Sharing the C-band: Better Broadband for 80 Million Americans

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With introduction by Claude Aiken, WISPA
& additional comments by Andrew Clegg, Google

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The Problem

- Tens of millions of Americans have no, or slow, broadband
- Thousands of fixed wireless providers can cost-effectively serve remote and other areas, but are often spectrum-constrained
- Much government & commercial licensed spectrum lies fallow, particularly in rural America
- Sharing spectrum can be a solution to this problem

The Opportunity

- The FCC is looking at changing or expanding the use of the 3.7-4.2 GHz satellite downlink band (i.e., “C-band”)
- Some portion may be cleared of satellite operations and auctioned for flexible/mobile use
- Remaining satellite operations will be repacked into that portion of the band that is not cleared
  - The Commission is considering allowing sharing between satellite earth stations and point-to-multipoint (P2MP) systems in this part of the band

What is the C-band?

- The C-Band (3.7 – 4.2 GHz) is primarily used for receiving content via satellite beamed to fixed earth stations
- Most earth stations are currently over-protected, with large exclusion zones across the entire 500 MHz of C-band spectrum
- The focus should be on making C-band spectrum available for terrestrial use while not harming existing operations
  - Flexible/mobile – 200 MHz cleared & exclusive licensed use
  - Fixed/P2MP – Share remaining 300 MHz with repacked earth stations

Sharing better utilizes C-band spectrum

- Existing terrestrial use for fixed service: how much more can we get out of it?
- Initial work by WISPA, Google, and others showed positive possibilities for sharing, even in same channel, much closer to the earth station than initially thought possible
- Coordination ensures spectrally efficient coexistence among all services – earth stations and fixed wireless
- This sharing plan would provide ample spectrum for P2MP wireless deployments at near-gigabit speeds “overnight”

Sharing C-band means fewer caught in digital divide

- Will quickly bring more broadband access for all Americans, including unserved/underserved communities
- Will help bridge the divide by delivering broadband at near-gigabit speeds most anywhere in the US
- Will bring more rural Americans into digital economy, enabling more robust precision agriculture, distance learning, telemedicine, IoT, entertainment, etc.

Technical Study: How much C-band sharing is possible?

- Over a year ago, we conducted a study to show sharing was possible. Since then, WISPA, Microsoft, and Google retained Professor Jeff Reed and his colleagues to gut-check those results
- Initial work showed promise, and the latest study confirms: P2MP can co-exist using the same frequencies as the earth stations
- Initial work studied a subset of earth station data available at that time. The current study uses all recently-submitted registration data (even data not yet accepted by FCC)
- **The study shows that more than 80 million Americans could quickly benefit from better broadband access and new broadband competition**

Improving Spectrum Utilization

"We no longer have the luxury of over-protecting incumbents via technical rules, enormous guard bands, or super-sized protection zones. Every megahertz must be used as efficiently as possible."

– *FCC Commissioner Michael O'Rielly*

Speaking at Wi-Fi Alliance, Washington D.C., June 4th 2019

3.7-4.2 GHz FSS and Fixed Wireless Access Co-channel Coexistence Study Summary

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July 2nd 2019

Study Sponsors:

