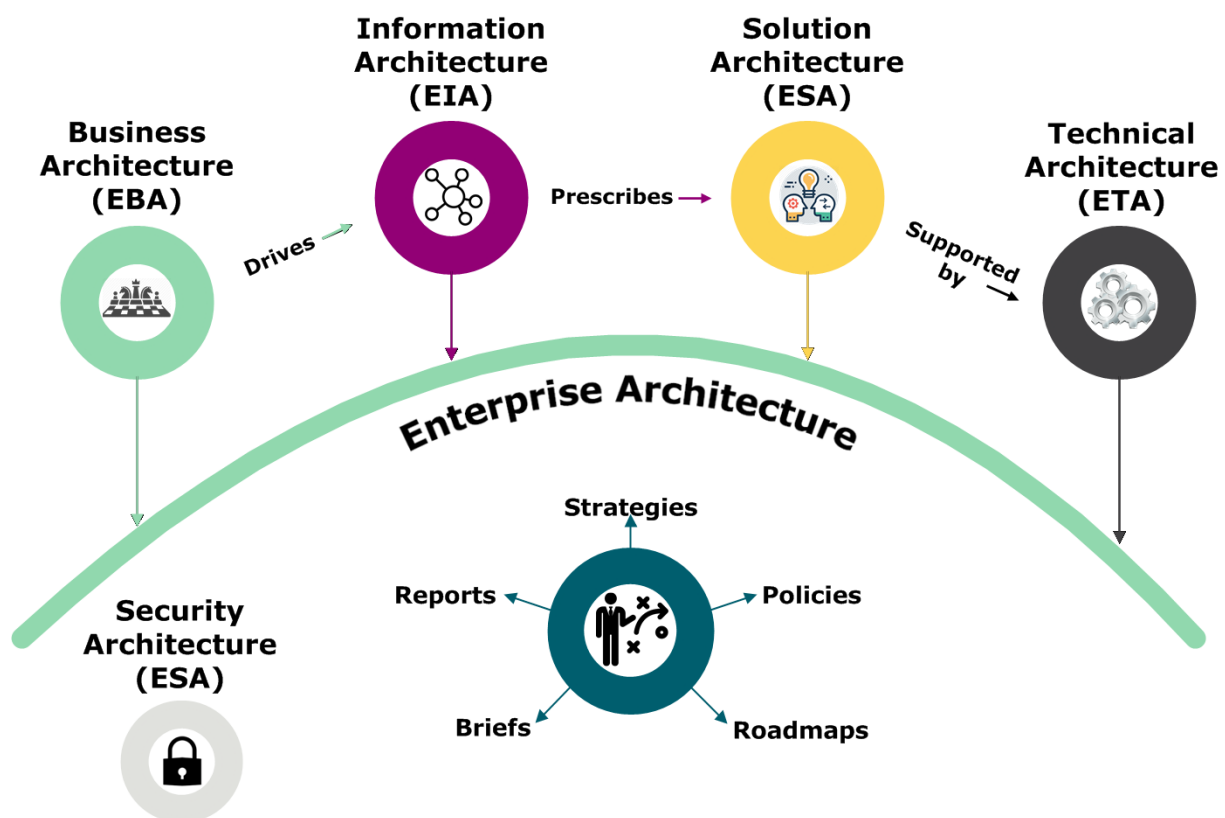


# Enterprise Architecture Technical Brief

## FIFTH GENERATION (5G) WIRELESS COMMUNICATIONS



Robert Kowalke  
August 2020



# Enterprise Architecture Fifth Generation (5G) Wireless

## Overview

This technical brief defines the meaning of 5G technology while identifying the pros and cons of this anticipated infrastructure enhancement in preparation for full implementation of the Internet of Things (IoT) during the decade of the 2020's.

Guidance from this technical brief intends to help commonwealth agencies make their implementation determinations on whether 5G is more beneficial to their business or not, when considering the pros and cons of 5G as provided in the research sections, and to what extent 5G supports increasing employee efficiencies while meeting citizen expectations for better and safer government services.



computerworld.com

For any comments, questions, and/or concerns with this technical brief, please contact VITA EA:  
[ea@vita.virginia.gov](mailto:ea@vita.virginia.gov)



## 5G Recommendations

1. The commonwealth of Virginia is interested in newer technical solutions such as 5G, which may positively increase infrastructure efficiencies, while beneficially increasing commonwealth employee and citizen interactions.
  - a. For 5G, VITA enterprise architecture identifies with the following:
    - i. Plan for 5G by modernizing your WAN infrastructure, because modernization efforts will support 5G technology and its subsequently higher bandwidths and different technologies.
      1. Software Defined WAN (SD-WAN) is the technology that delivers this modernization by applying software-defined methods to centralize control and bring intelligence to existing hybrid WAN environments. <sup>1</sup>
        - a. Software-Defined Networking (SDN) and Network Function Virtualization (NFV) are two key architectures to support the flexibility and mobility demands of the 5G network infrastructure. <sup>2</sup>
        - b. The network should have mature SDN and NFV deployments prior to moving forward with 5G as network slicing relies on these architectures. <sup>3</sup>
      2. Assess equipment purchases for 100% API-driven programmatic control capabilities, even if you are not sure how you will immediately leverage them. <sup>4</sup>
      3. To support 5G, a denser, fiber-rich network infrastructure is necessary. <sup>5</sup>
        - a. 5G can meet its requirements and achieve the technical and business potential for which it has been designed, only if 5G backhaul can cope with its unprecedented challenges. <sup>6</sup>



5G Graphic  
bell-labs.com  
April 26, 2020

<sup>1</sup> 2020 Planning Guide for Infrastructure and Operations by Gartner, #G00401228. October 7, 2019

<sup>2</sup> The Next Wave – The National Security Agency's Review of Emerging Technologies, Vol-21, No-3, 2017.

<sup>3</sup> The pros and cons of network slicing in 5G. CIMI Corporation. Downloaded on Nov-6-2019 from <https://searchnetworking.techtarget.com/tip/The-pros-and-cons-of-network-slicing-in-5G>

<sup>4</sup> 2020 Planning Guide for Infrastructure and Operations by Gartner, #G00401228. October 7, 2019

<sup>5</sup> 5G Networks' Impact on Fiber-Optic Cabling Requirements, by Cabling Installation Maintenance of Endeavor Business Media, LLC., August 1, 2018. <https://www.cablinginstall.com/wireless-5g/article/16468593/5g-networks-impact-on-fiber-optic-cabling-requirements>

<sup>6</sup> A Look at 5G Backhaul Challenges by Infovista on July 5, 2019. Obtained from [infovista.com/blog/5g-backhaul-challenges](http://infovista.com/blog/5g-backhaul-challenges) on August 4, 2020.



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4. Optical fiber continues to be the preferred medium for existing wireless backhaul networks. <sup>7</sup>
  - a. While integrated access backbone (IAB) is useful in situations where it is difficult to impossible to deploy fiber or emergency situations like a natural disaster, IAB is not considered a replacement for fiber. <sup>8</sup>
- ii. Machine type communications (MTC) such as vehicle-to-vehicle (V2V) and vehicle-to-everything (V2X) within the Internet of Things (IoT) will require a new way of thinking about how user authentication and attachment are handled in the network. <sup>9</sup>
  1. This is because in a 5G MTC system, the packet core would be quickly overwhelmed, doing nothing but trying to authenticate devices as they come on to the network and are periodically re-keyed.
- b. Because there are and have been many valid concerns identified regarding 5G technologies, and acknowledging the public health of Virginian's must be protected, VITA EA is monitoring 5G safety concerns such as the following:
  1. Because 5G is not an evolution of 4G, but an entirely new mobile system, a conservative approach to 5G implementation is reasonable for the safety of commonwealth employees and the public.
    - a. "If the probability of carcinogenicity is low, but the magnitude of the potential harm is high, good public policy dictates the risk should not be ignored." <sup>10</sup>
  2. More studies on the efficacy and safety of 5G on the human body are clearly needed as determined from research into 5G indicated by the large amount of experts' worldwide expressing concerns.
    - a. Until such a time as studies reasonably conclude the safety of the new 5G technology, a precautionary approach should be the model for deployment – especially in the current uncertain research environment. <sup>11</sup>
  3. A historic and massive class action lawsuit filed in 2019 by numerous cities spread across the U.S. indicates concern is warranted with 5G deployments.

<sup>7</sup> 5G Networks' Impact on Fiber-Optic Cabling Requirements, by Cabling Installation Maintenance of Endeavor Business Media, LLC., August 1, 2018. <https://www.cablinginstall.com/wireless-5g/article/16468593/5g-networks-impact-on-fiberoptic-cabling-requirements>

<sup>8</sup> Backhaul is finally getting an overhaul by Fierce Wireless on July 13, 2020. Obtained from [fiercewireless.com/5g/marek-s-take-thanks-to-iab-backhaul-finally-getting-overhaul](https://www.fiercewireless.com/5g/marek-s-take-thanks-to-iab-backhaul-finally-getting-overhaul) on August 4, 2020.

<sup>9</sup> The Next Wave – The National Security Agency's Review of Emerging Technologies, Vol-21, No-4, 2017.

<sup>10</sup> Superior Court for the District of Columbia - 2014 ruling on expert cell phone linked tumor testimony. Environmental Health Trust (EHT) <http://ehtrust.org>

<sup>11</sup> A 5G Wireless Future: Will it give us a smart nation or contribute to an unhealthy one? Dr. Cindy Russell, Vice President Community Health, SCCMA. The Bulletin, Volume 23 / Number 1; Official magazine of the Santa Clara County Medical Association, and the Monterey County Medical Society; January/February 2017 edition. <https://www.sccma-mcms.org>



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- a. Includes Los Angeles, CA, and New York City, NY, which reflects the 5G deployment conflict between U.S. cities and the FCC (federal government). <sup>12</sup> <sup>13</sup>
4. Reevaluate safety standards based on long term as well as short-term studies on biological effects. <sup>14</sup>
5. Because Virginia generally favors a conservative approach to responsible technology deployments (lower costs keep taxes lower, and lower risks keep implementation costs lower), many of these public health concerns may be resolved by the time a major deployment of 5G technology is considered for implementation within the commonwealth.

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<sup>12</sup> Joint Opposition of Petitioners, Et Al., and Other Local Governments to the Federal Communications Commission's Motion to Hold in Abeyance and Defer Filing of the Record, 2019. Obtained from URL: [scientists4wiredtech.com/wp-content/uploads/2019/03/2019-0307-Joint-Opposition-to-FCC-Motion-to-Hold-in-Abeyanc.pdf](https://www.scientists4wiredtech.com/wp-content/uploads/2019/03/2019-0307-Joint-Opposition-to-FCC-Motion-to-Hold-in-Abeyanc.pdf) on August 11, 2020.

<sup>13</sup> 5G: Class Action Lawsuit Filed Against the FCC by Municipalities Across the USA by Alexander Light, June 9, 2019. [Stateofthenation.com](https://www.stateofthenation.com)

<sup>14</sup> A 5G Wireless Future: Will it give us a smart nation or contribute to an unhealthy one? Dr. Cindy Russell, Vice President Community Health, SCCMA. The Bulletin, Volume 23 / Number 1; Official magazine of the Santa Clara County Medical Association, and the Monterey County Medical Society; January/February 2017 edition. <https://www.sccma-mcms.org>



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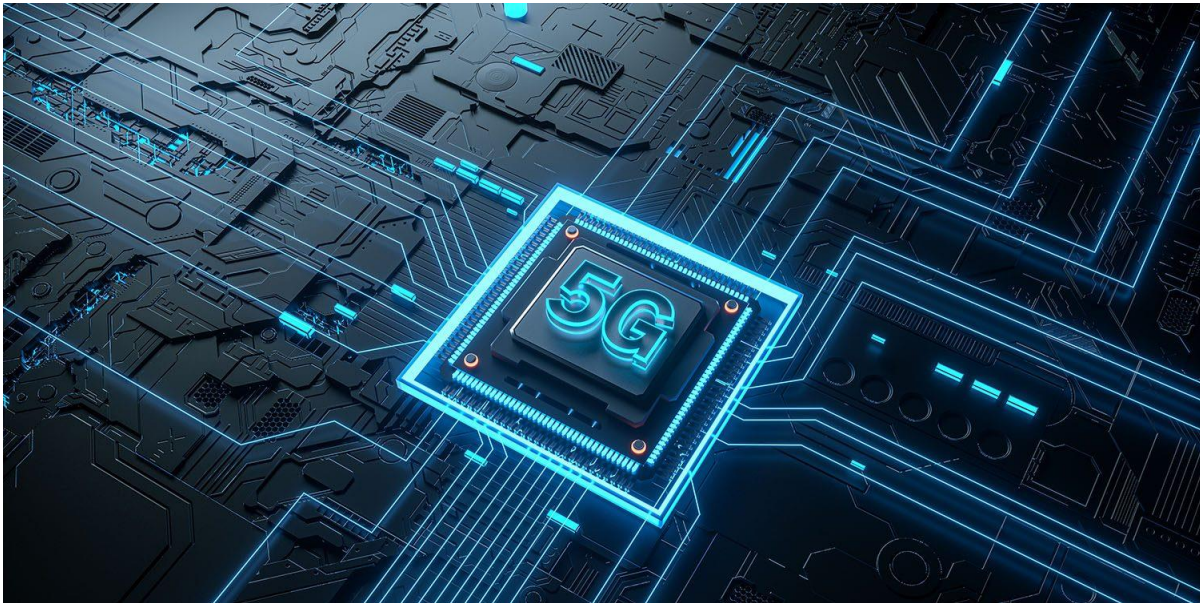
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## 5G Technology Research



## 5G – Deliberating the Pros and Cons <sup>15</sup>

- Increases data transmission speeds
- Faster response times
- Allows larger number of devices to be connected
- Characterized by low latency
- U.S. Government has banned Huawei for national security reasons



5G and EMF Explained - EMF Explained Series, AMTA 2019-2020 Edition.

## 5G: The Next Evolution of Mobile Network Technology <sup>16</sup>

Pros:

- Increased bandwidth
- Enhanced speed for data connectivity
- Reduced latency

<sup>15</sup> 5G – Deliberating the Pros and Cons, by Ambassador D. P. Srivastava, Distinguished Fellow, Vivekananda International Foundation (VIF), April 25, 2019. <https://www.vifindia.org/2019/april/25/5g-deliberating-the-pros-and-cons>

<sup>16</sup> 5G: The Next Evolution of Mobile Network Technology, by The HelloTech Blog, November 27, 2018. <https://www.hellotech.com/blog/5g-the-next-evolution-of-mobile-network-technology/>



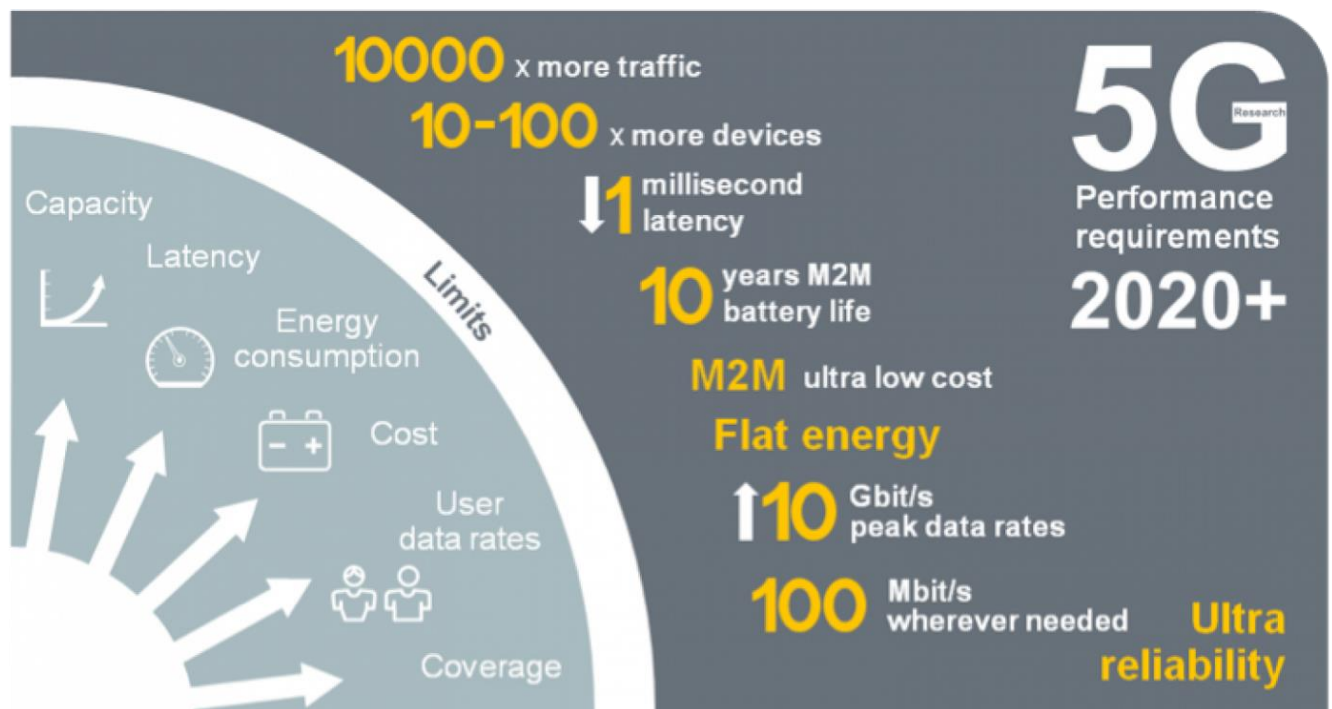
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### Cons:

- Costly
  - Each tower has smaller coverage radius requiring more tower installations
- More bandwidth means less coverage
- Possible occurrence of radio frequency problems

	4G	5G
<b>Speed</b> (Download)	20Mbps Average	10-50Gbps
Frequency	2.6GHz at most	24 GHz and higher
Latency	50 milliseconds	<10 milliseconds

The 5G standard was finalized in 2018.



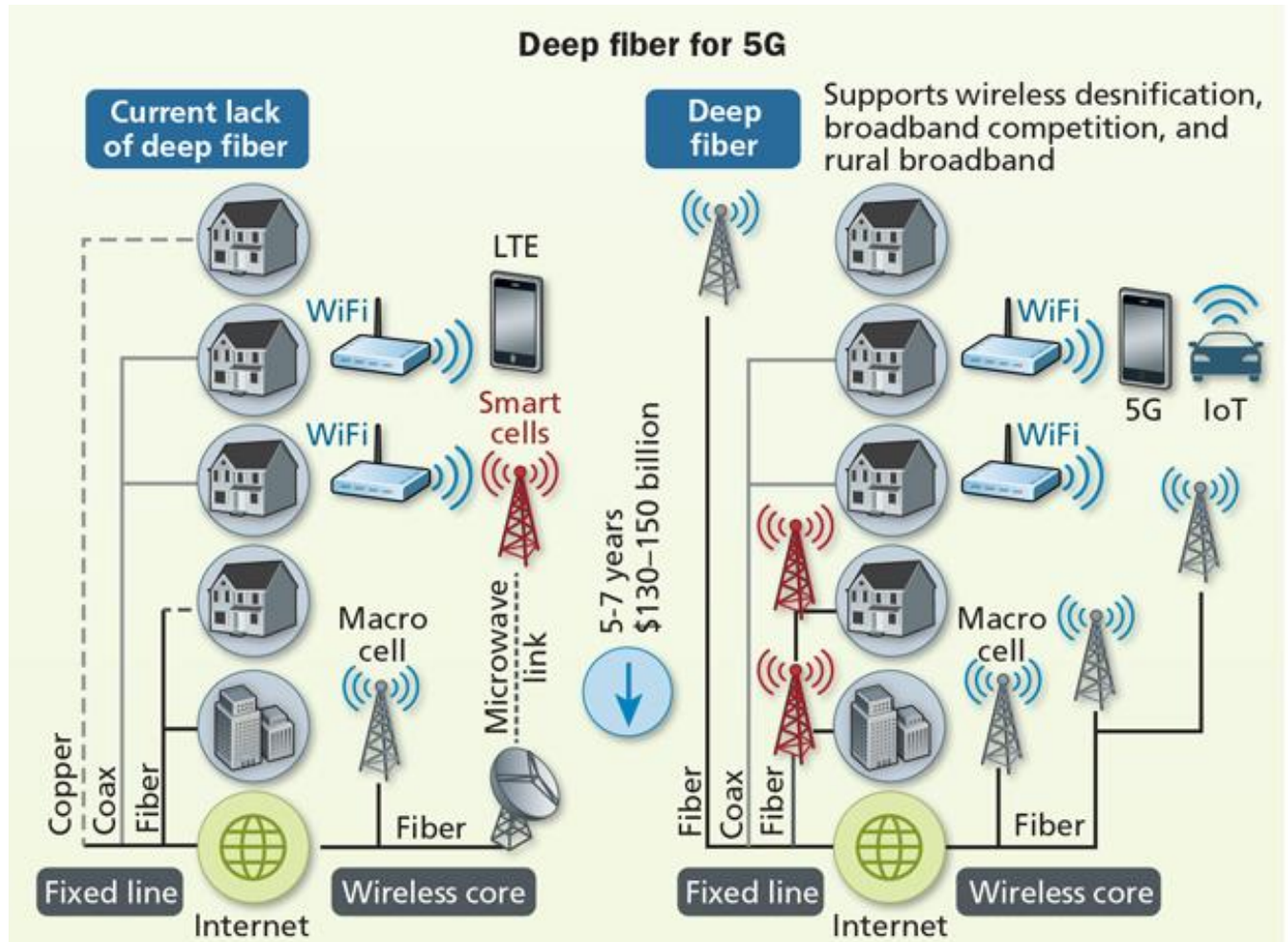
What is 5G? [medium.com/@timscottseo](https://medium.com/@timscottseo), March 29, 2019



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### 5G Internet vs Fiber Internet <sup>17</sup>

- 5G internet requires mobile companies to attach small cell towers or "nodes" to wired fiber networks, then those nodes send digital data to your home router; from there, your Wi-Fi modem sends data to your devices.



cablinginstall.com – July 1, 2018

- In some instances, the 5G network is just as fast as fiber internet, but is still subject to some issues that do not slow fiber broadband down, such as network congestion and weak signals.
  - To fix this, mobile companies need to install more towers in densely populated regions.

<sup>17</sup> 5G Internet vs Fiber Internet, by Ella Wagner, WhistleOut, April 15, 2019. <https://www.whistleout.com/Internet/Guides/5g-internet-vs-fiber-internet>

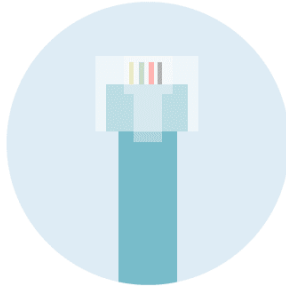


# Enterprise Architecture Fifth Generation (5G) Wireless

## Broadband ACCESS TYPES

### High-Speed Internet Connection Methods

High-speed broadband can be accessed via twisted copper pairs, coaxial cables, fiber, or wireless connections. The following will overview the different benefits and drawbacks associated with different connectivity methods.



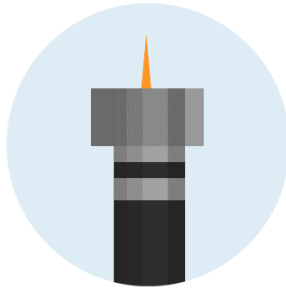
### DSL

#### Pros:

- Low deployment cost
- Uses existing telephone cabling
- Will continue to work in the case of an outage

#### Cons:

- Subscriber speeds attenuate the farther they are from the central office
- Copper cables require maintenance and replacement after a span of time



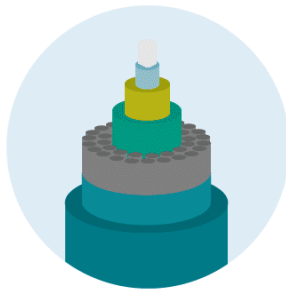
### COAXIAL CABLE

#### Pros:

- Faster than DSL
- Low deployment costs
- Uses existing coaxial cabling

#### Cons:

- Will not work in the case of a power outage
- Shared line architecture: Users may experience slower speeds during peak usage (but coaxial connections will usually offer higher average throughput than DSL)



### FIBER

#### Pros:

- Faster than DSL, Coaxial Cable and Wi-Fi
- Most future-proof medium
- Light technology makes for a noise-free networking environment

#### Cons:

- Very intrusive to deploy
- High deployment costs



### WIRELESS

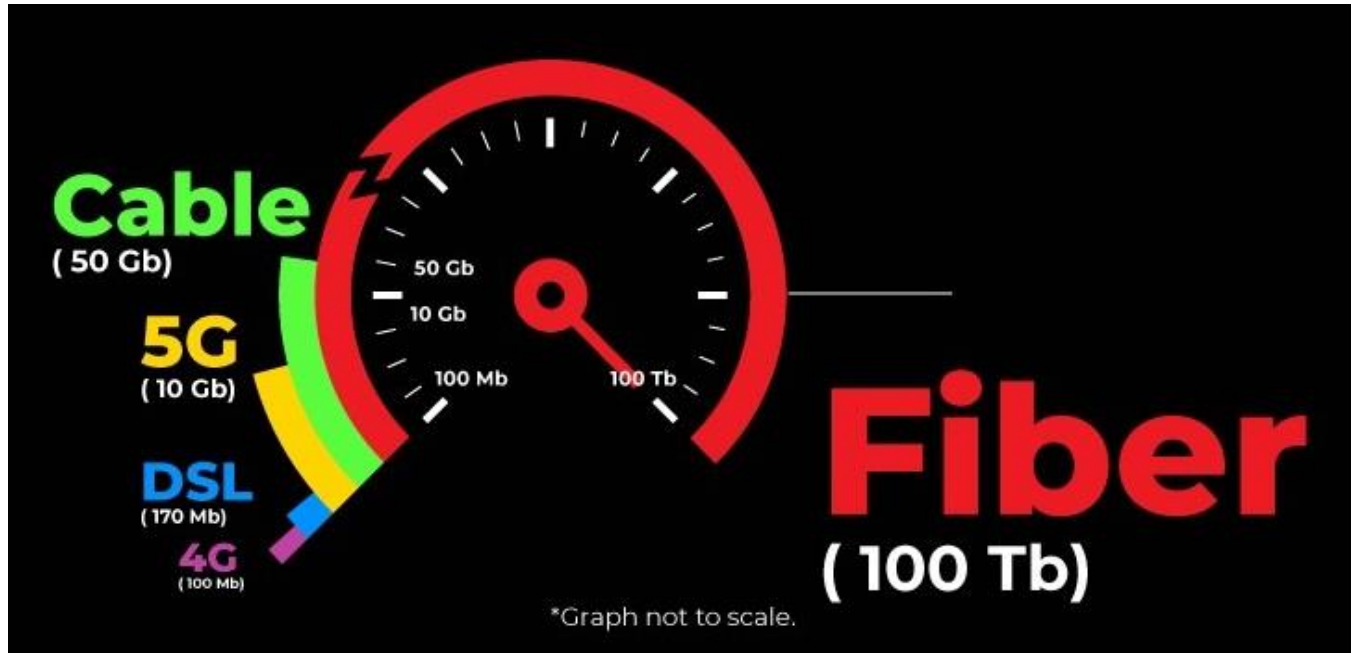
#### Pros:

- Highly mobile
- Ideal for frequent travelers
- 2-6 Mbps

#### Cons:

- Coverage depends on location
- Susceptible to interference

Broadband Access Types. versatek.com December 2015



Electronic Frontier Foundation (EFF)

## 5G Network: Going Deep into the Pros and Cons <sup>18</sup>

The 5G network has become a necessity in today's world, because of an increase in device automation, which relies on wireless networks.

- Pro: Uses high-frequency signals that travel faster than low-frequency signals (4G and earlier).
  - Con: The high-frequency signals can only travel for a short distance. Therefore, 5G will require several antennas, input and output, both spread out at short distances.

<sup>18</sup> 5G Network: Going Deep into the Pros and Cons, by Angelina of EMF Shield Protect, June 2, 2019. <https://emfshieldprotect.com/blog/5g-network-pros-cons-260649>



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Small cell 5G Examples – 5G Americas – August 2019



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- Con: 5G will require use of different types of frequencies to work efficiently.
  - Frequencies will then use different carriers.
  - Even more, the use of different kinds of frequencies will ultimately increase the levels of radiation.
  - Therefore, there will be a need for increased EMF protection.

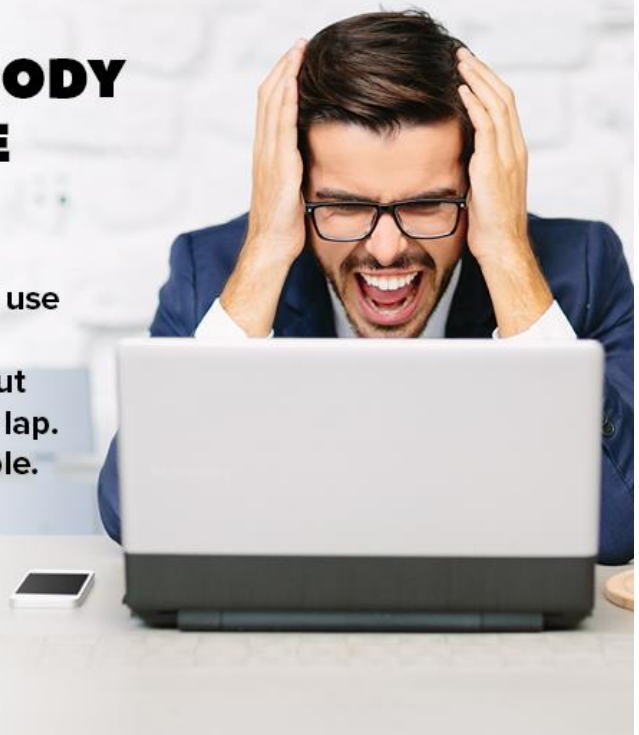
### DID YOU KNOW...



## WI-FI LAPTOPS EXPOSE YOUR BODY TO MICROWAVE RADIATION.

**Solution: Turn Wi-Fi OFF and use corded ethernet cables for internet connection. Never put your tablet or laptop on your lap. Always keep them on the table.**

**EHTrust.org**  
#PracticeSafeTech



- Con: Most likely higher than 4G, although most companies have not yet released the cost of a using a 5G network.
- Con: Most devices in use today will not be compatible with a 5G network and its frequencies.
- Con: Carriers will most likely be reluctant to drastically change to 5G in all customer locations due mostly to the number of infrastructural changes involved in the process.
- Con: Health Issues – Various studies reveal 5G will probably increase the levels of radiofrequency (RF) radiation in locations near the antennas.



- For instance, the 2011 IARC RF electromagnetic fields research reviewed RF effects in human and animal research.
  - The review confirmed RF radiation is carcinogenic to humans (Miller, 2018).
  - Basically, 5G as a rich source of radiofrequency radiation, can pose harmful effects to humans, animals, and the environment.
- To humans, RF radiation can cause various health-related concerns.
  - Such can include disruption of cell metabolism, increased blood-brain permeability, melatonin reduction, generation of stress proteins, and more.

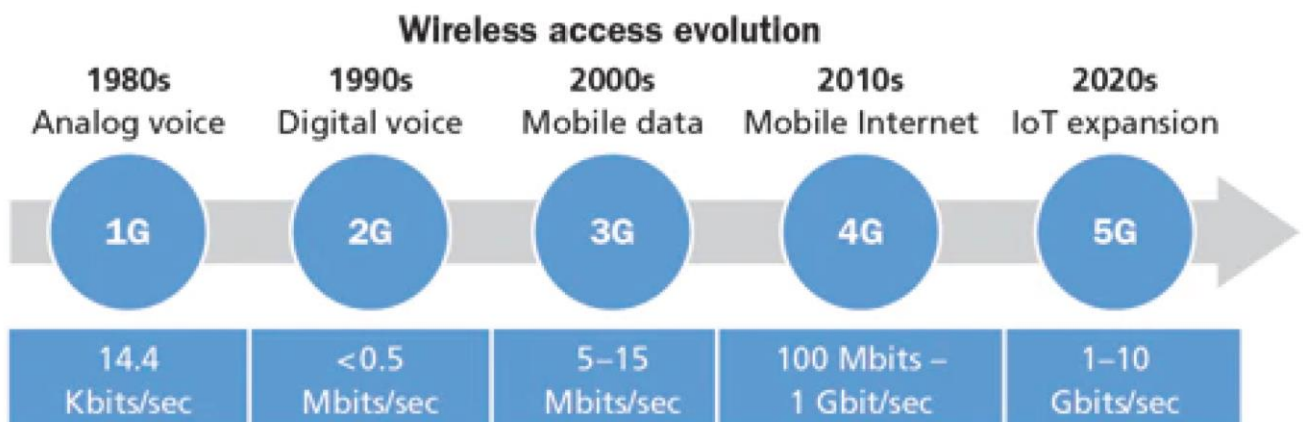


5G and EMF Explained - EMF Explained Series, AMTA 2019-2020 Edition.



## 5G Networks Can Change The Way We Live: For Better or Worse? <sup>19</sup>

- A new class of applications that are bandwidth intensive like VR (Virtual Reality), AR (Augmented Reality), and OTT will require 5G.
- Emerging technologies like self-driving cars, serverless applications, autonomous vehicles, live online gaming, IoT devices, time sensitive telemedicine and even blockchain projects have a potential to benefit from 5G.
- Proponents of 5G want to “get the show on the road”, but there are 5G opponents who argue about the risk to public health and security that 5G networks may bring.
  - At this point there are more questions than answers.
- 4G used LTE and WiMax to deliver a peak speed of 100Mbps to wireless devices.
  - 5G has a peak data rate of 20Gbps, using eMBB (Enhanced Mobile Broadband).



The possibilities seem endless, making it possible that 5G will be revolutionary rather than evolutionary in its demand on fiber infrastructure.

By Kara Mullaley, *Corning Inc.*

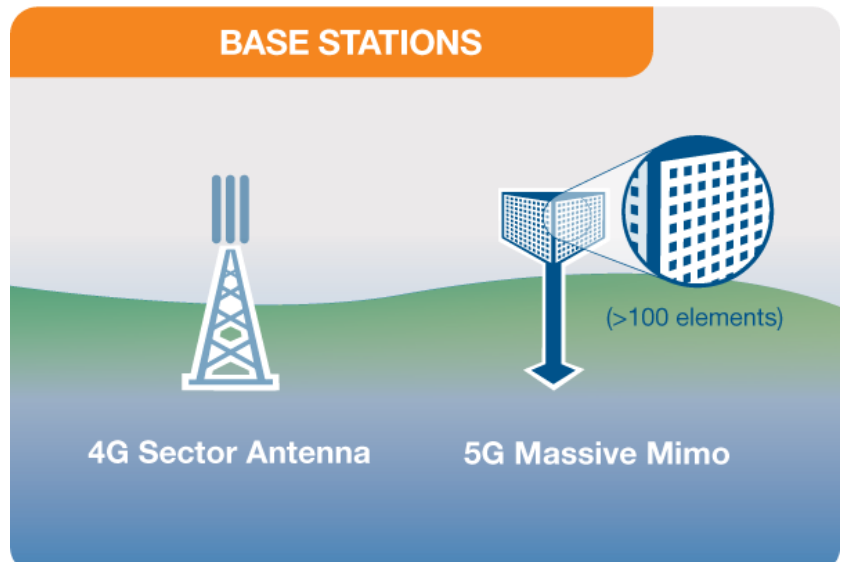
- 5G uses “millimeter waves”, or short wavelength radio signals.
  - Requires a new swath of bandwidth allocated between 30–300 GHz on the frequency spectrum.
  - Increases available bandwidth.
  - Shorter wavelengths cannot travel longer distances.

<sup>19</sup> 5G Networks Can Change The Way We Live: For Better or Worse? By Hacker Noon, December 20, 2018. <https://hackernoon.com/5g-networks-can-change-the-way-we-live-for-better-or-worse-ed2b3fc6b0e6>



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- Signals cannot easily penetrate through walls.
- Signals are easily absorbed by moisture and foliage.
- “Small cell” towers using a dense deployment will be installed within an area to handle signaling.
  - Much smaller than the currently typical cellular tower.
  - Placement between 200 feet up to 1,000 feet apart.
  - Can be put on the side of buildings, utility poles, rooftops, etc.
- 5G to replace high power, low frequency towers with low power, high frequency small cells that communicate with a base station.
- 2 main issues 5G critics are concerned about:
  - Public health
  - Network security
- 5G uses beamforming, which is a more concentrated signal, and is designed to reduce interference and determine best delivery path.
  - The problem of having so many antennas installed is addressed by beamforming.
  - With Multiple-Input Multiple Output (MIMO), a base station can send and receive more signals to boost capacity of a 5G network by a factor of 22; first reported by engineers at the University of Bristol and Sweden's Lund University.
- 5G has security problems.
  - Configuration of new IoT devices connected to public networks.
    - To address vulnerability concerns, cybersecurity experts always advise users to apply updates to their IoT devices, and make sure they do not use easy to guess passwords.
  - Faster ways for viruses and malware to spread.
  - 5G small cell towers can even be targeted, so they must be installed in such a way that they are not easily compromised.



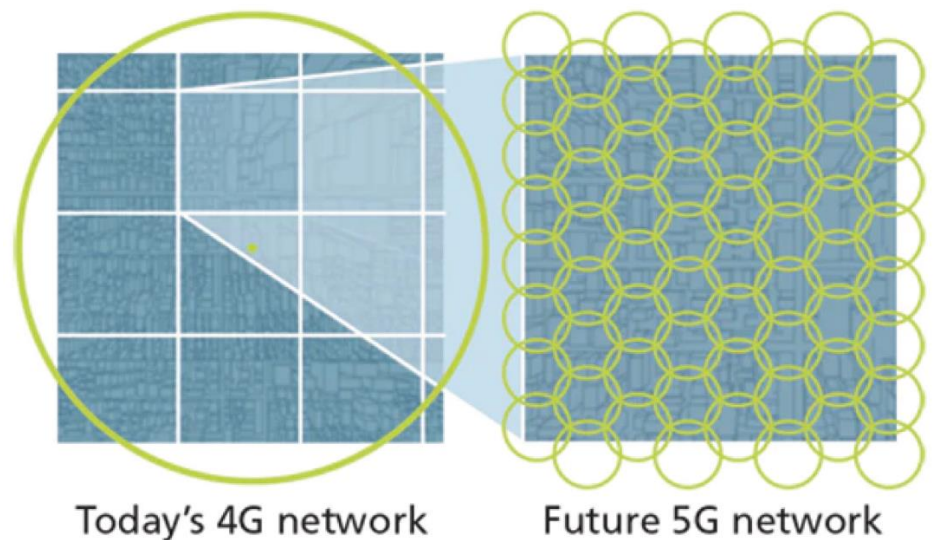


- They will likely have sensors and cameras to make sure they are not being tampered with.

## 5G Networks' Impact on Fiber-Optic Cabling Requirements <sup>20</sup>

- 5G networks to generate an immense amount of data.
  - Billions of devices
  - Trillions of megabits of data
- Network infrastructure has to be in place before 5G becomes a reality.
- 5G depends heavily on real-time data.
- A denser, fiber-rich network infrastructure is needed to support 5G.
- 5G uses a different set of frequencies.
  - Sub-6-GHz used for citywide mobile connectivity
  - Millimeter wave frequencies of 24GHz and above used for high-bandwidth coverage
  - Densification through as many as 60 small cells covering one square mile will be needed

### Current 4G vs. future 5G networks



- Optical fiber is the preferred medium for existing wireless backhaul networks.

