From Here to5G

The Good, The Bad & The Ugly…and the Unknown

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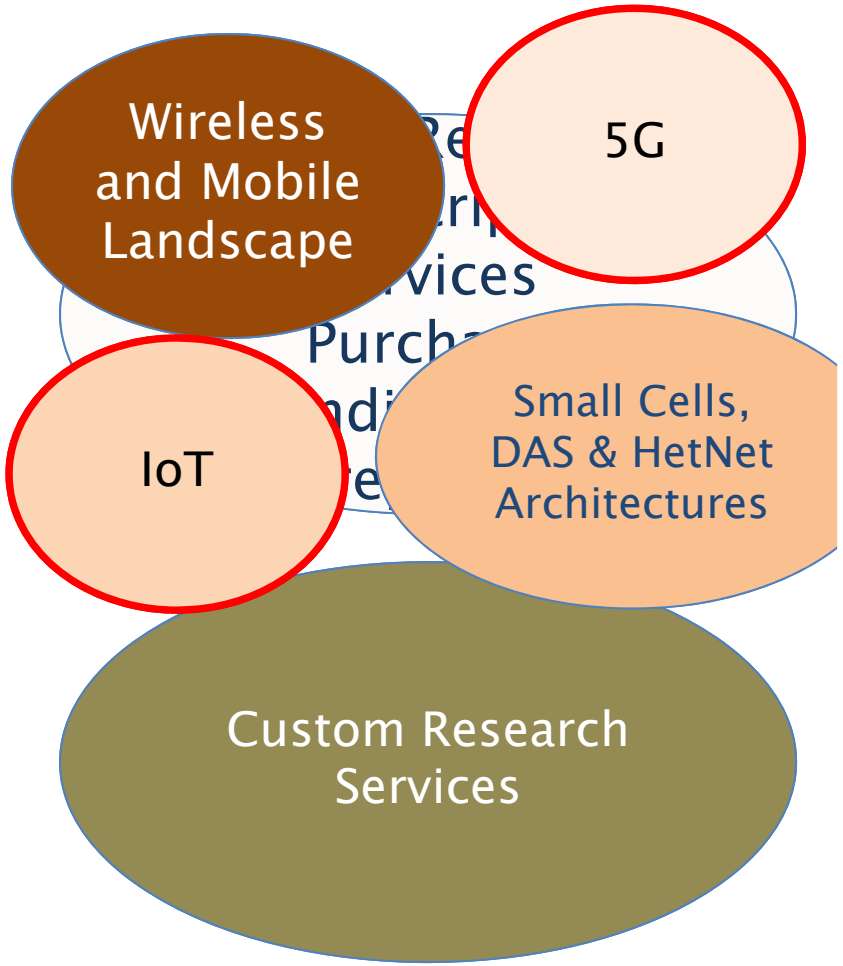
Agenda

- Intro to *iG*R
- What is driving 5G?
- What is 5G, really?
- User driven requirements
- Expected timeline for 5G deployment
  - And pre-5G
- Components of 5G
- 5G Issues
- Spectrum possibilities
- Potential revenue sources
  - And how much
- Global growth model
- Summary