WISPA

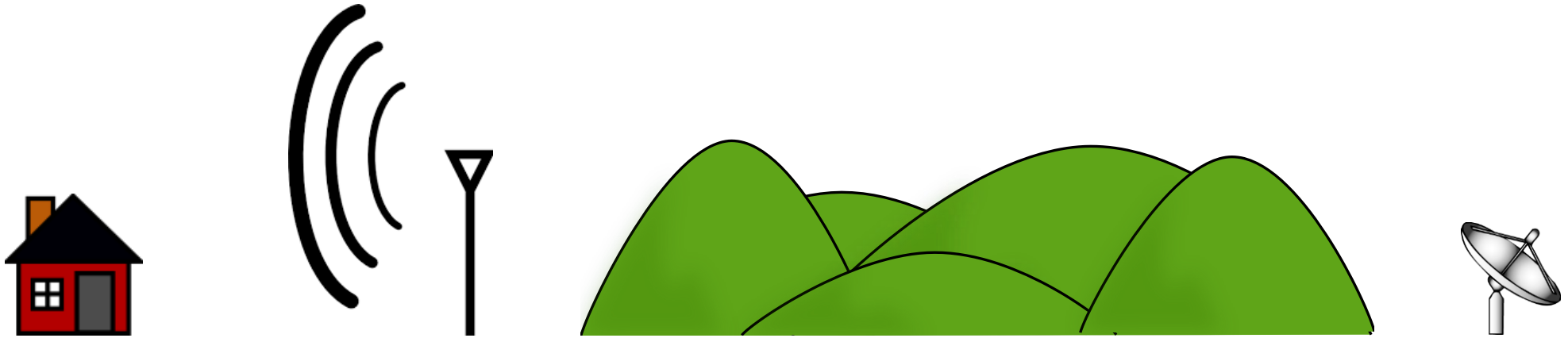
Microsoft

Google

Summary & Conclusions

Exclusion zones of about 10 km are sufficient to protect most fixed-satellite service (FSS) earth stations from harmful interference caused by properly-engineered co-channel point-to-multipoint (P2MP) broadband systems.

P2MP systems operating outside the exclusion zones could provide gigabit broadband access to more than 80 million Americans, particularly those in underserved communities.



Inputs & Key Assumptions

FCC database of 18,000+ FSS earth stations subsequent to 2018 registration filing window.

FCC FSS antenna gain pattern envelope.[1]

FCC FSS interference criterion[2] (same criterion used for adjacent-band CBRS).

Industry-standard (3GPP/ITU-R) rural macro non-line-of-sight propagation model.[3]

Nominal point-to-multipoint broadband system architecture

- 80 W base station (BS) and 20 W Customer Premise Equipment (CPE) effective radiated power per 20 MHz
- 35 m BS and 7 m CPE antenna height
- Industry-standard (3GPP) antenna model[4] with 6 deg downtilt

Co-channel operation of P2MP and FSS

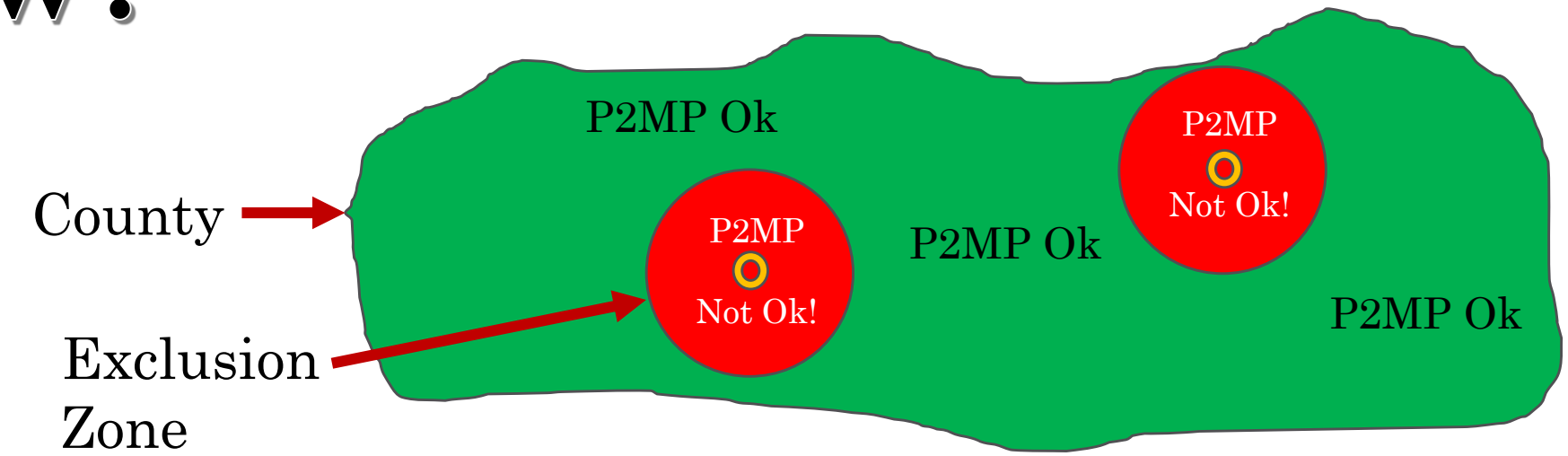
[1] 47 CFR 25.209(a)(1)
[2] -129 dBm/MHz based on 47 CFR 96.17(a)(2)
[3] ITU-R M.2135
[4] 3GPP TR 36.873, v12.5.0

Sharing the 3.7-4.2 GHz Spectrum

Provide P2MP broadband access in shared C-band spectrum while protecting the incumbent FSS earth stations

How?