<sup>20</sup> 5G Networks' Impact on Fiber-Optic Cabling Requirements, by Cabling Installation Maintenance of Endeavor Business Media, LLC., August 1, 2018. <https://www.cablinginstall.com/wireless-5g/article/16468593/5g-networks-impact-on-fiber-optic-cabling-requirements>

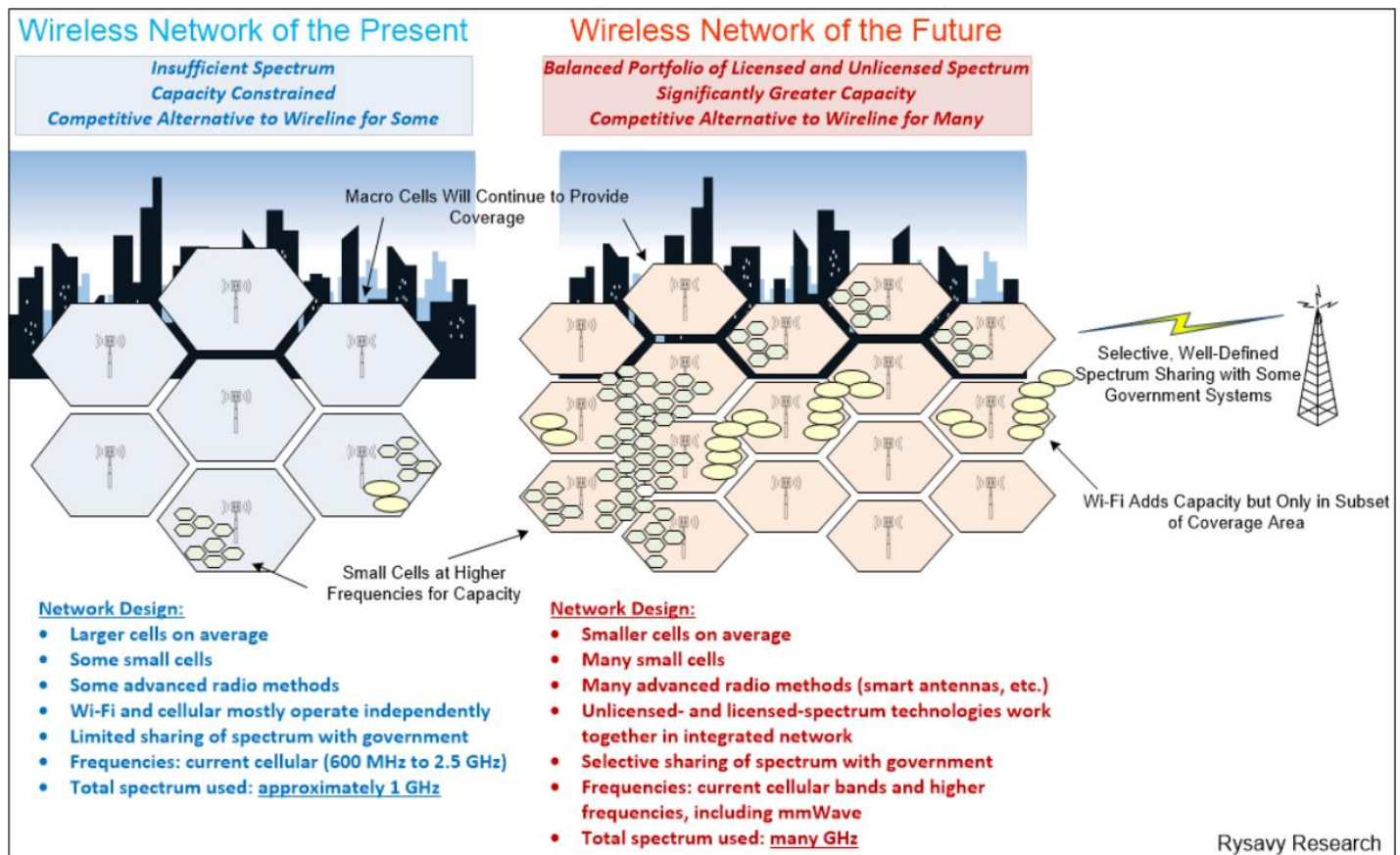


# Enterprise Architecture Fifth Generation (5G) Wireless

- Fiber will be the preferred fronthaul connecting the dense mesh of 5G cells.

## How is 5G Actually Going to Work? <sup>21</sup>

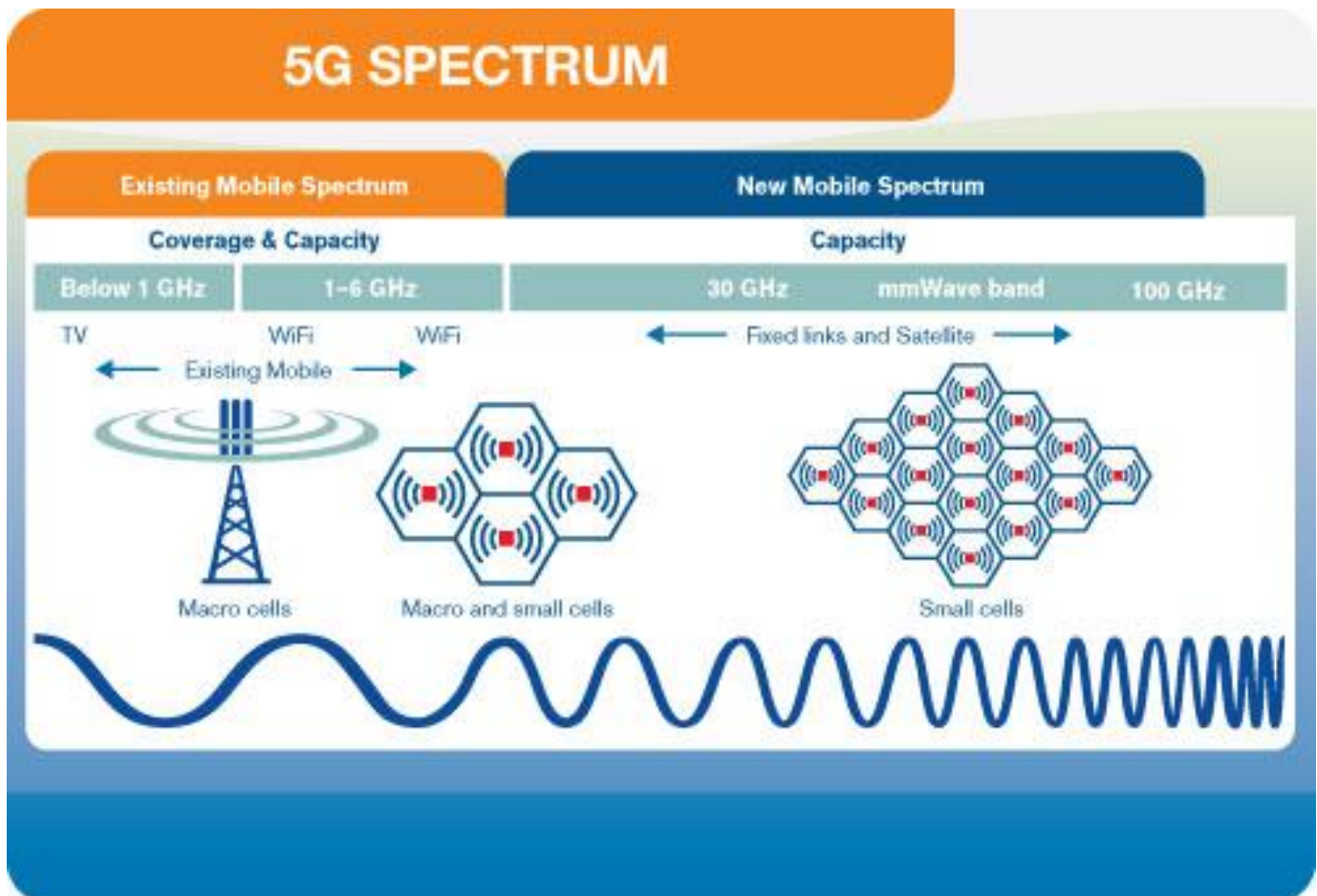
- While peak network data rates will reach, 20Gbps download and 10Gbps upload (20x improvement over IMT-Advanced 4G), users will likely see data rates hover somewhere above, but around 100Mbps.
- Some 5G features may be implemented as LTE-Advanced Pro extensions:
  - 256QAM
  - Massive MIMO
  - LTE-Unlicensed spectrum
- 5G networks will look more patch-worked than today's networks as seen in the following graphic:



<sup>21</sup> How is 5G Actually Going to Work? Android Authority, September 14, 2017. <https://www.androidauthority.com/5g-mobile-tech-explained-798540/>



- Existing 4G LTE bands will likely remain as they are for the near future.
- 5G development is primarily making use of currently unused cmWave (centimeter) and mmWave (millimeter) frequencies.



5G and EMF Explained - EMF Explained Series, AMTA 2019-2020 Edition.

## 5G Security and Privacy <sup>22</sup>

According to the International Telecommunication Union (ITU) and its vision for the fifth generation (5G) of cellular<sup>23</sup>, there are going to be three main drivers for 5G:

1. Enhanced mobile broadband (eMBB)

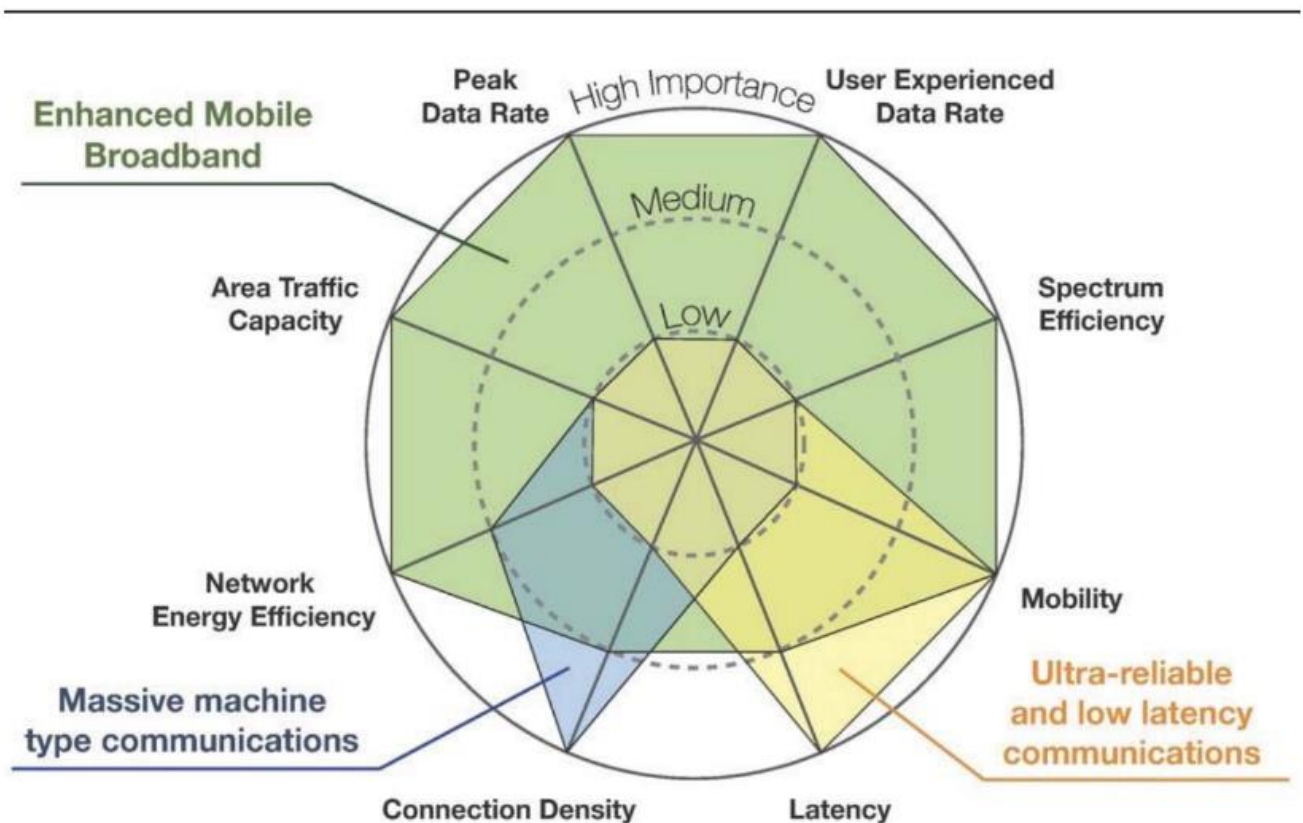
<sup>22</sup> The Next Wave – The National Security Agency’s Review of Emerging Technologies, Vol-21, No-4, 2017.

<sup>23</sup> International Telecommunication Union (ITU)-R. “IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond.” Recommendation ITU-R M.2083-0. September 2015. Available at: <http://www.itu.int/rec/R-REC-M.2083>



## Enterprise Architecture Fifth Generation (5G) Wireless

2. Low-latency ubiquitous connectivity
    - a. Ultra-reliable, low-latency communications (URC/LL)
  3. Machine type communications (MTC) – V2V/V2X/MTC
    - a. Internet of Things (IoT)
- The most important of the three are eMBB and URC/LL. Carriers will likely see eMBB as the most important feature, but MTC and URC/LL use cases will be what ultimately determines whether their network meets the requirements for 5G.
  - MTC requires a new way of thinking about how user authentication and attachment are handled in the network, because in a 5G MTC system, the packet core would be quickly overwhelmed, doing nothing but trying to authenticate devices as they come on to the network and are periodically re-keyed.



**FIGURE 2.** Eight key capabilities and their relative importance to 5G use cases [19].



# Enterprise Architecture Fifth Generation (5G) Wireless

## Introducing 5G <sup>24</sup>

- 1G – 1981; 2G – 1992; 3G – 2001; 4G – 2009; 5G – 2020(?).
- The Internet of Things (IoT) is a major driving force behind technologies being developed for 5G.
- Software-Defined Networking (SDN) and Network Function Virtualization (NFV) are two key architecture concepts in development to support the flexibility and mobility demands of the 5G network infrastructure.
- Applications using 5G technology correspond to a combination of multiple use cases as seen in the following Figure-1:

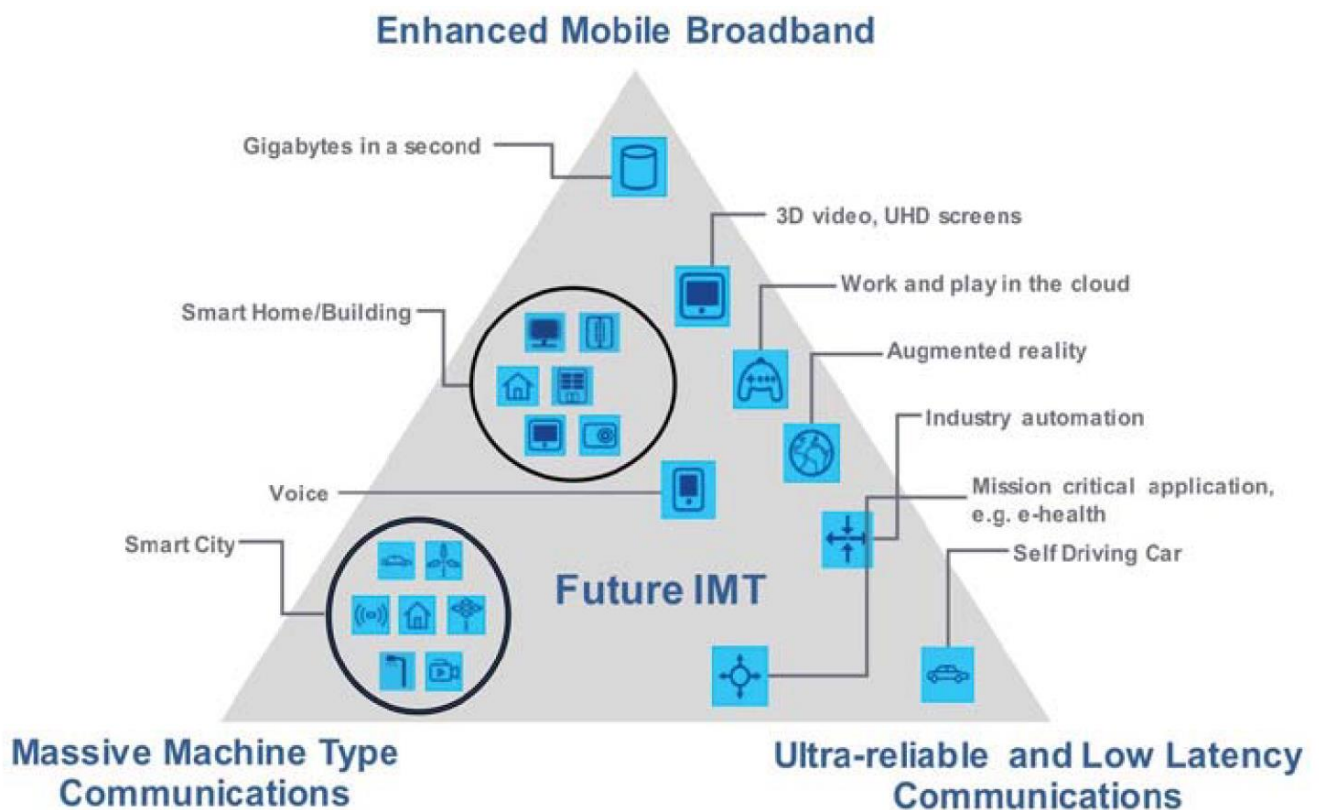


FIGURE 1. 5G use cases as defined by ITU for IMT-2020 [19].

- Virtualization is set to play a major role in the evolution of the 5G core network.
- 5G will be natively cloud based using software-centric networking technologies (SDN and NFV).

<sup>24</sup> The Next Wave – The National Security Agency’s Review of Emerging Technologies, Vol-21, No-3, 2017.





# Enterprise Architecture Fifth Generation (5G) Wireless

- 5G to be a key enabler that allows network connectivity in vehicles to shift from an optional accessory to a core feature.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
<b>Human driver monitors the driving environment</b>						
<b>0</b>	<b>No Automation</b>	the full-time performance by the <i>human driver</i> of all aspects of the <i>dynamic driving task</i> , even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
<b>1</b>	<b>Driver Assistance</b>	the <i>driving mode</i> -specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	Human driver and system	Human driver	Human driver	Some driving modes
<b>2</b>	<b>Partial Automation</b>	the <i>driving mode</i> -specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	<b>System</b>	Human driver	Human driver	Some driving modes
<b>Automated driving system (“system”) monitors the driving environment</b>						
<b>3</b>	<b>Conditional Automation</b>	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the dynamic driving task with the expectation that the <i>human driver</i> will respond appropriately to a <i>request to intervene</i>	System	<b>System</b>	Human driver	Some driving modes
<b>4</b>	<b>High Automation</b>	the <i>driving mode</i> -specific performance by an automated driving system of all aspects of the <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond appropriately to a <i>request to intervene</i>	System	System	<b>System</b>	Some driving modes
<b>5</b>	<b>Full Automation</b>	the full-time performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i>	System	System	System	<b>All driving modes</b>

**FIGURE 1.** SAE Levels of automation. The Society of Automotive Engineers (SAE) has defined levels of automation to clarify what role (if any) drivers have in operating a vehicle while a driving automation system is engaged. These levels are intended to establish a consistent framework that can be used across industries as the dialogue about autonomous vehicles continues. (Figure credit: SAE International J3016 [3].)

## Assessing 5G for IoT <sup>25</sup>

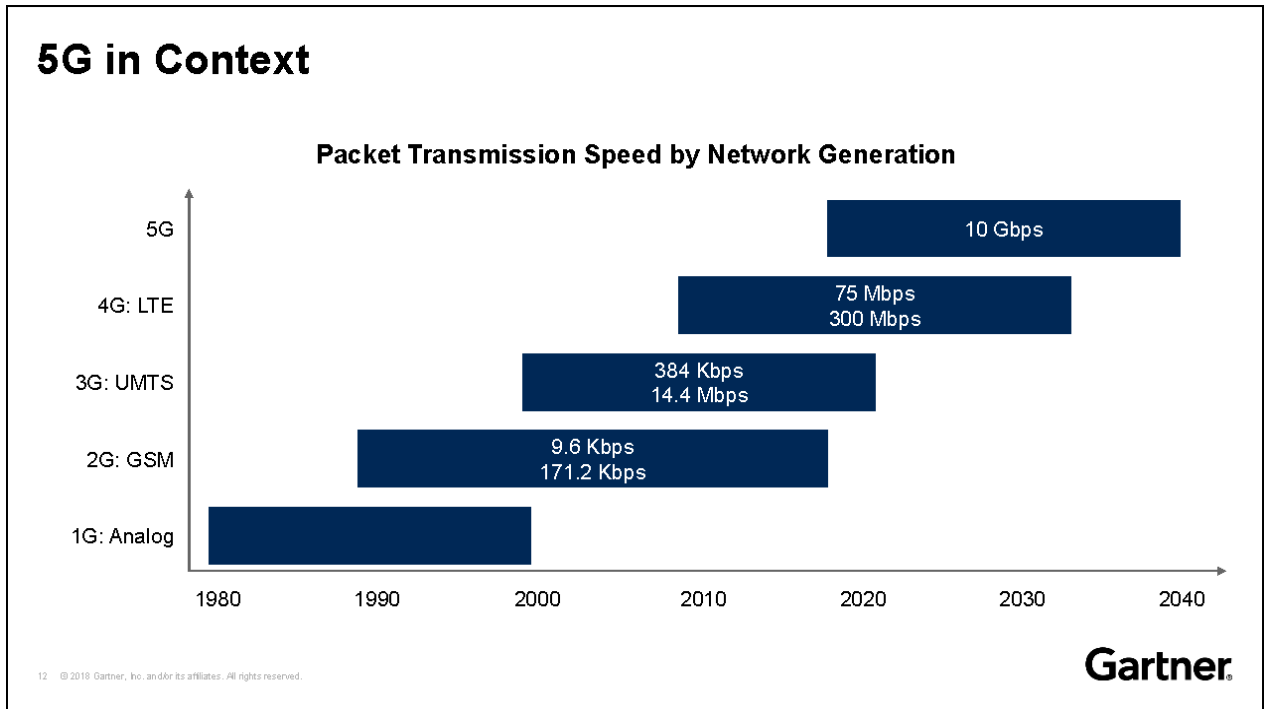
- Designed with machines in mind, 5G will turbocharge certain IoT cases.
- 5G is not LTE, LTE-A, LTE-A Pro, NB-IoT, LTE-M, or LPWA.

<sup>25</sup> Assessing 5G for IoT: Where is the Cellular Magic, by Gartner. August 23, 2018



## Enterprise Architecture Fifth Generation (5G) Wireless

- In IoT, 5G is most relevant with:
  - Higher throughput: Enhanced Mobile Broadband (eMBB)
  - Lower latency: Ultra-reliable and Low-Latency Communications (URLLC)
  - Greater scalability: Massive Machine-Type Communications (mMTC)



- Considering 5G? Use AcT:
  - **A**ssess your IoT solution
  - Consider your **C**overage requirements
  - **T**iming will be important
- Strategic Planning Assumption
  - By 2020, only 3% of network-based CSPs will have launched commercial 5G networks.
  - Less than 45% of CSPs globally will have launched a commercial 5G network by 2025.



## 2020 Planning Guide for Infrastructure and Operations – 5G <sup>26</sup>

- 5G in the WAN:
  - The state of 5G is a work in progress, with the R16 release expected to be finalized around the fourth quarter of 2019.
  - Plan for 5G by modernizing your WAN infrastructure.
    - SD-WAN is the technology that delivers this modernization by applying software-defined methods to centralize control and bring intelligence to existing hybrid WAN environments.
    - Assess equipment purchases for 100% API-driven programmatic control capabilities, even if you are not sure how you will immediately leverage them.

## Should You Buy a 5G Phone in 2019? Here's the Pros and Cons <sup>27</sup>

- Expect some growing pains with 5G.



This AT&T 5G icon refers to low-band 5G, which isn't noticeably faster than 4G right now

### Four Kinds of 5G to Understand

To choose your 5G phone, you need to understand about the four kinds of 5G that are out there or coming soon: low-, middle-, and high-band, and DSS. Low, middle, and high go, respectively, from having a lot of coverage but not much speed, to almost no coverage but crazy-fast speed.

There's a fourth term, DSS, that refers to a way of sharing airwaves between 4G and 5G. That will let carriers slowly reduce capacity on their 4G networks as 5G flourishes—which will be a boon for people with 5G phones, and potential trouble for people without them.

[pcmag.com/picks](https://www.pcmag.com/picks) – May-1-2020

<sup>26</sup> 2020 Planning Guide for Infrastructure and Operations by Gartner, #G00401228. October 7, 2019

<sup>27</sup> Should You Buy a 5G Phone in 2019? Here's the Pros and Cons. By Tom's Guide, April 25, 2019. <https://www.tomsguide.com/us/should-i-buy-a-5g-phone,review-6368.html>



- For instance, downloading a nearly 2GB app from Google Play took longer on 5G than it did over LTE.
- We can chalk that up to the inconsistency of a network still in its infancy, but that kind of hit-or-miss behavior is going to prove frustrating if you've bought a 5G phone based on the promise of better network performance.

### The Pros and Cons of 5G <sup>28</sup>

- Just like 5GHz, Wi-Fi does not travel as far as 2.4GHz and 5G cellular will not travel as far from the tower as 4G.
- Battery drain/heat:
- Phones running on 5G will experience a huge battery drain.
  - Users are also reporting that phones are almost hot to the touch while running 5G.
- Upload speeds:
  - With current technology, users see download speeds as high as 1.9 Gbps.
  - Current upload speeds seen by actual 5G users are not as groundbreaking as the download speeds.
    - Rarely are upload speeds seen over 100 Mbps.
  - Ping speeds seen by users on 5G phones are currently not in the anticipated low latency of 1ms or less.
    - Actual speeds are being seen in the 15 ms range.

### 5G vs 4G: What is the difference? <sup>29</sup>

- Ericsson (Switzerland) is predicting that 1.5 billion users – 40 per cent of the global population coverage – will have access to a 5G network by 2024.
- 5G is a new digital system using a New Radio interface, along with other new technologies, that utilize much higher radio frequencies (28GHz compared to 700MHz–2500MHz (2.5GHz) for 4G).

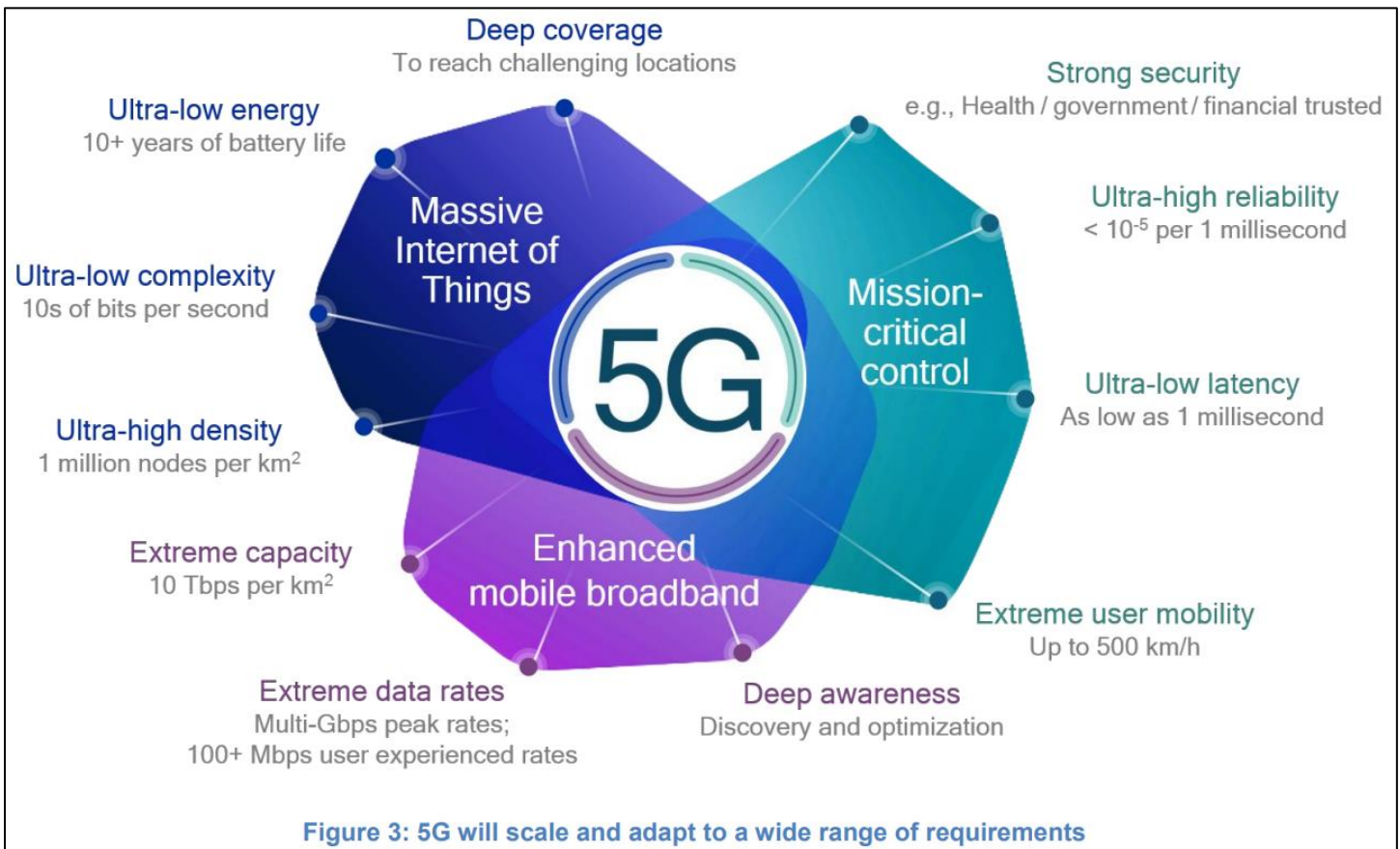
<sup>28</sup> The Pros and Cons of 5G. By Opt Connect at the Kiosk Marketplace. Article downloaded Nov-6-2019 from <https://www.kioskmarketplace.com/blogs/the-pros-and-cons-of-5g/>

<sup>29</sup> 5G vs 4G: What is the difference? RCNT.EU/OV9 - Heidi Vellamay, May 15, 2019. <https://www.raconteur.net/technology/4g-vs-5g-mobile-technology>



## Enterprise Architecture Fifth Generation (5G) Wireless

- 4G can support about 4,000 devices per square kilometer, whereas 5G will support around one million.



5G Scale and Adaptation – Qualcomm – 2016

- 5G also uses a new digital technology called Massive MIMO, which stands for multiple input multiple output.
  - Uses multiple targeted beams to spotlight and follow users around a cell site.
    - Current network technologies operate like floodlights, illuminating an area, but with lots of light/signal wastage.
    - Part of the rollout of 5G involves installing Massive MIMO and 5G New Radio to all mobile network base stations on top of the existing 4G infrastructure.
- Mr Mills warns, however, that much of what is published about the speed of 5G is hype – especially for consumers.
- “Gigabytes speeds are useful for a handful of applications, such as live streaming an 8k VR headset over a 5G network, however, for the average user, there is not



## Enterprise Architecture Fifth Generation (5G) Wireless

much need for that kind of speed on a mobile device,” he says, “Live streaming or downloading HD video is very achievable using a 4G network.”

- 5G will be the catalyst for connecting humans and machines together on an unprecedented scale for new business and economic opportunities.
  - An International Data Corporation (IDC) study estimates the amount of data created, captured, and replicated across the world could grow from 33 Zettabytes (ZB) in 2018 to 175 ZB by 2025..



5G Millimeter Wave (mmWave) Bandwidth Opportunity – Qualcomm February 2019

### The Pros, Cons, and Potentials of 5G <sup>30</sup>

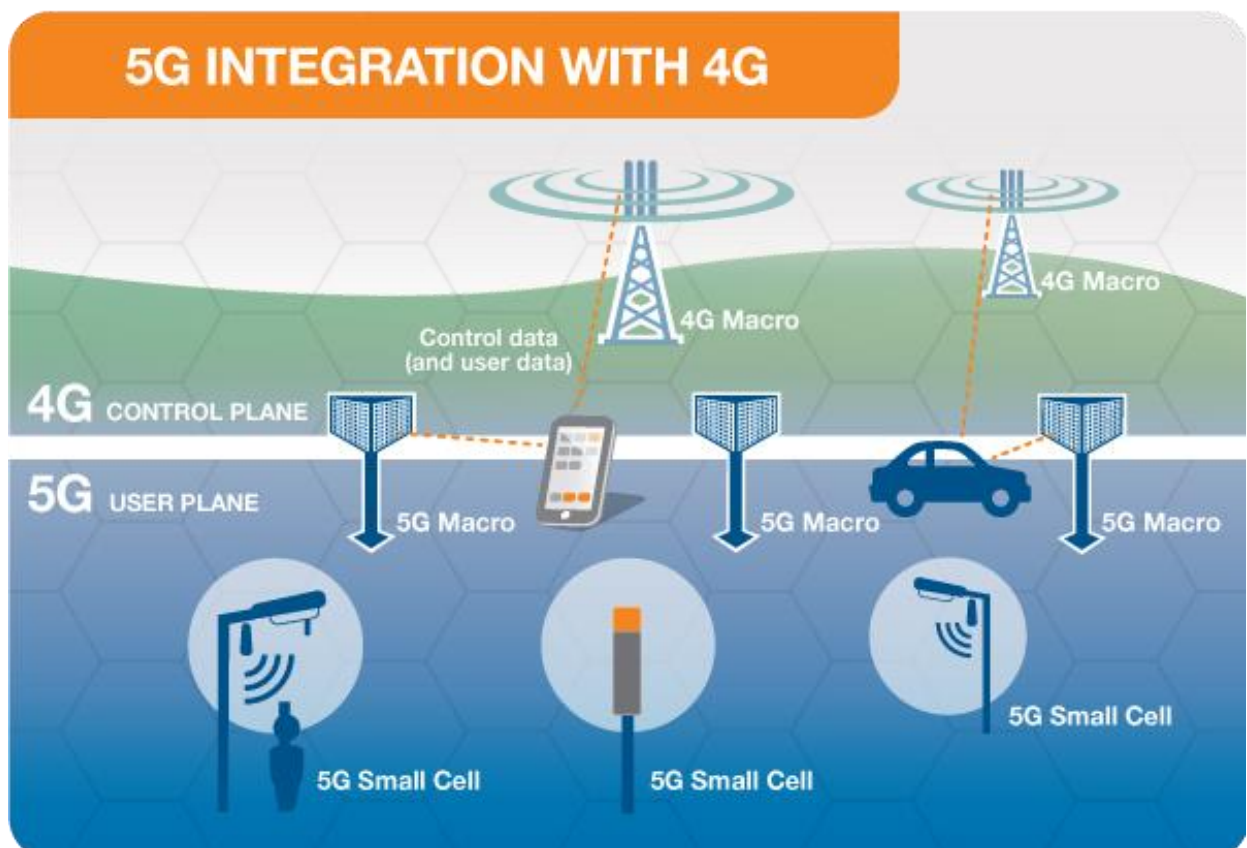
- Just like 5GHz, Wi-Fi does not travel as far as 2.4GHz and 5G cellular will not travel as far from the tower as 4G.
- Do not know how viable 5G’s increased bandwidth is until it gets released to consumers, and that’s where some of the cons start to creep to the surface.
  - For one, worldwide implementation of 5G will require many new cellular towers to be built, which could take a long time and require the purchase of new land leases.
    - Will lead to deforestation and the cluttering of rural areas with new towers.

<sup>30</sup> The Pros, Cons and Potentials of 5G. Article downloaded on Nov-6-2019 from <https://www.gomultilink.com/blog/multilog/the-pros-cons-and-potentials-of-5g>



## Enterprise Architecture Fifth Generation (5G) Wireless

- Having a higher bandwidth also means 5G signals take up more space on the radio frequency, which is already largely consumed by 3G and 4G networks.
  - Placing extra stress on the radio spectrum could lead to slow connections or interruptions entirely.
- It will take longer to establish new 5G networks.
  - While 4G was indeed faster than 3G, it required more cell towers to be built very close to one another; they were putting out a stronger signal, sure, but that signal covered a smaller area, resulting in a longer period of rollout for 4G than 3G; it will likely take even longer for 5G to become prevalent.



5G and EMF Explained - EMF Explained Series, AMTA 2019-2020 Edition.



## What is 5G? <sup>31</sup>

- All four major US carriers have some form of 5G wireless, although it's all limited rollouts in only a few cities, using expensive phones that won't support future nationwide 5G networks.
- Around the beginning of 2020, AT&T, Verizon, and T-Mobile all intend to launch 5G networks that use existing 4G spectrum, which will have slower speeds but broader coverage.
- 5G is an investment for the next decade (2020s).
- You should expect the big 5G apps crop up around 2021 or 2022.
- If you are hearing, 5G means millimeter-wave towers on every lamppost, that is not true.
  - That is how some US carriers are choosing to implement 5G it right now, but it is not a necessary or required form of 5G.
- Wireless Technology Generations:
  - 1G was analog cellular.
  - 2G technologies, such as CDMA, GSM, and TDMA, were the first generation of digital cellular technologies.
  - 3G technologies, such as EVDO, HSPA, and UMTS, brought speeds from 200kbps to a few megabits per second.
  - 4G technologies, such as WiMAX and LTE, were the next incompatible leap forward, and they are now scaling up to hundreds of megabits and even gigabit-level speeds.
- The symbiosis between 4G and 5G has caused AT&T to get a little overenthusiastic about its 4G network.
- The carrier has started to call its 4G network "5G Evolution," because it sees improving 4G as a major step to 5G.
  - The phrasing is designed to confuse less-informed consumers into thinking 5G Evolution is 5G, when it is not.