iGR's Products and Services



5G research so far…

Soon: 5G Economics in the U.S

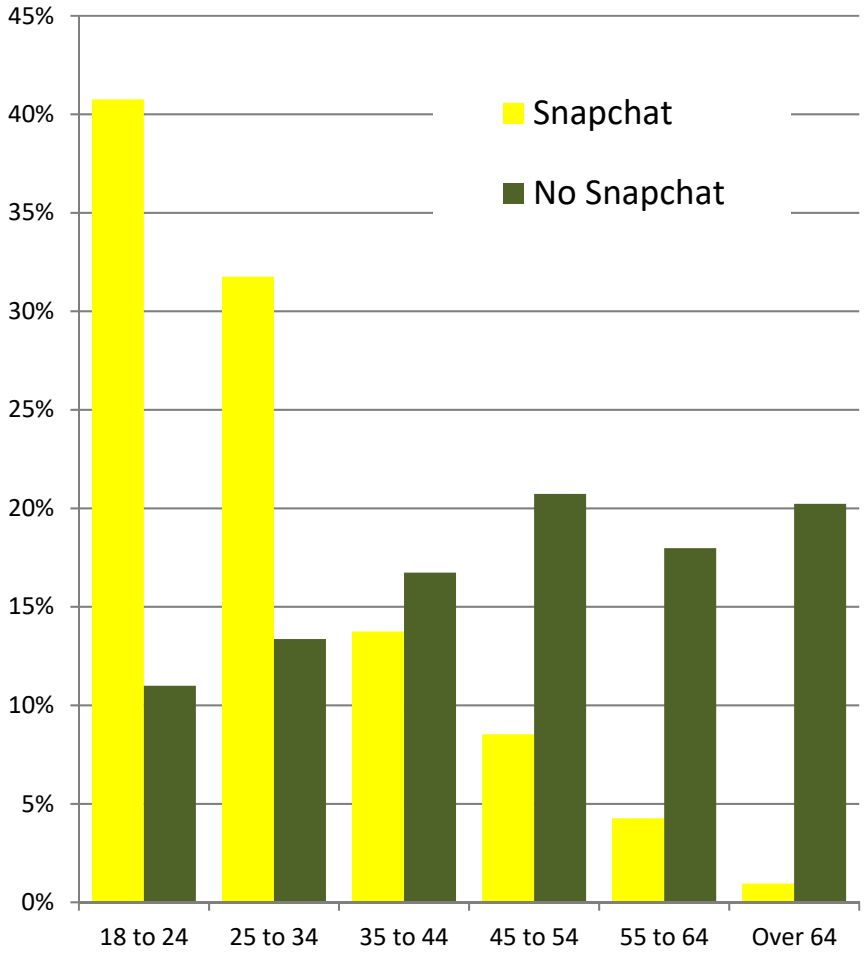
U.S. Mobile Data Forecast by Spect Band, 2015 – 2020: The Impact Densification

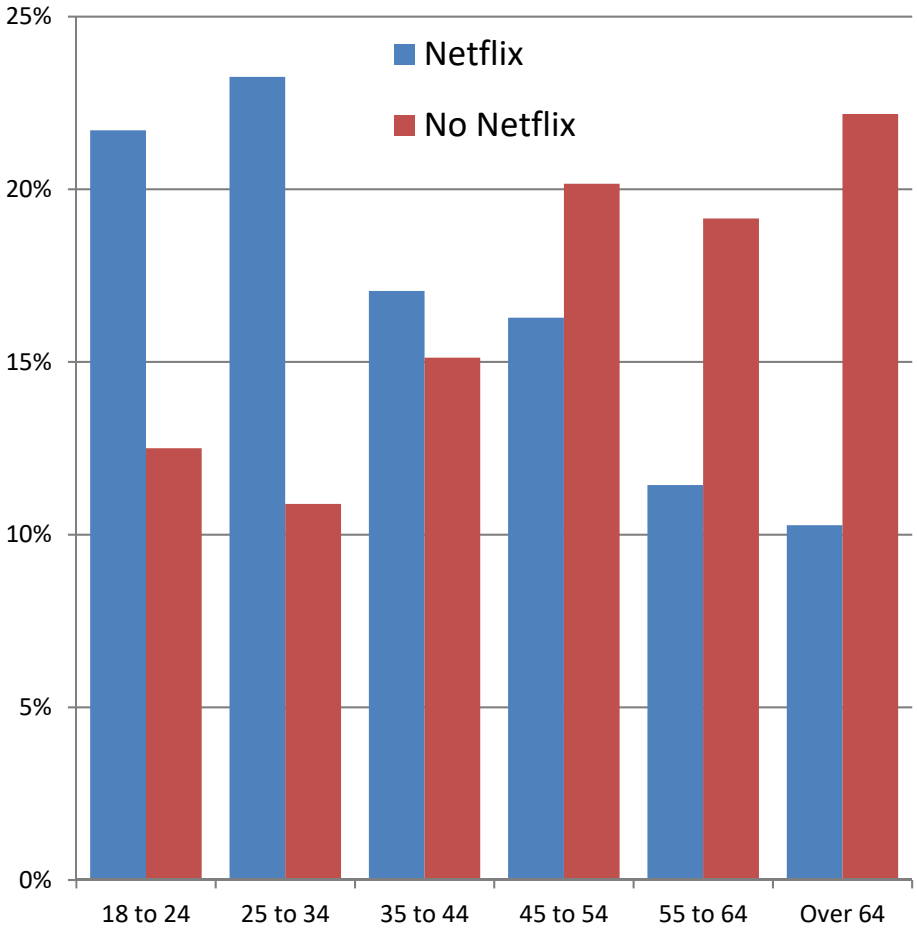
Global 5G: Connections and Bandwidth Model 2021-2026

5G in the U.S.: What will it cost build?