Answer: Determine the Exclusion Zone around an FSS earth station based on detailed **co-channel interference** analysis!



Key Considerations

FSS earth stations point upwards towards satellites. They are specifically designed to mitigate their response to signals arriving from the horizon (i.e., from terrestrial P2MP links). The FCC's FSS beam pattern envelope (47 CFR 25.209(a)(1)) takes this into account and was used in this study.

P2MP antennas are directional and are designed to place energy where it's desired (toward customers), and to greatly reduce emissions in directions where they are not desired (toward earth stations). The 3GPP beam pattern, used in this study, takes this into account.

Clutter (buildings, trees, etc.) will greatly reduce the strength of any stray signals arriving at earth stations due to P2MP emissions. The propagation model used in this study takes that into account.

Propagation Model

Propagation models are key to any interference analysis.

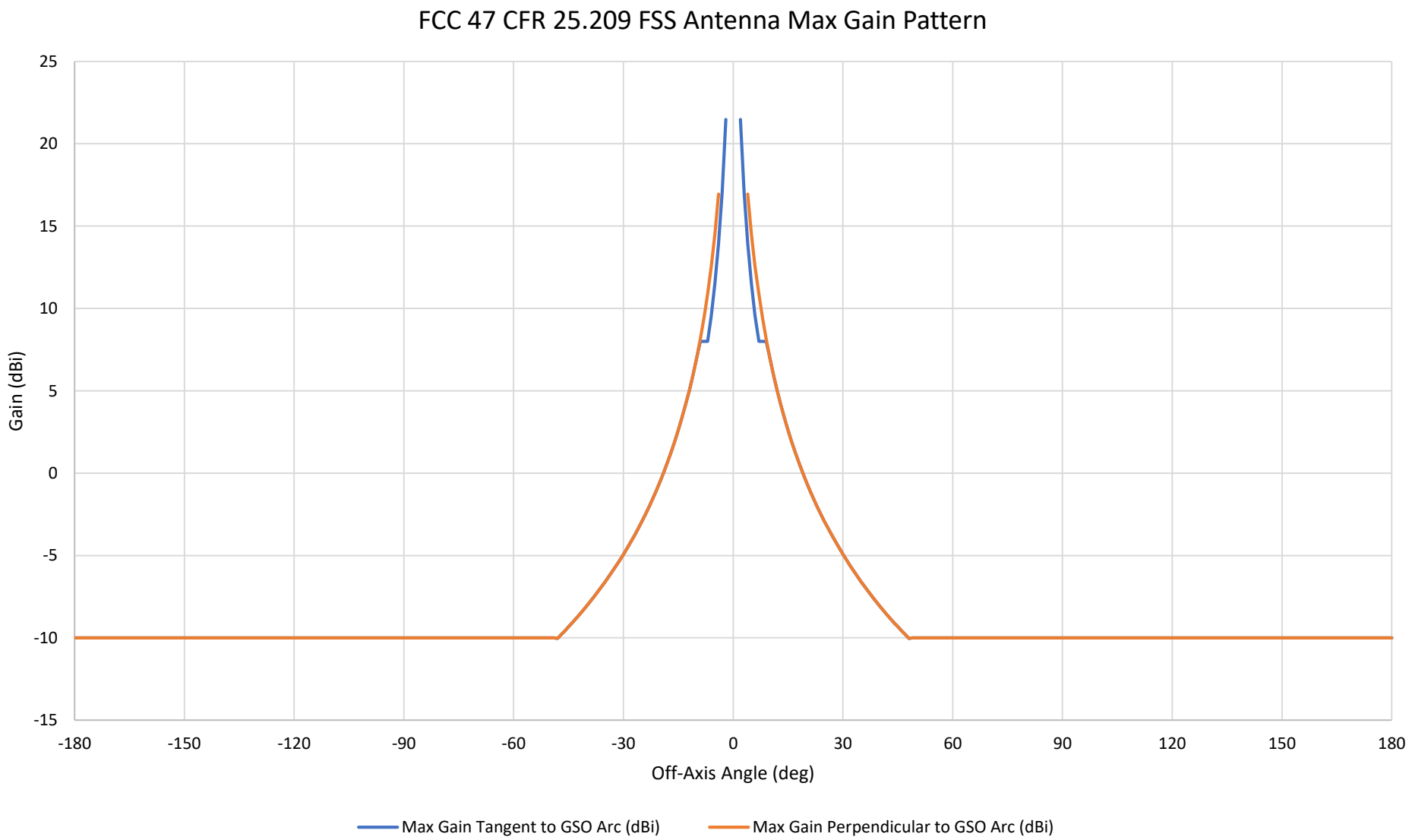
We chose a non-line-of-sight model because it better reflects reality: Terrain, trees, bridges, gas stations, churches, residences, water towers, barns, restaurants, silos, berms, (the list goes on) will almost always separate P2MP systems from FSS earth stations.