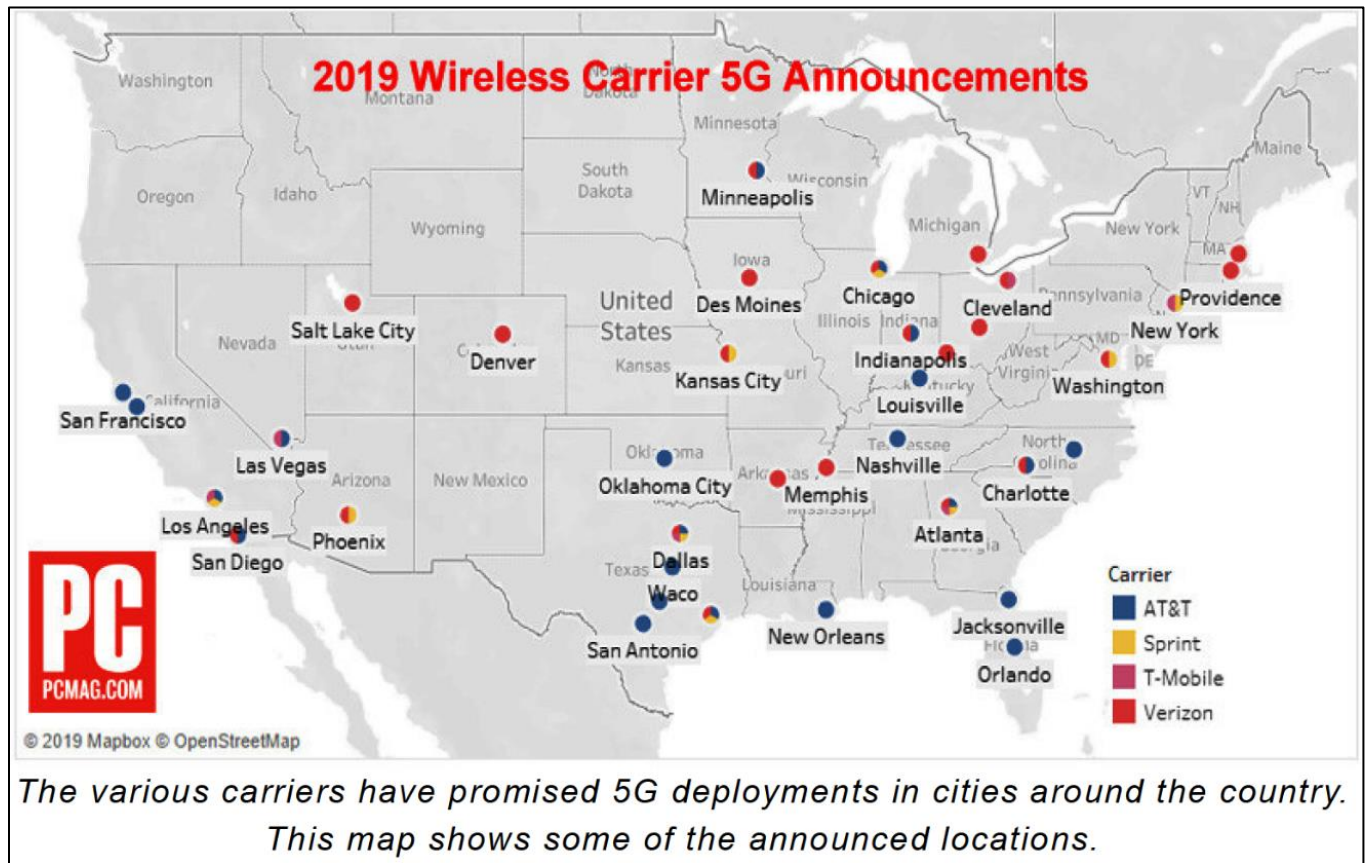
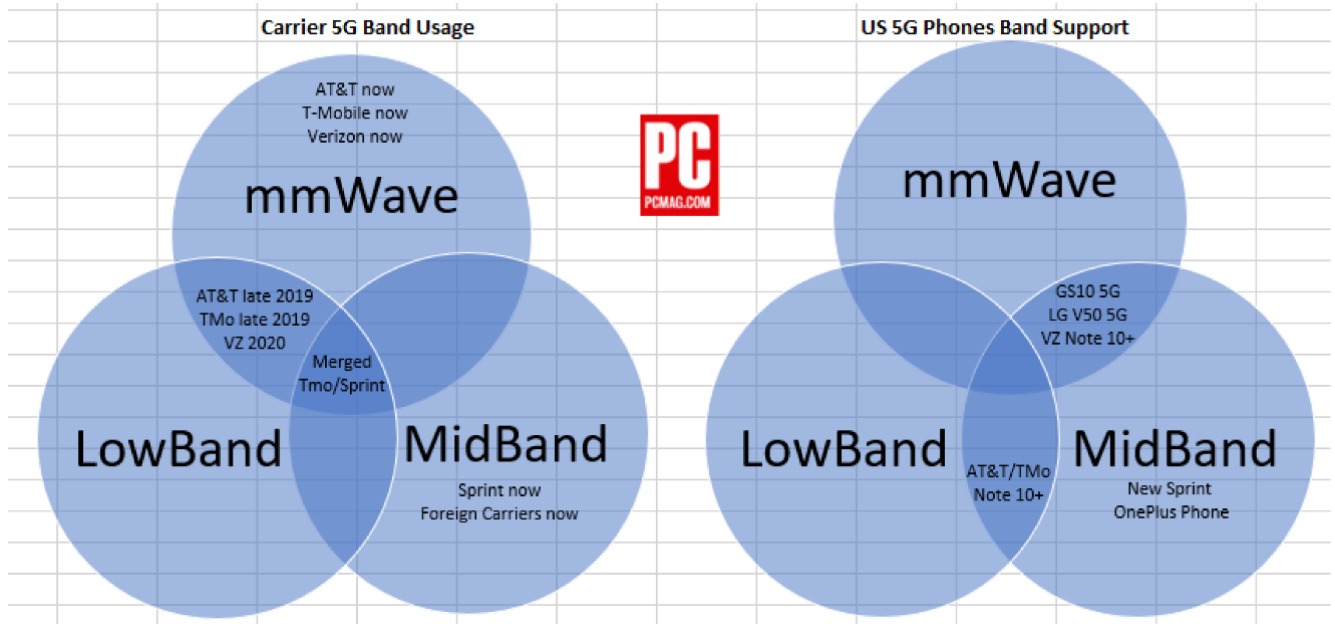
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<sup>31</sup> What is 5G? PCMag, October 31, 2019. <https://www.pcmag.com/article/345387/what-is-5g>



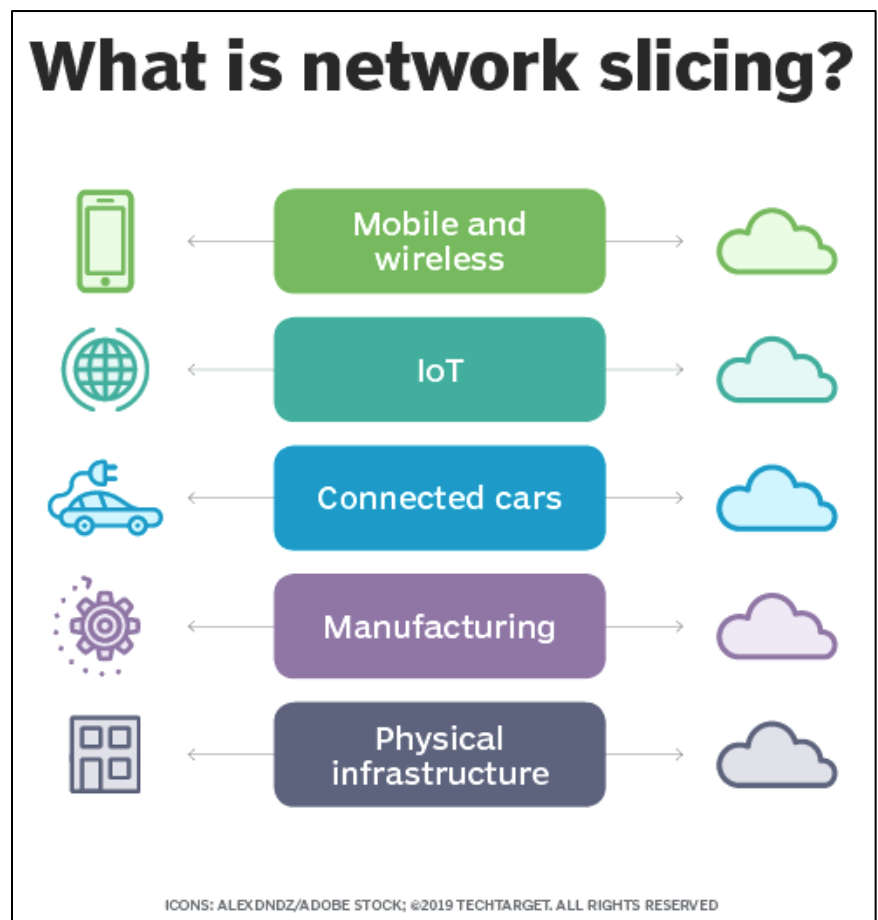


# Enterprise Architecture Fifth Generation (5G) Wireless



## The Pros and Cons of Network Slicing in 5G <sup>32</sup>

- The critical piece that separates 5G from being just a different radio access network model is the concept of network slicing.
  - Network slicing applies virtualization principles to mobile networks.
    - Many tout it as the launch-pad for a new wave of software-defined networking (SDN) and network functions virtualization (NFV) deployment.
  - Creates multiple independent virtual networks -- or slices -- that allow mobile operators to separate users, devices, and applications that require a different quality of service (QoS).



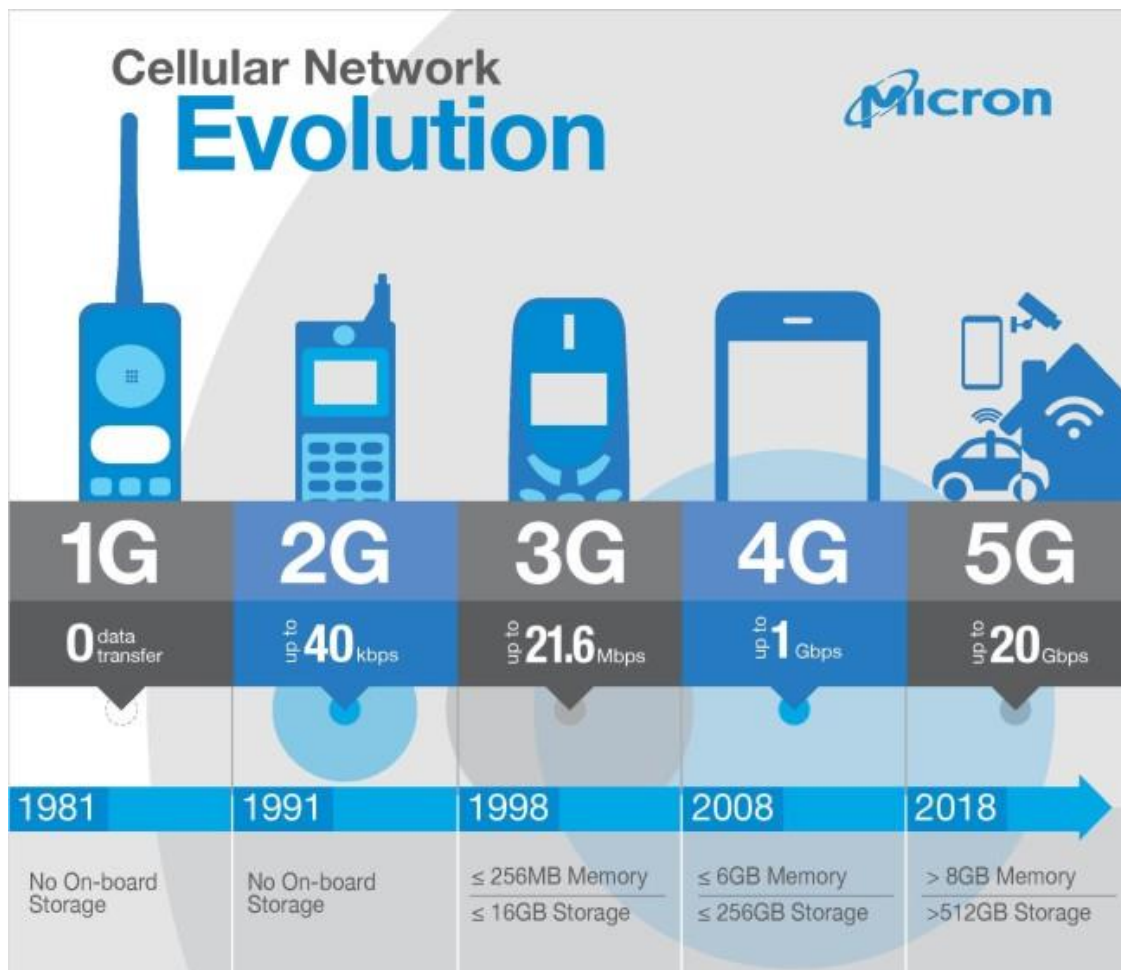
- Slices can also be used to give mobile virtual network operators (MVNO) their own virtual infrastructure, potentially improving MVNO-based services.

<sup>32</sup> The pros and cons of network slicing in 5G. CIMI Corporation. Downloaded on Nov-6-2019 from <https://searchnetworking.techtarget.com/tip/The-pros-and-cons-of-network-slicing-in-5G>



## Enterprise Architecture Fifth Generation (5G) Wireless

- Horizontal slicing offers cross-application and cross-service segmentation of a network.
  - Each horizontal slice has its own virtual resources highly independent of the resources used for other slices.
  - Differs from current network segmentation – or vertical slicing, which does not partition resources as much as it allocates them based on the application or mission.
- Network slicing, in theory, isolates the slices fully for better security and QoS control, but it risks lower efficiency when using network and hosting resources, in addition to higher operations costs due to the need to manage the slices independently.
- Network slicing is anticipated to be retrofitted into 5G networks later, perhaps beyond 2025, when new applications actually demand the stringent separation of resources that network slicing provides.



Cellular Network Evolution – 1G to 5G – Micron August 2019

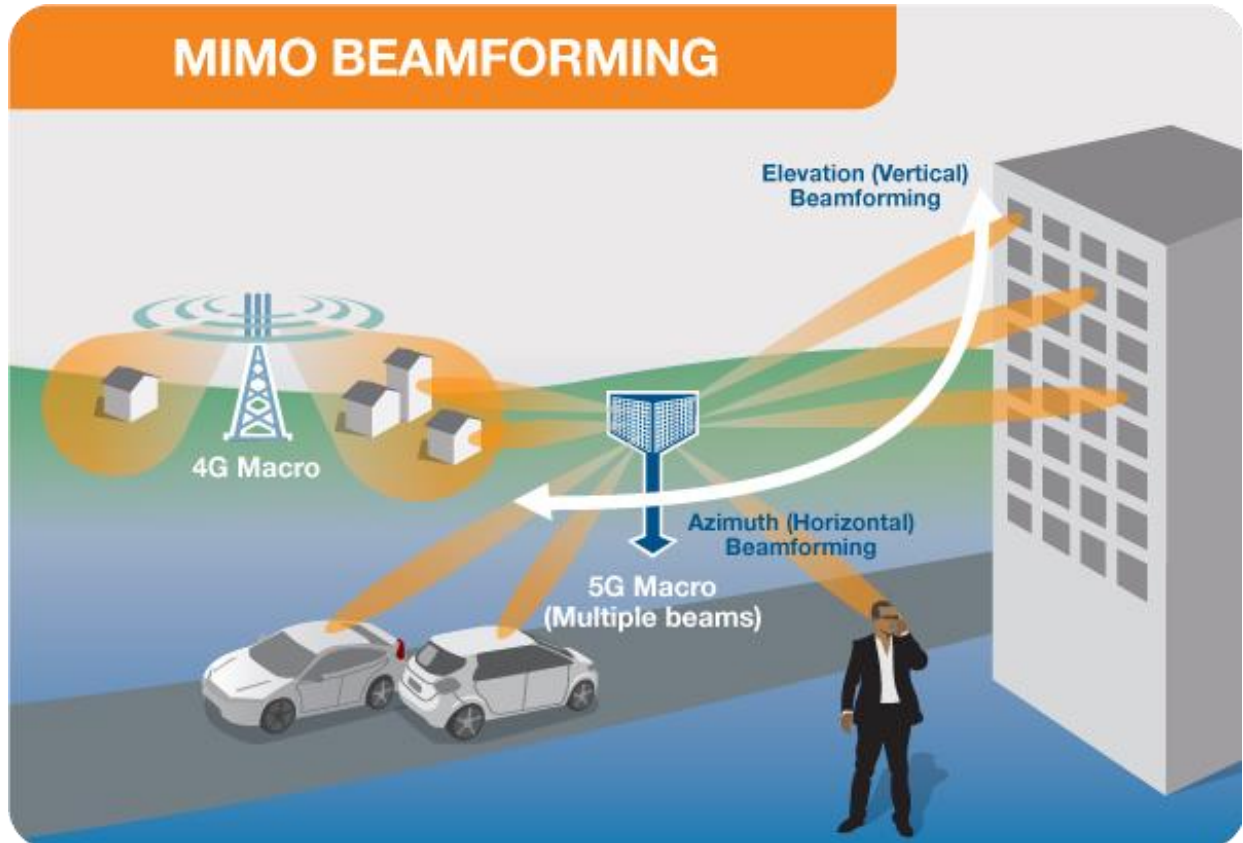


## 5G and EMF Explained <sup>33</sup>

- 5G will initially operate in conjunction with existing 4G networks before evolving to fully standalone networks in subsequent releases and coverage expansions.
  - When a 5G connection is established, the user device will connect to both the 4G network to provide the control signaling, and to the 5G network to help provide the fast data connection by adding to the existing 4G capacity.
  - Where there is limited 5G coverage, data is carried on the 4G network providing the continuous connection. Essentially, with this design, the 5G network is complementing the existing 4G network.
- Initial 5G services commenced in many countries in 2019 and widespread availability of 5G is expected by 2025.
- Small cells are essential for the 5G networks as the mmWave frequencies have a very short connection range.
  - Small cells are mini base stations designed for very localized coverage, typically from 10 meters to a few hundred meters providing fill-in for a larger macro network.

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<sup>33</sup> 5G and EMF Explained - EMF Explained Series, 2019-2020 Edition. Australian Mobile Telecommunications Association (AMTA) and GSMA and Mobile and Wireless Forum (WMF).

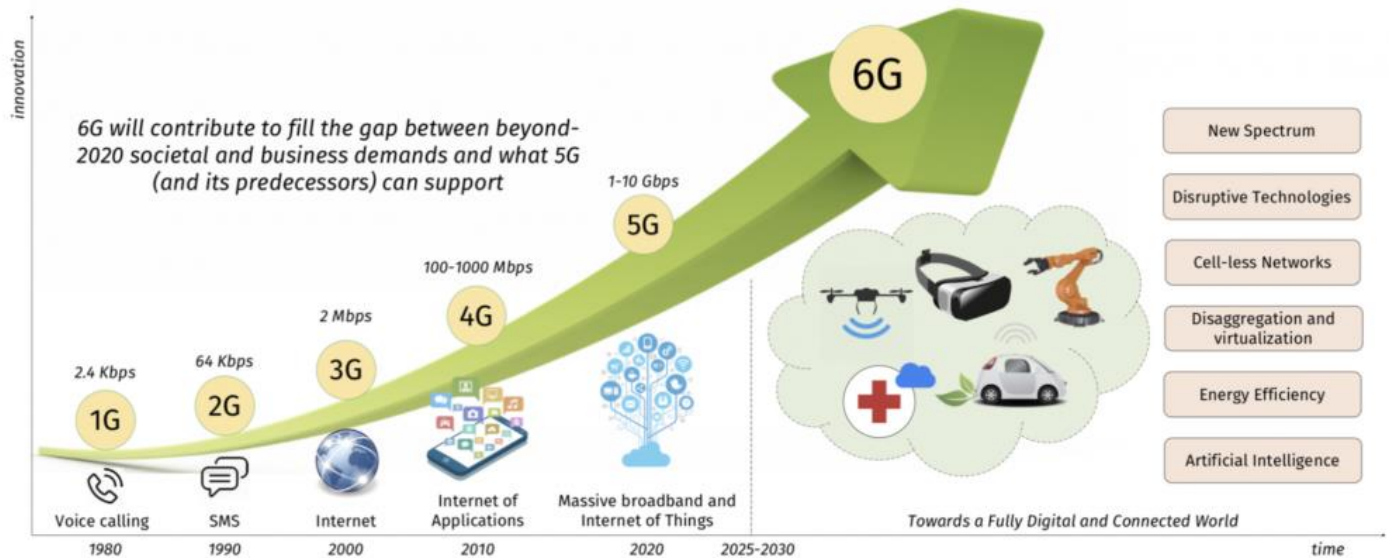


5G and EMF Explained - EMF Explained Series, AMTA 2019-2020 Edition.

- Initial frequency bands for 5G are below 6GHz (in many cases in the 3.3-3.8GHz bands) and similar frequencies to existing mobile and Wi-Fi networks.
  - Additional mobile spectrum above 6 GHz, including the 26-28 GHz bands often referred to as millimeter (mm) Wave, will provide significantly more capacity compared to the current mobile technologies.
    - The increased spectrum in the mmWave band will provide localized coverage as they only operate over short distances.
    - Future 5G deployments may use mmWave frequencies in bands up to 86 GHz.
    - The additional spectrum and greater capacity will enable more users, more data and faster connections.
    - Expected to be future reuse of existing low band spectrum for 5G as legacy networks decline in usage and to support future use cases.



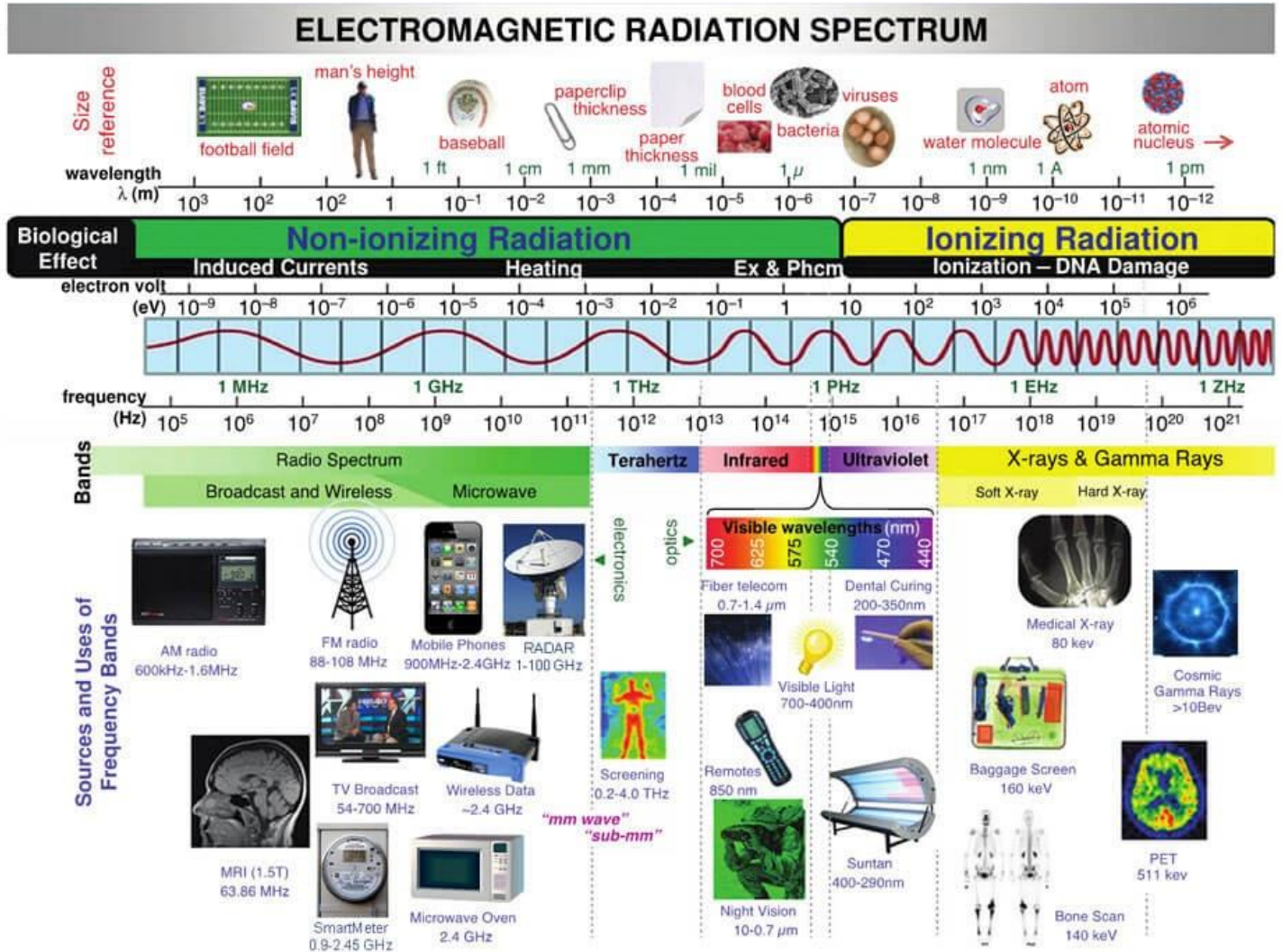
# Enterprise Architecture Fifth Generation (5G) Wireless



- 5G will use 'massive' MIMO (multiple input, multiple output) antennas that have very large numbers of antenna elements or connections to send and receive more data simultaneously.
  - User benefit is that more people can simultaneously connect to the network and maintain high throughput.
- 5G User Equipment including mobile phones and devices will also have MIMO antenna technology built into the device for the mmWave frequencies.
- MIMO – Beam steering is a technology that allows the massive MIMO base station antennas to direct the radio signal to the users and devices rather than in all directions.
  - Uses advanced signal-processing algorithms to determine the best path for the radio signal to reach the user.
  - Designed to increase efficiency as it reduces interference (unwanted radio signals).



# Enterprise Architecture Fifth Generation (5G) Wireless



Electromagnetic Radiation Spectrum – defendershield.com/safe-levels – April 30, 2020

## Nationwide 5G – AT&T’s 700MHz vs. T-Mobile’s 600MHz <sup>34</sup>

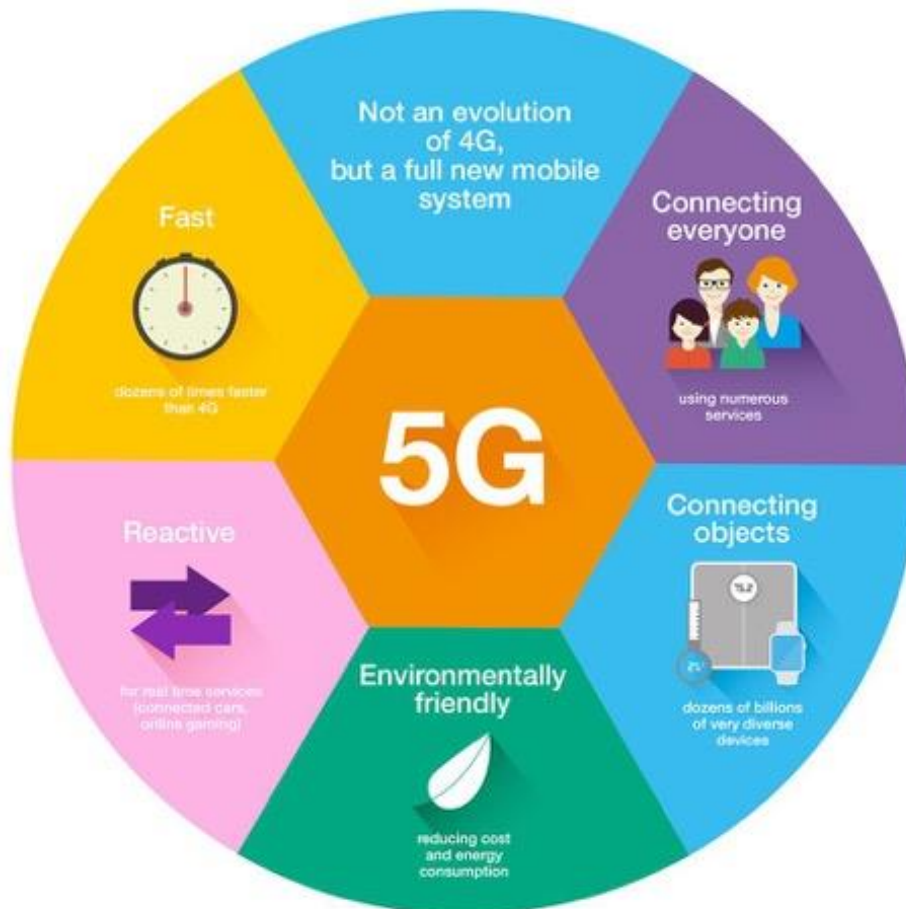
- MindCommerce blog entry reports:
  - We believe 5G actually will not be a big deal for consumers - except higher data speeds when it comes to ROI for the carriers.

<sup>34</sup> In Nationwide 5G, It Will Be AT&T’s 700MHz vs. T-Mobile’s 600MHz. 5G & Mobile Strategies. May 28, 2019. <https://www.lightreading.com/mobile/5g/in-nationwide-5g-it-will-be-atandts-700mhz-vs-t-mobiles-600mhz/a/d-id/751774> 1/4



## Enterprise Architecture Fifth Generation (5G) Wireless

- The 5G Applications Market is going to have much more reliance upon enterprise, industrial, and government customers, and many of them will go with private networks for their own facilities.
  - Mobile Edge Computing will also be important in support of this market.



5G Different From 4G-LTE – sdxcentral.com – November 17, 2017





## 5G Safety Research





## 5G Networks Can Change The Way We Live: For Better or Worse? <sup>35</sup>

- 2 main issues that 5G critics are concerned about:
  - Public health
  - Network security
- 5G Can Pose A Risk To Public Health
  - Health professionals, researchers, and activists alike have concern for the high frequency millimeter radio signals 5G uses.
  - Physicians warn the amount of radiation 5G small cells emit can have irreversible effects on people who live, or are exposed to these radio waves on a daily basis.
  - The issue is when you deploy a system of 5G small cells, they are continuously transmitting wireless signals that bombard its surroundings.
    - 5G uses beamforming to concentrate signal transmission rather than broadcasts, more evaluation and testing to verify the safety of 5G is needed.

## DID YOU KNOW...



### WIRELESS DEVICES EMIT RADIATION 24/7

Corded connections do not emit radiation. Disable all wireless transmitters when not in use, particularly when handing a device to a child. Set Airplane Mode ON with Wi-Fi OFF & Bluetooth OFF.

**EHTrust.org**  
#PracticeSafeTech

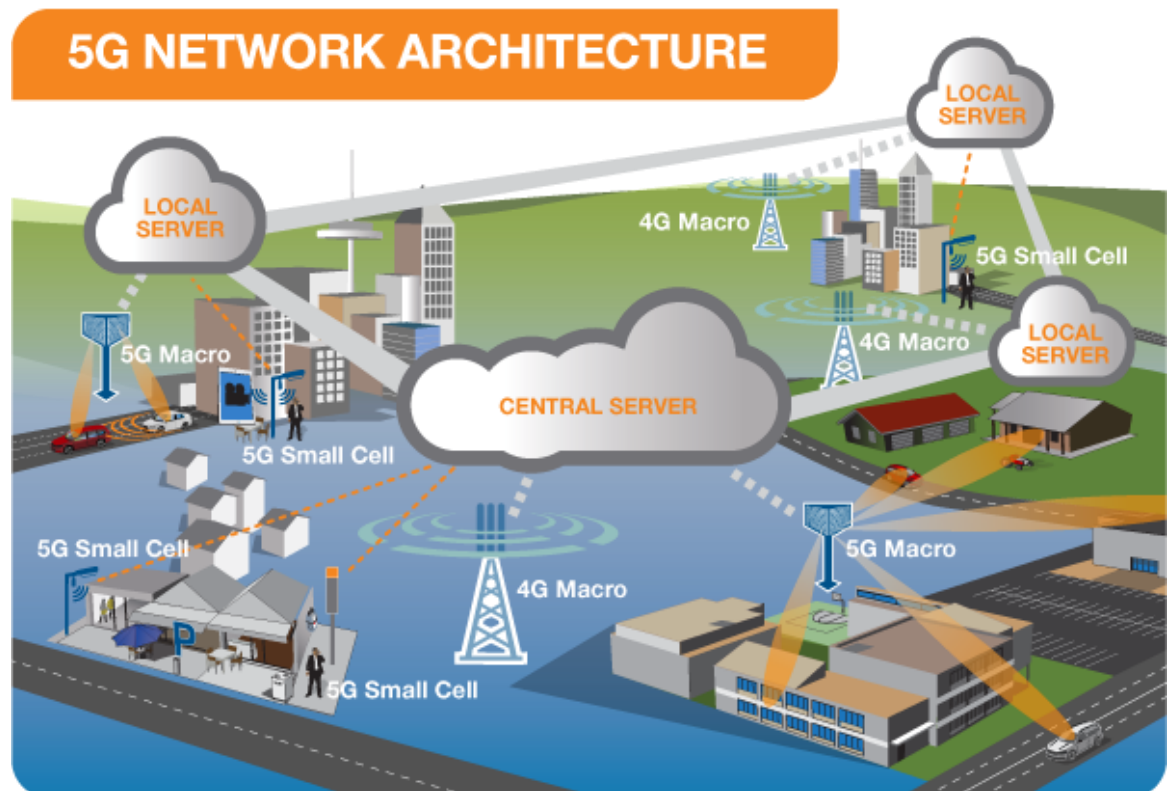


<sup>35</sup> 5G Networks Can Change The Way We Live: For Better or Worse? By Hacker Noon, December 20, 2018. <https://hackernoon.com/5g-networks-can-change-the-way-we-live-for-better-or-worse-ed2b3fc6b0e6>



## A 5G Wireless Future: Will it give us a smart nation or contribute to an unhealthy one? <sup>36</sup>

- Ask NASA: Is electro-sensitivity real or imagined?
  - More scientific evidence links biologic effects with increased reports of health related effects including electro sensitivity.
    - In a 1981 NASA report, "Electromagnetic Field (EMF) Interactions: Observed Effects and Theories" microwave sickness was also described.



5G and EMF Explained - EMF Explained Series, AMTA 2019-2020 Edition.

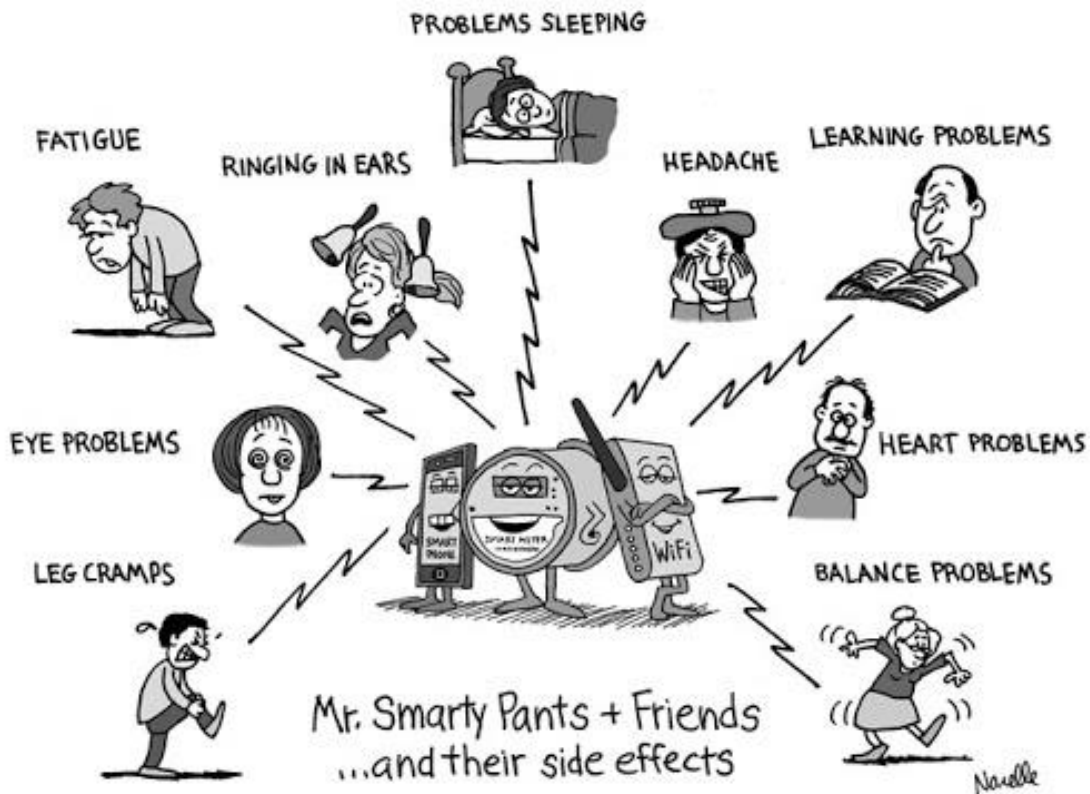
- Symptoms recorded were:
  - Headaches
  - Eyestrain

<sup>36</sup> A 5G Wireless Future: Will it give us a smart nation or contribute to an unhealthy one? Dr. Cindy Russell, Vice President Community Health, SCCMA. The Bulletin, Volume 23 / Number 1; Official magazine of the Santa Clara County Medical Association, and the Monterey County Medical Society; January/February 2017 edition. <https://www.sccma-mcms.org>



## Enterprise Architecture Fifth Generation (5G) Wireless

- Fatigue
- Dizziness
- Sleepiness in daytime
- Moodiness
- Irritability
- Unsociability
- Hypochondriac reactions
- Feelings of fear
- Nervous tension
- Mental depression
- Memory impairment
- Pulling sensation in the scalp and brow
- Loss of hair
- Pain in muscles and heart region
- Breathing difficulties
- Increased perspiration of extremities
- Disturbed sleep at night <sup>(63)</sup>



EMF Side Effects – EMF Safety Network

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## Enterprise Architecture Fifth Generation (5G) Wireless

- In 1971 Russian scientists Gordon and Sadchikova from the Institute of Labor Hygiene and Occupational Diseases described a comprehensive series of symptoms which they called “microwave sickness” and presented this at an international WHO meeting. <sup>(109)</sup>
  - Gaps in Data for Launching 5G Millimeter Devices
    - Commercial production often precedes research on consumer protection and health effects such as lead, asbestos, smoking, and our modern unregulated nanoparticles to mention just a few.
    - Research shows wireless microwave radiation adds yet another dose of toxic exposure to our daily lives.
  - 5G Research and Policy
    - Safety testing for 5G is the same as other wireless devices and only based on heat.
    - This is an obsolete standard and not considering current science showing cellular and organism harm from non-thermal effects.
    - Large gap in safety data for 5G biological effects that has been demonstrated in older studies including the military.



- New Recommendations to Protect Public Health
    - Do not proceed to roll out 5G technologies pending pre-market studies on health effects.



## Enterprise Architecture Fifth Generation (5G) Wireless

- Reevaluate safety standards based on long term as well as short-term studies on biological effects.
- Rescind a portion of Section 704 of the Telecommunications Act of 1996 which preempts state and local government regulation for the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects, so that health and environmental issues can be addressed.
- Rescind portions of The Spectrum Act, which was passed in 2012 as part of the Middle Class Tax Relief and Job Creation Act, which strips the ability of city officials and local governments to regulate cellular communications equipment, and provides no public notification or opportunity for public input.



### **Spectrum Policy: Provisions in the 2012 Spectrum Act**

- Create an independent multidisciplinary scientific agency tasked with developing appropriate safety regulations, premarket testing, and research needs in a transparent environment with public input.
- Label pertinent EMF information on devices along with proper precautionary warnings.
  - A full list of references used in this article are available at: [www.sccma-mcms.org](http://www.sccma-mcms.org)



# Enterprise Architecture Fifth Generation (5G) Wireless



## 5G, Your Health And The Environment

### WHAT IS 5G?

5G is the fifth generation of wireless technology promising to connect the Internet of Things (IoT) at blazing fast speeds. Millions of new cell antennas are being installed in front of homes on street lights and utility poles. Telecom has heavily lobbied governments to pass new regulations that fast track new wireless antenna installations by removing public notice and public hearings and usurp local control.

#### Issues With 5G

- Experimental technology
- Increases radiation exposure
- Outdated radiation guidelines
- Children are more vulnerable
- Inadequate regulations
- Impact to tree canopy
- No oversight by health authority
- No environmental review
- Increases energy usage
- Increases e-waste and pollution
- Lowers property values
- Local authority overruled
- Loss of privacy
- Interferes with weather forecasting
- Screen addiction
- Uninsured liability
- Cyber security risks

#### Peer Reviewed Research On Wireless Radiation

- Sperm damage
- Oxidative stress
- Altered brain development
- DNA damage
- Immune system damage
- Memory problems
- Sleep problems
- Hyperactivity
- Behavior problems
- Breach of blood-brain barrier
- Brain tumors
- Cancer
- Harm to birds, bees, and trees

#### Harvard Investigation Finds Industry Funding Influences Science and Policy

"Industry control, in the case of wireless health issues, extends beyond Congress and regulators to basic scientific research."  
— Norm Alster, in *Captured Agency*, Harvard University

#### Medical Doctors Caution

"An Egyptian study confirmed concerns that living nearby mobile phone base stations increased the risk for developing headaches, memory problems, dizziness, depression and sleep problems. In large studies, an association has been observed between symptoms and exposure to these fields in the everyday environment."  
— *The American Academy of Pediatrics*

#### Scientists Worldwide Are Calling For A Halt To 5G

"We recommend a moratorium on the roll-out of the fifth generation, 5G, for telecommunication until potential hazards for human health and the environment have been fully investigated by scientists independent from industry...RF-EMF has been proven to be harmful for humans and the environment."  
— *The 5G Appeal (signed by over 250 independent scientists and medical doctors from 40 countries)*

#### Worldwide Opposition

Governments are taking action to stop 5G. Dozens of cities in Italy, the U.K., the U.S. and Switzerland are passing resolutions/restrictions to halt the 5G roll-out until adequate safety testing has been done. Several countries recommend reducing children's exposures to cellular phone radiation.



5G was not premarket safety tested. LEARN MORE AT [EHTRUST.ORG](http://EHTRUST.ORG)



## BOLI Civil Rights Division Complaint Conciliation Agreement <sup>37</sup>

- RF exposure guidelines currently used by the FCC were adopted in 1996, are thermally based, and are believed to protect against injury that may be caused by acute exposures that result in tissue heating or electric shock.



