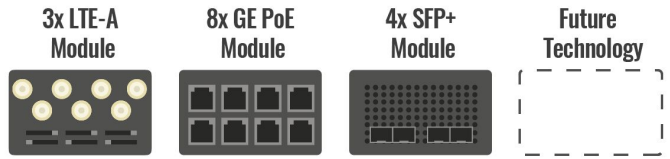
- 4x SFP+ Ports*

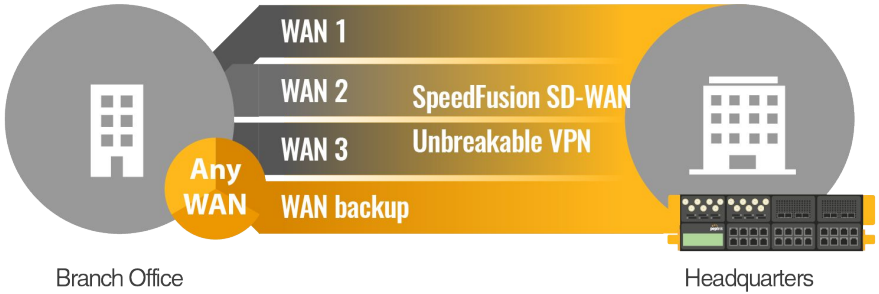
* Module can be configured with LAN or WAN ports as needed.

Get Started on 5G with Peplink

SDX | Modular Enterprise Grade Router

Enterprise





Branch Office Network Resilience

- **combine** multiple DSL, cable, 4G LTE, and **future 5G links** into a single high-speed SD-WAN connection
- allows access to headquarters at **greater speed and reliability** that can be achieved with a single link

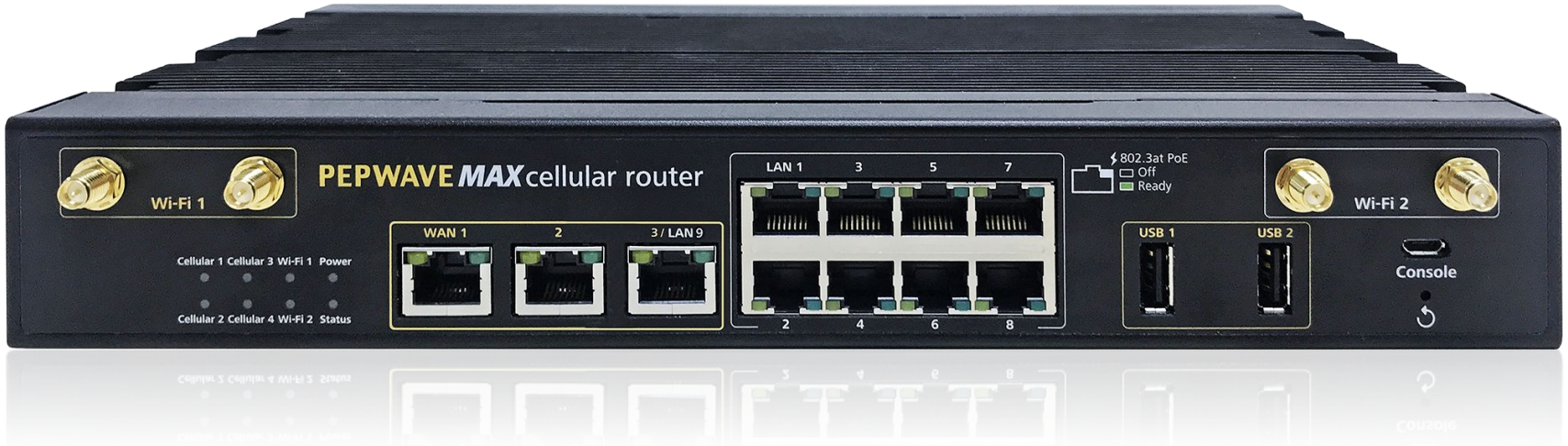
HD4 MBX

Quad Cellular Gigabit LTE Mobile Powerhouse

Get Started on 5G with Peplink

HD4 MBX | Quad Cellular Gigabit LTE Mobile Powerhouse

Industrial Transport



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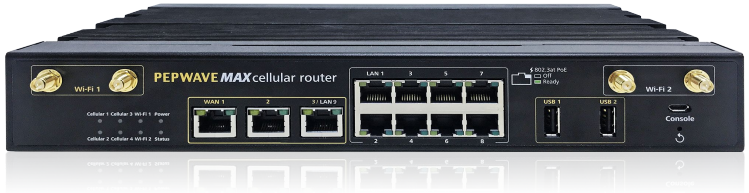
HD4 MBX | Quad Cellular Gigabit LTE Mobile Powerhouse

Industrial Transport

▼ Upgradable Cellular Module, 5G



- supports **Gigabit LTE**
- features a **swappable cellular module** for 5G upgrade
- **2.5Gbps of throughput**, giving you plenty of bandwidth for Gigabit Ethernet, 5G, or any future mobile technologies