More reports in the works…

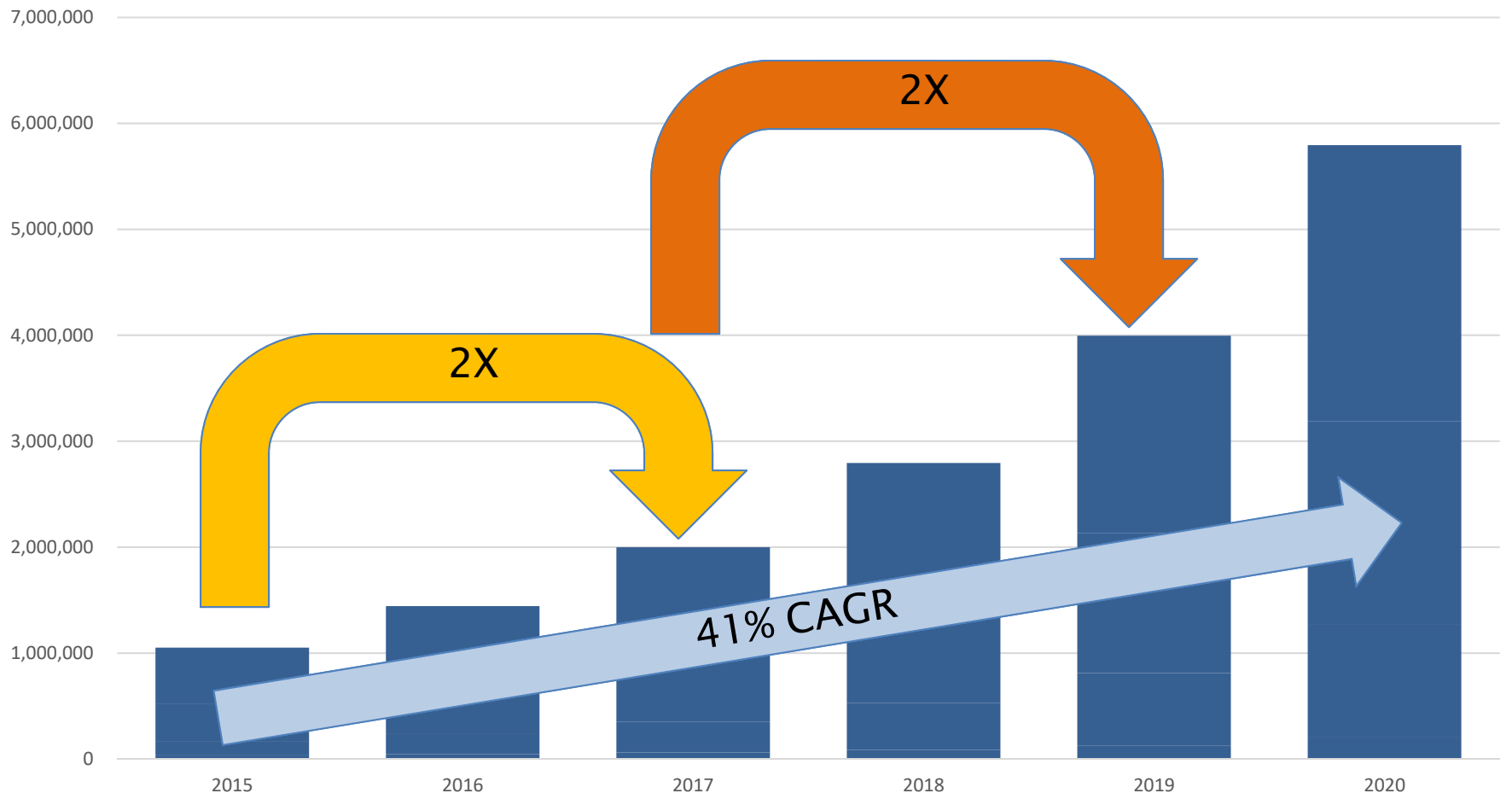
Age of Netflix and Snapchat Users





Source: *iGillottResearch, Inc, 2017*