- FCC guidelines have a much lower certainty of safety than standards.
- Meeting current FCC guidelines only assures that one should not have heat damage from SmartMeter exposure.
- Says nothing about safety from many chronic disease risks the public is most concerned about such as cancer, miscarriage, birth defects, semen quality, autoimmune diseases, etc.
- Therefore, when it comes to non-thermal effects of RF, FCC guidelines are irrelevant, and cannot be used for any claims of SmartMeter safety unless heat damage is involved (Li, 2011).

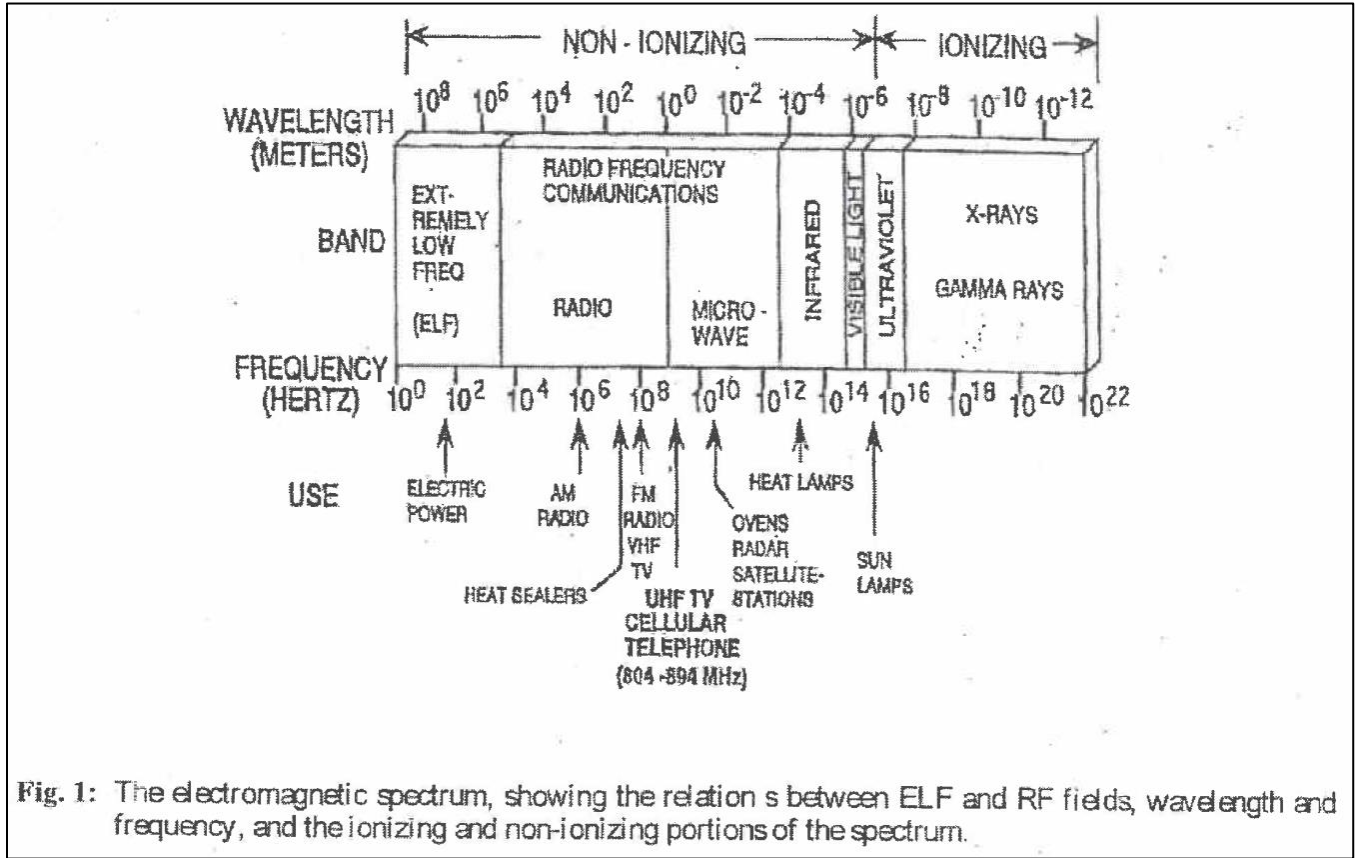
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<sup>37</sup> Bureau of Labor and Industries of the State of Oregon and FHEO Complaint. EMF/RF Smog – BOLI Case #HUHODP131125-11510, California Public Utilities Commission, January 24, 2012.





# Enterprise Architecture Fifth Generation (5G) Wireless



- There are no current, relevant public safety standards for pulsed RF involving chronic exposure of the public, nor of sensitive populations, nor of people with metal and medical implants that can be affected both by localized heating and by electromagnetic interference (EMI) for medical wireless implanted devices.
- Many other countries (9) have significantly lower RF/MW exposure standards ranging from 0.001 to 50  $\sim$ W/cm<sup>2</sup> as compared with the US guideline of 200-1 000  $\sim$ W/cm<sup>2</sup>.
  - Note that these recommended levels are considerably lower than the approximately 600  $\sim$ W/cm<sup>2</sup> (time-averaged), allowed for the RFR from SmartMeters operating in the low 900 MHz band mandated by the FCC based on only thermal consideration.
- In summary, there is no scientific data to determine if there is a safe RF exposure level regarding its non-thermal effects.
- The question for governmental agencies is that given the uncertainty of safety, the evidence of existing and potential harm, should we err on the side of safety and take the primary avoidance measures?



- Governmental agencies for protecting public health and safety should be much more vigilant towards involuntary environmental exposures because governmental agencies are the only defense against such involuntary exposure.

## DID YOU KNOW...



### **YOU LOVE YOUR CELL PHONE, BUT YOUR CELL PHONE DOES NOT LOVE YOU.**

Long term use is linked to increased brain cancer in human studies. Animals exposed to low levels of cell phone radiation have developed increased cancers in the largest ever cell phone radiation rat study done at NIH.

**EHTrust.org**

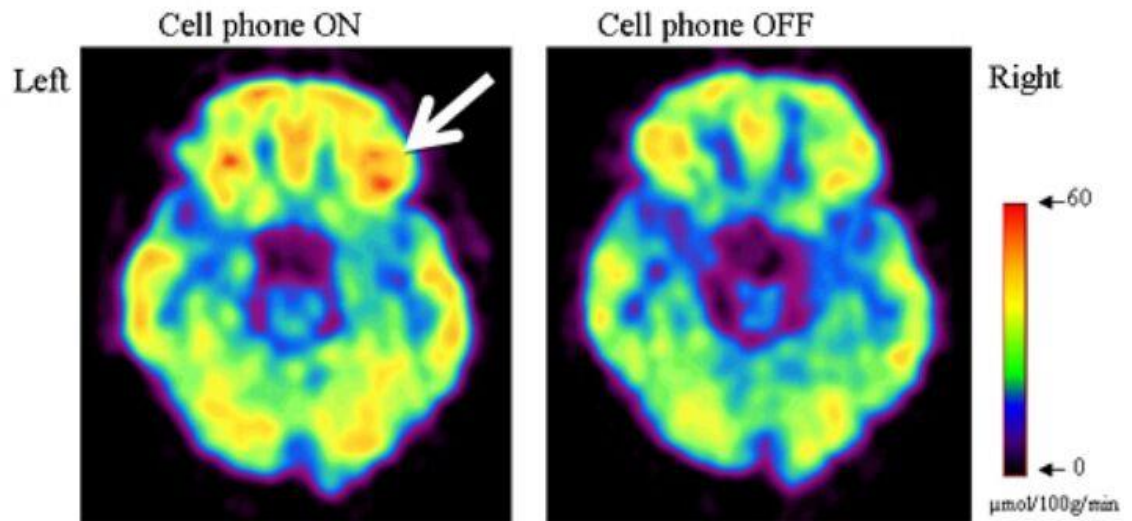
#PracticeSafeTech



- An intriguing divide, noted by Genuis, 2011 is that most research carried out by independent non-government or non-industry affiliated researchers suggests potentially serious effects from many non-ionizing radiation exposures; research funded by industry and some governments seems to cast doubt on the potential for harm.
  - Elements of the controversy stem from inability to replicate findings consistently in laboratory animal studies.
  - However, analysis of many of the conflicting studies is not valid as the methodology used is not comparable.
  - Despite this controversy, evidence is accumulating on the results of exposure to RF at non-thermal levels including increased permeability of the blood-brain barrier in the head (Eberhardt, 2008), harmful effects on sperm,

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double strand breaks in DNA which could lead to cancer genesis (Phillips, 2011), stress gene activation indicating an exposure to a toxin (Blank, 2011), and alterations in brain glucose metabolism (Volkow, 2011).



- In terms of meta-analyzed epidemiological studies, all case-control epidemiological studies covering 10 years of cell phone use have reported an increased risk of brain tumors from the use of mobile phones (Hallberg, 2011).
- Examples of actions the public might take to limit exposure to electromagnetic radiation can be found in Attachment B2.

## The Science of Why 5G Is (Almost) Certainly Safe for Humans <sup>38</sup>

- When light interacts with matter, there are three possibilities for what
- can occur:
  - The light is of the wrong wavelength to be absorbed by the matter, and therefore is reflected.
  - The light is of the right wavelength to be absorbed by matter but too low in energy to kick any electrons off of their parent atoms/molecules.

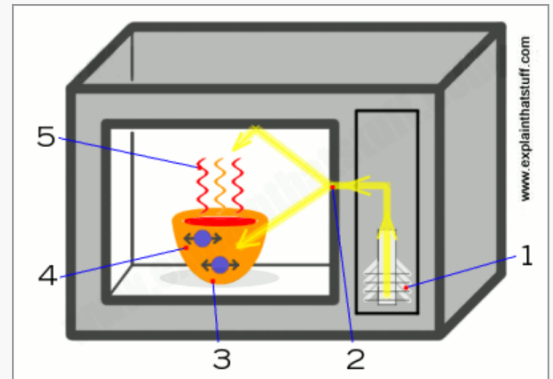
<sup>38</sup> The Science of Why 5G Is (Almost) Certainly Safe for Humans. Forbes, November 1, 2019. <https://www.forbes.com/sites/startswithabang/2019/11/01/the-science-of-why-5g-is-almost-certainly-safe-for-humans/#330de62d70e3>

- Light gets absorbed and each photon is energetic enough to ionize one (or more) electrons.
  - Food is cooked in a microwave because liquid water molecules (along with some others) are excellent absorbers of microwave radiation, enabling it to heat up.
  - Instead of ionizing individual electrons, this radiation can get absorbed and converted into thermal (heat) energy, and too much heat — just as it can cook plants, animals or fungi — can permanently damage living tissue.

## How do microwaves cook food?

How does a microwave turn electricity into heat? Like this!

1. Inside the strong metal box, there is a microwave generator called a **magnetron**. When you start cooking, the magnetron takes **electricity** from the power outlet and converts it into high-powered, 12cm (4.7 inch) radio waves.
2. The magnetron blasts these waves into the food compartment through a channel called a wave guide.
3. The food sits on a turntable, spinning slowly round so the microwaves cook it evenly.
4. The microwaves bounce back and forth off the reflective metal walls of the food compartment, just like light bounces off a **mirror**. When the microwaves reach the food itself, they don't simply bounce off. Just as radio waves can pass straight through the walls of your house, so microwaves penetrate inside the food. As they travel through it, they make the molecules inside it vibrate more quickly.
5. Vibrating molecules have heat so, the faster the molecules vibrate, the hotter the food becomes. Thus the microwaves pass their energy onto the molecules in the food, rapidly heating it up.



- The best measure one can take is to simply have a small exclusion zone around the radio masts (or towers) that emit the most powerful signals for this type of radiation.
  - So long as that exclusion zone is about 10 meters in all directions, any humans outside of the zone will undoubtedly be safe.
  - A receiver/transmitter perched very high above the ground or a tall building will automatically be safe for any humans directly beneath it, so long as they are more than 10 meters below the active device.



## The BioInitiative Report 2012-2017 <sup>39</sup>

- Bioeffects are clearly established, and occur at very low levels of exposure to electromagnetic fields (EMFs) and radiofrequency radiation (RF).
  - Many of these bioeffects can reasonably be expected to result in adverse health effects, if the exposures are prolonged or chronic, because they:
    - interfere with normal body processes (disrupt homeostasis)
    - prevent the body from healing damaged DNA
    - produce immune system imbalances, metabolic disruption and lower resistance to disease across multiple pathways
  - Bioeffects can also occur in just minutes of exposure to mobile phone masts [cell towers], Wi-Fi, and wireless utility 'smart' meters that produce whole-body exposure.
  - Chronic base-station level exposure can result in illness.
  
- A Masaryk University of Czech Republic and National Academy of Sciences of Ukraine oncologists medical team conducted a study in 2011:
  - Population living in the area near (up to 350 meters) a cell phone base transmitting station (850 MHz 1500 Watts of full power) during one year of operation in Israel.
  - Matched individuals from other areas in Israel and compared.
  - 4.15 times more cases of cancer in the transmitter station area than in the rest of the city.
    - Relative cancer rates for females were 10.5 times higher in close to the station area
      - 0.6 for control area
      - 1.0 for the whole town
    - A very significant increase in cancer took place during only a one year period.



<sup>39</sup> BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors. BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Radiation at [www.bioinitiative.org](http://www.bioinitiative.org), December 31, 2012.



- Authors of this study suggested that microwaves could provoke latent cases of cancer in inhabitants of the area nearby the transmitting station.
- The Bio-Initiative Report is based on over 1,800 published medical and scientific studies, and organized by 29 experts from 10 nations.

### We Have No Reason to Believe 5G is Safe <sup>40</sup>

- 5G will not replace 4G.
- 5G employs new technologies, which pose unique challenges for measuring exposures:
  - active antennas capable of beam-forming
  - phased arrays
  - massive multiple inputs and outputs, known as massive MIMO, which pose unique challenges for measuring exposures.
- Telecommunications industry and their experts have accused many scientists of "fear mongering" over 5G.
- Because much of our (University of California, Berkeley) research is publicly funded, we have an ethical responsibility to inform the public about wireless radiation health risks.

Joel M. Moskowitz, PhD, is director of the Center for Family and Community Health in the School of Public Health at the University of California, Berkeley.

- The World Health Organization's International Agency for Research on Cancer (IARC) classified radio frequency radiation (RFR) as "possibly carcinogenic to humans" in 2011.
- A \$30 million study conducted by the U.S. National Toxicology Program (NTP) found "clear evidence" that two years of exposure to cell phone RFR increased cancer in male rats and damaged DNA in rats and mice of both sexes.
- The Ramazzini Institute in Italy replicated the key finding of the NTP using a different carrier frequency and much weaker exposure to cell phone radiation over the life of the rats.

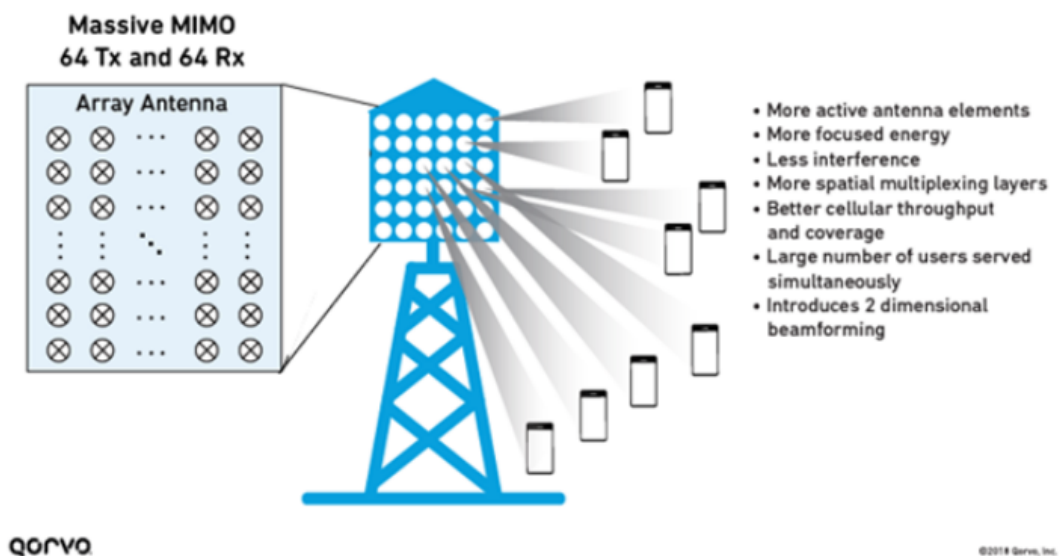


<sup>40</sup> We Have No Reason to Believe 5G is Safe. Scientific American, October 17, 2019. <https://blogs.scientificamerican.com/observations/we-have-no-reason-to-believe-5g-is-safe/>

## Massive MIMO Defined

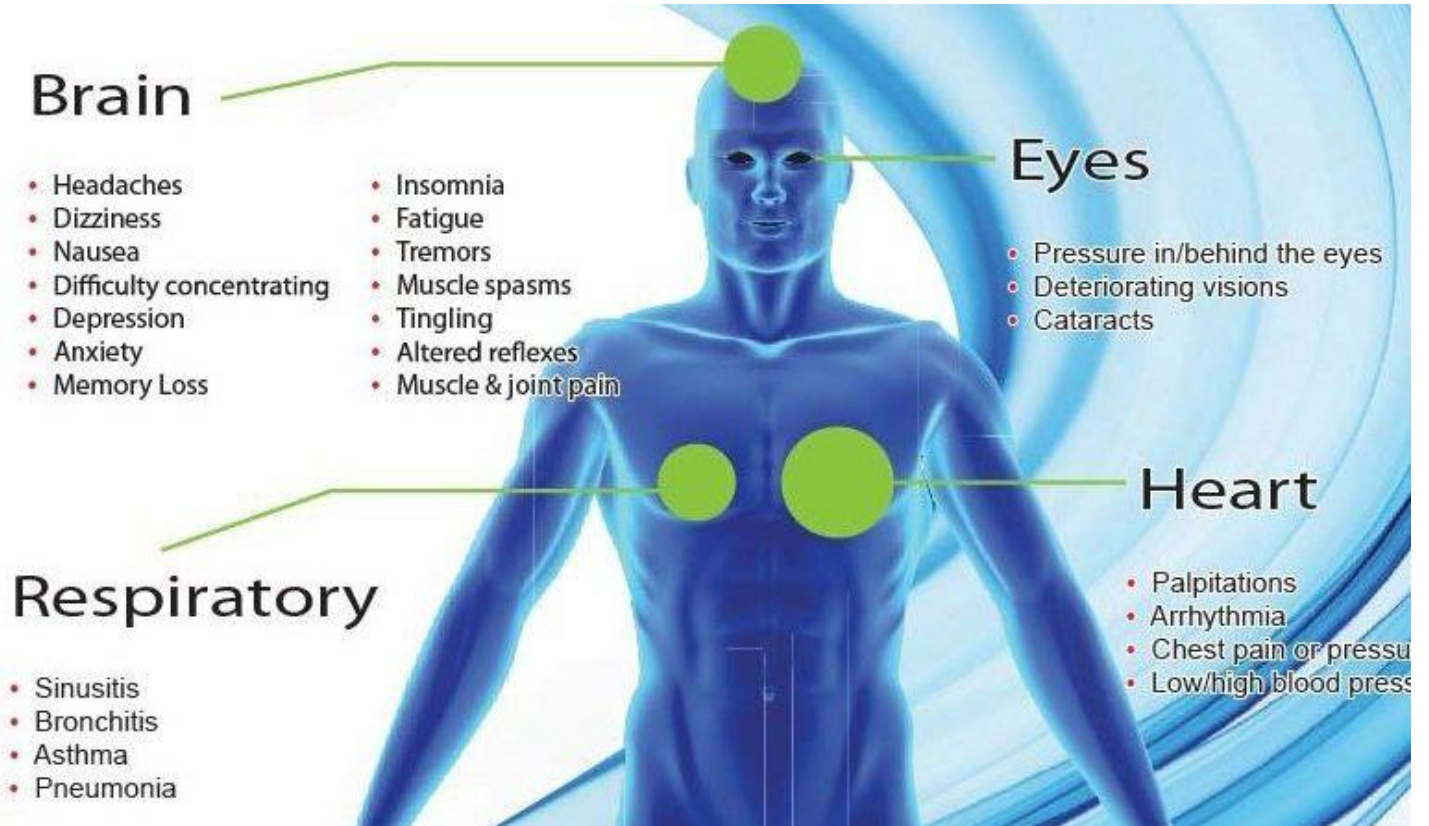
Massive MIMO uses many base station antennas to communicate with multiple users, making use of beamforming techniques in phased adaptive array technology. Massive MIMO improves capacity without the increase in design complexity of intercell coordination. Using massive MIMO, it's possible to form beams such that there is almost always only a single user in each beam. Thus, giving each user their interference-free, high-capacity link to the base station.

Massive MIMO technology uses large antenna arrays (typically comprising 16, 32, or 64 array elements) to exploit spatial multiplexing (see below image). Spatial multiplexing delivers multiple parallel streams of data within the same resource block. By expanding the total number of virtual channels, it increases capacity and data rates without additional towers and spectrum.



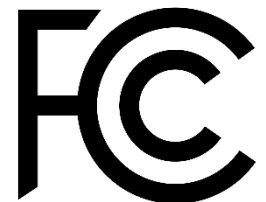
*Massive MIMO benefits.*

- 5G, will employ millimeter waves for the first time, in addition to microwaves that have been in use for older cellular technologies, 2G through 4G.
  - Millimeter waves are mostly absorbed within a few millimeters of human skin and in the surface layers of the cornea.
  - Short-term exposure can have adverse physiological effects in the peripheral nervous system, the immune system and the cardiovascular system.
  - The research suggests that long-term exposure may pose health risks to the skin (e.g., melanoma), the eyes (e.g., ocular melanoma) and the testes (e.g., sterility).



Radio Wave Sickness Body of Symptoms – 5gsacramentodangers.com – December 16, 2019

- Given limited reach, 5G will require cell antennas every 100 to 200 meters, exposing many people to millimeter wave radiation.
- If there are synergistic effects from simultaneous exposures to multiple types of RFR, our overall risk of harm from RFR may increase substantially.
- Cancer is not the only risk as there is considerable evidence that RFR causes neurological disorders and reproductive harm, likely due to oxidative stress.
- Seeing increases in certain types of head and neck tumors in tumor registries.
  - These increases are consistent with results from case-control studies of tumor risk in heavy cell phone users.
- Federal Communications Commission (FCC) recently announced they will soon reaffirm the radio frequency radiation (RFR) exposure limits they adopted in the late 1990s.
  - Limits based upon a behavioral change in rats exposed to microwave radiation.
    - New exposure limits needed accounting for these differential effects.
    - Limits should be based on a biological effect, not a change in a laboratory rat's behavior.
  - Limits based largely on research from the 1980s.







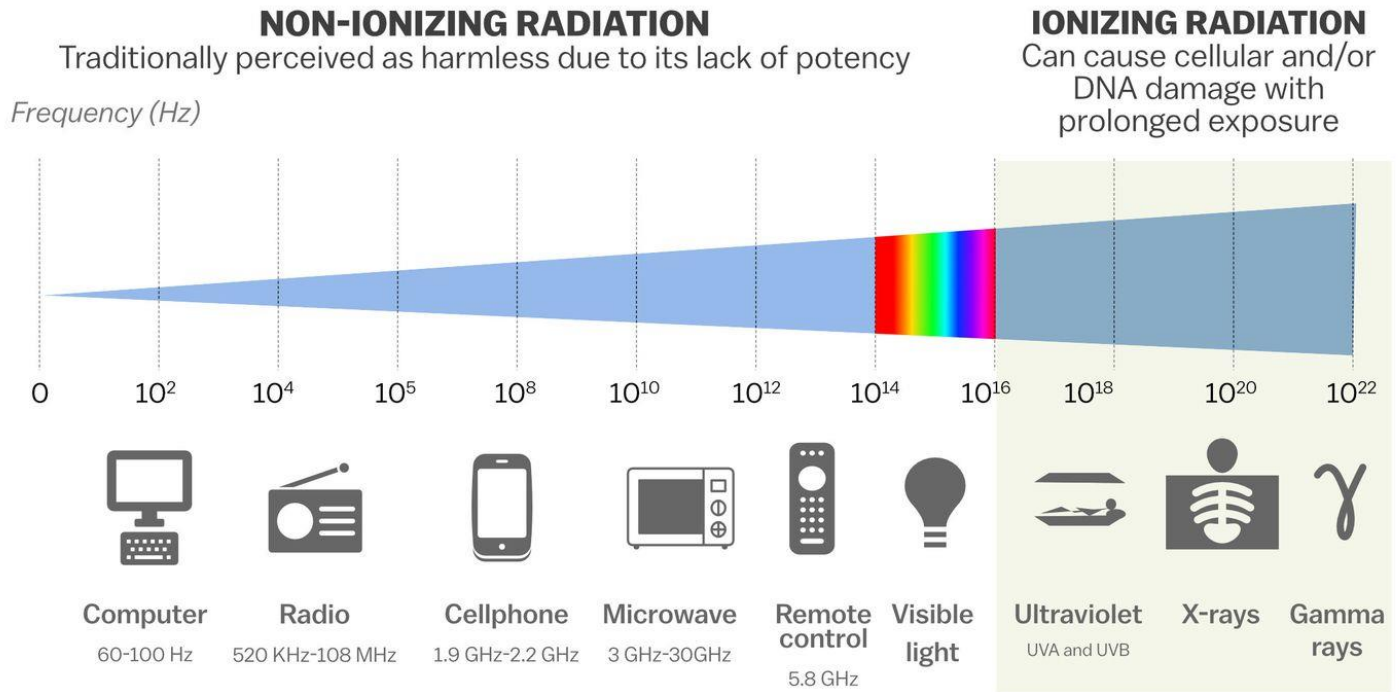
## Enterprise Architecture Fifth Generation (5G) Wireless

- Designed to protect us from short-term heating risks due to RFR exposure.
  - The FCC's RFR exposure limits regulate the intensity of exposure, taking into account the frequency of the carrier waves, but ignore the signaling properties of the RFR.
    - Along with the patterning and duration of exposures, certain characteristics of the signal (e.g., pulsing, polarization) increase the biologic and health impacts of the exposure.
  - Preponderance of more than 500 studies peer-reviewed research have found harmful biologic or health effects from exposure to RFR at intensities too low to cause significant heating.
- More than 240 scientists who have published peer-reviewed research on the biologic and health effects of nonionizing electromagnetic fields (EMF) signed the International EMF Scientist Appeal.
  - Constitute the majority of experts on the nonionizing radiation effects.
  - Have published more than 2,000 papers and letters on EMF in professional journals.
  - The appeal calls for stronger exposure limits.
    - Appeal assertions:
      - Numerous recent scientific publications have shown that EMF affects living organisms at levels well below most international and national guidelines.
      - Effects include:
        - increased cancer risk
        - cellular stress
        - increase in harmful free radicals
        - genetic damage
        - structural and functional changes of the reproductive system
        - learning and memory deficits
        - neurological disorders
        - negative impacts on general well-being in humans
      - Damage goes well beyond the human race, as there is growing evidence of harmful effects to both plant and animal life."





## Our exposure to radiation on the electromagnetic spectrum



SOURCE: National Institute of Environmental Health Sciences

**Vex**

### 5G Telecommunications Uses Gigahertz (GHz) Millimeter Sized Wavelengths <sup>41</sup>

- This 5G system uses high frequency electromagnetic radiation with Gigahertz (GHz) wavelengths in the millimeter range.
  - These high frequency tiny wavelengths penetrate only the outer layer of the skin, unlike 2G, 3G and 4G technology, which passes through the body.
  - Major health concerns with exposure to 5G are to skin, eye, and adverse systemic metabolic signaling through skin sensors, as well as heat effects.



<sup>41</sup> 5th Generation (5G) Telecommunications Uses Gigahertz (GHz) Millimeter Sized Wavelengths. Physicians for Safe Technology – 5G Telecommunications Service, October 25, 2019. <https://mdsafetech.org/5g-telecommunications-science/>



## Enterprise Architecture Fifth Generation (5G) Wireless

- Some in Congress have seriously questioned the lack of independent research on 5G safety.
- The first reported injury of 5G in a July 18, 2019 news report comes from Switzerland, where 5G has been launched in 102 locations.
  - The weekly French-language Swiss magazine L'Illustré interviewed people living in Geneva after the 5G rollout with alarming details of illness.
  - In their article they report neighbors met to discuss their many common symptoms and many unanswered questions.
- 5G is not 5Gigahertz (GHz) frequencies used in wireless devices.
- Some devices state they're 5G, but it is meant to be 5GHz frequency of transmission.
- 5G technology while still in development stages (other than pilot projects reported in several cities where it has been turned on), has been said to use much higher frequencies (10-300 GHz).
- According to an article dated May 28, 2019, in Nationwide 5G, it will be:



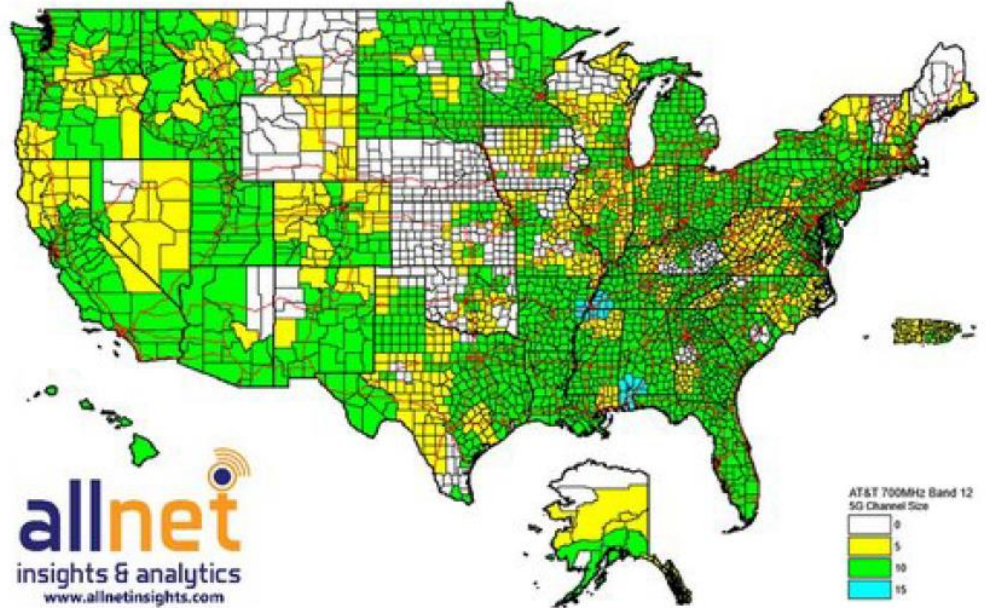
L'illustré March 29, 2012 Cover



# Enterprise Architecture Fifth Generation (5G) Wireless

- AT&T 700MHz.

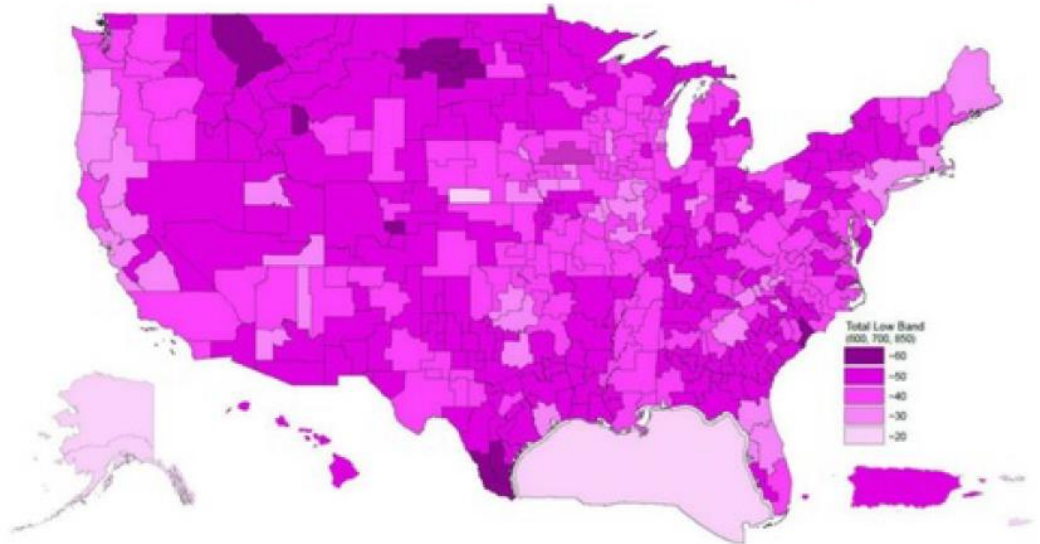
**AT&T - Low Band 5G Channel Size  
700MHz - Band 12**



Source: AllNet Insights & Analytics

- T-Mobile 600MHz to 700MHz.

**T-Mobile's 600MHz and 700MHz holdings**

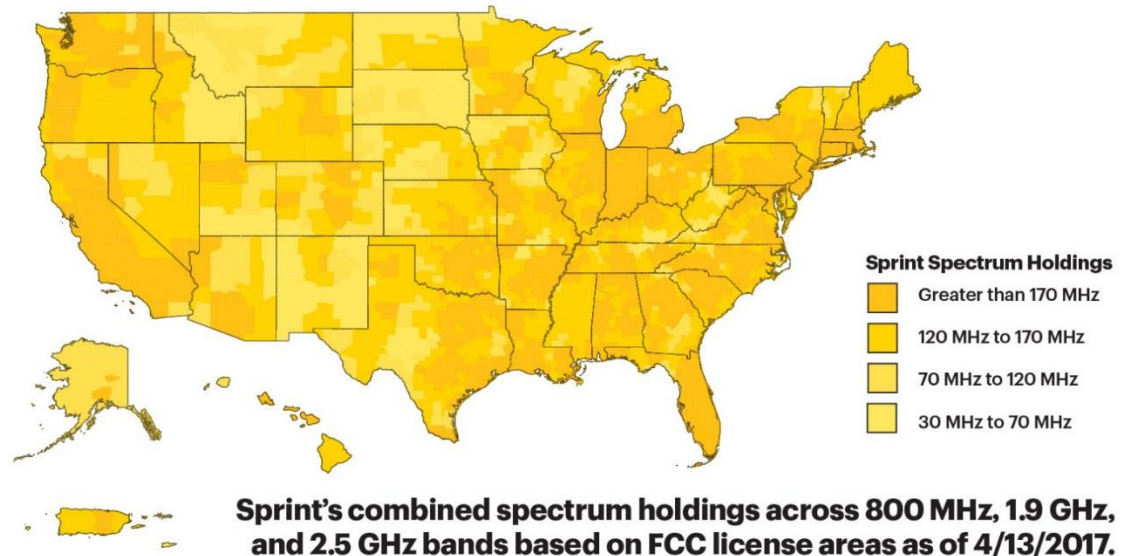


Source: T-Mobile



## Enterprise Architecture Fifth Generation (5G) Wireless

- Sprint says it will use their own 2.5GHz for the 5G rollout, which is called mid-band and will penetrate walls.

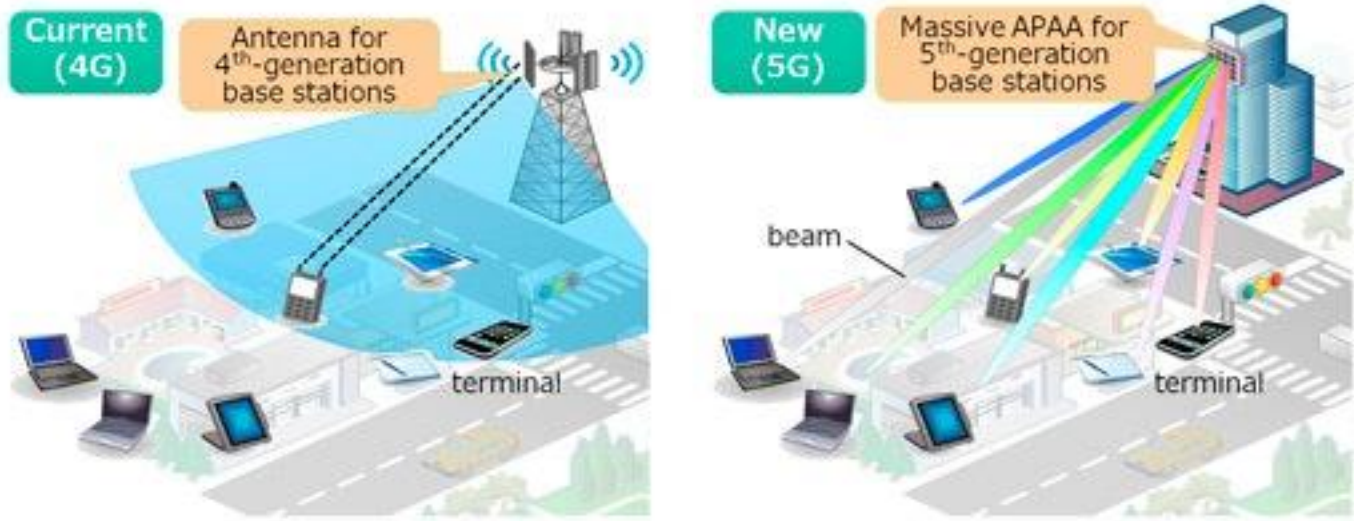


Does not represent actual network coverage, capacity, data throughput or speed.

- Verizon has not said what it will use, but acknowledges it cannot use millimeter technology for broad coverage.
- Scientists would like to see studies of all these wavelengths (and their mixes) before further deployment of 5G or 4G.
- 5G technology is different than prior 2G, 3G or 4G technology in the following ways:
  - Frequencies:
    - 4G uses several different frequencies from 750MHz to about 2,400-5,000 MHz(2.4 GHz to 5 GHz- typical Wi Fi and cell phone)
    - 5G (proposed 5th generation) uses 10GHz to 300GHz, but lower frequencies will also be used and the frequencies and speed will vary with each carrier.



# Enterprise Architecture Fifth Generation (5G) Wireless



4G vs. 5G Coverage Comparison – inverse.com – August 23, 2018

- The actual 5G radio system, known as 5G-NR, is not compatible with 4G.
  - All 5G devices in the US, to start, will need 4G because they will lean on it to make initial connections before trading up to 5G where it is available.
    - Technically known as a “non standalone,” or NSA network.
 

<https://www.pcmag.com/article/345387/what-is-5g>
  - Wavelengths:
    - 4G electromagnetic wavelengths are inches to feet long
    - 5G frequencies are in centimeters to millimeters
    - 5G will also use lower frequencies, creating a mix of frequencies and therefore wavelengths.
  - Depth of Skin and Body Absorption:
    - 4G microwave radiation (2.4GHz and low band 5GHz (600MHz)) passes through bodies and the energy is absorbed by anything that contains water (can't cook dry rice in a microwave oven).
    - 5G penetrates only the outer layers of the skin in humans.
      - Although the mix of frequencies will have a mix of skin and body penetration.
  - Distance Radiation Travels:
    - 4G can travel dozens of miles in a line of sight when poles are placed high.



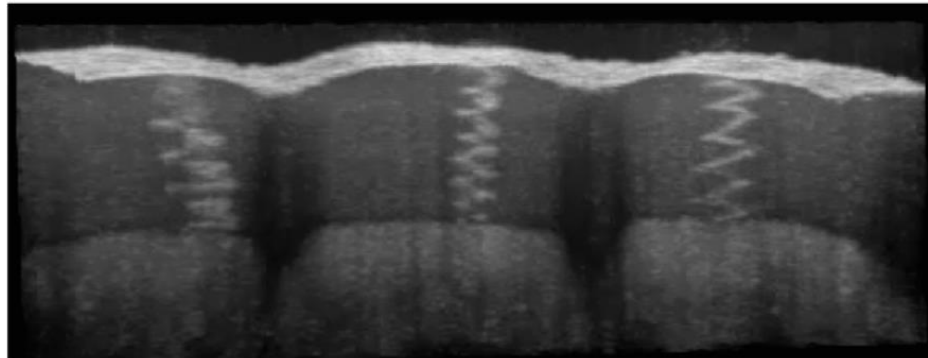
- In experiments, 5G can travel a few miles, but is easily blocked by objects, trees, and plants.
      - 5G poles are planned for every 300 feet in cities.
  - Mechanisms of Harm:
    - 4G and low band 5G (600MHz) emissions can cause oxidation of tissues (93 of 100 studies).
    - 5G millimeter wavelengths can have their effect through heat (tissue destruction):
      - Through a resonance-effect of increased vibration in an object the size of the wavelengths.
      - At low power levels through signaling of skin structures that can affect metabolism, the nervous system, the endocrine system, and the reproductive system (Declassified Military studies).
  - Amount of Testing Done:
    - 4G technology has been tested by the military and by international scientists with an abundance of studies showing broad harm to animals, humans, plants, insects, and bacteria.
    - Some in the US military have studied 5G technology and have shown there is broad harm.
      - Some newer studies are showing damage to insects, and tissue burns and overheating with streaming of data.
      - There has been no independent safety testing of 5G before roll out.