> Learn more <

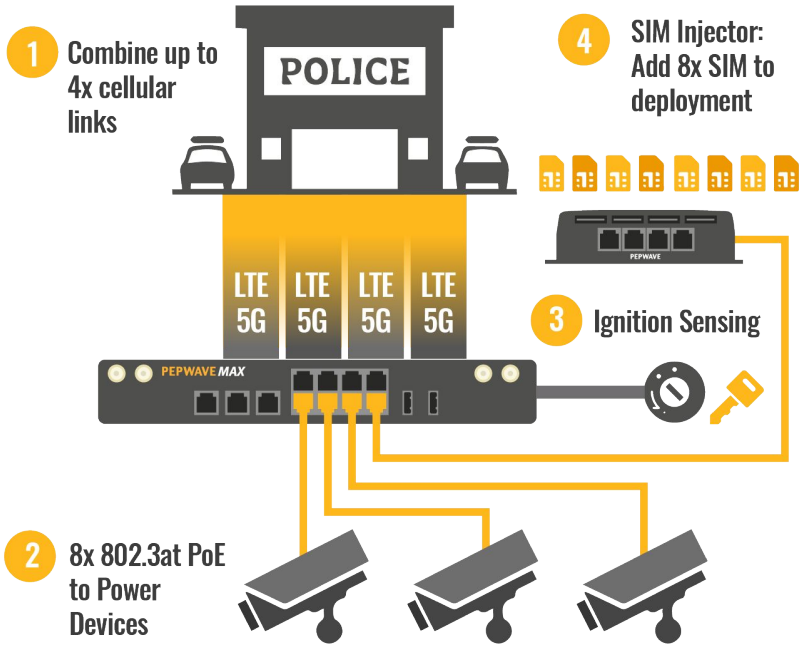
Get Started on 5G with Peplink

HD4 MBX | Quad Cellular Gigabit LTE Mobile Powerhouse

Industrial Transport

Public Safety Mobile Command

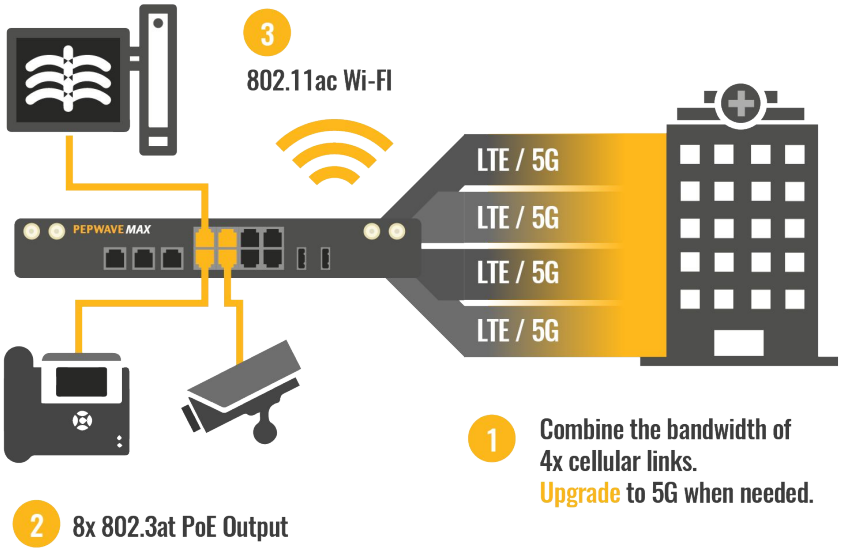
- **combines** the bandwidth of **4x Gigabit LTE links** into a fast, reliable, and secure SD-WAN connection
- **without investing in any further infrastructure**
- **monitor** on the ground situation from multiple perspectives without needing a line-of-sight connection



Get Started on 5G with Peplink

HD4 MBX | Quad Cellular Gigabit LTE Mobile Powerhouse

Industrial Transport



Mobile Clinic – Telemedicine

- x-ray images and videostreams require **large amounts of data**, more data than a single cellular link can transfer in a timely manner
- HD4 MBX can **combine the bandwidth of 4x Gigabit LTE connections** to form a fast and reliable VPN connection that can handle the requirements of remote diagnosis

Case Study:

HD4 MBX | Quad Cellular Gigabit LTE Mobile Powerhouse

- **Company**
  - Mobile media truck reporting on major ski races across the world.
- **Project highlights**
  - HD4 MBX is the gear of connectivity solution for the mobile command center
  - The truck travels across multiple countries with expandable trailer into workshop cabin
- **Winning Factors**
  - High throughput for live streaming
  - Support worldwide band & frequency
  - Future proof, easy for future upgrade
  - Durable, working even in low temperature

PDX

Portable, Rapid Deployable SD-WAN

Get Started on 5G with Peplink

PDX | Portable, Rapid Deployable SD-WAN

Industrial

Get Started on 5G with Peplink

PDX | Portable, Rapid Deployable SD-WAN

Industrial

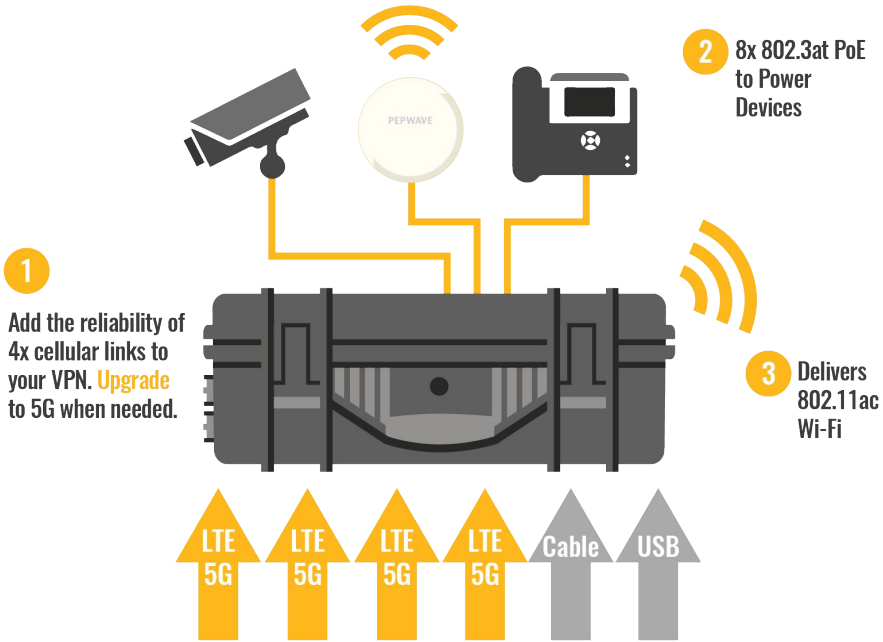
- **Quad Cellular Modems** and **Redundant SIM slots** allow you to use up to four different cellular providers for bandwidth bonding, data overage protection or eliminating blind spots
- SpeedFusion bandwidth bonding and intelligent load balancing
- modular cellular modem, ready to upgrade to 5G