North America: Total Mobile Data Traffic (TB/month), 2015–2020



Source: *iGillottResearch, Inc, 2017*

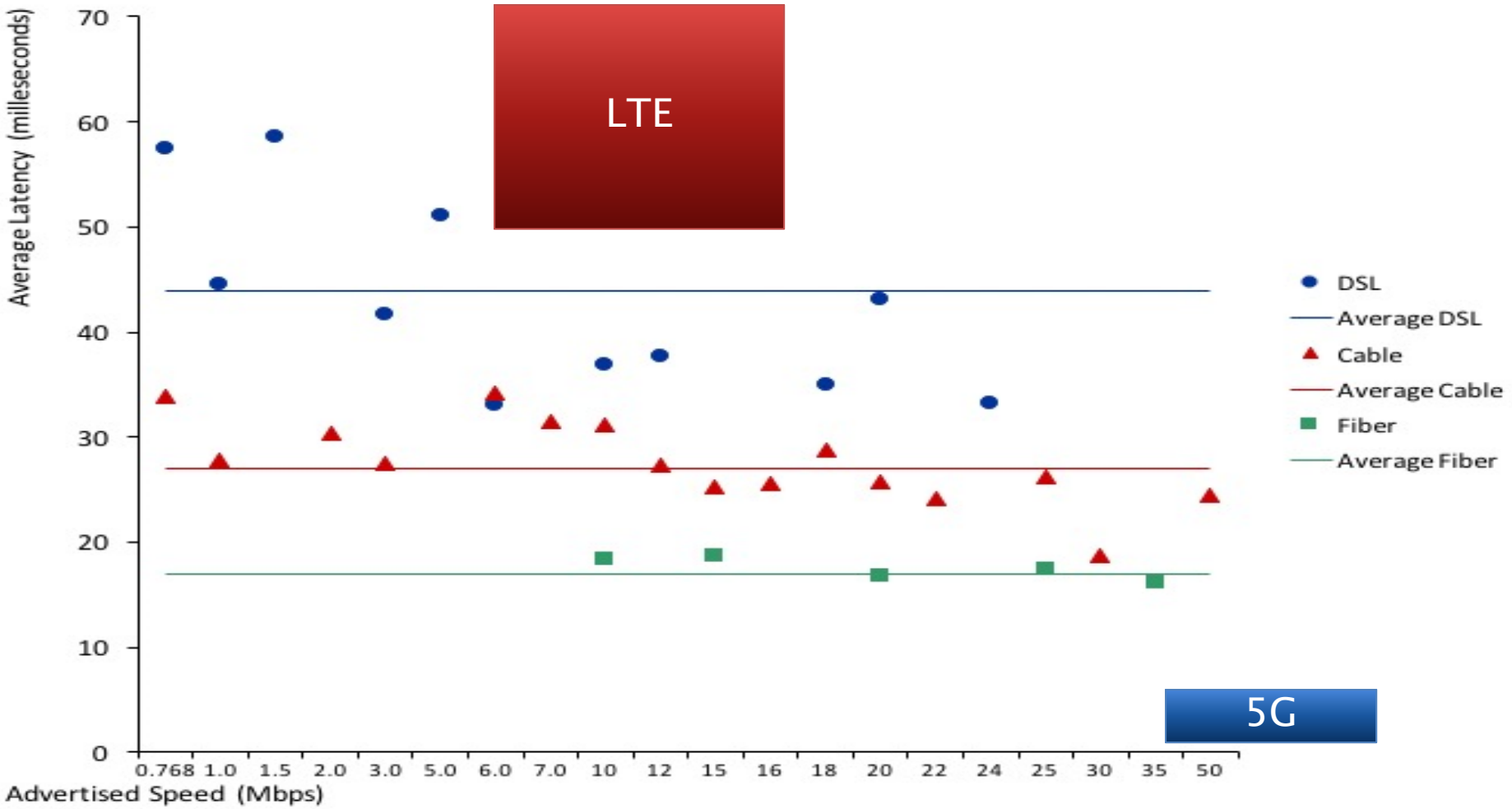
What is 5G, really?