The 3GPP TR38.901 model predicts less than a 0.0046% chance of having a completely unobstructed path over a distance of 10 km or greater.

This model is consistent with a large number of propagation loss measurements obtained in the immediately-adjacent CBRS band: "clutter" adds approximately 40-60 dB over terrain-based propagation models.[1]

[1] See *Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, GN Docket 12-354, comments of Google Inc., filed Feb 16, 2016; specifically Fig. 4 of Clegg Declaration. Document available at https://ecfsapi.fcc.gov/file/60001462642.pdf

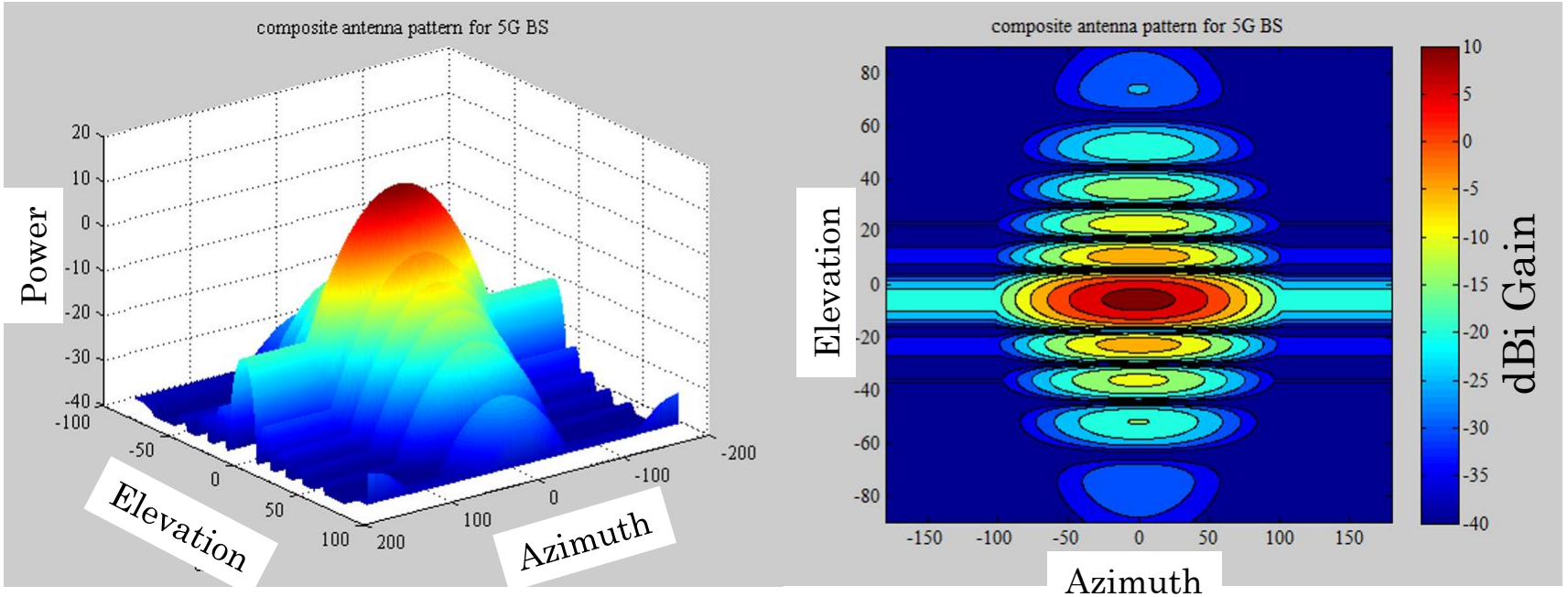
FSS Antenna Pattern



P2MP Base Station Antenna Pattern

3D Antenna Pattern

Look-Down 2D View



Roughly 120 degrees sectorization.

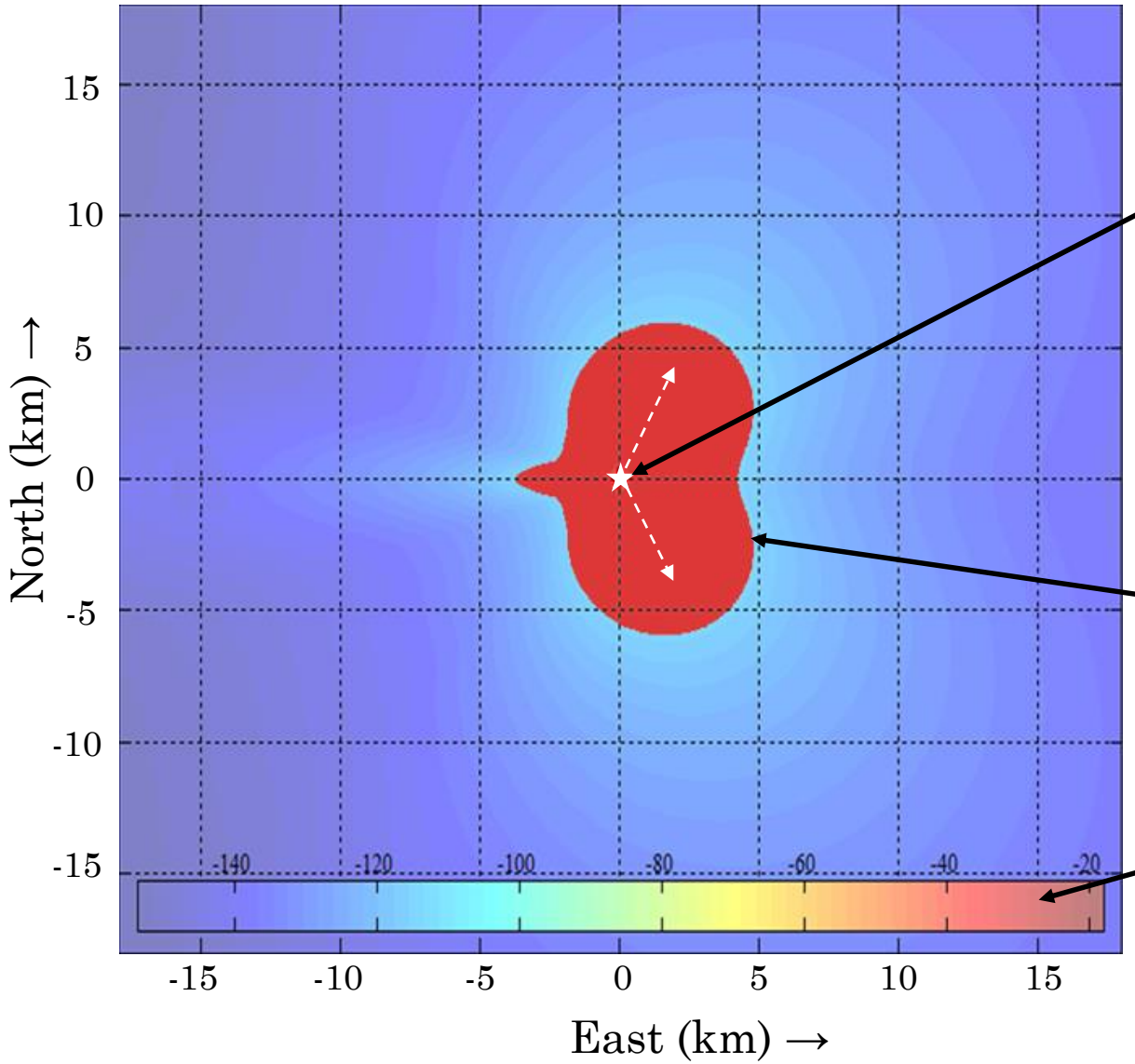
- ✓ 12 dBi Peak Antenna Gain
- ✓ Based on 3GPP TR 36.873