Upgradable Cellular Module Inside

Get Started on 5G with Peplink

PDX | Portable, Rapid Deployable SD-WAN

Industrial



Instant Connectivity for Temporary Sites

- instantly deployable connectivity
- **combine the bandwidth** of up to 4x Gigabit LTE connections, perform fast and reliable connectivity no matter where the site is located
- **quickly and safely** transmit project data, emails, plans, and blueprints between personnel, sites, and headquarters

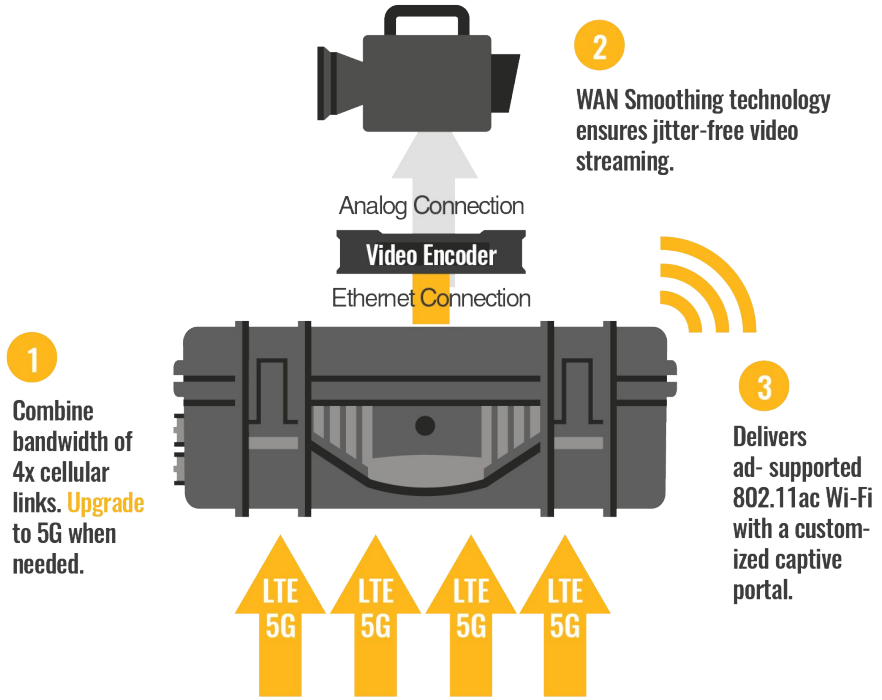
Get Started on 5G with Peplink

PDX | Portable, Rapid Deployable SD-WAN

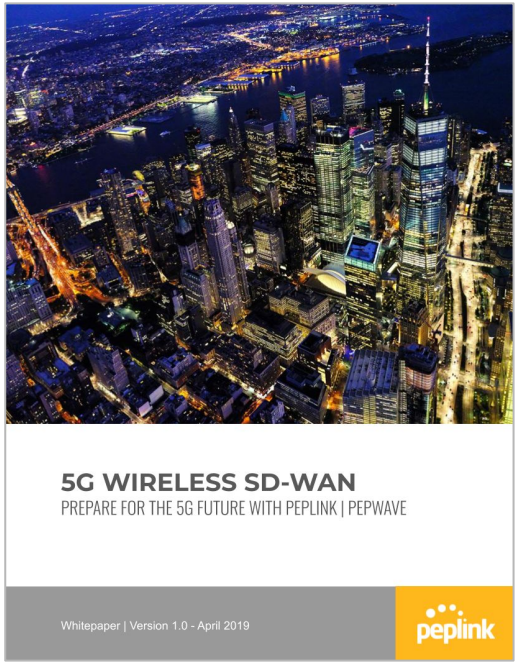
Industrial

Event Live Streaming and Connectivity

- **keep your event connected** no matter where it is held
- **8x 802.3at PoE ports** simplify the cabling when connecting and powering the devices
- **802.11ac Wi-Fi** which supports a customizable captive portal with advertisements



Learn more



> Download Whitepaper <

> Visit web page <

Stay Connected & Up-to-Date

Social Media

Stay up to date on the latest offerings from Peplink on all the major Social Media channels.

Community Forum

Our Forum (forum.peplink.com) truly keeps you connected to all the latest from Peplink directly.

In addition, the forum is a direct channel to our Teams for questions, help, etc.

Q & A

Appendix I

5G development status by country (May 2019)

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Australia	5G Telstra 5G Optus	5G Telstra / Ericsson testing; 5G Optus / Huawei testing in Newcastle;	5G Telstra / Ericsson is planning for trial in Gold Coast during the 2018 Commonwealth Games Over 200 Telstra 5G mobile base stations are now online across Australia. Telstra to offer 5G smartphones in the first half of 2019.	Telstra plans to release Australia's first 5G smartphone and modem on May 28, 2019.

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Bangladesh	Robi Axiata Limited (Axiata Group Berhad - Malaysia, Bharti Airtel Limited - India, NTT DoCoMo Inc. - Japan) / Huawei	July 25, 2018- Huawei has conducted Bangladesh's first 5G trial at Sonargaon Hotel during Bangladesh 5G Summit 2018 in Dhaka, Bangladesh;		
Brazil	5G America Movil and Ericsson to test 5G system in Brazil during 2016.			