- Many different definitions and descriptions of 5G
  - And more added each day…☺
- Most common is the technical specification for IMT-2020, just as 4G was defined by IMT-2000
- Some operators discussing first 5G deployments in 2017 or 2018
  - These will be pre-IMT-2020 networks
  - Will likely meet some of the 5G requirements…
  - …but not all
  - Muddy the '5G' branding
- Basically, more bandwidth, lower latency mobile network service
  - Includes broadband to the home
- *By the time we get to IMT-2020 5G, some operators will be marketing '7G'…☺*

5G User-driven requirements

- Battery life: better
  - Has been a requirement of every network technology since analog
  - Applies specifically to IoT for 5G – battery life measured in years
- Per user data rate and latency: better
  - New "tactile Internet" which means 100x increase in data rate and a 5x-10x reduction in latency
  - Support for fixed broadband applications
  - Poor name ☺
- Robust and resilient
  - 5G may end up being the only communications network for many people
- Seamless experience
  - High data rates and low latency regardless of where you are
  - Interruptions of a few milliseconds for both inter-RAT and intra-RAT handovers
  - Latency on certain apps of 1 millisecond (UHD video, tactile Internet)
- Context aware
  - 5G network to provide the correct resources to meet the unique needs of each application and device, especially with Machine Type Communications

Average Wired Broadband Latency, 2014



Source: FCC, 2014

First 5G Services

- Likely to include some or all of the following:
  - High bandwidth services for mobile devices, including support for HD video
  - Support for fixed wireless video and Internet services, including HD video
  - Some type of "evolved" IoT use case that goes beyond today's examples
    - More than metering, connected cars and homes, and B2B applications that connect stoves and vending machines to their owners' back-end systems
  - Wide-support for advertising-driven business models to support new mobile business cases
  - Support for network 'slicing' enabling mobile operators to provide private network services to third party organizations
- Many new services to be defined
  - New area of research for *iGR*
- New capabilities not yet imagined
  - LTE Advanced Pro and 5G networks enable new business models

5G Use Cases

- Connected car and automotive more generally, with vehicular internet/infotainment, pre-crash sensing & mitigation, cooperative vehicles, inter-vehicle information exchange
- Augmented reality
- Multi-person video calls
- Tactile Internet
  - The ITU defines this as "extremely low latency in combination with high availability, reliability and security"
- Monitoring of sensor networks
- Smart grid and smart cities: smart transportation, building, home
- M-health and telemedicine
- Sports & fitness
  - Cloud-connected wearables (independent of Bluetooth-based synching)
- Gaming, extreme video
  - Virtual reality, etc., including 4K and 8K video
- Public safety
  - Mission-critical voice, broadband data (security cameras, drones, wireless sensors/tracking)
- And many others…