Example Analysis: Single P2MP Base Station

This plot shows the predicted interference from a P2MP base station received by an FSS dish pointed east with an elevation angle of 10 deg, at any point within about 15 km of the base station.

In the red zone, the predicted signal level into the FSS exceeds the interference criterion. This constitutes the exclusion zone for this particular scenario.

For more complex scenarios (i.e., multiple base stations and CPEs), the exclusion zone will be somewhat larger.



Base station with two beams, one pointed northeast, one pointed southeast

Exclusion zone in which predicted signal strength into FSS exceeds -129 dBm/MHz (-116 dBm/20 MHz)

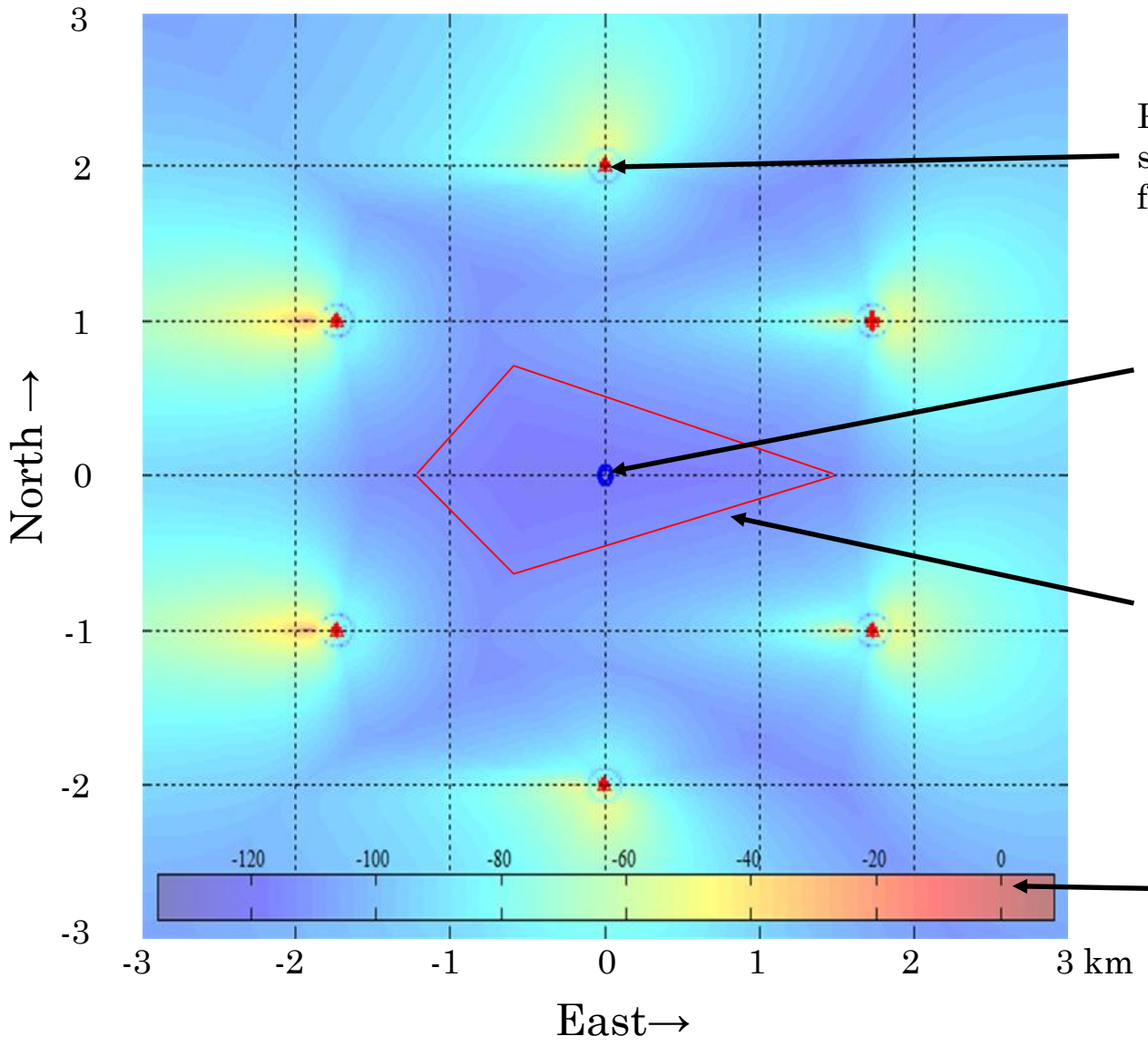
Color key of P2MP signal strength received by FSS (in dBm/20 MHz)