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
China	5G China Mobile	5G China Mobile / ZTE completed testing the world's first pre-5G massive MIMO base station.	Chinese ZTE Gigabit Phone- the world's first phone capable of using 5G connectivity was unveiled at the Mobile World Congress (MWC)- Feb 28, 2017. ZTE GM 5G standalone architecture functionality test (Sep 2018). ZTE plans to launch its first 5G phone in the first half of 2019 Huawei to launch 5G at Africa Cup of Nations in Egypt (June 21- July 19, 2019) Huawei claims world first 5G hardware for automotive industry (April 22, 2019) China plans to commercialize 5G mobile networks as early as 2020.	China to roll out nationwide (40 cities) 5G coverage by Oct 1, 2019

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Estonia	5G TeliaSonera	5G TeliaSonera / Ericsson testing in in Stockholm, Tallinn (Estonia);	Ericsson, Intel and Telia Estonia - first live public 5G network in Europe at the Port of Tallinn to connect with Tallink cruise ships at the port. TeliaSonera / TalTech University/ Ericsson first 5G test network went live on Dec 20, 2018.	

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
European Union	5G PPP	Promoting preliminary trials, under the 5G-PPP arrangement, to take place from 2017 onwards, and pre-commercial trials with a clear EU cross-border dimension from 2018. Encouraging Member States to develop, by end 2017, national 5G deployment roadmaps as part of the national broadband plans. Ensuring that every Member State will identify at least one major city to be "5G-enabled" by the end of 2020 and that all urban areas and major terrestrial transport paths have uninterrupted 5G coverage by 2025.	To deploy 5G technology for each EU member state at least one city in 2020.	

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Finland	5G Test Network Finland	5G TNF / Ericsson, Huawei, Nokia testing in Oulu, Finland;	Telia / Helsinki Airport - first 5G airport in the world in pre-commercial 5G network (Dec 2018). Elisa Oyj Finland opened a commercial 5G network in Tampere and Tallinn in June 2018 (second carrier to launch 'world's first' 5G network ?) DNA to launch 5G in Helsinki in the beginning of 2019.	
France	5G Orange	5G Orange testing in Belfort;	5G Orange plans to provide this new telephony standard to its customers from 2019	

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
India	5G Indian Telcos and Nokia is in discussion to start 5G trials.		Reliance Jio plans to provide 5G services in 2020 ?	
Japan	5G NTT DoCoMo	5G NTT DoCoMo / Huawei have demonstrated mobile internet speeds of 3.6Gbps in the world's first large-scale public network test of 5G in Chengdu, China; 5G NTT DoCoMo / Nokia trial of real-time transmission of 8K of 48Gbps video (on May 19, 2016) ; 5G NTT DoCoMo / Toyota tested controlling a humanoid robot on 5G (Nov, 2018)	5G NTT DoCoMo is planning to launch 5G service at venues of the 2020 Tokyo Olympic and Paralympic Games.	

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Netherlands	5G T-Mobile Netherlands 5G Ericsson / VodafoneZiggo	T-Mobile Netherlands activates a Massive MIMO antenna at the Leidseplein in Amsterdam. 5G test Ericsson / VodafoneZiggo	Dutch govt sees 5G roll-out starting in 2020	
Norway	5G - Telenor Norway; 5G - Telia;	Telenor tested 5G in early 2017 before launching three 5G base stations in Kongsberg in November, 2018. Telia opened its first 5G test network (Dec, 2018). Telia / Odeon movie theater in Oslo test- world's first 5G cinema.	Telenor plans to launch 5G in Norway in 2020.	

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Pakistan	Pakistan approves the launch of 5G technology and allowed the PTA (Pakistan Telecommunication Authority) to conduct tests and trials for its marketing in the future.	Pakistan to test 5G mobile internet by 2020.		

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Russia	5G MegaFon; 5G Rostelecom; 5G MTS ; 5G VimpelCom (Beeline) ;	5G MegaFon / Huawei testing fifth-generation cellular networks via TV channel "Russia 24" 5G MTS / Nokia & Ericsson tested at the World Cup soccer games in Russia in 2018. 5G trial Rostelecom / Ericsson in St. Petersburg and 5G trial Rostelecom / Nokia in Skolkovo	5G MegaFon tested in Russia World Cup 2018 Russian mobile operators are set to launch commercial 5G networks in 2020; MTS, Megafon, Beeline and Tele2 to create a single 5G operator.	

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Serbia	5G testing - Telenor Serbia;			
Singapore	5G Singtel	5G Singtel / Ericsson trial in the second half of 2016;	StarHub / Nokia have completed the first outdoor pilot of 5G New Radio in Singapore (Nov 2018);	
South Africa	MTN South Africa / Huawei	May 8, 2018- MTN South Africa and Huawei conducted the African continent's first outdoor 5G field trial in Hatfield, Pretoria;	South Africa data-only network Rain is planning its own 5G roll-out in early in 2019.	

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
South Korea	5G SK Telecom (SKT) 5G LG Uplus 5G Korea Telecom	5G SKT / Samsung (Nokia, Ericsson, Samsung, Intel and Rohde & Schwarz) completes 5G field trial; 5G Korea Telecom / NEC is testing at Phoenix Park Ski World in PyeongChang; KT Corporation launched 5G at Lotte World Tower in Seoul;	5G SKT and 5G Korea Telecom showcase 5G service at the 2018 Olympic Winter Games in PyeongChang Plan to have 5% of the country's mobile users on a 5G network by 2020.	South Korea (SK Telecom, KT and LG Uplus) launched the world's first nationwide 5G mobile on April 3, 2019 USA dismisses South Korea’s launch of world-first 5G network; European Commission dismisses USA and South Korea 5G launches; The Samsung Galaxy S10 5G was launched to tie into the release of South Korea's 5G network