Problem #1

Many of these use cases can be met with LTE Advanced Rel. 11 and 12

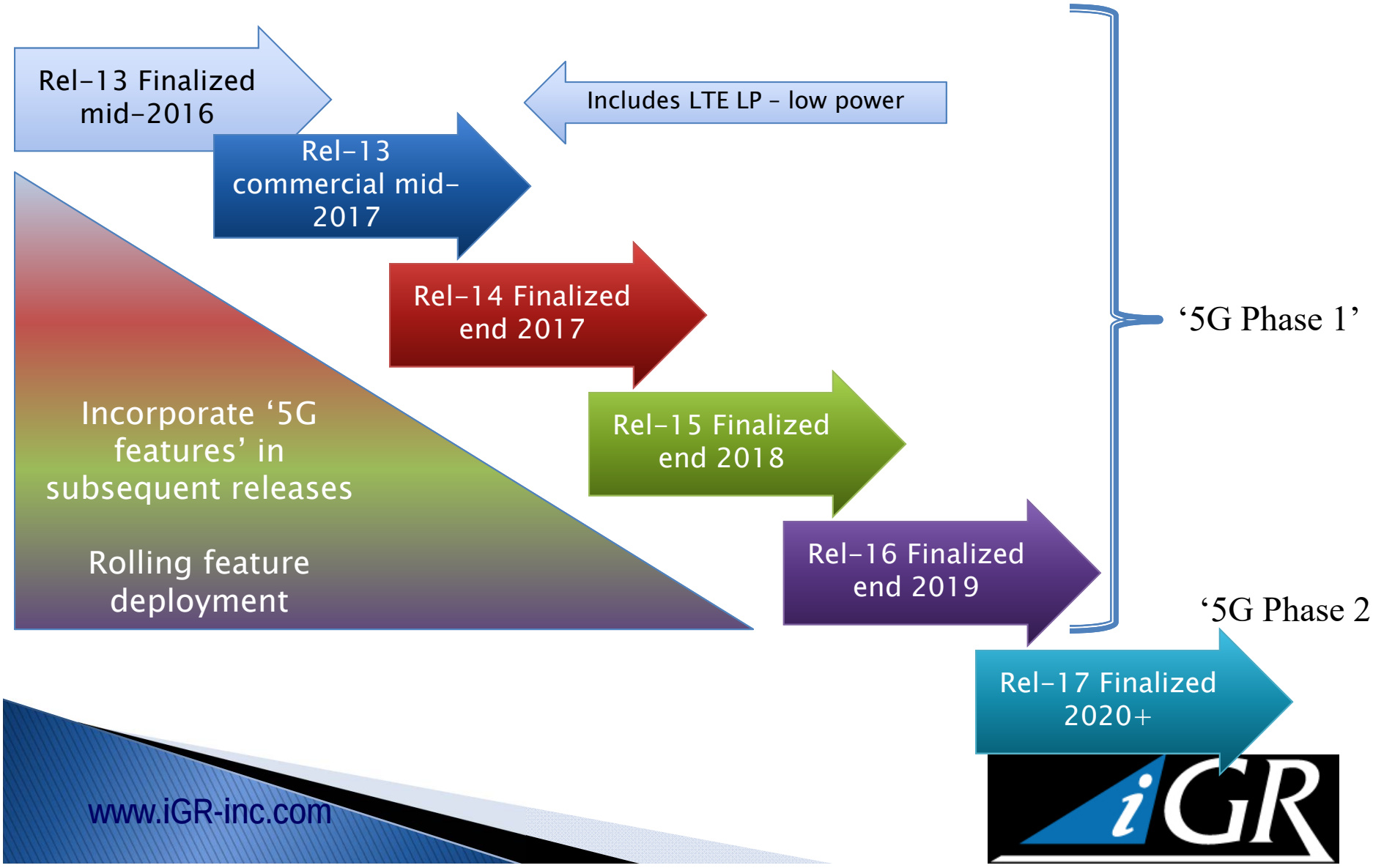
Problem #2

More advanced 5G use cases can be met with LTE Rel. 13 and 14

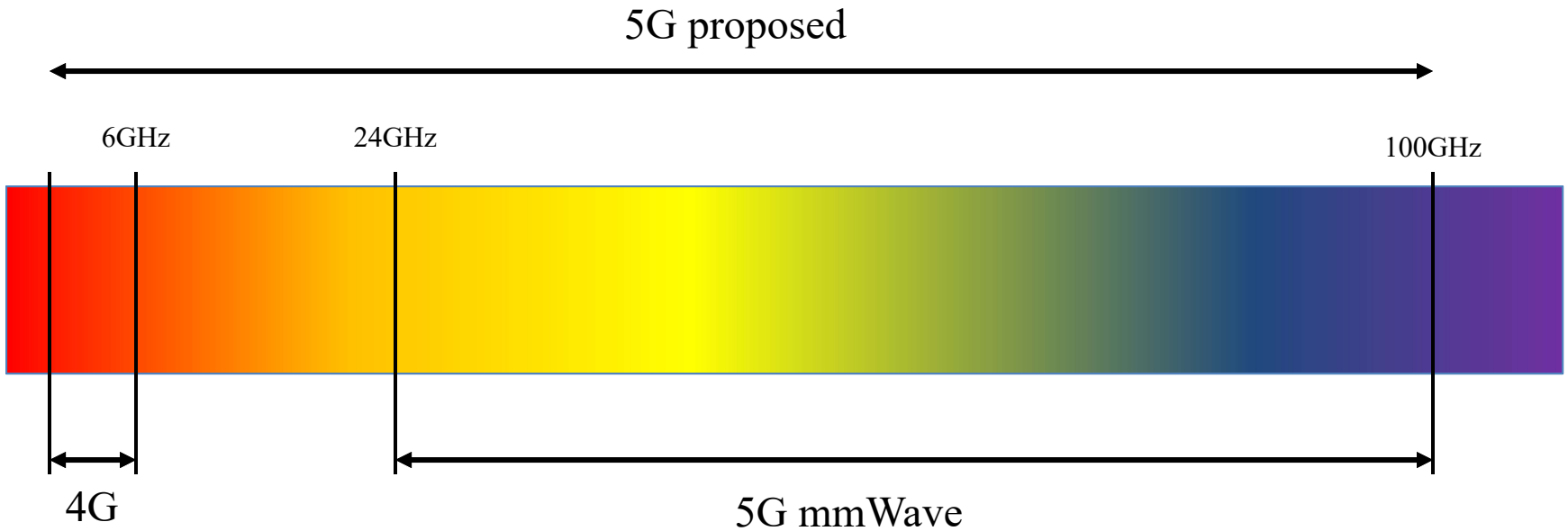
5G Network Requirements

- Massive MIMO
- RAN transmission
  - Centimeter wave
  - Millimeter wave
- New waveforms
  - Optimized OFDM
- Shared spectrum access
- Simultaneous Transmission Reception
- Multi-RAT integration and management
- Device-to-Device communications
- Efficient small data transmission
- All of the improvements made to LTE via the 3GPP's Release 12, 13 and 14
  - Includes need for MEC and edge data centers