## The human skin as a sub-THz receiver - Does 5G pose a danger to it or not? <sup>42</sup>

- In the interaction of microwave radiation and human beings, the skin is traditionally considered as just an absorbing sponge stratum filled with water. This view is shown to be flawed. Computational approach (regarding the flaw):
  - In the near future, applications will come online that require data transmission in ultra-high rates of 100 Gbit per second and beyond. In fact, the planning for new industry regulations for the exploitation of the sub –

<sup>42</sup> "The human skin as a sub-THz receiver - Does 5G pose a danger to it or not?", Noa Betzalel, Paul Ben Ishai, and Yuri Feldman of Elsevier, Inc. Published February 22, 2018 on PubMed: <https://www.ncbi.nlm.nih.gov/pubmed/29459303> And published in the Elsevier Environmental Research publication, Volume 163, pages 208-216, in May 2018. <https://www.sciencedirect.com/science/article/abs/pii/S0013935118300331?via%3Dihub>

THz band are well advanced under the auspices of IEEE 802.15 THz Interest Group (Kürner and Priebe, 2014), and on July 14, 2016, the US Federal Communications Commission (FCC) adopted new rules for wireless broadband operations above 24 GHz (Kürner and Priebe, 2014).



**Fig. 1.** OCT imaging of the sweat ducts in upper epidermis of the human fingertip in vivo (Lademann et al., 2007).

- In these EHF bands, the dimensions of tissues like skin are on a par with those same wavelengths of the impinging signal. Therefore, the human skin tissues cannot be considered as an infinite layer, compared to the wavelengths of the new communication regulations signal. This reduces the relevance of methods used by the industry today for the assessment of SARs: the use of phantoms (Palka et al., 2013; Reid et al., 2007; Walker et al., 2004) and the alternative electromagnetic simulations software packages.
  - The more sophisticated of these packages are voxel-based models for the Human anatomy (Nagaoka and Watanabe, 2009). Voxel based models were originally developed for the dosimetry of MRI, where the relevant EM wavelengths are in the GHz range. Consequently, for layered structures of less than 1 mm, they are limited (Betzalel et al., 2017).
- The coiled portion of the sweat duct in the upper skin layer is regarded as a helical antenna in the sub-THz band has been demonstrated.
- We also revealed correlation of electrocardiography (ECG) parameters to the sub-THz reflection coefficient of human skin.





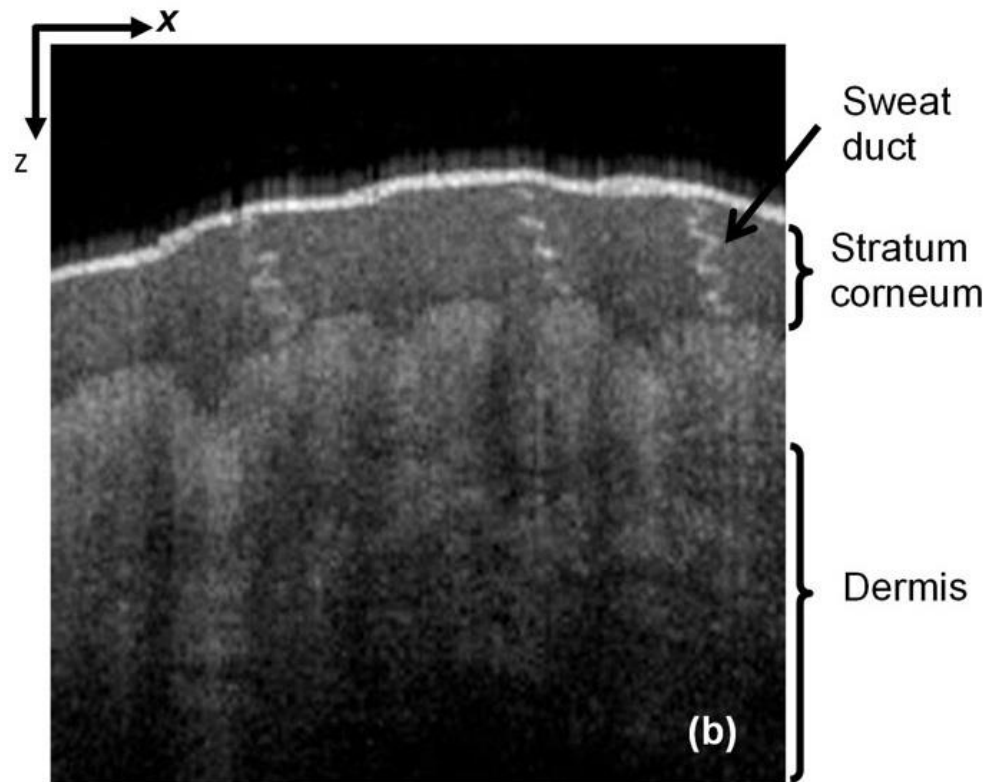
- In a recent work, we developed a unique simulation tool of human skin, taking into account the skin multi-layer structure together with the helical segment of the sweat duct embedded in it.
  - The presence of the sweat duct led to a high specific absorption rate (SAR) of the skin in extremely high frequency band.
    - Sweat ducts constitute an active system, working according to a number of different stimuli (physiological, mental, emotional, or gustatory), not only due to thermoregulation (Guyton, 1990).
- In this paper, we summarize the physical evidence for this phenomenon and consider its implication for the future exploitation of the electromagnetic spectrum by wireless communication.
- We are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored.



### Morphology of Human Sweat Ducts - Frequency of Terahertz Resonance <sup>43</sup>

- Electromagnetic waves with a frequency extending from a few hundreds of gigahertz (GHz) to a few terahertz (THz) are terahertz waves, which lie between the microwave and infrared regions in the electromagnetic spectrum.
  - The THz frequency region remains the least explored.
- The thermal and non-thermal effects of THz waves have been investigated.
  - Exposing human tissue to intense pulses (beamforming) of THz radiation may cause DNA damage and change gene expression.
  - Other studies on THz-induced non-thermal effects suggest genomic instability, mutagenesis, DNA synthesis, spindle disturbances in cells and stem cell reprogramming.
- Recently novel phenomena of skin-THz interaction have been reported.
  - These studies have demonstrated that sweat glands present in the skin play a critical role in THz wave interaction with human beings.

<sup>43</sup> "Morphology of human sweat ducts observed by optical coherence tomography and their frequency of resonance in the terahertz frequency region. Published March 13, 2015 in Scientific Reports, Volume 5, Article No: 9071. <https://www.nature.com/srep> / <https://www.nature.com/articles/srep09071#citeas>



- We explored the morphological features of sweat ducts and their influence on THz-wave-induced effects on the human body.
  - The sweat duct is considered as a pipe filled with water.
- Recent studies investigating the bioeffects of THz have demonstrated that THz waves interact with human skin in various ways.

## Human Skin Sub-THz Radiation Absorbance <sup>44</sup>

- While the skin is a platform for a plethora of functional structures, such as hair follicles and nociceptors, their physical dimensions and geometries do not render them sensitive to sub-THz radiation.
- We take into account the human skin's multiple layers and the helical segment of the sweat duct. It was previously shown that the helically shaped structure of human sweat ducts, together with the dielectric properties of human skin, could be considered as an array of helical antennas, with a working bandwidth of a few hundreds of gigahertz and centered around 380 GHz. These findings have been

<sup>44</sup> The Modeling of the Absorbance of Sub-THz Radiation by Human Skin. IEEE Transactions on Terahertz Science and Technology, Vol-7, No-5, September 2017.

confirmed by the existence of circular dichroism in the reflection coefficient of the human palm, measured at 380 GHz. Furthermore, both simulation and experimental results show that the human skin absorbs radiation in the sub-THz frequencies region as a function of sweat duct activity. These results are extremely important if the explosion in sub-THz communications will occur in the next few years.

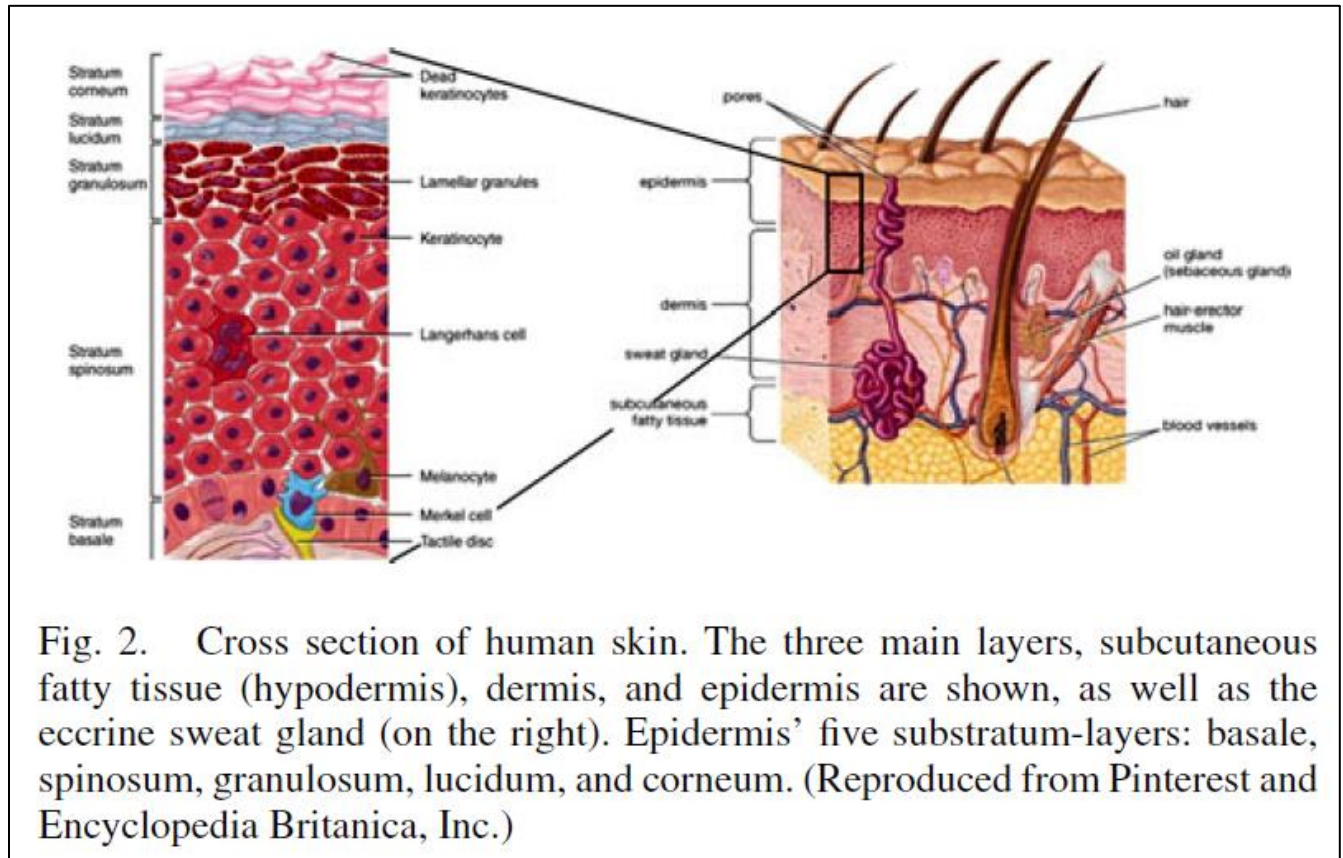


Fig. 2. Cross section of human skin. The three main layers, subcutaneous fatty tissue (hypodermis), dermis, and epidermis are shown, as well as the eccrine sweat gland (on the right). Epidermis' five substratum-layers: basale, spinosum, granulosum, lucidum, and corneum. (Reproduced from Pinterest and Encyclopedia Britannica, Inc.)

- Starting from July 2016 the US Federal Communications Commission (FCC) has adopted new rules for wireless broadband operations above 24 GHz (5G).
  - This trend of exploitation is predicted to expand to higher frequencies in the sub-THz region.
  - One must consider the implications of human immersion in the electromagnetic noise, caused by devices working at the very same frequencies as those, to which the sweat duct (as a helical antenna) is most attuned.



## The BioInitiative Report 2014-2020 Update <sup>45</sup>

- Conclusions from the 1800 or so new studies report:
  - abnormal gene transcription (Section 5)
  - genotoxicity and single-and double-strand DNA damage (Section 6)
  - stress proteins because of the fractal RF-antenna like nature of DNA (Section 7)
  - chromatin condensation and loss of DNA repair capacity in human stem cells (Sections 6 and 15)
  - reduction in free-radical scavengers – particularly melatonin (Sections 5, 9, 13, 14, 15, 16 and 17)
  - neurotoxicity in humans and animals (Section 9)
  - carcinogenicity in humans (Sections 11, 12, 13, 14, 15, 16 and 17)
  - serious impacts on human and animal sperm morphology and function (Section 18)
  - effects on offspring behavior (Section 18, 19 and 20)
  - effects on brain and cranial bone development in the offspring of animals that are exposed to cell phone radiation during pregnancy (Sections 5 and 18)



## Mankind's Worst Ever Genocide Is Now Brewing <sup>46</sup>

- Leo Cashman, BS Physics and MA Mathematics, explained the following in support of Jerry Flynn's technical letter to the Canadian judiciary, May 7, 2015:

<sup>45</sup> Summary of the BioInitiative Report. Based on over 1,800 published medical and scientific studies, and organized by 29 experts from ten nations. © Copyright 2006 – 2020. Daveworks Inc.

<sup>46</sup> Mankind's Worst-Ever Genocide Is Now Brewing. Omega Group. Jerry Flynn's technical letter to the Canadian Judiciary. May 7, 2015.

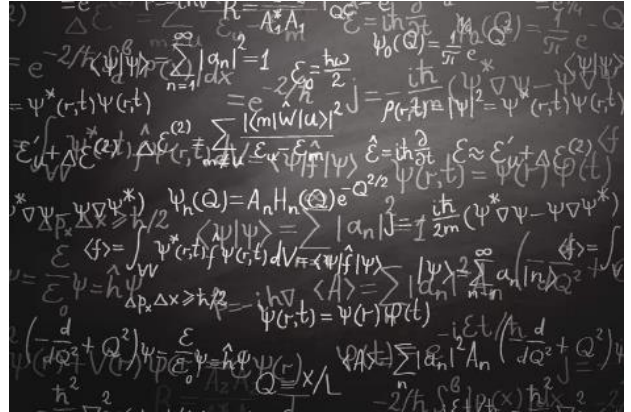


# Enterprise Architecture Fifth Generation (5G) Wireless

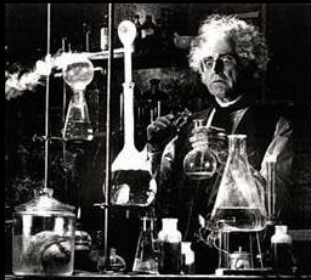
Physicist Leo Cashman explains that manmade radio waves are especially threatening because:

"...The pulsing adds to the frequencies that are actually in the wave, making it hold lots of other frequencies and

increasing the biological impact of the wave, the radiation. And then the modulation, putting the information onto the pulsed carrier wave, whether by amplitude modulation or by frequency modulation, adds more actual frequencies onto the wave and very often those modulating frequencies are very biologically active in their impacts, mostly detrimental, on the human or animal's body....The results are not good. And spewing this kind of pulsed, modulated radiation into our human environment all the time is recklessly dangerous."



## Physicist



What kids think I do



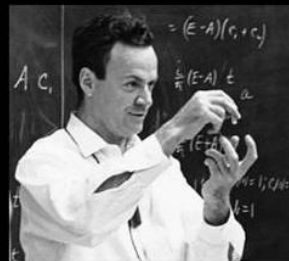
What my wife thinks I do



What society thinks I do



What I thought I would do



What I think I do



What I actually I do



## The Cell Phone and the Cell <sup>47</sup>

- Not just antenna air pollution afflicting national public health; most water towers across the US now support a variety of RF/microwave installations.
- Preliminary research confirms that continually irradiating community water supplies with carcinogenic waves could be an additional contributing factor to the human suffering and disease reported across the nation.
- Radiation expert Dr. Andrew Goldsworthy explains: Weak pulsed radiation is routinely used in "electronic" water conditioners to remove lime scales from plumbing.
  - The treated water has biological effects similar to those from direct exposure to weak electromagnetic radiation, perhaps due to its removing calcium ions from cell membranes just as it removes lime scales from water pipes.
  - The growing tendency to mount mobile phone base station antennas on water towers may seem convenient, but it carries a hidden risk because the radiation may also "condition" the water to make it biologically active, which could have adverse effects on public health.
    - Situation needs urgent attention by water companies since, unlike the mobile phone operators, they have no legal immunity from prosecution for distributing a potentially toxic product.

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<sup>47</sup> The Cell Phone and the Cell: The Role of Calcium, Dr. Andrew Goldsworthy, 2008.



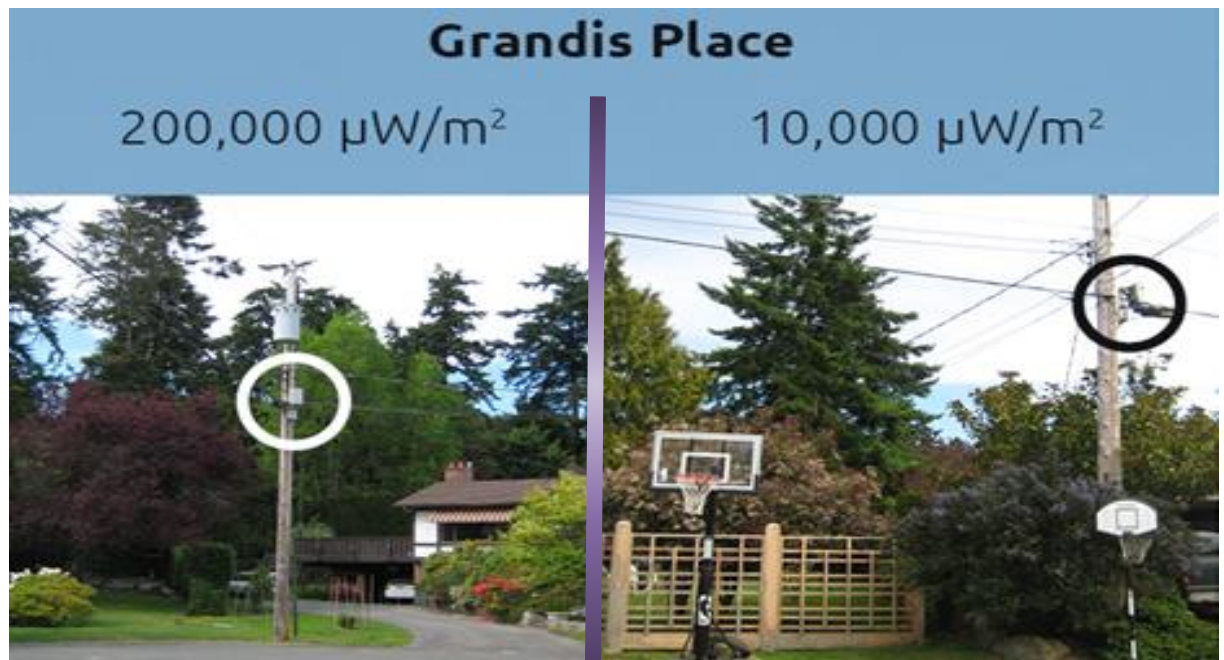
# Enterprise Architecture Fifth Generation (5G) Wireless





## Palo Alto 4G Small Cells <sup>48</sup>

- The utility pole-mounted 4G microcell in the following picture is radiating the residential neighborhood at almost nine volts per square meter of modulated microwave radiation as measured on the ground.
  - Microcell on right is measuring close to two volts per square meter on the ground.
- Physicist Ronald Powell, Ph.D., explains what this means: "The surface area of an adult body is about 2 square meters (m<sup>2</sup>). So the surface area that an adult presents to an RF wave arriving from the front, or from the back, is about 1 square meter. So when an adult human faces an oncoming wave of radiation with a power density of say, 10 milliwatts per square meter (mW/m<sup>2</sup>) that human will receive a total of 10 milliwatts of radiation over the entire body."



- An adult walking a dog within range of the microcell on the left could be radiated with nine volts of microwave carcinogen across and through his entire body.
- A teenager playing ball under the microcell antenna on the right will be radiated with two volts of microwave carcinogen across and through his entire body.

<sup>48</sup> Palo Alto 4G Small Cells: An Extreme Health Hazard, ScientistsforWiredTechnology.com, April 23, 2017.





## Enterprise Architecture Fifth Generation (5G) Wireless

- The power density of these low-hanging DAS antennas is impressive in light of recent research showing that the human immune system can be functionally disabled at microwave levels as low as .00675 volts per meter.  
49
- Paul McGavin, who provides this latest information, testified before the California Assembly on June 28, 2017:
  - "In Palo Alto (California) right now we have measured over one million microwatts per meter squared [this equates to about 21 volts per meter] on the sidewalk from the 4G antennas that were put there in November 2016. That is 60 times higher than [what] the Soviets beamed at our embassy personnel in Moscow from 1953 to 1968, killing three of our ambassadors, two from brain cancer, one from leukemia. In addition we had miscarriages, we had fatigue, we had migraine headaches, we had blood problems, neurological problems; all very common symptoms of microwave radiation sickness..."
  - McGavin explained that new small cell antennas are actually replacements for macro cell towers and therefore, despite their small size, they are emanating radiation equivalent to pollution propagated by large towers with multiple antennas:
    - Planning documents for the installed 4G Palo Alto small cells show that even though the RF/MW radiation calculations were made for 6 watts of input power, the actual input power for each small cell antenna is 300 to 500 watts.
- Documents for a 2017 Verizon small cell deployment in Weston, Massachusetts, state that each antenna outputs 1,257 watts of effective irradiated power (ERP), a significant RF/MW exposure.
- These military grade radiation exposures do not belong in residential zones. 50

<sup>49</sup> Biological Effects from RF Radiation at Low-Intensity Exposure, Based on the BioInitiative Report 2012 and the Implications for Smart Meters and Smart Appliances, by Ronald M. Powell, Ph.D., June 11, 2013.

<sup>50</sup> June 2015, the results of these studies were presented by lead researchers at a neuroimmunity conference in St. Petersburg, Russia. Leading researcher in the project, Professor Trevor Marshall, has disclosed: "My own group's contribution has been in demonstrating that the human immune system is affected at very low levels, being functionally disabled at peak levels as low as .00001uW/cm2 [.00675 V/m]--functionally disabled at levels to which most of the population are exposed these days." Omega Group, omega-today.net, May 14, 2015.



## IAFF Votes to Study Health Effects of Cell Towers on Fire Stations <sup>51</sup>

- The wireless industry has long sought placing cell antennas on or near fire and police stations.
  - Municipalities receive revenues from wireless companies in exchange for locating antennas on fire and police station property.
- The following picture is a fire station in the Midwest with a large cell tower on site.
  - An audio detector literally vibrates with the energy imparted from this installation as the radiation emanates for many meters around it.
  - Beams from the antennas high up on this pole affect a school for deaf children directly across the street.
    - The school's exercise yard, enclosed by metal fencing and full of metal playground equipment [metal = hotspot], incurs extensive antenna radiation.



<sup>51</sup> International Association of Firefighters (IAFF) Votes to Study Health Effects of Cell Towers on Fire Stations, Press Release, Susan Foster Ambrose, Santa Fe, California, August 24, 2004.



- In 2004, the US and Canadian membership of the International Association of Fire Fighters (IAFF) passed a resolution opposing the siting of cell tower antennas on or adjacent to fire stations.
  - Resolution was inspired by a pilot medical study conducted by Dr. Gunnar Heuser of Agoura Hills, California, which raised serious concerns about the safety of fire fighters working and sleeping in stations with towers on the premises.
  - The study focused on neurological symptoms of six firefighters who had been working for up to five years in stations with cell towers. Their symptoms included:
    - slowed reaction time
    - lack of focus
    - lack of impulse control
    - severe headaches
    - anesthesia-like sleep
    - sleep deprivation
    - depression and tremors [64]
- Dr. Heuser, along with Dr. J. Michael Uszler of Santa Monica, used functional brain scans to assess changes in the brains of these six firefighters, as compared to healthy brains of men of the same age.
  - SPECT scans revealed a pattern of abnormal changes concentrated over a wider area than would normally be seen in the brains of individuals exposed to toxic inhalation, as might be expected from fighting fires.
  - Dr. Heuser confirmed the only plausible explanation would be chronic RF radiation exposure.

### Los Angeles Selects Motorola for Communications Project <sup>52</sup>

- The city of Los Angeles, California has been partnering with Motorola and the Department of Homeland Security to complete the rollout of over 200 new cell

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<sup>52</sup> LA-RICS Selects Motorola Solutions to Develop Interoperable Public Safety Radio System For the Los Angeles County Region, Motorola Press Release, August 20, 2013.



## Enterprise Architecture Fifth Generation (5G) Wireless

tower installations required by the new Los Angeles Regional Interoperable Communications System (LA-RICS).

- The LA-RICS project, known by the locals as “Fry and Spy”, was underwritten by hundreds of millions in federal grant money, connects more than 80 public safety agencies with a new 700MHz wireless network covering 4,000 square miles.
- LA-RICS is comprised of two subsets:
  - Land mobile radio system
  - LTE broadband (4G) communications system



- Original LA-RICS plans mandated initial 200+ new antenna installations to be sited at fire and police stations across many cities in the LA area.
- In March 2015, IAFF Local 1014 petitioned the Los Angeles County Board of Supervisors to halt construction of LA-RICS towers on county fire stations until proper health studies could be conducted, and until transparency could be obtained on the interest-conflicted political machinations behind the LA-RICS project. <sup>53</sup>

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<sup>53</sup> County Supervisors Unanimously Halt Construction of Toxic Cell Towers," IAFF Local 1014, March 28, 2015.



## Enterprise Architecture Fifth Generation (5G) Wireless

- Sadly, cancer already accounts for more than half of line-of-duty firefighter deaths nationwide. <sup>54</sup>
- IAFF and supporters miraculously convinced the Board to declare this antenna moratorium on behalf of not only first responders, but also the innumerable families living near fire and police stations.

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<sup>54</sup> Firefighters Decry 'Slow Death' of Flame Retardant Bill," Star Tribune, Duluth, Minnesota, May 4, 2015.

## 5G Pictorial Research



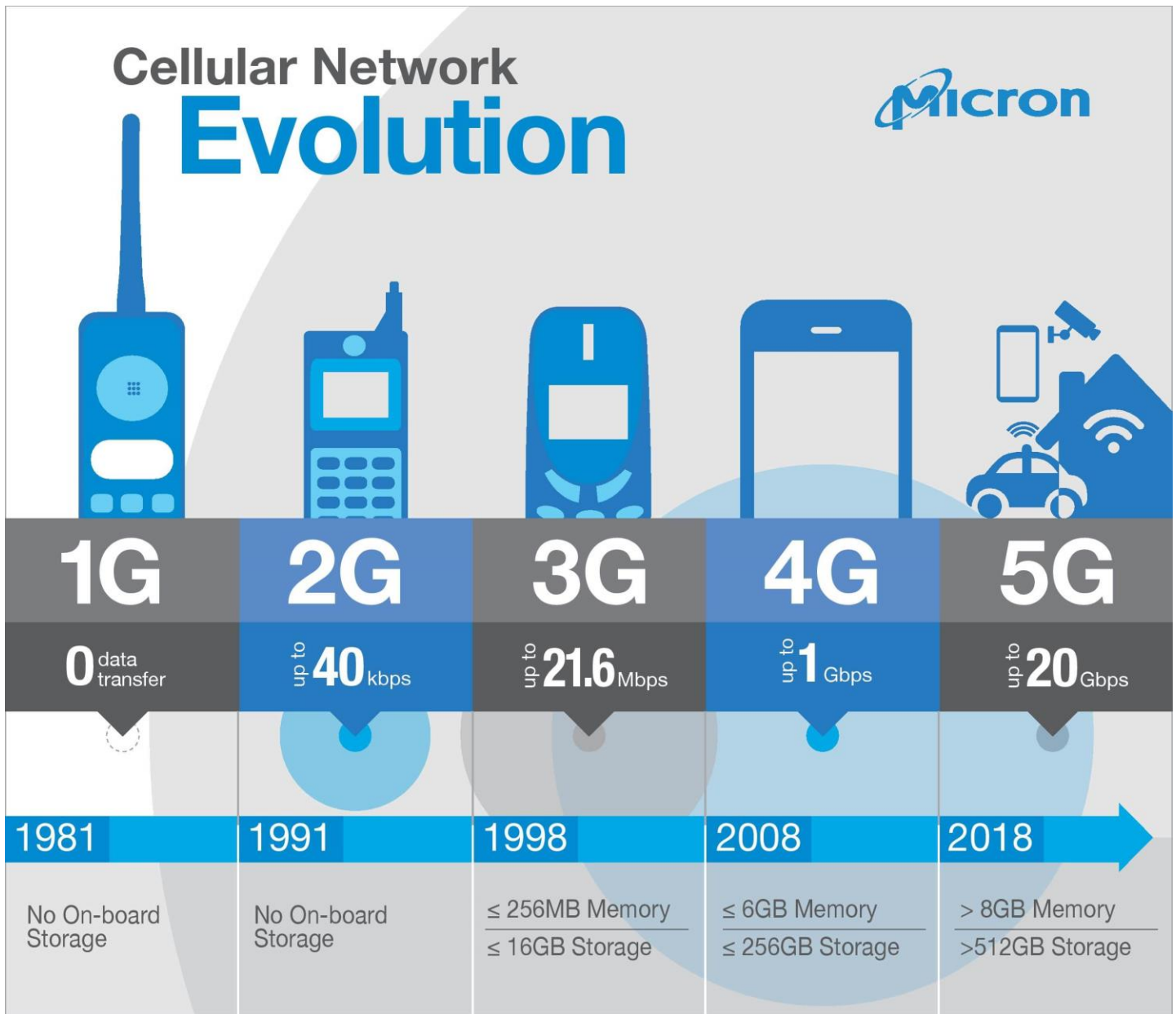
- 5G graphics are provided to assist with understanding the technology.
  - Many graphics were obtained from already identified sources in this document – where not applicable, reference is provided if known.
  - It is understood some graphics may not help one’s understanding at all.
    - Viewer discretion is advised.



# Enterprise Architecture Fifth Generation (5G) Wireless



## 5G Vision and Requirements for Mobile Communications Systems: [hindawi.com/journals/cje](http://hindawi.com/journals/cje)

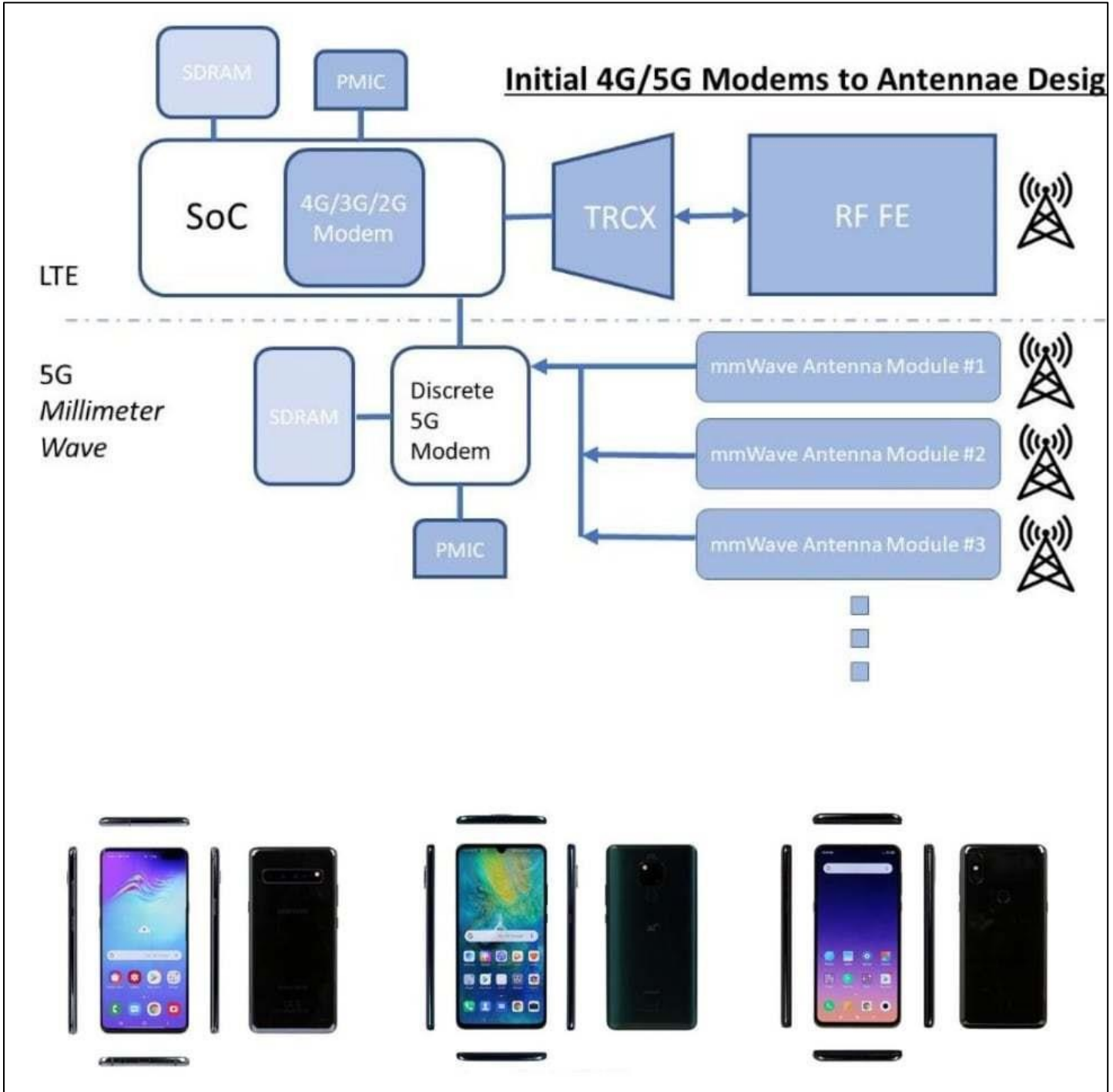


**1G to 5G Cellular Network Evolution** – Micron





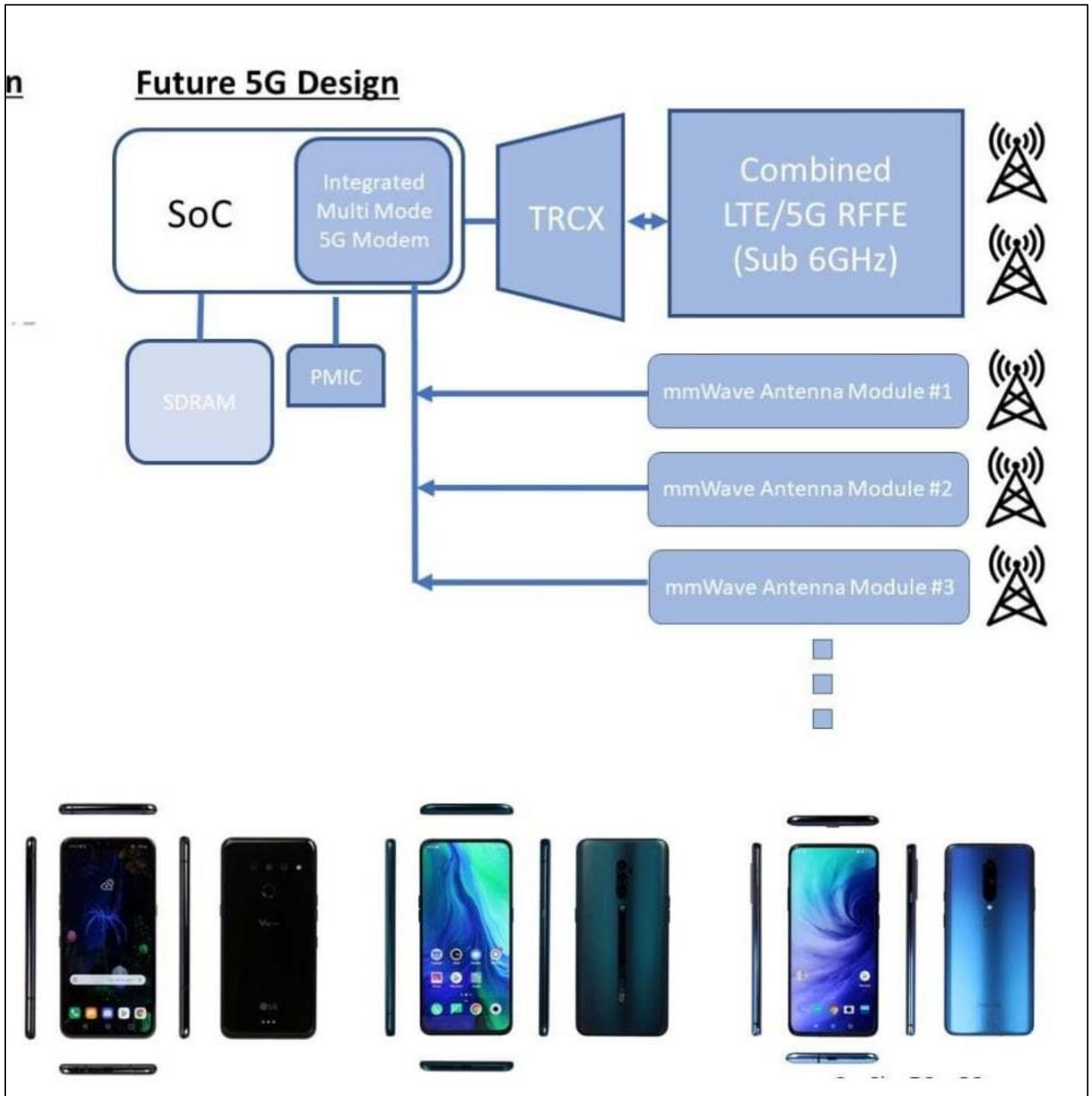
# Enterprise Architecture Fifth Generation (5G) Wireless



## Initial 4G / 5G Modems to Antennae Design



# Enterprise Architecture Fifth Generation (5G) Wireless



## Future 5G Modems to Antennae Design



# Enterprise Architecture Fifth Generation (5G) Wireless

## Read The Fine Print

**All cell phones and wireless devices instruct that they should be held away from your body.**



"Usage precautions during 3G connection : Keep safe distance from pregnant women's stomach or from lower stomach of teenagers. Body worn operation: Important safety information regarding radiofrequency radiation (RF) exposure. To ensure compliance with RF exposure guidelines the Notebook PC must be used with a minimum of 20.8 cm antenna separation from the body."

*Samsung 3G Laptop Manual*



"To be sure that human exposure to RF energy does not exceed the FCC, IC, and European Union guidelines, always follow these instructions and precautions: Orient the device in portrait mode with the Home button at the bottom of the display, or in landscape mode with the cellular antenna away from your body or other objects." *Apple iPad Manual*



"Keep the BlackBerry device at least 0.59 in. (15 mm) from your body (including the abdomen of pregnant women and the lower abdomen of teenagers) when the BlackBerry device is turned on and connected to the wireless network." *Blackberry Bold 9930 Manual*



"To be sure that human exposure does not exceed the FCC guidelines, always follow these instructions... keep iPhone at least 15 mm (5/8 inch) away from the body, and only use carrying cases, belt clips, or holders that do not have metal parts and that maintain at least 15 mm (5/8) inch separation between the iPhone and the body." To view the information on your iPhone go to Settings > General > About > Legal > RF Exposure.