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Spain	5G lab testing - Telefonica / ZTE Corporation .	Vodafone Spain launched 5G trials in Madrid, Valencia, Seville, Barcelona (June 2018). 5G network in La Nave, Madrid (Sep, 2018).	Orange plans to launch 5G in Spain in 2019.	
Sri Lanka	5G Sri Lanka Telecom	Successful field test Pre-5G LTE Advanced Pro Technology in South Asia	Dialog Axiata / TRCSL did 5G transmission using commercial grade base stations and end user devices (dec 31, 2018)	

Current Status of 5G

5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
Sweden	5G TeliaSonera	5G TeliaSonera / Ericsson testing in in Stockholm, Tallinn (Estonia);	TeliaSonera / Ericsson / KTH Royal Institute of Technology launched 5G testbed in Stockholm (Dec 2018); TeliaSonera plans a commercial launch of 5G in Sweden in 2020.	
UK	5G Centre for Communication Systems Research	5G CCSR (Huawei, Fujitsu, EE, Aircom, BT, Samsung, Telefonica, Vodafone, Aeroflex and Rohde & Schwarz) testing in Surrey University	EE plans to offer the OnePlus 5G smartphone. The UK operator EE plans to launch 5G in 2019 (London, Cardiff, Edinburgh, Belfast, Birmingham, Manchester) Vodafone UK plans to release 5G in the Lake District and Cornwall in 2019	**EE Launched May 30th, 2019 in 6 cities.**

Current Status of 5G

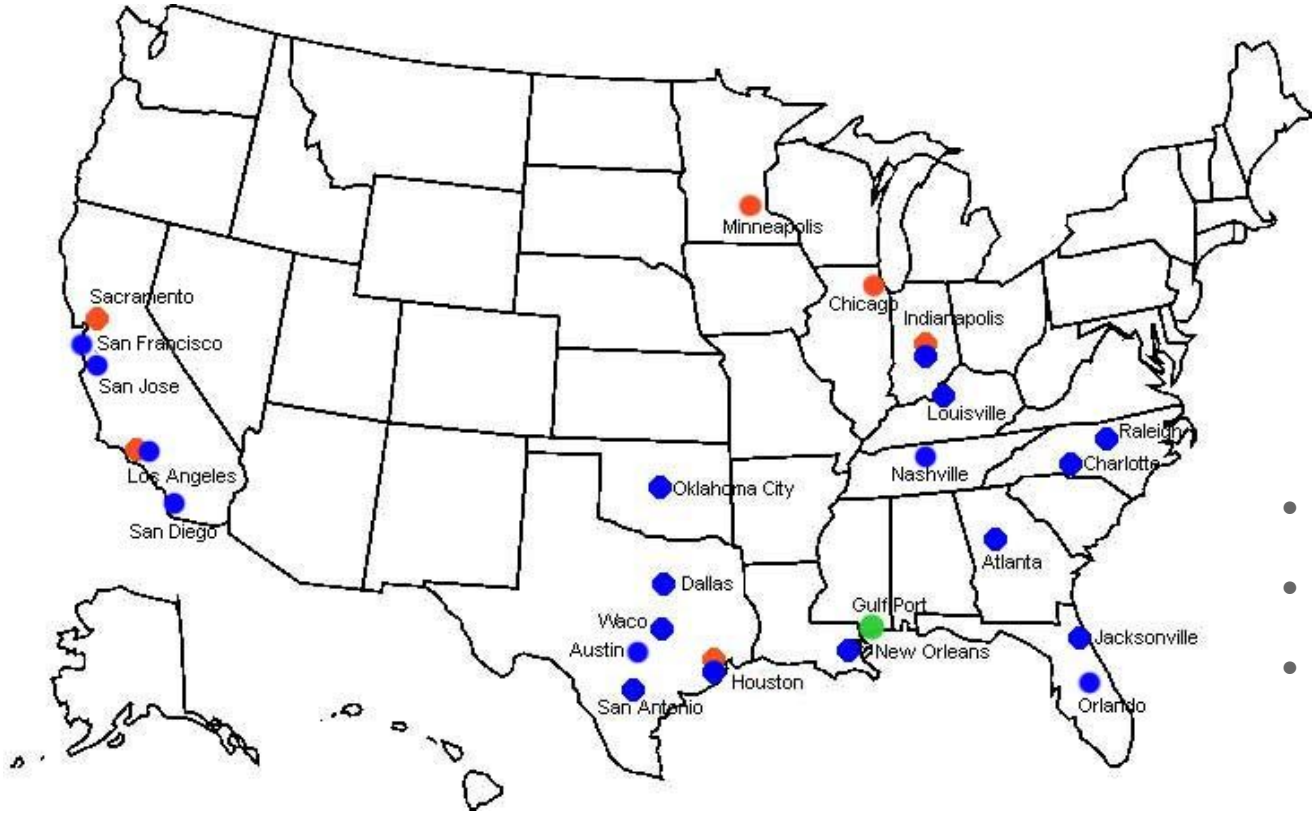
5G development status by country (May 2019)