Pre-5G LTE Releases



Move to higher bands …and large bandwidths



Source: Qualcomm, 2016

Potential 5G Spectrum Bands

Frequency Band	Bandwidth	eMBB	Device availability	Europe	US	Japan	Korea	China
3.4-3.8GHz	400MHz	😗	😀	😀	😗 3.4-3.7GHz only	😗 For 4G	😀	😗 3.3-3.6GHz only
3.8-4.2GHz	400MHz	😗	😀	😱	😱	😗	?	😱
4.4-4.99GHz	500MHz	😗	😀	😱	😱	😀	😱	😗 4.4-4.5, 4.8-4.99GHz only
5.15-5.35GHz	200MHz	😗	😀	😗 Indoor only	😀	😗 Indoor only	😗 Indoor only in 5.1-5.25GHz	😗 Indoor only
5.47-5.85GHz	380MHz	😗	😀	😗 Not above 5.725GHz	😀	😗 Not above 5.725GHz	😀	😗 Not above 5.725GHz
24.25-27.5GHz	3,250MHz	😀	?	😀?	😀? 24.25-24.45GHz 25.05-25.25GHz	😗	😗 Unlic band used for V2V	😱
27.5-29.5GHz	2,000MHz	😀	?	😱	😀 27.5-28.35GHz	😗	😀	😱

Source: NTT DoCoMo, 2016

One problem that needs to be addressed

Consumers are unable and/unwilling to pay significantly more for mobile broadband service that they do today
Ergo: Consumer Mobile ARPU ≠ Funding for 5G

Categorizing 5G Revenue Sources

Mobile Broadband

Will provide *some* revenue – more than likely similar to today's ARPU

Obviously, ~300 million potential consumer customers

Home Broadband

What we know today as DSL, FTTH, Cable Modem

~110 million U.S. homes
~7 million U.S. small businesses

Why give up traditional broadband connection?

Source: iGillottResearch, Inc, 2017

Categorizing 5G Revenue Sources

Entertainment

The Netflix model?

Another model?

Good content not limited to broadcast/cable TV

Can mobile operators be content distributors or creators?

AT&T – DirecTV?

Advertising

Specifically video and entertainment

Emulates the Internet model?

How do you overcome ad-blockers?

Insert in the entertainment stream?

Consumer willing to get ads?