Example Analysis: Multi P2MP Systems Protecting FSS

Similar analysis to previous example, demonstrating a P2MP network design consisting of six base stations whose combined power does not exceed the FSS interference criterion at or near the location of the earth station

The interference objective is met by designing the P2MP network such that no base stations point towards the earth station

Assumes an earth station with 25.209(a)(1) pattern, elevation of 10 deg, azimuth of 0 deg (east)



P2MP base stations (red dots), single beam each (pointed away from FSS earth station)

FSS earth station (blue circle)

Approximate area within which the FSS earth station interference objective is met

Color key of combined P2MP signal strength received by FSS (in dBm/20 MHz). Interference criterion is -116 dBm/20 MHz

Simplified Analysis Workflow

1. For each county in the U.S.:
    1. Retrieve list of FSS earth stations in the county
    2. Compute area covered by exclusion zones for each earth station
    3. Calculate population within county outside of exclusion zones
2. Sum population outside of exclusion zones across the U.S.
3. Run analysis for simple (single P2MP base station) and more complex scenarios (multiple base stations/CPEs)

Key Results

Radius of the Exclusion Zone	Potential P2MP Coverage	
	P2MP Coverage Area (million square km) (U.S. Land Area: 7.7million km^2)	Number of P2MP Beneficiaries (millions) (U.S. Population: 327 M)
10 km	6 million km^2 (78%)	81 million people (25%)

- ✓ Population is assumed to be distributed uniformly within a county
- ✓ These are conservative estimates. The actual geographic area and the number of people benefitting from P2MP coverage would be somewhat larger than the values shown here (see next slide)
- ✓ The greatest availability (population-wise) tends to be in rural and less-densely populated areas

Our Analysis is Conservative

Non-fully-loaded P2MP Base Stations would transmit less power and cause less interference.

Distribution of frequency resources (“Resource Blocks” or radio channels) among active CPEs in a sector would reduce power per MHz, because the CPE would distribute its transmit power among larger transmission bandwidths.

Currently, only one sector of the P2MP BS toward the earth station is turned off; in practice, more accurate network planning & design can be carried out to further reduce interference for fixed P2MP deployments.

CPEs are assumed to be mounted at 7-10 m height. Real installations are often lower.

Low-pointing earth station dish.

Fixed 5G New Radio (NR) uses narrower and device-specific beamforming even for non-traffic transmissions, further reducing interference (instead of 4G blanket sector-wide transmissions).

Summary & Conclusions

Exclusion zones of about 10 km are sufficient to protect most fixed-satellite service (FSS) earth stations from harmful interference caused by properly-engineered co-channel point-to-multipoint (P2MP) broadband systems.