Country	5G research	5G trials/field test	5G partial	5G commercial
United States (USA)	5G Verizon; 5G AT&T ; 5G T-Mobile USA; 5G Sprint; 5G Google; 5G Facebook;	Qualcomm Technologies (San Diego)- first 5G mobile connection (Snapdragon X50 5G modem chipset), with a connection speed of 1 Gbit/s 5G Verizon (with Alcatel-Lucent, Cisco, Ericsson, Nokia, Qualcomm, Samsung) testing in "sandboxes" (small testing areas) in Waltham (MA), San Francisco (CA),Basking Ridge, Bridgewater, Piscataway (NJ), HQ New York; 5G AT&T / Ericsson testing in Middletown (NJ) ; 5G AT&T / Nokia testing in Austin (TX): 5G AT&T testing in Atlanta (GA) , San Ramon (CA); 5G T-Mobile USA testing in HQ Bellevue (WA); 5G Sprint/Nokia & Ericsson demos at Copa soccer games in Santa Clara, Philadelphia in June 2016 ; 5G Google (Skybender) testing via solar drones in NM; 5G Facebook (Terragraph / ARIES) testing in Menlo Park (CA), San Jose;	AT&T rolls out mobile 5G service in 12 US cities- requires Netgear hotspot (Dec 2018); Verizon - Disney and The New York Times are using high-speed 5G technologies; Sprint /Nokia/Qualcomm completed the world's first over-the-air 5G data transmission using 2.5 GHz on its commercial network (Jan 2019); T-Mobile / Ericsson / Intel - world's first 5G data call and video call on 600 MHz on a live commercial network. (Jan 2019);	Verizon began rolling out its 5G services in Chicago and Minneapolis on April 3, 2019, a week ahead of schedule. USA dismisses South Korea's launch of world-first 5G network; European Commission dismisses USA and South Korea 5G launches; The Samsung Galaxy S10 5G will be available in the USA starting in May.

Appendix II

Current 5G coverage

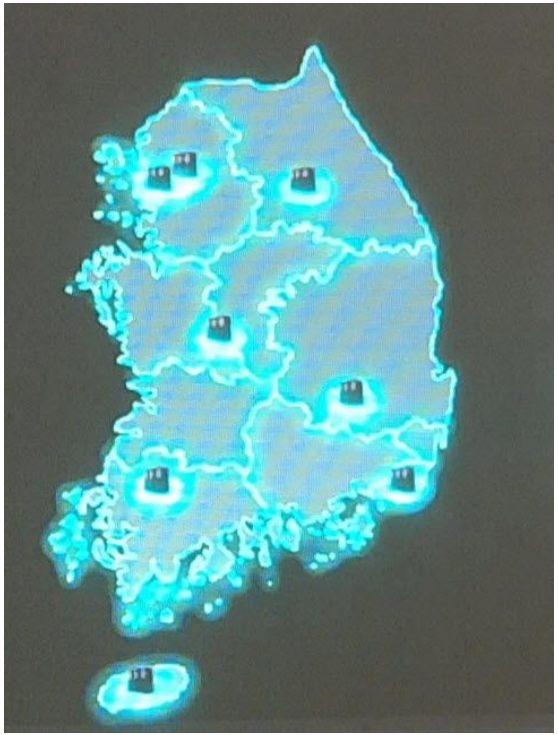
Current Coverage in the US



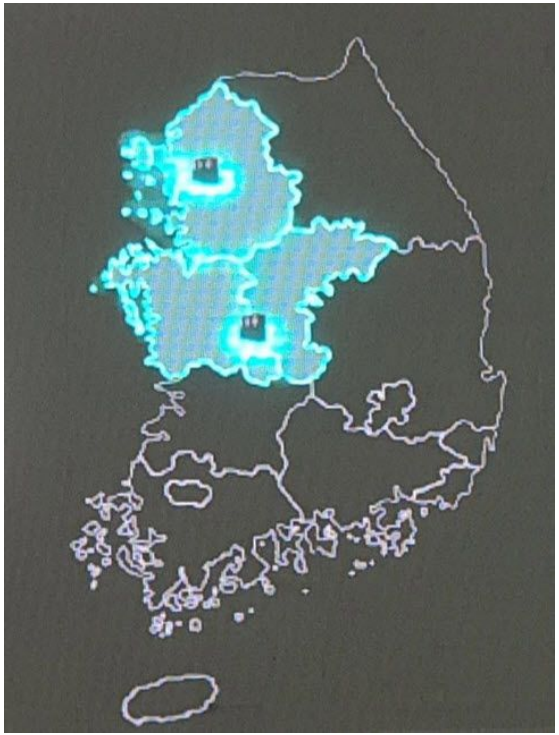
Key:
- AT&T
- Sprint
- T-Mobile
- Verizon
- C Spire

- Coverage is in *parts* of the indicated cities.
- AT&T currently only offers a 5G hotspot.
- Verizon *Mobile* 5G is only available in Minneapolis & Chicago.