*iPhone 4 Instructions*



"Caution: Exposure to Radiofrequency Radiation: The device shall be used in such a manner that the potential for human contact normal operation is minimized. This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator and your body." *Belkin WiFi Router Manual*



"In order to avoid the possibility of exceeding the FCC radio frequency exposure limits, human proximity to the antenna shall not be less than 20 cm (8 inches) during normal operation." *HP WiFi Printer Manual*



"Caution: To Comply with FCC RF exposure compliance requirements, a separation distance of at least 20 cm must be maintained between the antennae of this device and all persons." *Summer Baby Monitor Manual*

[ehtrust.org](http://ehtrust.org)

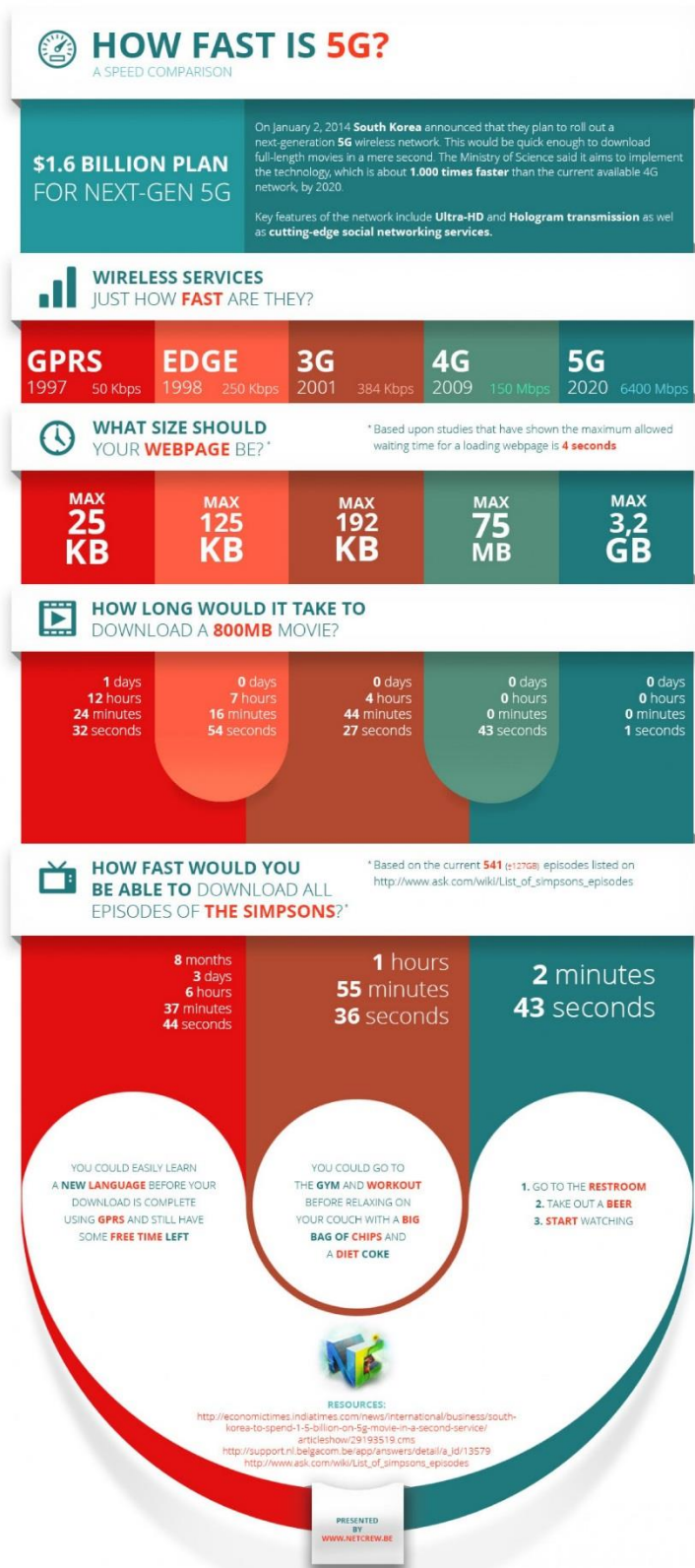
**Wireless Fin Print Fact Sheet – ehtrust.org**

[robert.kowalke@vita.virginia.gov](mailto:robert.kowalke@vita.virginia.gov)

[ea@vita.virginia.gov](mailto:ea@vita.virginia.gov)



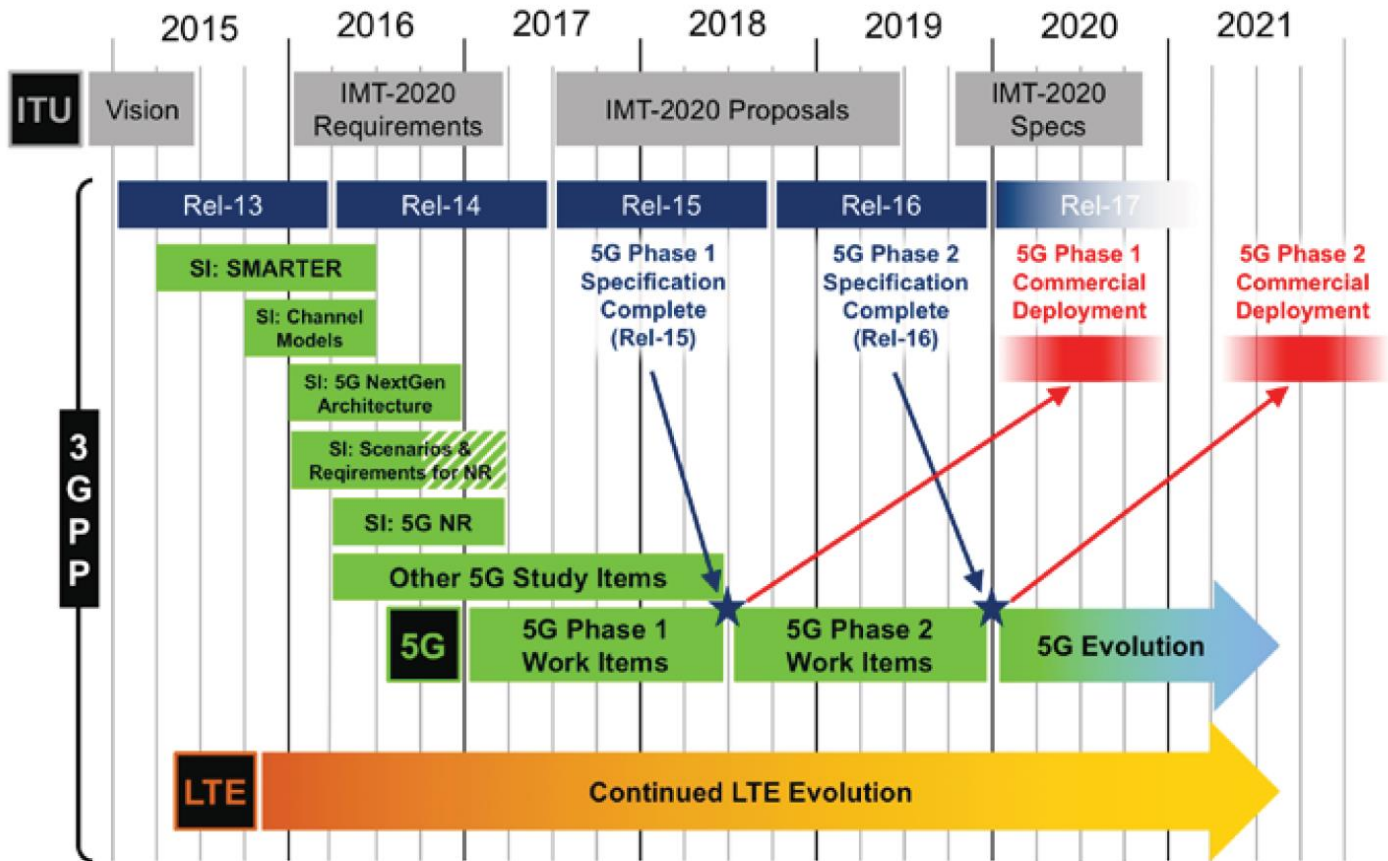
# Enterprise Architecture Fifth Generation (5G) Wireless



How Fast is 5G? – robertchaen.com – April 23, 2019



# Enterprise Architecture Fifth Generation (5G) Wireless

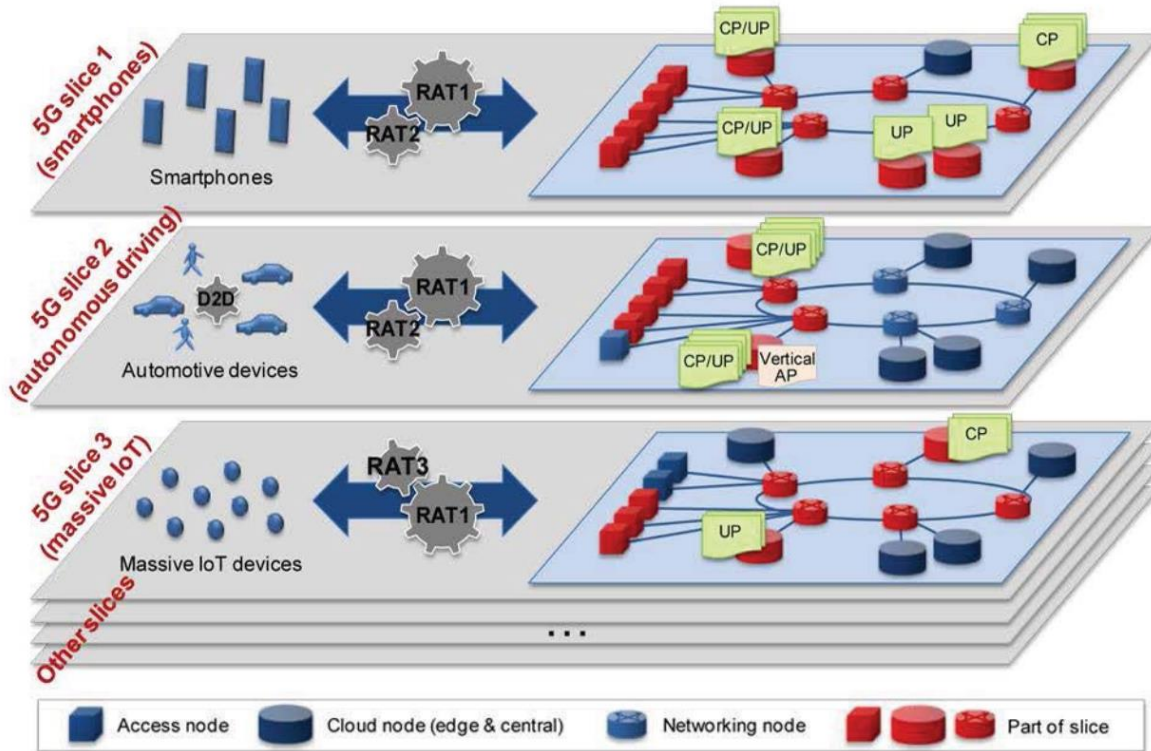


**FIGURE 4.** Emerging 5G standardization timeline for 3GPP. (Figure is a composite from [34] and [35] that includes additional data from various sources.)

## Emerging 5G Standardization Timeline for 3GPP – NSA’s Emerging Technologies Magazine 2017



# Enterprise Architecture Fifth Generation (5G) Wireless

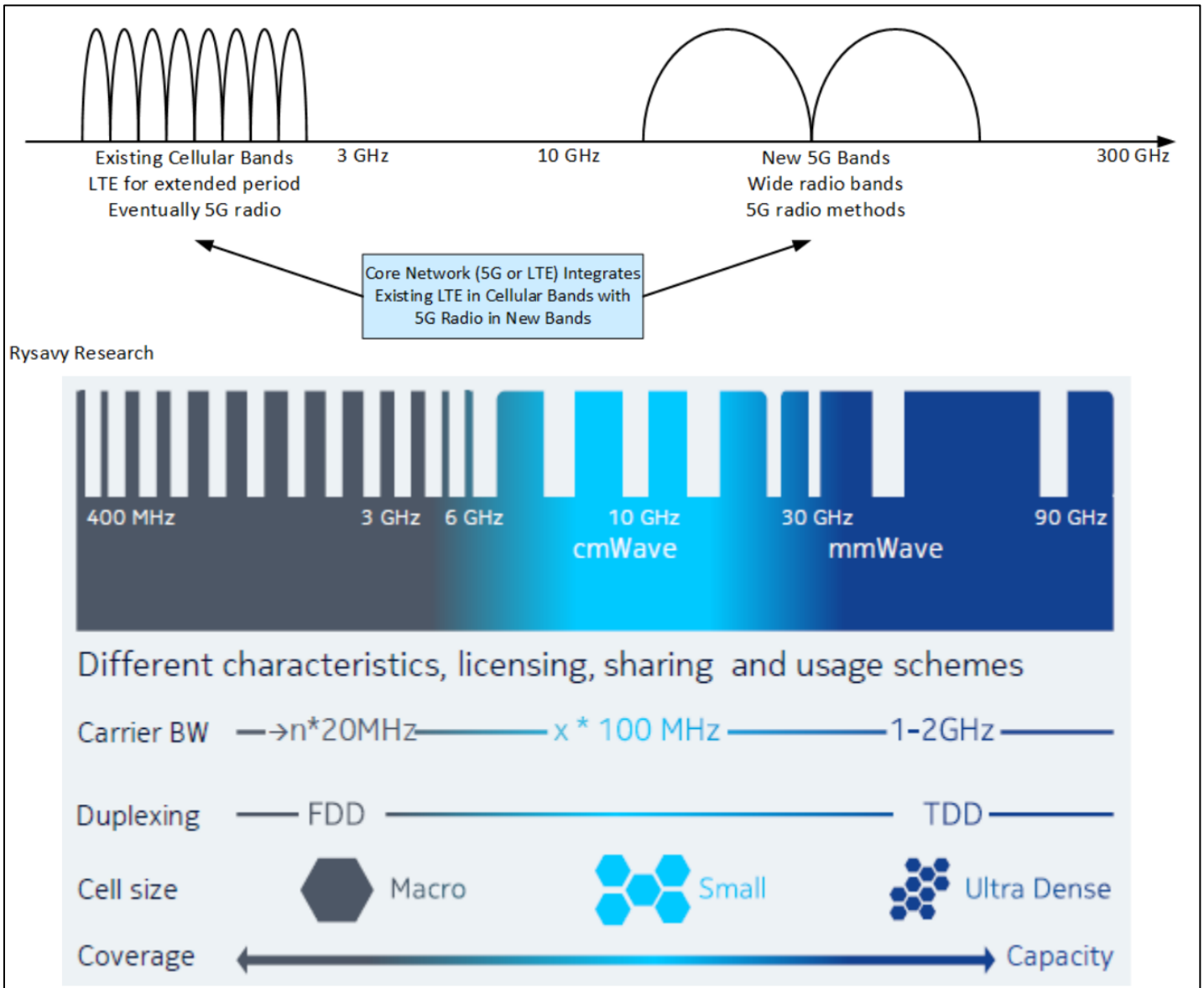


**FIGURE 1.** 5G’s incorporation of SDN and NFV would allow network slices to be created dynamically and deployed as needed to accommodate a variety of scenarios [2].

## 5G Incorporation of SDN and NFV Network Scenario Slices – NSA’s Emerging Technologies Magazine 2017



# Enterprise Architecture Fifth Generation (5G) Wireless



## Combination of Lower and Higher Frequencies for 5G – Rysavy Research



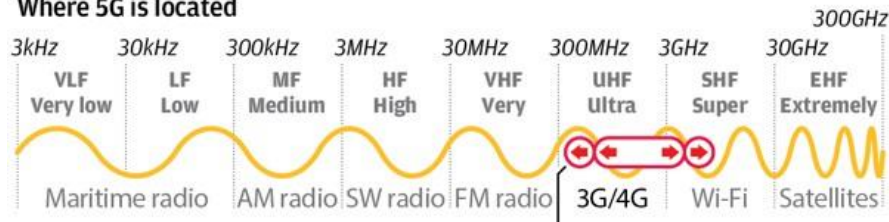
# Enterprise Architecture Fifth Generation (5G) Wireless

## The faster 5G network coming soon

With the first 5G-ready smartphones expected to be released in 2019, mobile phone operators are gearing up to test the new super-fast network

Comparison	4G	5G
Latency	10	<b>1</b> millisecond(s)
Data traffic	7.2	<b>50</b> exabytes/month*
Available spectrum	3	<b>30</b> GHz
Connection density	0.1	<b>1</b> million connections/km <sup>2</sup>

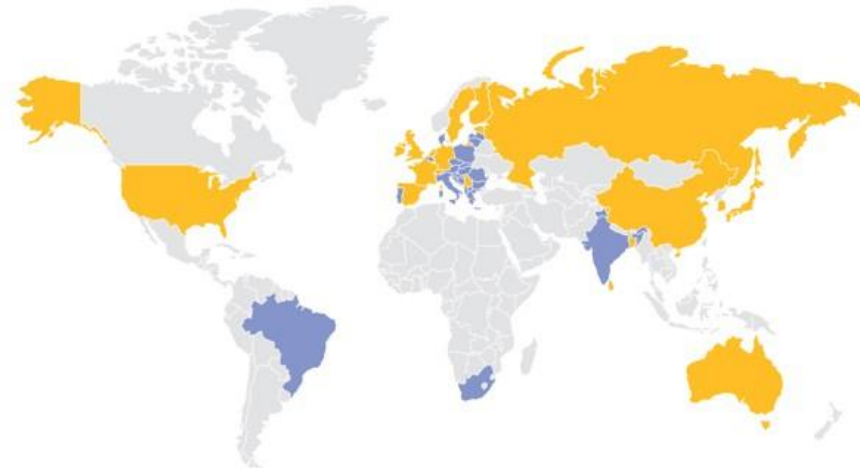
### Where 5G is located



**Electromagnetic spectrum:** 5G will occupy clutter-free areas around 3G/4G (European allocations shown - Sub 1GHz, 1GHz-6GHz, above 6GHz)

### Countries field testing or researching 5G

■ Field testing ■ Researching



### Mobile network evolution

Year	Generation	Maximum data speed**	Data transfer per second**	Time to download full HD movie***
1979	1G	none (voice only)	n/a	n/a
1991	2G	14.4 Kbps	1.8K	Over a month
2000	2.5G	53.6 Kbps	6.7K	Over a week
2001	3G	384 Kbps	48K	Over a day
2010	4G	100 Mbps	12.5MB	7 minutes
2020	5G	1 Gbps	125MB	40 seconds

\* 1 exabyte = 1 billion gigabytes

\*\* Theoretically possible

\*\*\* 5GB file size

Sources: Wired, 5G, Qorvo, European Commission

SCMP / Graphic News

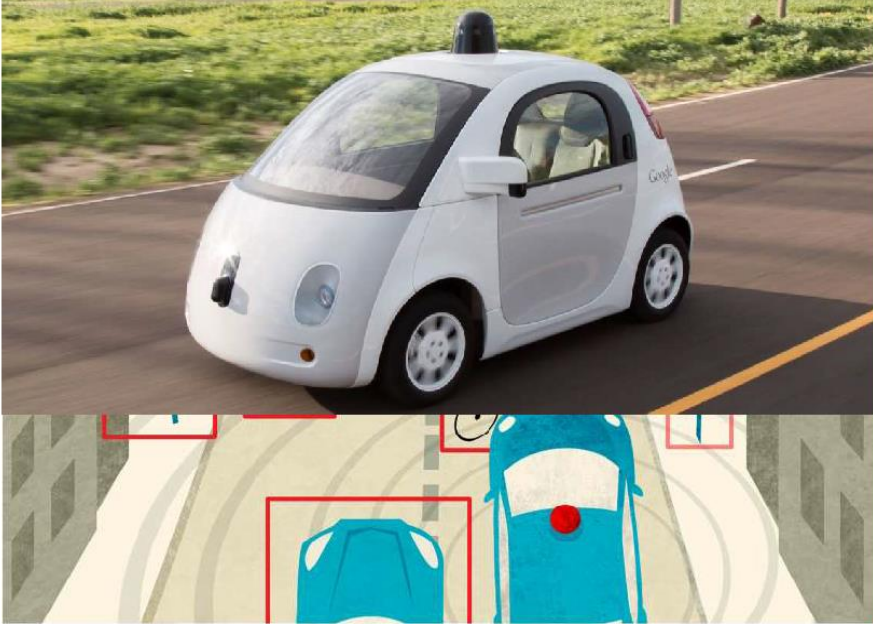
**Faster 5G Network Coming Soon** – robertchaen.com – April 23, 2019

robert.kowalke@vita.virginia.gov





# Enterprise Architecture Fifth Generation (5G) Wireless



**5G and  
autonomous  
vehicles go  
well together ...**

**Gartner**

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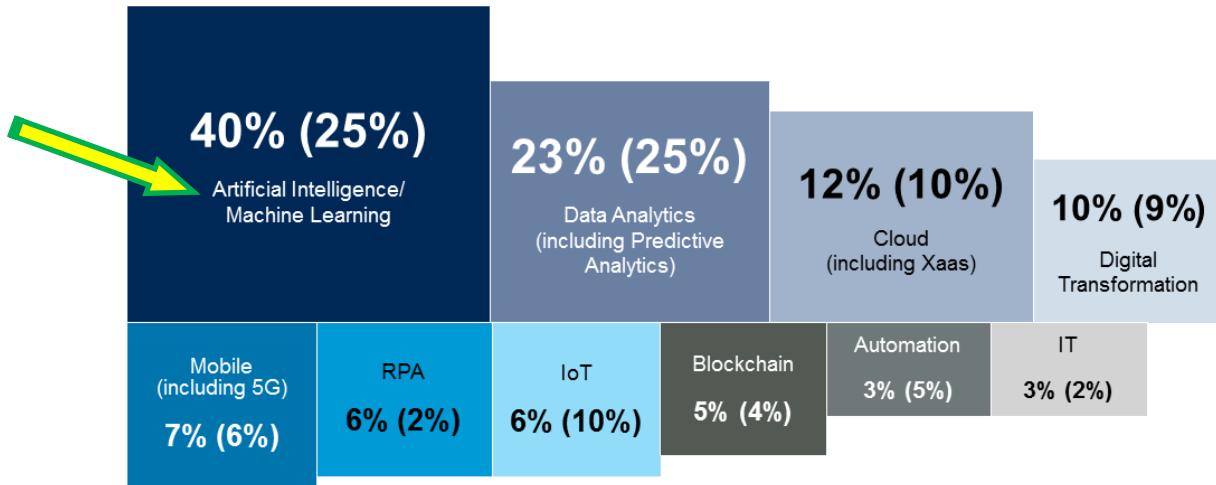
## 5G and Autonomous Vehicles Go Well Together – Gartner



## AI Tops List of Game-Changer Technology

**Q. Which technology area do you expect will be a game changer for your organization?**

Coded. Multiple responses allowed. First percentages are for "top performers" (n = 230), parentheses include "typical performers" (n = 2,329)



For more details on this research, see ["2019 CIO Survey: CIOs Have Awoken to the Importance of AI."](#)

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## 5G and Game Changer Technology Survey Results – Gartner



**Smart City solutions to the challenges of urban mobility –**  
Smart.City\_Lab



# Enterprise Architecture Fifth Generation (5G) Wireless



Sources: Libro Blanco Smart Cities, Ministerio de Industria, Comercio y Turismo, Eltis and Movilidad Conectada.



**Small Cell Towers – Wireless Radiation and Adverse Health Effects**  
Presentation to NC Governor – July 6, 2017



Rooftop antennas polluting directly down into residential buildings below, creating hotspots within numerous interior areas.

**Mobile Phone Masts and Wireless Computing** – Alasdair and Jean Philips, 2009



## IARC Press Release 208 – May 31, 2011

Hardest hit are those caught in "beam patch" areas. A beam patch is a confluence of energy with the highest field strength. Beam patches hit the ground at several times the height of the mast away. 4G antennas, which use MIMO and beamforming technologies, point multiple data streams in the same direction. 5G antennas will also blast multiple beams, but with hyper-velocity and intensity as roaming beam patches change frenetically.

Microwave frequencies flowing to and from most US commercial 3G and 4G cell towers and base stations are generally between 400 megahertz (400 million hertz) to 6 gigahertz (6 billion hertz). All frequencies within this range are designated by the International Agency for Research on Cancer (IARC) as Group 2B carcinogenic, while leading scientists are now calling for an upgrade to Group 1A, a designation reserved for the worst of confirmed human carcinogens like asbestos, benzene, X-ray and gamma radiation. We know from decades of science that the electromagnetic voltage generated by modulated wireless signals is especially damaging to human genetic material, including DNA. <sup>55</sup>

<sup>55</sup> IARC Press Release 208: IARC CLASSIFIES RADIOFREQUENCY ELECTROMAGNETIC FIELDS AS POSSIBLY CARCINOGENIC TO HUMANS, Lyon, France, May 31, 2011.



**Unfinished 5G Cell Tower Being Built in Santa Rosa, CA -**  
[mummyanglais.wordpress.com](http://mummyanglais.wordpress.com)





# Enterprise Architecture Fifth Generation (5G) Wireless

## The Cell Phone and the Cell: The Role of Calcium

Dr. Andrew Goldsworthy, 2008.

### Water Tower Antenna Pictures



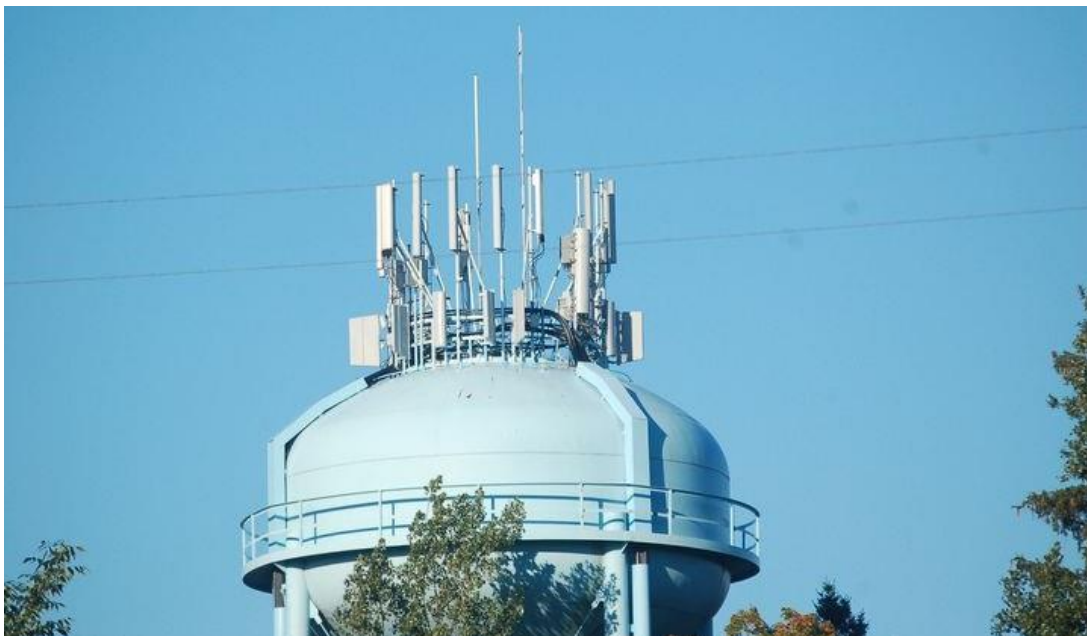


# Enterprise Architecture Fifth Generation (5G) Wireless





# Enterprise Architecture Fifth Generation (5G) Wireless





## Enterprise Architecture Fifth Generation (5G) Wireless

**Stealth Antennas** – If they blend in to their surroundings, then you will not think about them nor their impact on you or the environment, which means it’s got to be ok – right!?



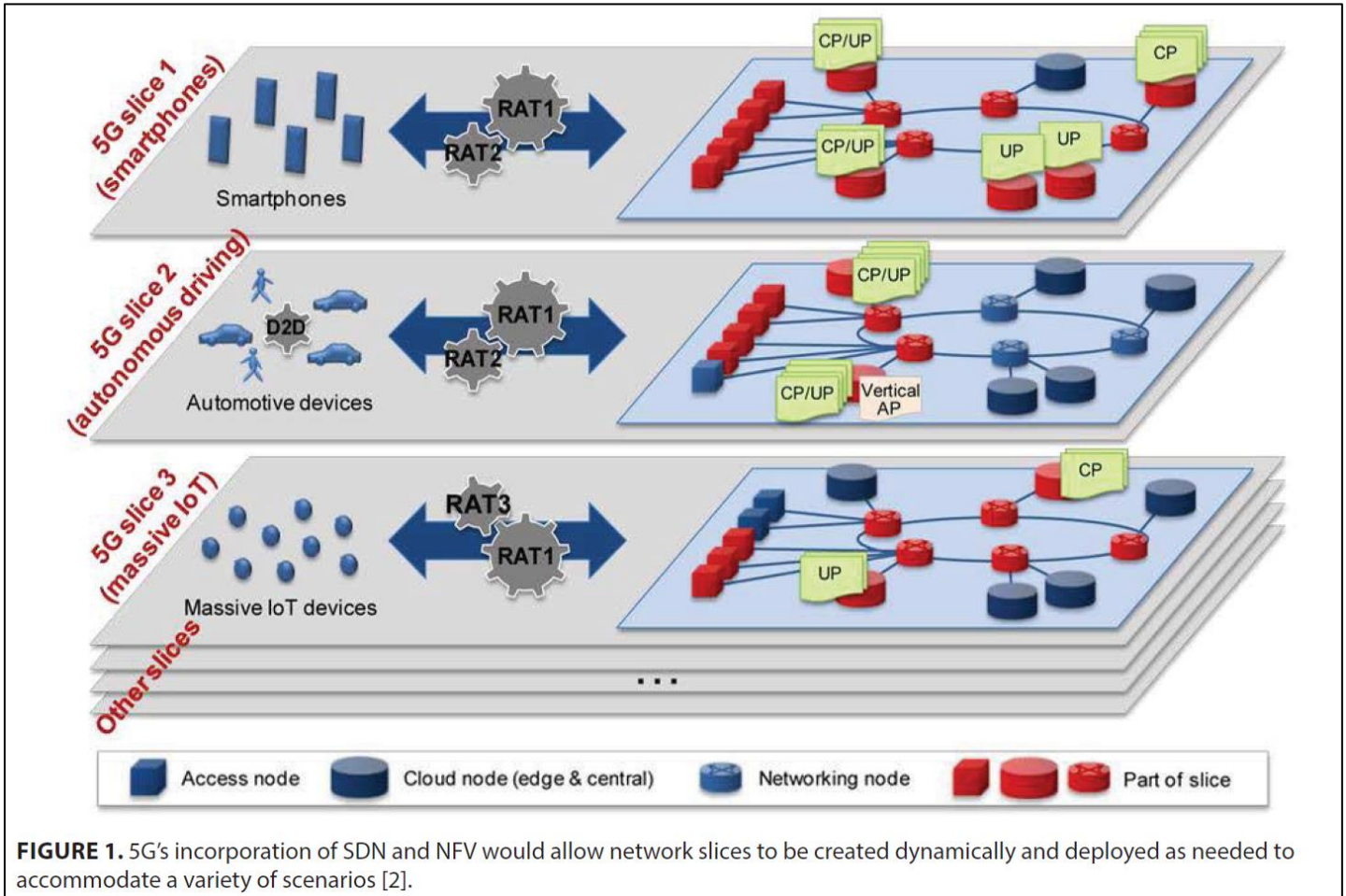


## Rooftop Antennas





# Enterprise Architecture Fifth Generation (5G) Wireless



## 5G's Incorporation of SDN and NFV Slicing



# Enterprise Architecture Fifth Generation (5G) Wireless

# 5G

## the driver for smart cities of the future

Smart city projects are already straining with the current wireless network infrastructure. The promise of 5G, low latency, ultra-low energy connections, high speed, will be the foundation for large-scale IoT deployments in cities, which are set to revolutionize existing services and business models.

Smart.City\_Lab

## 2020 - 2035

**5G will drive economic growth**

**\$12.3**  
Trillion

Global output of industry goods and services enabled by 5G.



**\$3.5**  
Trillion

Economic output in the 5G value chain alone



**22**  
Million  
Jobs



**\$3.3 = INDIA'S GDP**  
Trillion

Worldwide GDP  
From 2020 to 2035, the total contribution of 5G to real global GDP



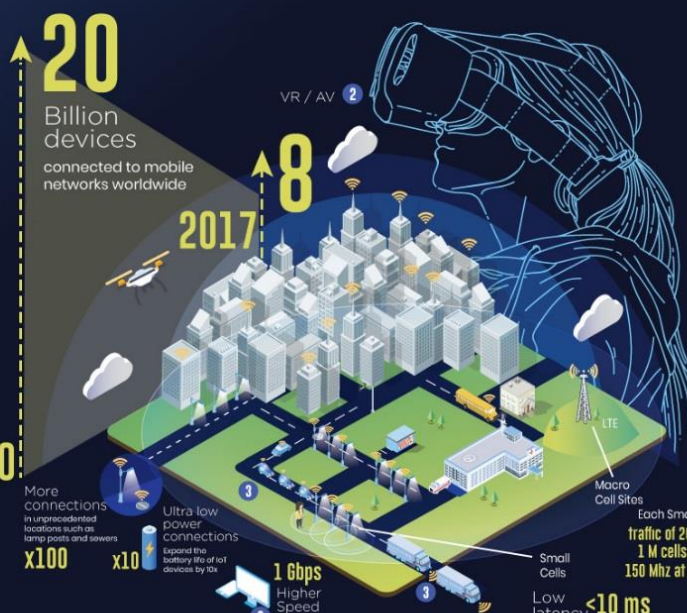
By Smart.City\_Lab - Fira de Barcelona 2019. May be used with attribution to @smartcity\_lab @SmartCityexpo

Source: <https://www.qualcomm.com/invention/5g/economy>

## How will 5G benefit the smart city vision?

**\$160 billion in benefits and savings in energy**

- Energy and Utilities**
  - Water Pipes leaks and sewers
  - Smart Lighting: Save power, Reduce pollution, Keep people safe
  - Smart Grids: Economies of scale, Automated real-time grid switching
- Mobility and Transport**
  - Smart Traffic: Autonomous vehicles, Vehicle Platooning, Road Safety, Smart Parking
  - Smart Parking
  - On-vehicle communication
- Sustainability**
  - Security: Surveillance Cams, Drones
  - Air Quality Sensors
  - Broadband Video



## IOT

**5G capacity increases with densification**

Cities play a critical role for Small Cell deployment in Mobile Network Densification.

Tomorrow's wireless networks will require hundreds, or even thousands, of small cells densely deployed across cities.