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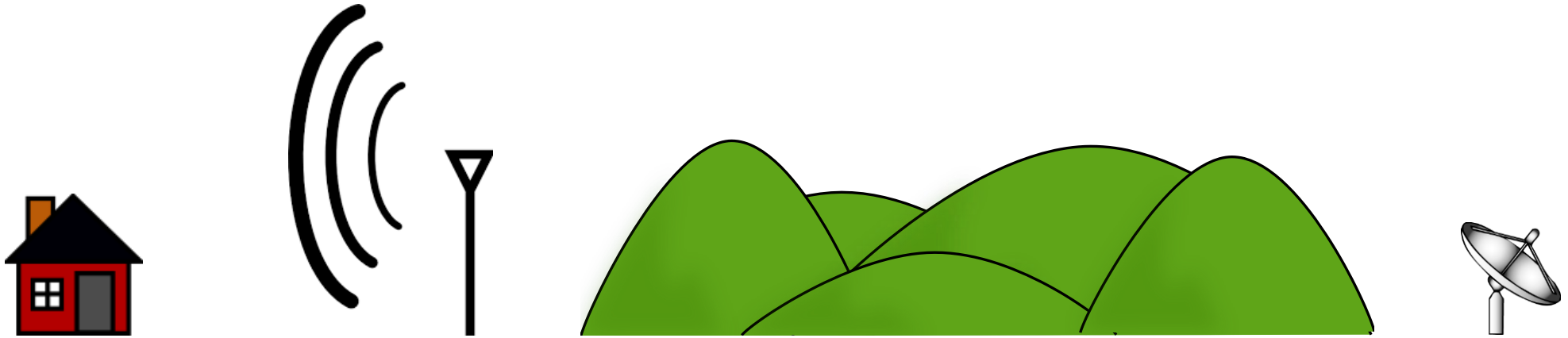

Additional Considerations

Dr. Andrew Clegg
Google LLC

July 2nd 2019

Public Benefits

- **Point-to-multipoint in shared C-band spectrum can provide gigabit fixed wireless access for over 80 million Americans**
  - 300 MHz x 4 bits/second/Hz = 1.2 Gbps gross throughput
  - 300 MHz of spectrum is:
    - Six times greater than the amount of mid-band spectrum currently available for Wireless ISPs in the 3.65 GHz band today
    - Twice as much mid-band spectrum than is available in the entire CBRS band

No Interference

- **P2MP will not cause harmful interference to co-channel FSS**
  - The study results clearly demonstrate that P2MP systems can operate *co-channel* with existing earth stations without causing harmful interference, by:
    - Employing “right-sized” exclusion zones
    - Properly designing P2MP systems such that no signals exceeding Commission-declared interference criteria are received at any FSS earth station

Repacking C-band Does not Affect Coexistence

- **Repacking C-band will have <u>no effect</u> on the results of the study**
  - Co-channel sharing with all 18,000+ registered earth stations is assumed from the start
  - The only criterion that matters is the location of the earth stations
    - We note, however, that if the study had considered non-co-channel use, the results would be even more dramatic.
  - The Commission <u>should ban</u> full-arc registrations for the vast majority of C-band earth stations because they have no legitimate ongoing need for it.

All C-band Earth Stations are Considered

- **All C-band registrations have been taken into account**
  - The study includes all 18,000+ C-band earth station registrations in the FCC's database, including many that have not been validated yet by the Commission

Conservative Assumptions

- **The study utilizes several conservative assumptions**
  - Co-channel
  - 100% P2MP duty cycle
  - Greater CPE height than is often used in reality
  - No allowance for specific interference mitigation measures by FSS, such as berms and other site-specific shielding in use at earth station sites

No Impact on Flexible Use

- **P2MP will have no interference effect on flexible use operations in the lower part of the band**
  - The same guard band that will protect earth stations from flexible use operations in the lower part of the 3700-4200 MHz band will also work as a guard band between those flexible use systems and P2MP systems in the upper portion of the band
  - It's likely that no guard band is actually needed to protect flexible use and P2MP use, given that there may be no guard band at all between flexible use systems operating within the lower 200 MHz of the band

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Thank You

- **Questions?**