Current Coverage in South Korea

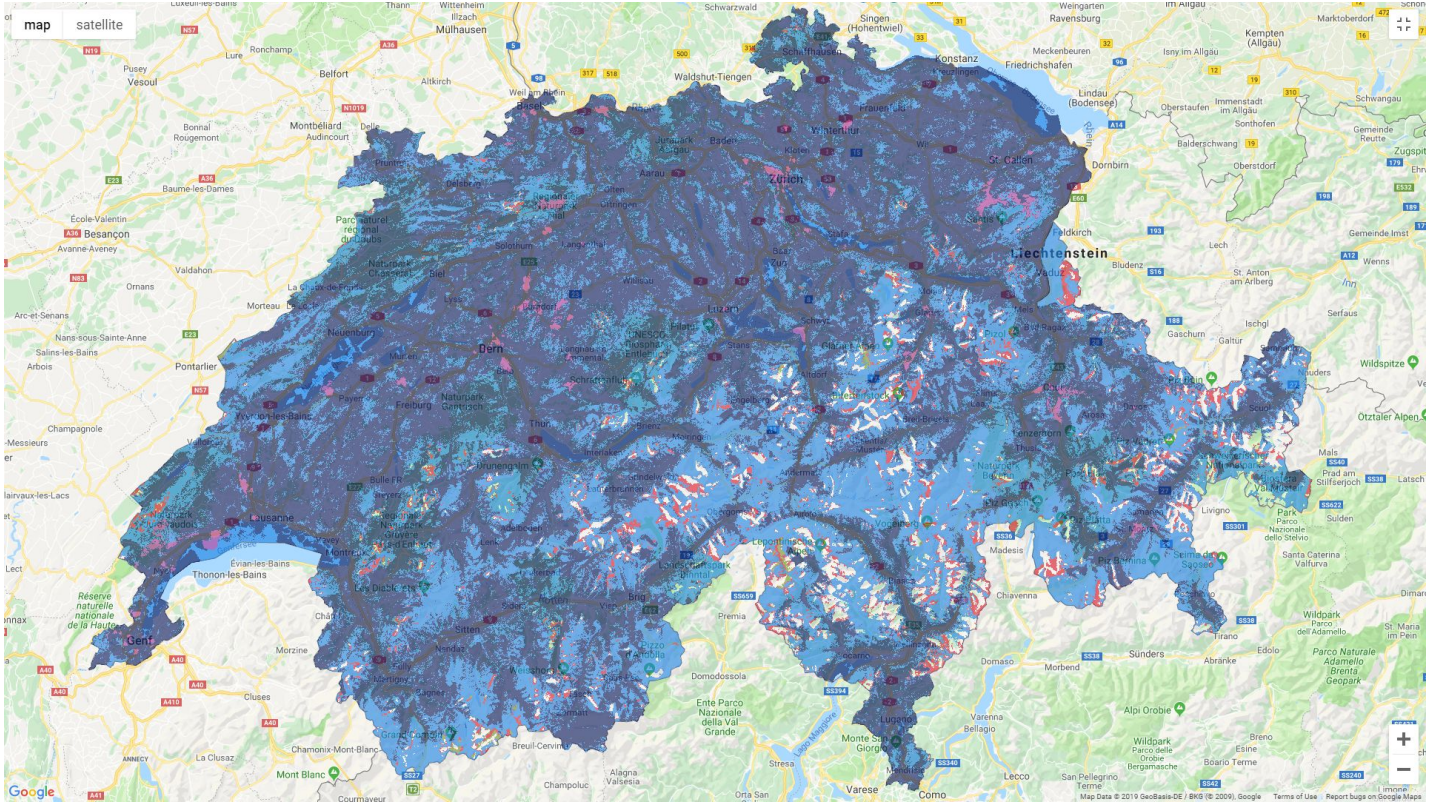


KT - 8 Cities: Guro, Hyehwa, Daejeon, Daegu, Gwangju, Busan, Jeju and Wonju



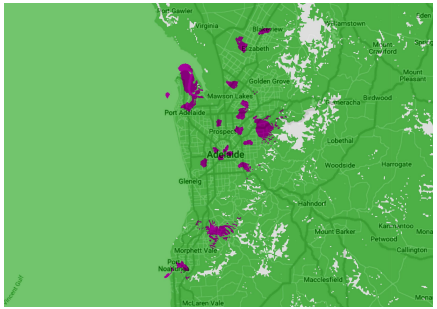
SK Telecom - 2 Cities: Sungsoo, Dusan

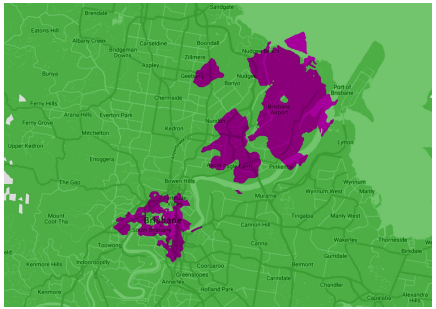
Current Coverage in Switzerland

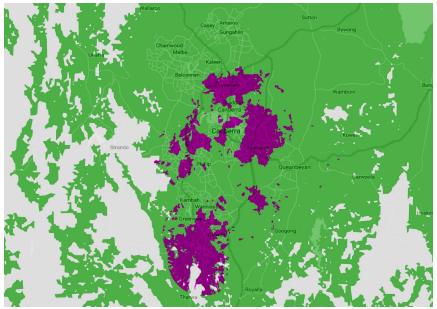


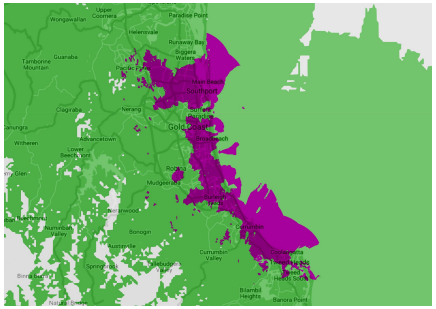
- April 10th, 2019 - 102 Locations with multiple cellular mobile devices from multiple major brands