**small cells**

The full promise of Smart Cities and 5G requires a robust deployment of small cells

- How will 5G be used?**
- 1 Massive Internet of Things **MIoT**
  - 2 Enhanced Mobile Broadband **EMBB**
  - 3 Mission Critical Services **MCS**

By Smart.City\_Lab - Fira de Barcelona 2019. May be used with attribution to @smartcity\_lab @SmartCityexpo

Source: <https://www.qualcomm.com/invention/5g/economy>

## 5G – The Driver for Smart Cities of the Future – Smart.City\_Lab

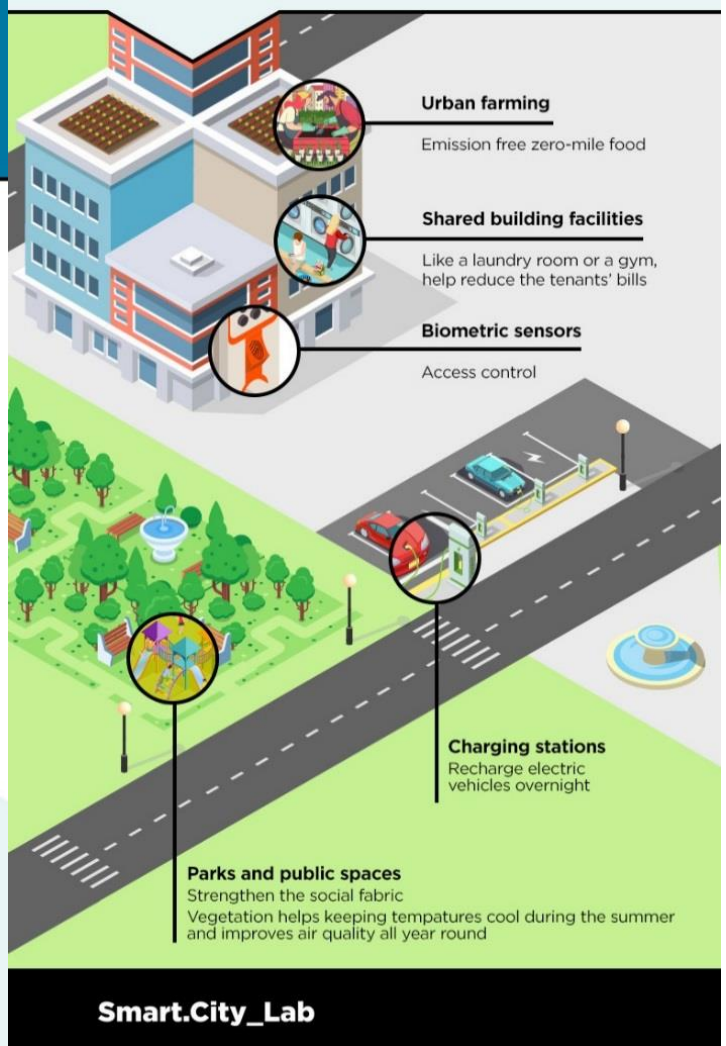
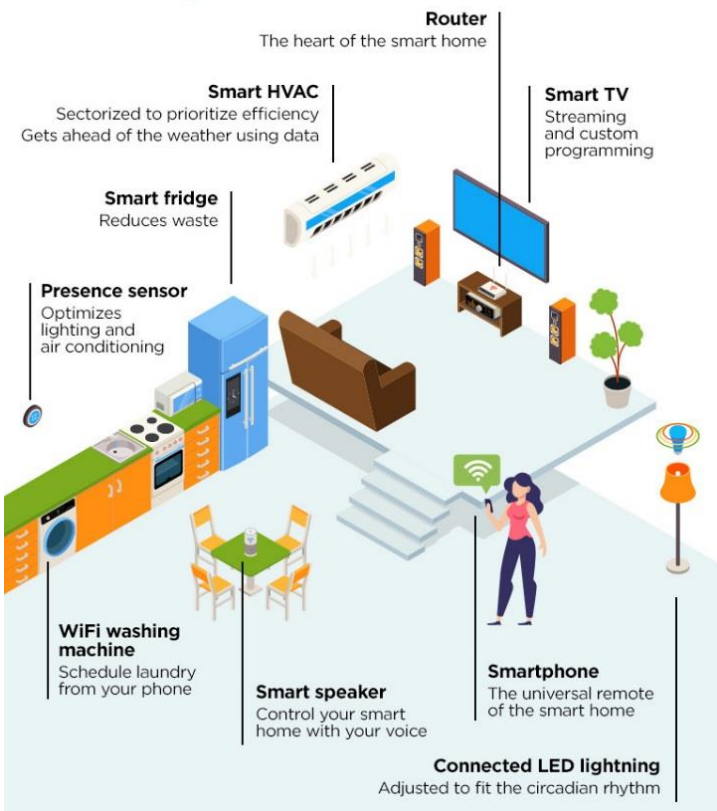
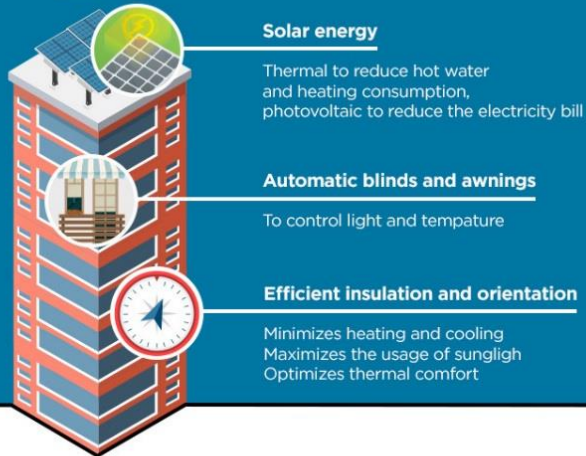


# Enterprise Architecture Fifth Generation (5G) Wireless

## How a Smart Home Works

Take a look inside

Smart homes are the basic bricks with which smart cities are built

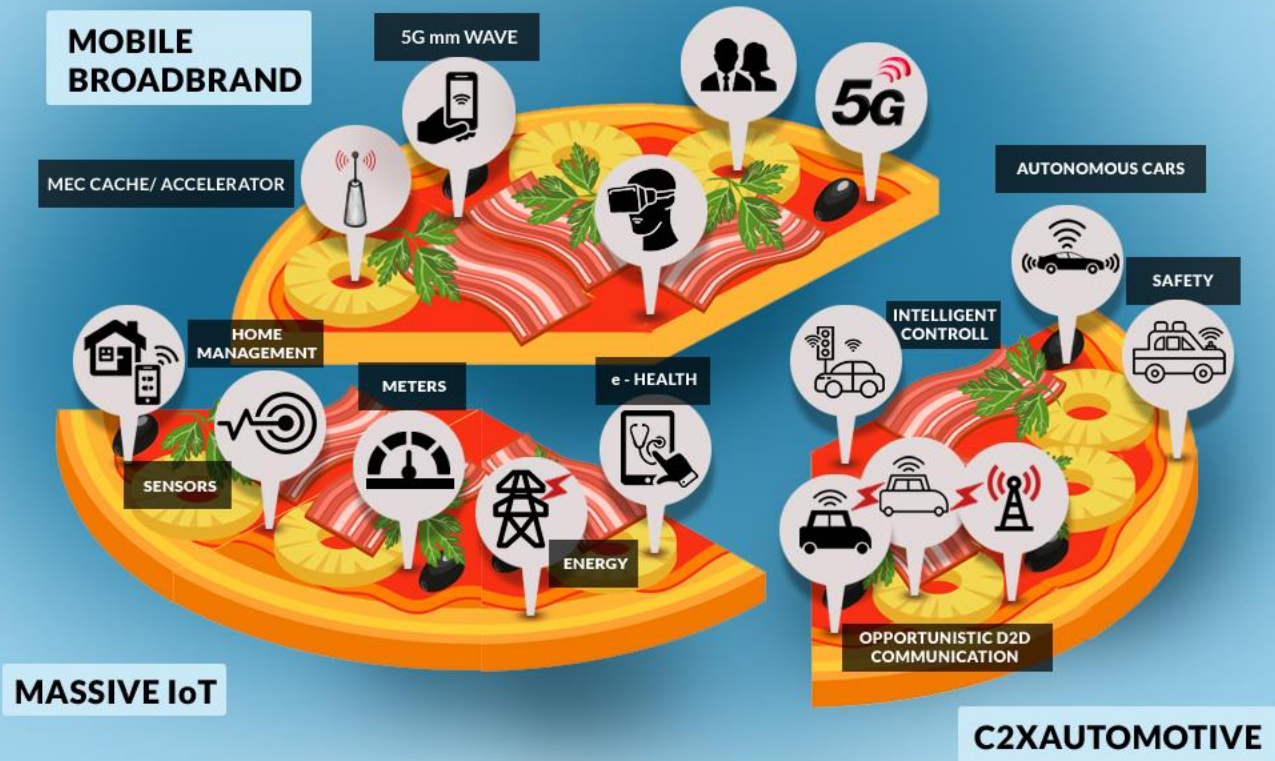


## How a Smart Home Works – Smart.City\_Lab





# Enterprise Architecture Fifth Generation (5G) Wireless



## 5G Network Slices

5G Network Slices - Rebaca



# Enterprise Architecture Fifth Generation (5G) Wireless

## 120 Years of History

1900

1950

1975

2000

### Wireless communications~Mobile measurement

**Quality assurance for microwave tele-communications equipment**  
Contributed to the installation of NTT's microwave systems linking Tokyo and Osaka

**Signaling tester**  
Contributed to realization of the third-generation mobile virtual network and the rapid spread of service area



**TYK-type wireless telephones**  
Became pioneer in commercializing wireless telephone sets, thus contributing to making safe navigation through Ise Bay possible



**Measuring devices for all tests in mobile device development**  
PDC terminal measuring devices contributed to spreading digital mobiles in Japan



### Japan "firsts" and world "firsts" that changed society

**TV broadcasting equipment**  
Developed TV broadcasting equipment in response to requests from Japan's father of TV, Dr. Kenjiro Takayanagi

**Cable loss tester**  
World's first handheld measurement device for maintenance and management of wireless networks



**Radio receivers**  
Japan's first radio receiver



**Bit error tester**  
Featured fastest error detection in the world, thus contributing to the stability of communications

### Wireline communications~Network Infrastructure Measurement

**Semiconductor laser**  
Began in-house development of key devices to support the coming age of optical communications

**Quality assurance for optical communications equipment**  
Contributed to the spread of ultra-high-speed Internet and broadband communications



**Automatic public telephone unit**  
The first public telephone installed in Japan



**Optical fiber damage inspection equipment**  
Searches for damage to optical fiber and supports communications security

**120 Years of Communication History – 1900-2000, Anritsu, 2019**



# Enterprise Architecture Fifth Generation (5G) Wireless



## 5G, Your Health And The Environment

### WHAT IS 5G?

5G is the fifth generation of wireless technology promising to connect the Internet of Things (IoT) at blazing fast speeds. Millions of new cell antennas are being installed in front of homes on street lights and utility poles. Telecom has heavily lobbied governments to pass new regulations that fast track new wireless antenna installations by removing public notice and public hearings and usurp local control.

#### Issues With 5G

- Experimental technology
- Increases radiation exposure
- Outdated radiation guidelines
- Children are more vulnerable
- Inadequate regulations
- Impact to tree canopy
- No oversight by health authority
- No environmental review
- Increases energy usage
- Increases e-waste and pollution
- Lowers property values
- Local authority overruled
- Loss of privacy
- Interferes with weather forecasting
- Screen addiction
- Uninsured liability
- Cyber security risks

#### Peer Reviewed Research On Wireless Radiation

- Sperm damage
- Oxidative stress
- Altered brain development
- DNA damage
- Immune system damage
- Memory problems
- Sleep problems
- Hyperactivity
- Behavior problems
- Breach of blood-brain barrier
- Brain tumors
- Cancer
- Harm to birds, bees, and trees

#### Harvard Investigation Finds Industry Funding Influences Science and Policy

"Industry control, in the case of wireless health issues, extends beyond Congress and regulators to basic scientific research."  
— Norm Alster, in *Captured Agency*, Harvard University

#### Medical Doctors Caution:

"An Egyptian study confirmed concerns that living nearby mobile phone base stations increased the risk for developing headaches, memory problems, dizziness, depression and sleep problems. In large studies, an association has been observed between symptoms and exposure to these fields in the everyday environment."  
— *The American Academy of Pediatrics*

#### Scientists Worldwide Are Calling For A Halt To 5G:

"We recommend a moratorium on the roll-out of the fifth generation, 5G, for telecommunication until potential hazards for human health and the environment have been fully investigated by scientists independent from industry...RF-EMF has been proven to be harmful for humans and the environment."  
— *The 5G Appeal (signed by over 250 independent scientists and medical doctors from 40 countries)*

#### Worldwide Opposition

Governments are taking action to stop 5G. Dozens of cities in Italy, the U.K., the U.S. and Switzerland are passing resolutions/restrictions to halt the 5G roll-out until adequate safety testing has been done. Several countries recommend reducing children's exposures to cellular phone radiation.



LEARN MORE AT [EHTRUST.ORG](http://EHTRUST.ORG)

**5G, Your Health, and the Environment** – EHT, October 18, 2019



# Enterprise Architecture Fifth Generation (5G) Wireless



## 5G Standardization Roadmap for 3GPP and ITU – SDX Central, Nov 7, 2019



## Enterprise Architecture Fifth Generation (5G) Wireless

Technology	1G	2G	3G	4G	5G
Start/Deployment	1970-80	1990-2004	2004-10	Now	Soon (probably by 2020)
Data Bandwidth	2Kbps	64 Kbps	2 Mbps	1 Gbps	Higher than 1 Gbps
Technology	Analog	Digital	CDMA 2000, UMTS,EDGE	Wi-Max, Wi-Fi, LTE	WWWW
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet
Multiplexing	FDMA	TDMA/CDMA	CDMA	CDMA	CDMA
Switching	Circuit	Circuit,Packet	Packet	All Packet	All Packet
Primary Service	Analog Phone Calls	Digital Phone Calls and Messaging	Phone calls, Messaging, Data	All-IP Service (including Voice Messages)	High speed, High capacity and provide large broadcasting of data in Gbps
Key differentiator	Mobility	Secure, Mass adoption	Better Internet experience	Faster Broadband Internet, Lower Latency	Better coverage and no dropped calls, much lower latency, Better performance
Weakness	Poor spectral efficiency, major security issue	Limited data rates, difficult to support demand for internet and e-mail	Real performance fail to match type, failure of WAP for internet access	Battery use is more, Required complicated and expensive hardware	?

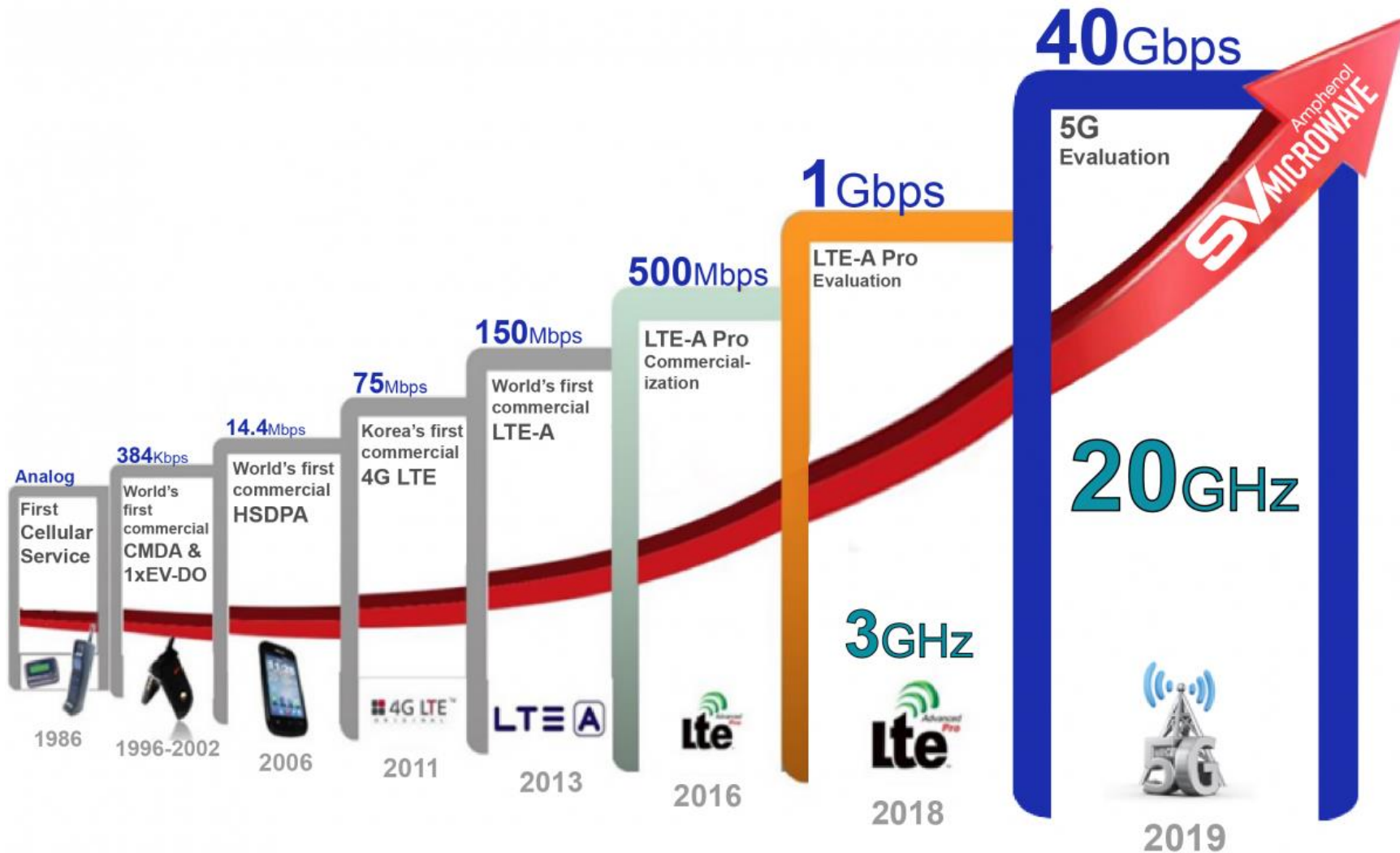
Source: IJMTER ISSN (online) 2349 - 9745 Evolution of Mobile Generation Technology: 1G to 5G and Review of Upcoming Wireless Technology 5G

### Evolution of Mobile Generation Technology – 1G to 5G – electricssense.com – January 15, 2020

This page intentionally blank – More pictures follow.



# Enterprise Architecture Fifth Generation (5G) Wireless

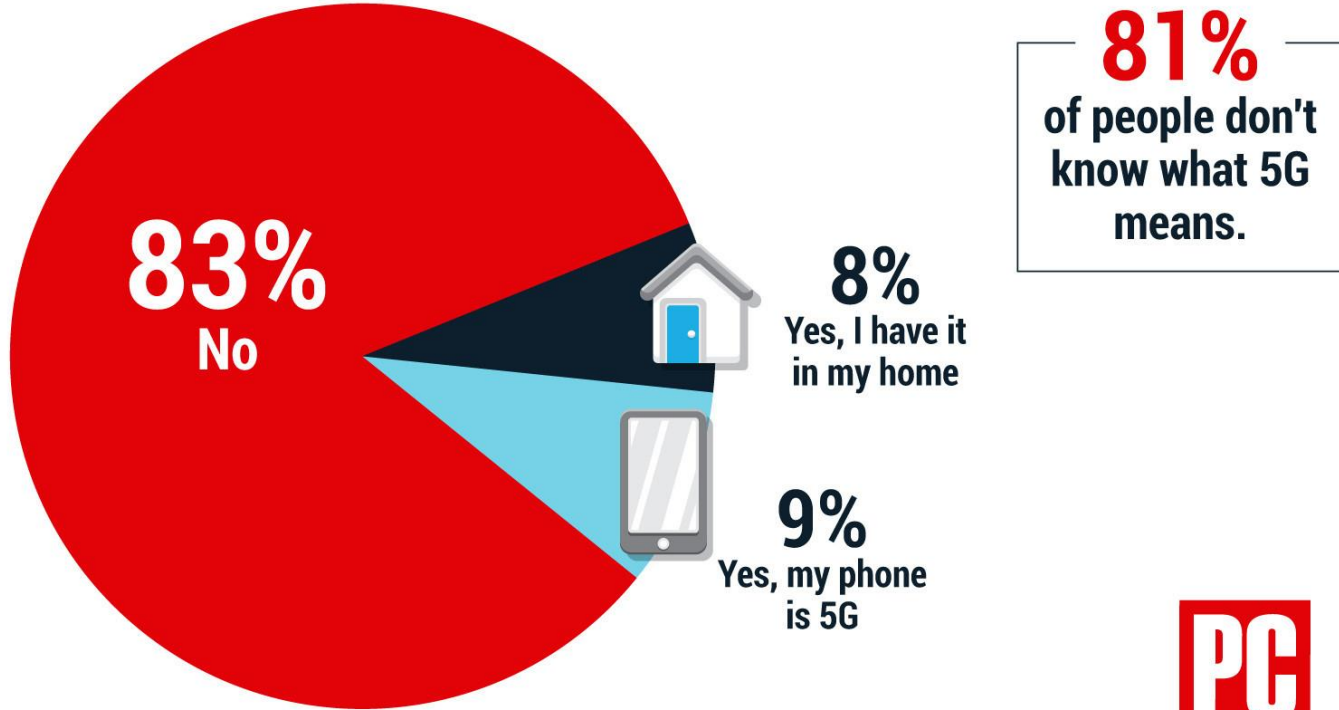


**Analog to 5G (40Gbps) – SV Microwave**



# Enterprise Architecture Fifth Generation (5G) Wireless

## 5G CONFUSION Do you already have 5G?



**5G Confusion – Do you already have 5G?** PC Magazine







# Enterprise Architecture Fifth Generation (5G) Wireless

## Who Is Leading The Race To Develop 5G?

Number of 5G standard technical contributions by company worldwide



As of December 2018  
Source: IPlytics  
@StatistaCharts



Leading the Race to 5G – robertchaen-com – April 23, 2019

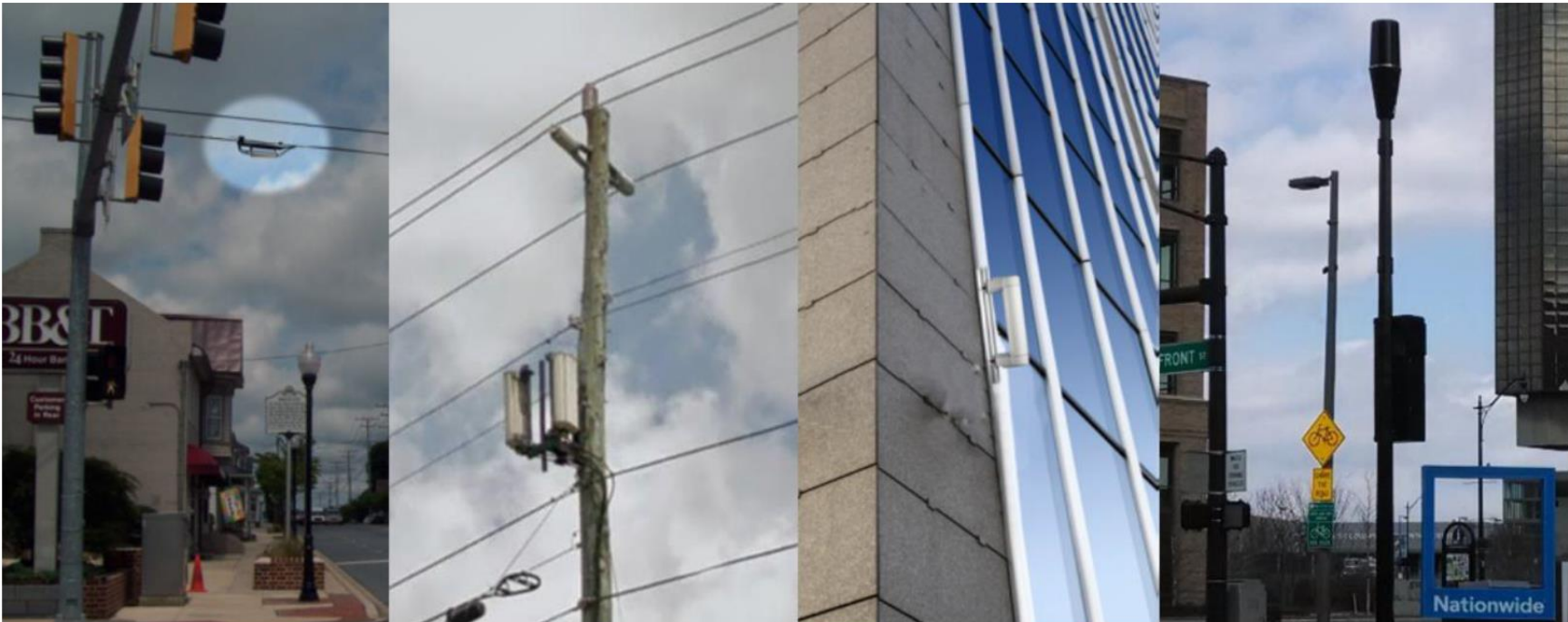


## Enterprise Architecture Fifth Generation (5G) Wireless



**Small Cell Towers – Wireless Radiation and Adverse Health Effects** Presentation to NC Governor – July 6, 2017

Small cells, shown in Figure 5.2 are typically camouflaged to blend into their environment and are sometimes called Street Macros. They operate on both licensed and unlicensed spectrum and cover less range than their macrocell counterparts.



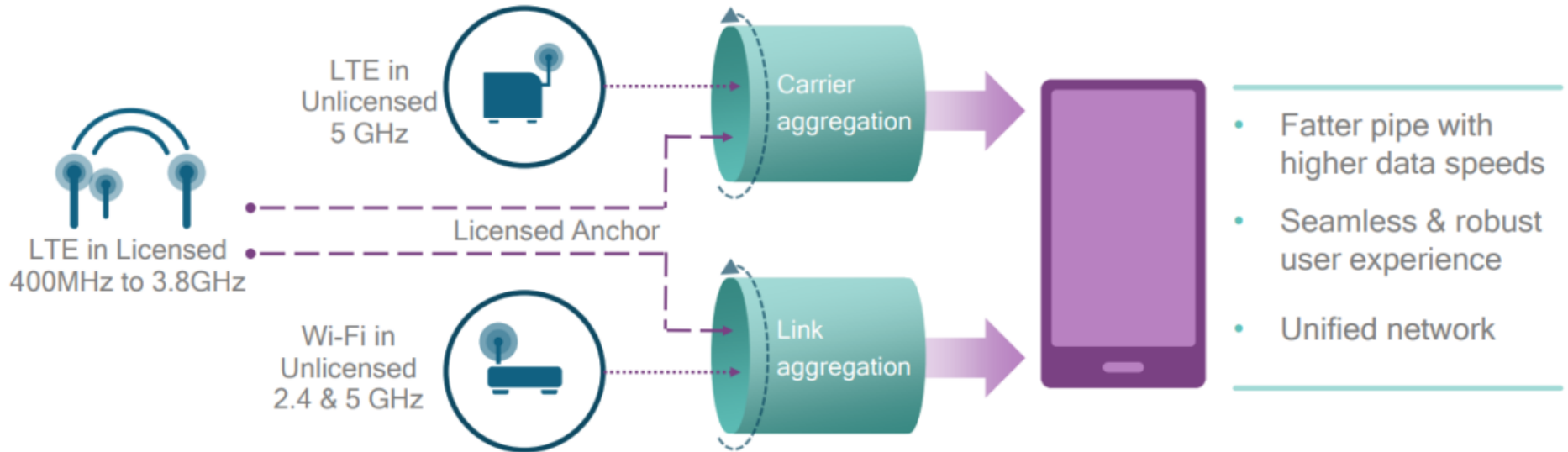
**Figure 5.2. Examples of Different Types of Small Cells in the Field.**

**Small cell 5G Examples – 5G Americas – August 2019**



# Enterprise Architecture Fifth Generation (5G) Wireless

## LAA / LTE-U (Licensed-Assisted Access)



## LWA (LTE Wi-Fi Link Aggregation)

### Licensed Assisted Access (LAA) / LTE-U; LWA (LTE WiFi Link Aggregation)



# Enterprise Architecture Fifth Generation (5G) Wireless

HOW DOES MASSIVE AND WIDESPREAD EMF AFFECT THE ENVIRONMENT? MANY SPECIES OF PLANTS AND ANIMALS (INCLUDING HUMANS) HAVE BEEN STUDIED. THE HEALTH OF INDIVIDUAL SPECIES AS WELL AS BIODIVERSITY AND INTERDEPENDENCE ARE ADVERSELY AFFECTED IN COMPLEX WAYS.

THIS MAP INDEXES OTHER MAPS AT [WWW.OSCILLATORIUM.COM](http://WWW.OSCILLATORIUM.COM) WHICH DISCUSS THE EFFECTS OF NATURAL AND ARTIFICIAL EMF ON THE ENVIRONMENT AT LARGE, OR SPECIFIC SPECIES.

Home: [Oscillatorium](http://Oscillatorium)  
Newest version [this map](#)  
Date of this update: 08-24-17

## MAP INDEX: TOPICS PERTINENT TO ENVIRONMENTAL HEALTH

### EFFECTS ON MANY INDIVIDUAL SPECIES

*Oxidative and nitrosative stress*  
*Alterations in gene expression and function*  
*Magnetic, electric field effects on cells*  
*Microwave effects on cells*  
*Tissues vary in sensitivity depending on shape*  
*Tissues vary in sensitivity depending on content*  
*Immune, hormonal, cyclic disruptions*

### EFFECTS ON ECOSYSTEMS, BIODIVERSITY

*Alterations in food supply*  
*Alterations in food chain, predation*  
*Disorientation, migration disruption*  
*Clusters of illness near transmitters*  
*Very little non-contaminated space left*



## EMF Environmental Health Effects Map Index – by oscillatorium.com – August 2017



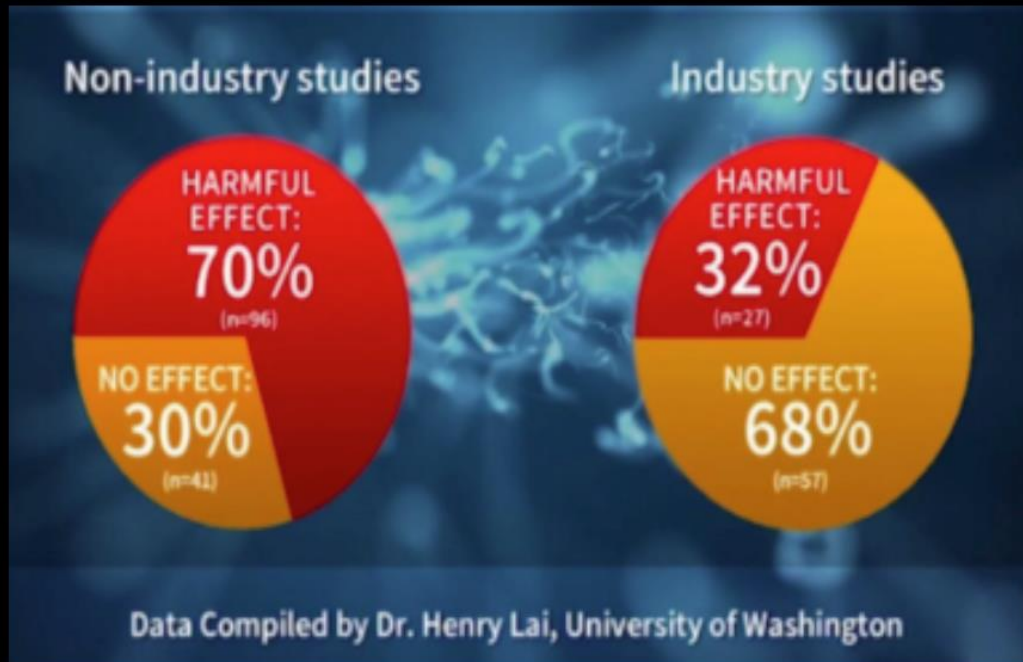
# Enterprise Architecture Fifth Generation (5G) Wireless



## 5G To Transform Lives – 2G (1991) to 5G (2020)



## Why So Many Inconsistent Results?



Huss 2007: Systematic review- industry funded studies 90% less likely to report effect.

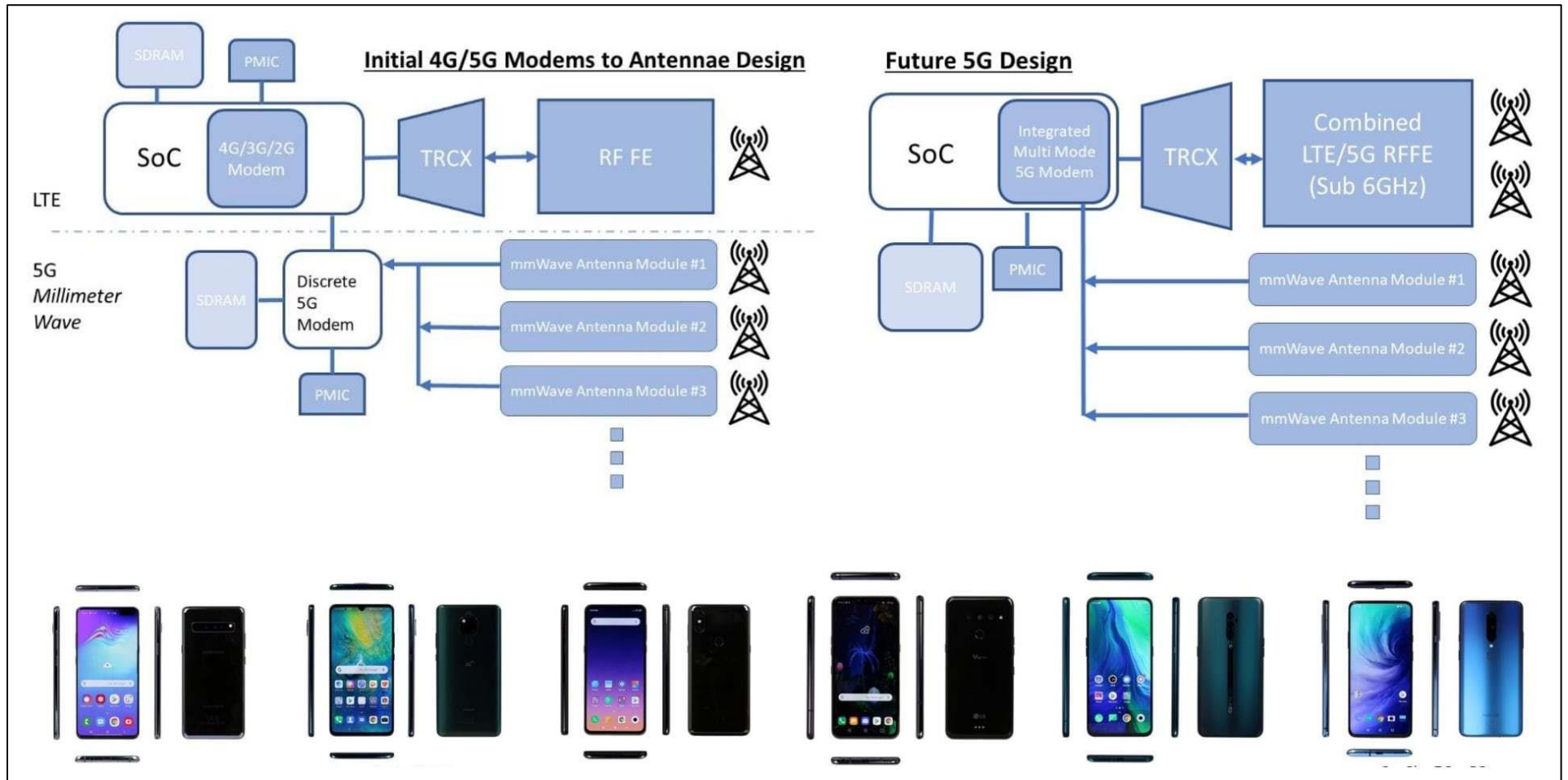
Valentini et al. 2011: "the existence of sponsorship and publication biases should encourage WHO intervention to develop official research standards and guidelines."



**Inconsistent Test Results Between Industry and Non-industry** – Wireless Radiation and Adverse Health Effects Presentation to NC Governor – July 6, 2017



# Enterprise Architecture Fifth Generation (5G) Wireless



**Future 5G Design** – VentureBeat

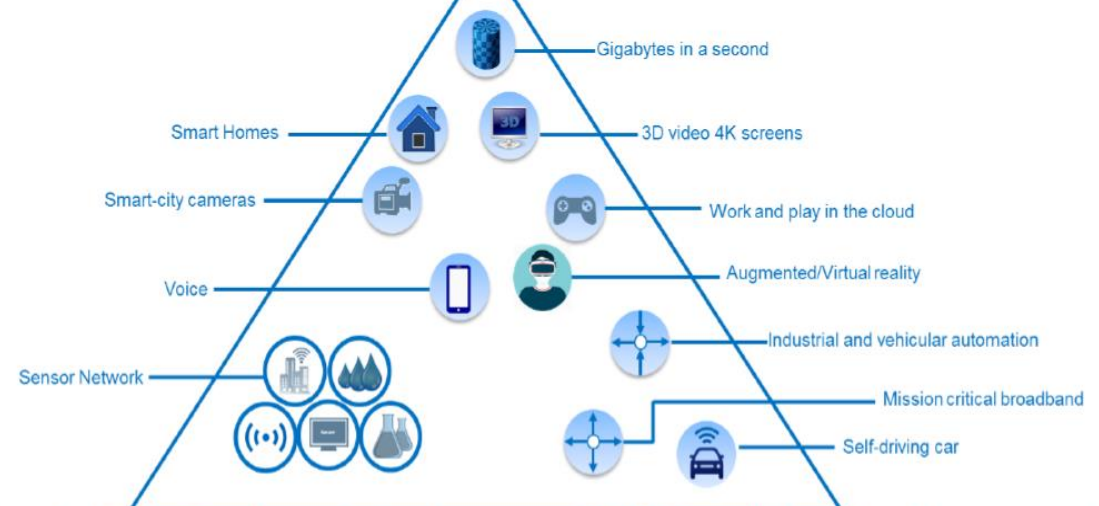




# Enterprise Architecture Fifth Generation (5G) Wireless

High Data Rates

eMBB (enhanced Mobile Broadband) – Capacity Enhancement & Fixed Wireless Access (FWA) – High Speed Home / SOHO Broadband



mMTC (massive Machine Type Communications) – Massive connectivity

URLLC (Ultra-reliable and Low-latency communications) – High reliability, Low latency

High Density

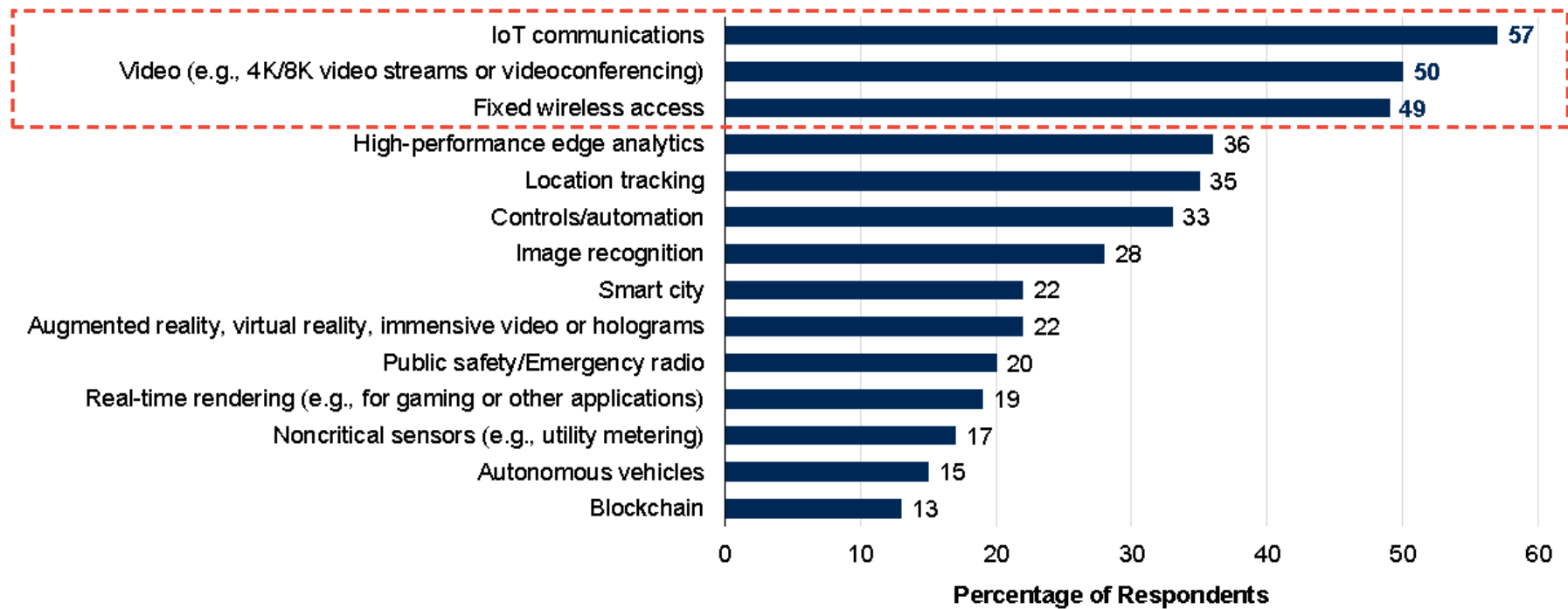
Ultra-Reliability & Low Latency

## 5G Use Cases – 3G4G



# Enterprise Architecture Fifth Generation (5G) Wireless

## 5G IoT Use Cases as Users Anticipate



Base: n = 203. Gartner Research Circle Members/External Sample/Excludes "Don't know"  
Q. In your opinion, how will organizations like yours potentially use 5G-capable networks?

18 © 2018 Gartner, Inc. and/or its affiliates. All rights reserved.



### 5G IoT Use Cases as Users Anticipate – Gartner



# Active Denial System Crowd Control Weapon

Millimeter waves are used in US Government weapons at higher power to cause pain on contact and disperse crowds.



Images from videos on Active Denial System [and History Channel Report](#) on US Government Active Denial System  
[US Department of Defense Non-Lethal Weapons Program FAQs](#)  
[A Narrative Summary and Independent Assessment of the Active Denial System The Human Effects Advisory Panel](#)

**mmWaves Used in Crowd Control Weapon – Wireless Radiation and Adverse Health Effects**  
Presentation to NC Governor – July 6, 2017

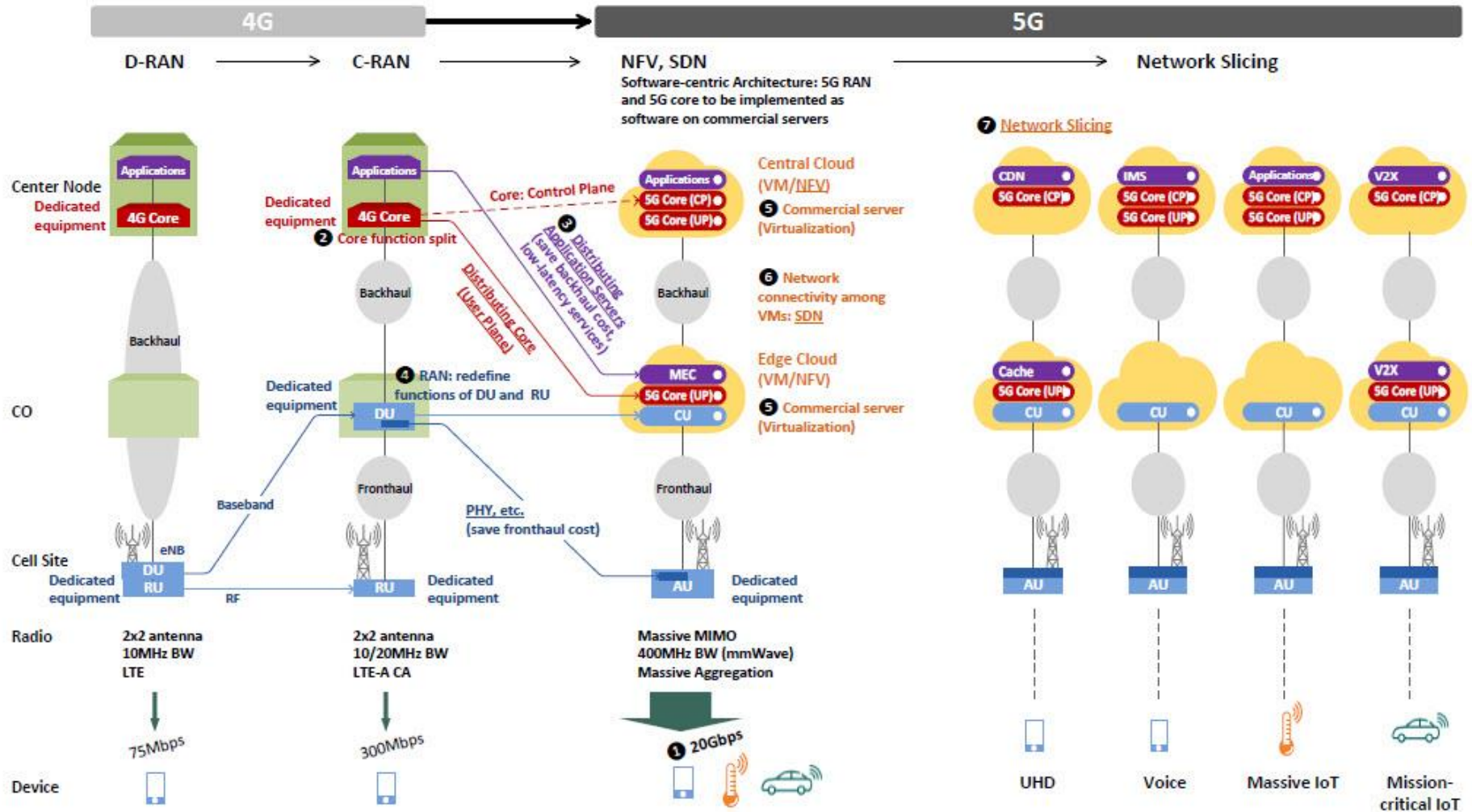


# Enterprise Architecture Fifth Generation (5G) Wireless

NETMANIAS ONE-SHOT

Network Architecture Evolution: 4G→5G

December 31, 2015



DU: Digital Unit (BBU)  
RU: Radio Unit (RRH)

CU: Central/Cloud Unit  
AU: Access Unit

UP: User Plane  
CP: Control Plane

MEC: Mobile Edge Computing  
NFV: Network Function Virtualization

SDN: Software Defined Networking  
V2X: Vehicle-to-X

IoT: Internet of Things  
IMS: IP Multimedia Subsystem



## Enterprise Architecture Fifth Generation (5G) Wireless

### **5G will enable instantaneous connectivity to billions of devices, the Internet of Things (IoT) and a truly connected world.**

#### **There are three major categories of use case for 5G:**

- **Massive machine to machine communications** – also called the Internet of Things (IoT) that involves connecting billions of devices without human intervention at a scale not seen before. This has the potential to revolutionise modern industrial processes and applications including agriculture, manufacturing and business communications.
- **Ultra-reliable low latency communications** – mission critical including real-time control of devices, industrial robotics, vehicle to vehicle communications and safety systems, autonomous driving and safer transport networks. Low latency communications also opens up a new world where remote medical care, procedures, and treatment are all possible.
- **Enhanced mobile broadband** – providing significantly faster data speeds and greater capacity keeping the world connected. New applications will include fixed wireless internet access for homes, outdoor broadcast applications without the need for broadcast vans, and greater connectivity for people on the move.