Categorizing 5G Revenue Sources

IoT

Can be provided with LTE, LP LTE, LPWAN, etc

Does not *need* 5G

Hundreds of millions of potential connections in multiple market segments

Some revenues likely available

Network Slicing

Carve out network resources for specific entities/apps

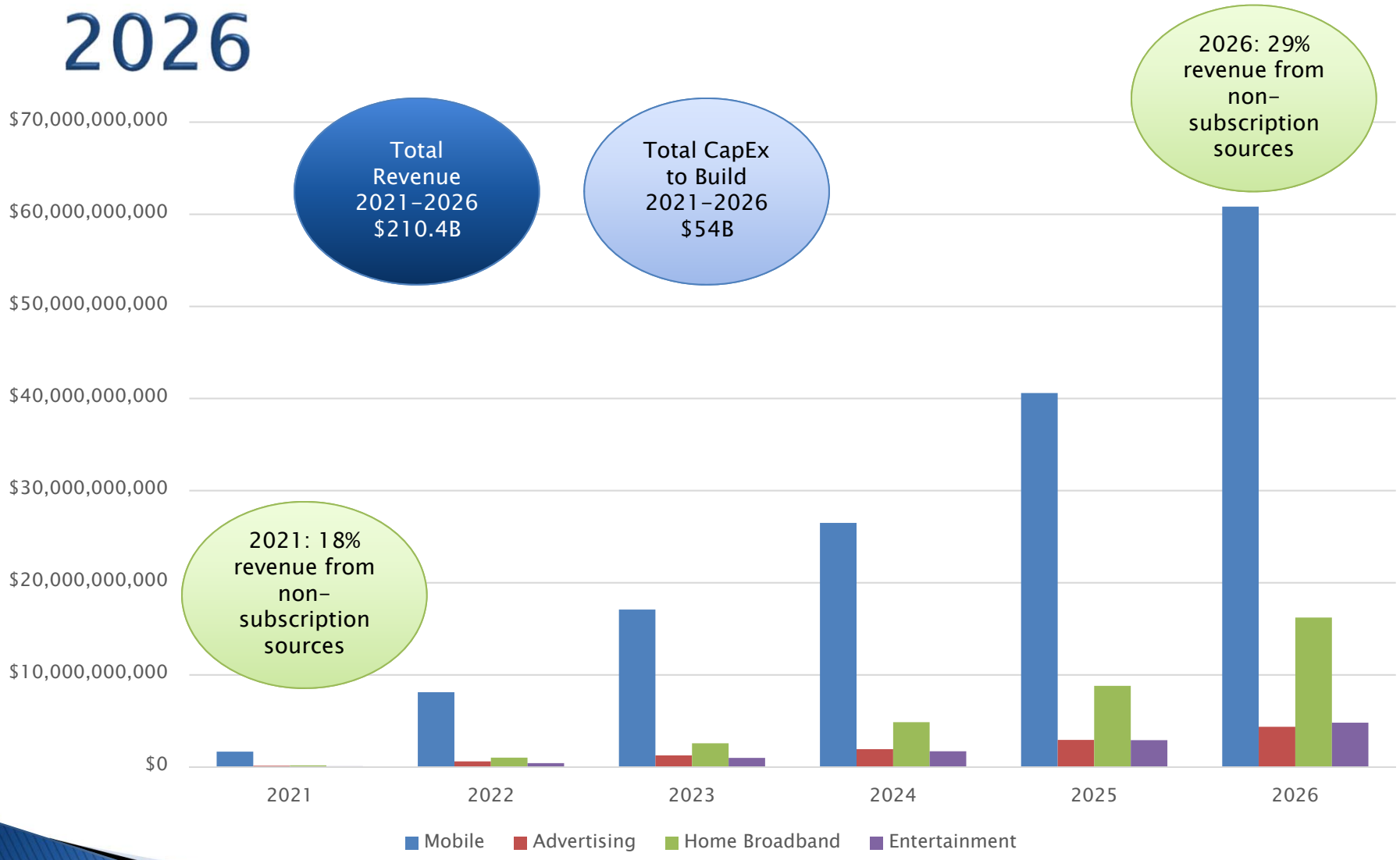
Corporation supports employees

Brand/app/service provides bandwidth

Unknown revenue potential

Net neutrality?

U.S. 5G Potential Revenue, 2021–2026



Source: iGillottResearch, Inc, 2017

What this all means

- Confused? You should be ☺
  - Multiple definitions of 5G
  - Multiple development paths
  - Many companies discussing timing
  - Many companies talking about capabilities
- In reality, one 'true' 5G definition: IMT-2020
  - Expected in 2020 and not before
  - But 3GPP 5G features will be available before then
- Economic justification for 5G unclear
  - Do not believe that IoT will justify this level of investment
  - Can consumers really justify paying for more bandwidth?
  - Video delivery can be addressed by LTE
- Some operators likely to introduce '5G' services in 2017 or 2018
  - Technically pre-5G
  - How will other operators react? 'Me-too'?
  - IMT-2020 could be 7G by the time we get there…
- 5G features released by 3GPP mean that 5G deployment will be gradual, not a 'switch' like LTE was
  - Likely that some operators will define 5G as Rel. 14 and higher or market '5G features'
  - Confusion

What this all means…

- *iG*R 5G model shows connections and bandwidth for 2021 – 2026
  - Major assumptions made in the model
  - Will be proven or amended in the next few years
- IMT-2020 will be based on LTE evolutions and basic infrastructure
  - New network topologies
  - But uses the groundwork
  - Next few years therefore key to 2021 – 2026 5G market development
- Significant 5G growth
  - Vaires by region
  - Massive bandwidth growth
- Advertising and entertainment new areas for mobile operators
  - Many questioning if they can be successful in this area
  - Why not? Would you have picked Netflix over Blockbuster, NBC/ABC/CBS or HBO five years ago?
- New business models yet to appear
  - Remember we have four years before 5G commercial service launched
  - Time for new business models, apps/services to emerge
    - Snapchat launch ~2012
    - Instagram launched ~2010
  - What is out there now that could help drive 5G?

Questions?