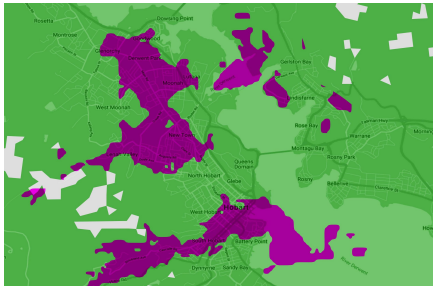
Current Status in Australia

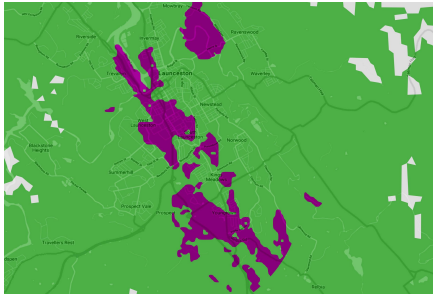


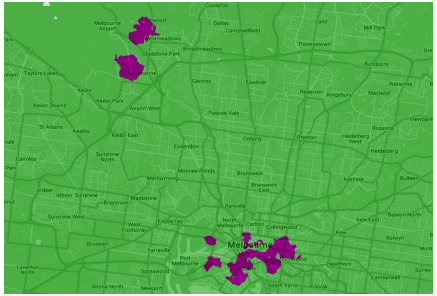


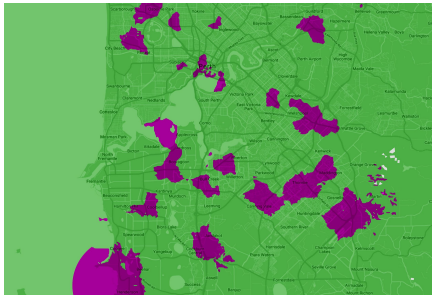






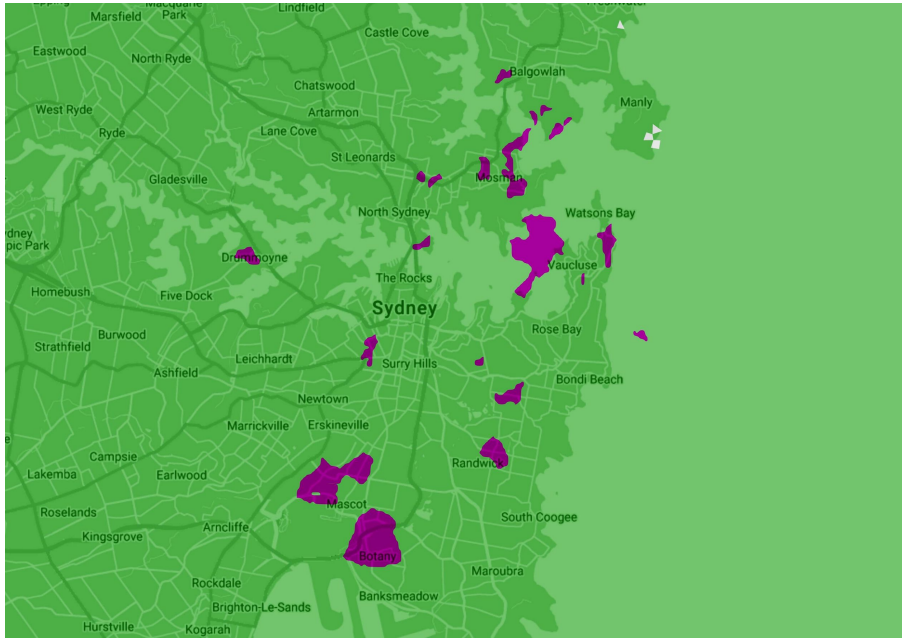


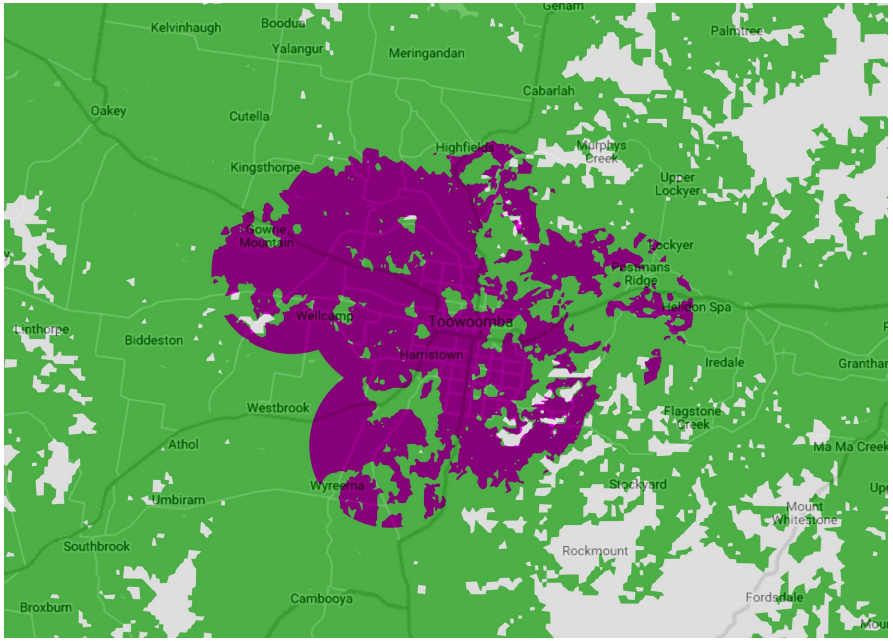




Telstra - 10 Cities Adelaide, Brisbane, Canberra, Gold Coast, Hobart, Launceston, Melbourne, Perth, Sydney, Toowoomba

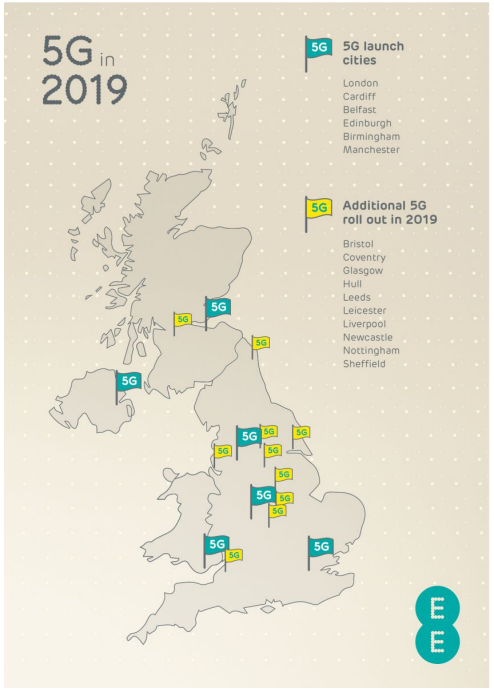
Current Status in Australia





Telstra - 10 Cities Adelaide, Brisbane, Canberra, Gold Coast, Hobart, Launceston, Melbourne, Perth, Sydney, Toowoomba

Current Status in the UK



EE - 6 Cities London, Cardiff, Belfast, Edinburgh, Birmingham and Manchester