**For communities,** 5G will enable the connection of billions of devices for our smart cities, smart schools and smart homes, smart and safer vehicles, enhance health care and education, and provide a safer and more efficient place to live.

**For businesses and industry,** 5G and IoT will provide a wealth of data allowing them to gain insights into their operations like never before. Businesses will operate and make key decisions driven by data, innovate in agriculture, smart farms and manufacturing, paving the way for cost savings, better customer experience and long term growth.

**New and Emerging technologies** such as virtual and augmented reality will be accessible by everyone. Virtual reality provides connected experiences that were not possible before. With 5G and VR you will be able to travel to your favourite city, watch a live football match with the feeling of being at the ground, or even be able to inspect real estate and walk through a new home all from the comfort of your couch.

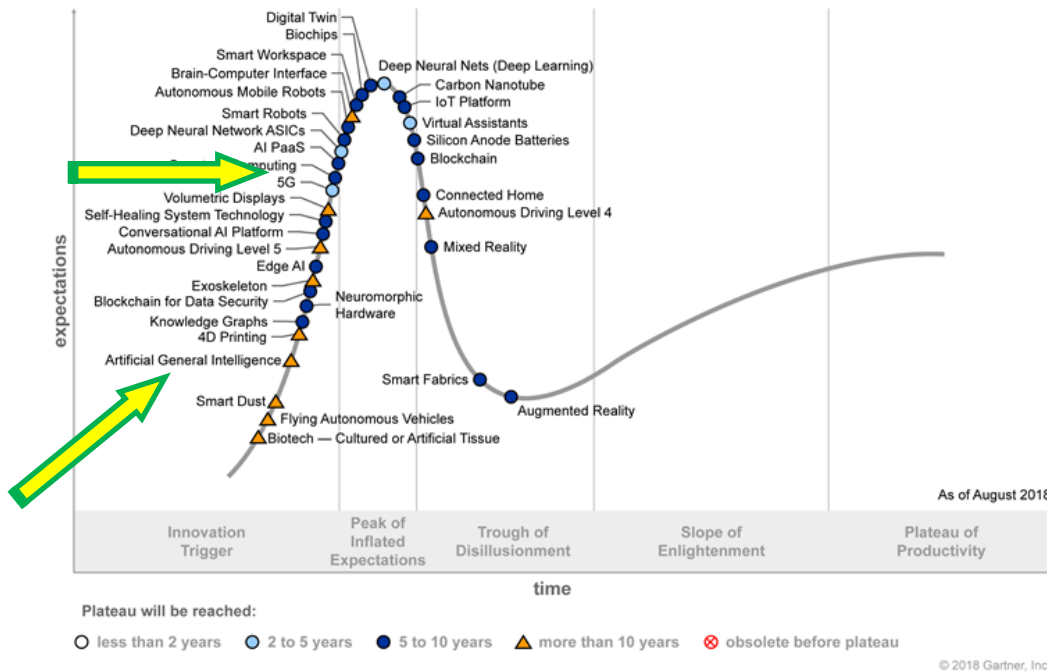
**5G will keep us connected in tomorrow's smart cities, smart homes and smart schools, and enable opportunities that we haven't even thought of yet.**

**What Will 5G Enable?** AMTA [emfexplained.info.site.mis/emf](http://emfexplained.info.site.mis/emf) - August 20, 2019



# Enterprise Architecture Fifth Generation (5G) Wireless

## Emerging Technologies Directly Affect How to Architect Business and Technology Innovation



### Major emerging technology themes for 2018+:

- Democratized AI
- Digitalized ecosystems
- Do-it-yourself biohacking
- Transparently immersive experiences
- Ubiquitous infrastructure



### 5G in the Emerging Technologies Hype Cycle 2018 – Gartner



# Nonionizing Electromagnetic Fields

**Myth: No effects At *low non thermal levels***

**Fact: Research has found biological effects at low non-thermal levels in thousands of studies.**

- EEG well replicated
- Serious sleep disturbances
- Brain Cancer: All human epi- independent +10yrs
- Oxidative stress markers
- Immune system
- Neurological and reproductive development

**Nonionizing Electromagnetic Fields (EMFs) – Wireless Radiation and Adverse Health Effects** Presentation to NC Governor – July 6, 2017



# Enterprise Architecture Fifth Generation (5G) Wireless

**3G (single frequency)**  
2100MHz – 21.6Mbps

**4G (3 frequencies)**  
2600MHz/150Mbps    1800MHz/100Mbps    800MHz/21Mbps

- 3G works in a single frequency of 2100MHz and gives speeds up to 7.2Mbps (21.6 and some cases 42.2Mbps), but mainly urban due to the small radius of coverage
- 4G (LTE) is multi-band 3 frequencies; 2600 and 1800MHz in urban areas (small coverages) with small radius but high bandwidth (150Mbps), and 800MHz in high radius but smaller bandwidth (21Mbps)

**3G vs. 4G Frequencies – LTE** – andoridauthority.com February 25, 2020





# Enterprise Architecture Fifth Generation (5G) Wireless



## The 5G Era

**5G Connections**  
Incl. Cellular IoT

Early 5G Commercial launches

5G Commercial launches

4.3 B

3.10 B\*

5G connections to grow at 350+% over the next 5 years

**Total Mobile Data Traffic**  
EB/month#

14 EB

Video, Audio, and Social Networking represent over 80% of total data traffic

160 EB

**Global Internet Users**

3.6 B

Global Internet users to grow at 6% CAGR between 2017-2025

5.6 B

**Overall SIM Connections**  
Incl. Cellular IoT

8.4 B

600 M\*

17.8 B

8.85 B\*

2017

2019

2020

2023

2025

# 5G

will play an enabling role in realizing full potential of IoT, Internet, video and other emerging technologies

Source: GSMA Intelligence, Industry estimates

\* Cellular IoT included within total connections | # Exabyte per month

### The 5G Era – Zinnov





## Enterprise Architecture Fifth Generation (5G) Wireless

2011 classification was based on epidemiological research:  
Long term use of cell phones by humans is linked to brain cancer.

### International Agency for Research on Cancer



PRESS RELEASE  
N° 208

31 May 2011

**IARC CLASSIFIES RADIOFREQUENCY ELECTROMAGNETIC FIELDS AS  
POSSIBLY CARCINOGENIC TO HUMANS**

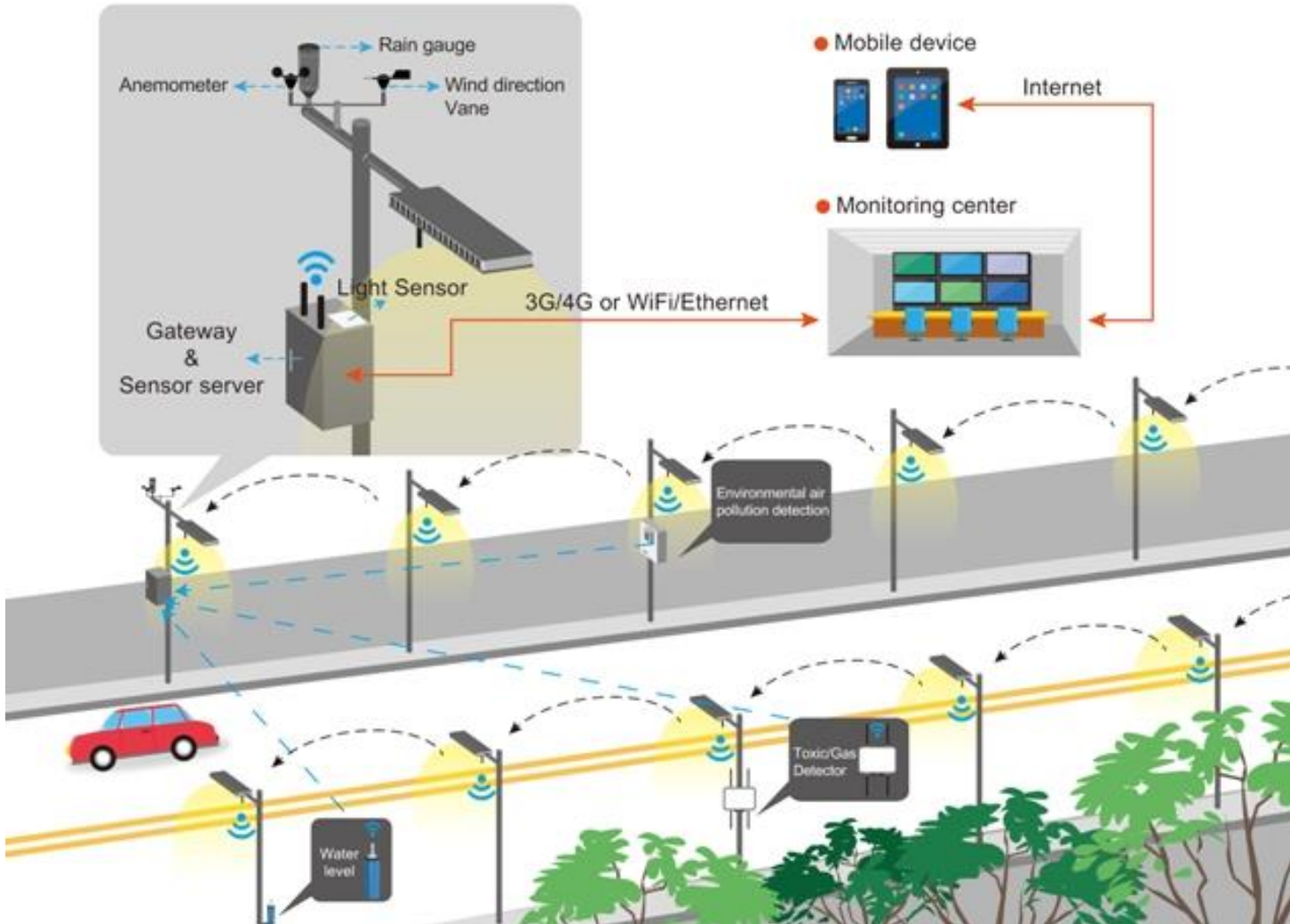
Since the IARC classification, the evidence *has increased* which finds radiofrequency exposure associated with increased brain cancer risk.

- Analysis of Canadian data, *American Journal of Epidemiology*, Momoli et al., 2017
- French National Study, *Occupational and Environmental Medicine*, Coureau et al. 2014.
- Analysis of research and Bradford Hill criteria *BioMed Research International*, 2017.
- Hundreds of published studies

**Cell Phones Linked to Brain Cancer – 2011 – Wireless Radiation and Adverse Health Effects**  
Presentation to NC Governor – July 6, 2017



# Enterprise Architecture Fifth Generation (5G) Wireless





Enterprise Architecture  
**Fifth Generation (5G) Wireless**

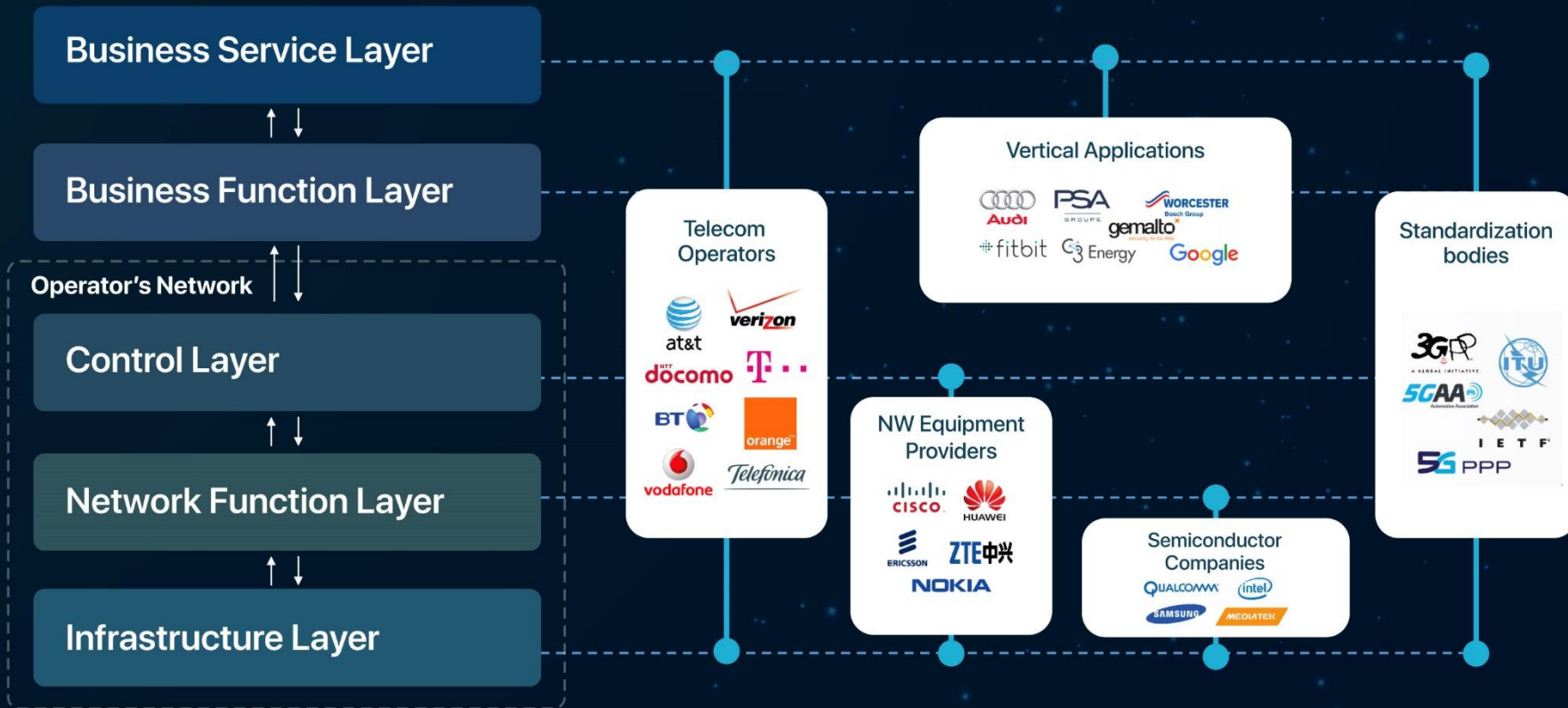
**5G Micro Base Station Smart Pole (First Choice for 5G Deployments) –**  
[mummyanglais.wordpress.com](http://mummyanglais.wordpress.com)



# Enterprise Architecture Fifth Generation (5G) Wireless



## The 5G Tech Stack



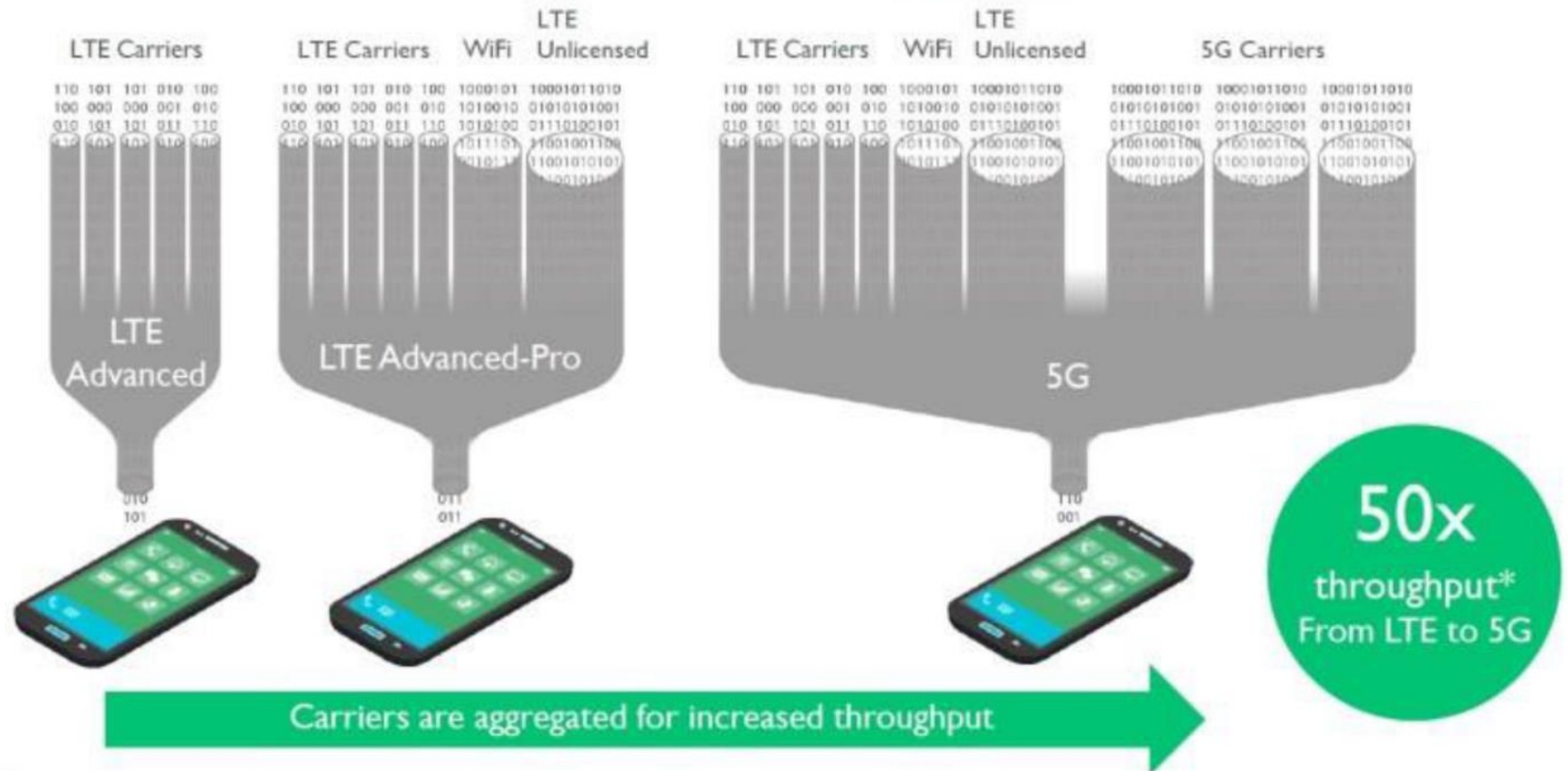
Source: GSMA, Zinnov Research

**5G Technology Supplier Stack – Zinnov Research / GSMA – March 2019.**



# Enterprise Architecture Fifth Generation (5G) Wireless

## 'LTE-Advanced Pro' – The Stepping Stone To 5G



10 ©ARM 2016

\* ARM Estimate, LTE Rel 8 to 5G wave 2

### LTE Advanced Pro – Stepping Stone to 5G – ARM



# Enterprise Architecture Fifth Generation (5G) Wireless

## 4G vs. 5G



# VS.



Experience: Smooth social media, music and video streaming, etc.	10ms	Latency	<1ms	Experience: Near real-time for remote monitoring and control of solutions that require precision (ie. autonomous vehicles, remote surgery, etc.)
Example of solutions: Smart utility meters, Vehicles tracking, etc.	100 Thousand Connections/Km2	Connection Density	1 Million Connections/Km2	Example of solutions: Smart cities with connected infrastructures, Smart factories, etc.
Best for mobile Video, social media, Internet and game	1Gbps	Peak Data Rate	20Gbps	Best for mobile 4K video and game streaming, AR and VR

4G vs. 5G – klgadgetguy.com – April 19, 2019





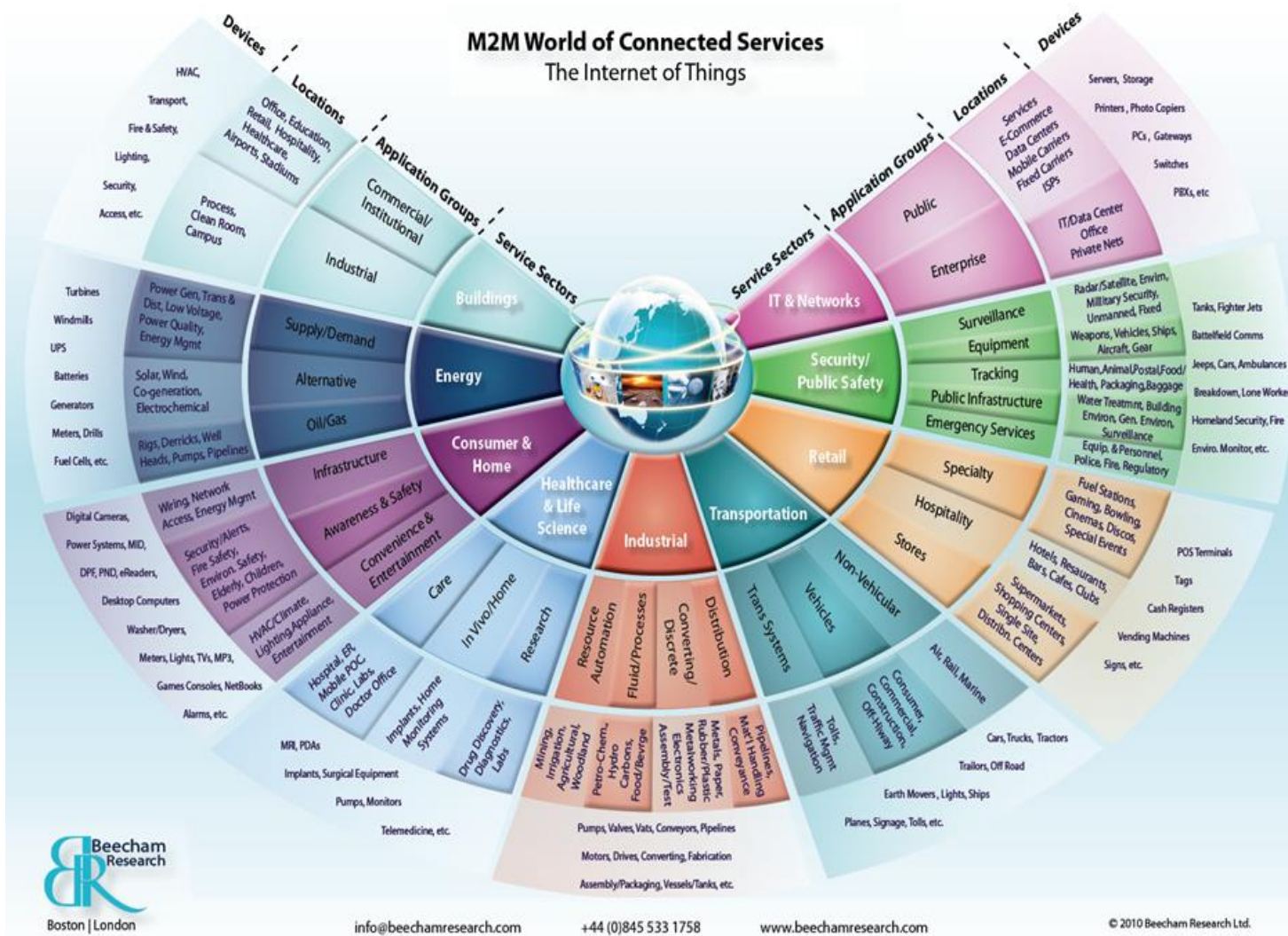
# Enterprise Architecture Fifth Generation (5G) Wireless



**5G Street Light, Electronic Communications Package, and Weather Station –**  
[mummyanglais.wordpress.com](http://mummyanglais.wordpress.com)



# Enterprise Architecture Fifth Generation (5G) Wireless



## Machine-to-Machine (M2M) World of Connected Services – Beecham Research



## 5G Millimeter Waves Uniquely Interact With Skin

Sweat glands act as helical antennas when exposed.

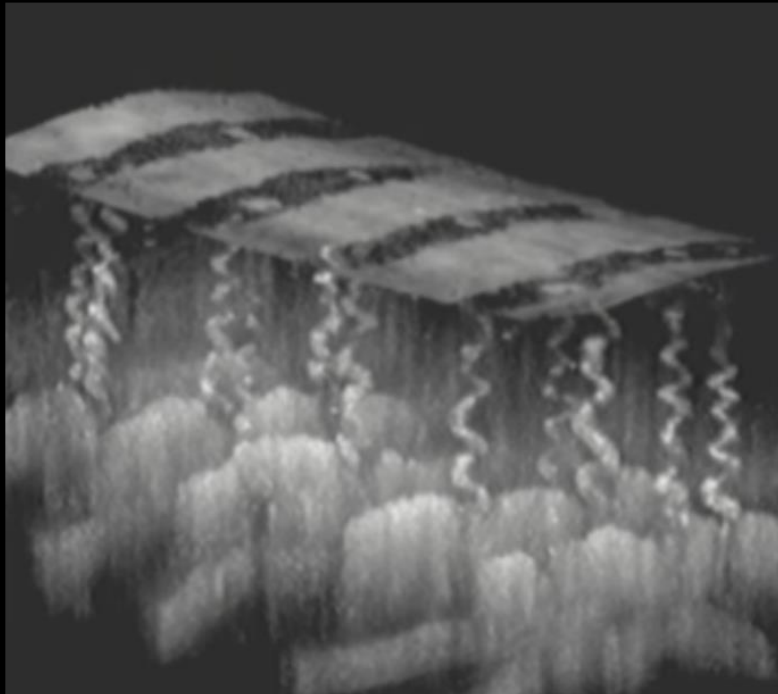


Image From Lecture by Dr. Ben-Ishai and Dr. Yuri Feldman of the Spectroscopy Laboratory of the Department of Applied Physics, Hebrew University of Jerusalem

[Israel Institute for Advances Studies Conference 2017](#)



## 5G mmWaves Uniquely Interact With Skin – Wireless Radiation and Adverse Health Effects

Presentation to NC Governor – July 6, 2017



# How long to download a two hour film?



**3G**  
384 Kbps  
(2001)



**4G**  
100 Mbps  
(2003)



**5G**  
10 Gbps  
(2020)

**Time to download a two (2) hour film – 3G through 5G – [urtech.ca/2019/06](http://urtech.ca/2019/06) – June 2019**



# Enterprise Architecture Fifth Generation (5G) Wireless

## UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM

**RADIO SERVICES COLOR LEGEND**

AIR/NAVIGATION SERVICE	AIR/NAVIGATION SERVICE	AIR/NAVIGATION SERVICE
AIR/NAVIGATION SERVICE	AIR/NAVIGATION SERVICE	AIR/NAVIGATION SERVICE
AIR/NAVIGATION SERVICE	AIR/NAVIGATION SERVICE	AIR/NAVIGATION SERVICE
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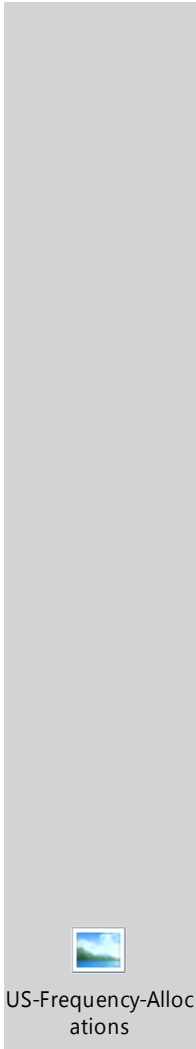
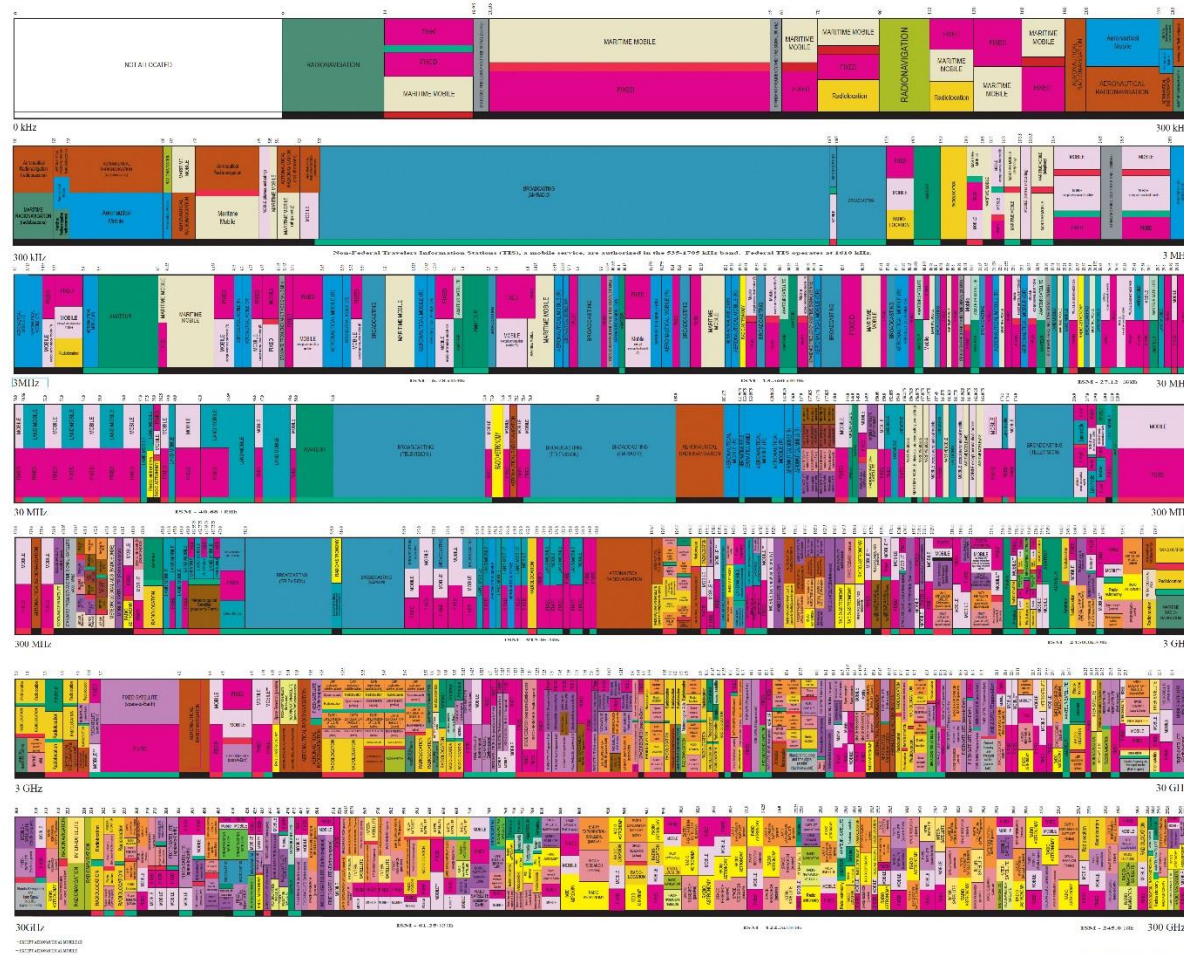
**ACTIVITY CODE**

FEDERAL SERVICE    FEDERAL SERVICE

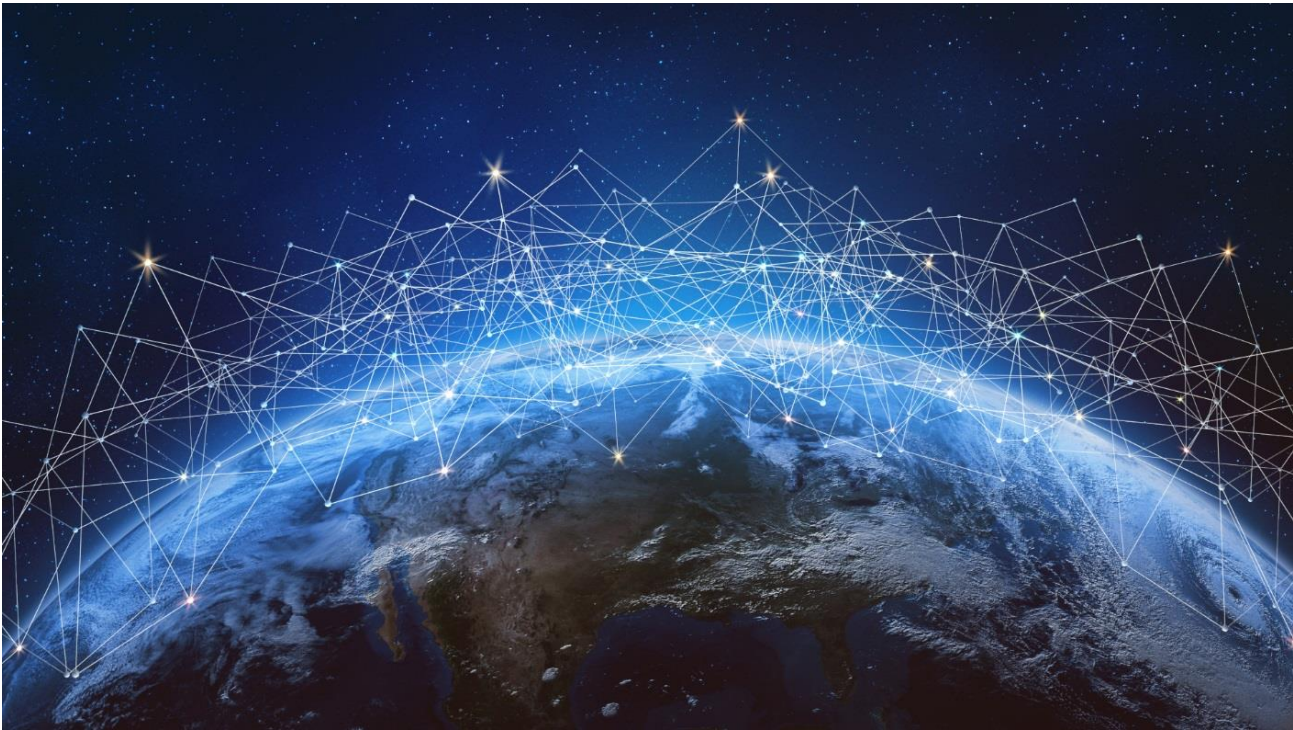
**ALLOCATION USAGE DESIGNATION**

SERVICE	EXAMPLE	DESCRIPTION
FIXED	FIXED	FIXED SERVICE
MOBILE	MOBILE	MOBILE SERVICE

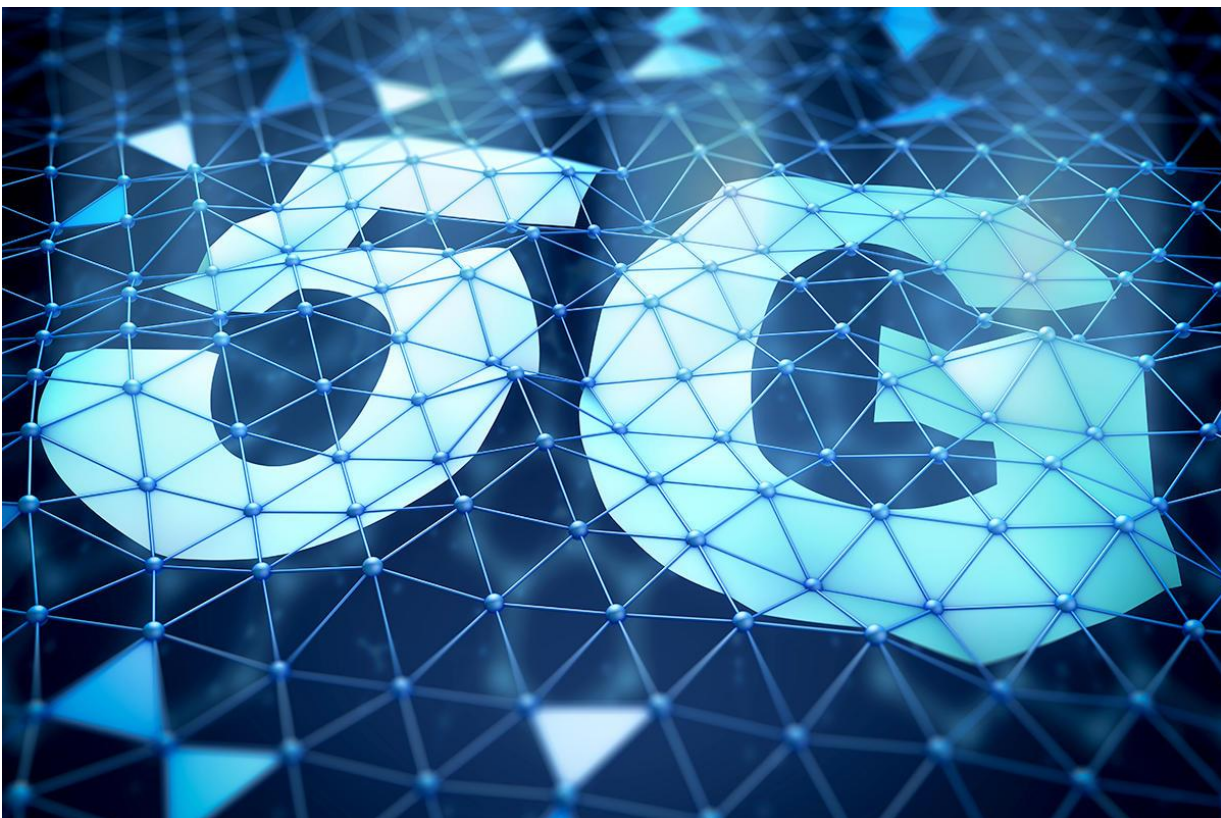
U.S. DEPARTMENT OF COMMERCE  
National Telecommunications and Information Administration  
Office of Spectrum Management  
FEBRUARY 2016



# United States Frequency Allocations – The Radio Spectrum: US Department of Commerce – January 2016



5G satellite space view pointing down to earth communications coverage.



5G from above looking down shows the web of immersion imposed on everyone.



## Enterprise Architecture Fifth Generation (5G) Wireless



Visual of what 5G looks like showing total immersion of everyone in the web.



Cool 5G graphic!