# Cognitive Radio & The Whitespace Revolution

## A New Zealand Perspective

Sponsored in part by InternetNZ


Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2013 TerraMetrics
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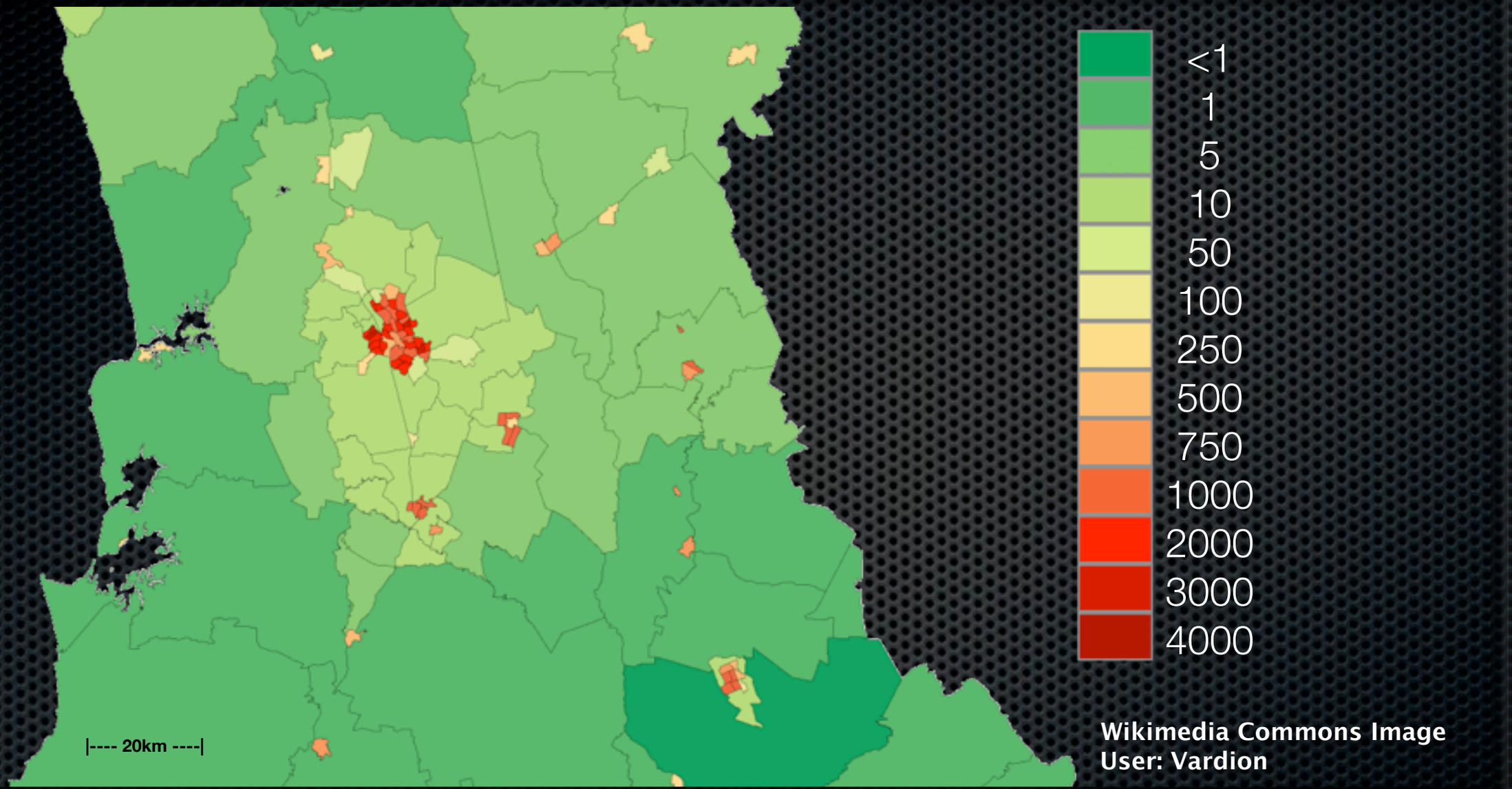
Tour Guide
lat -0.114006° lon 94.919540° elev -4402 m eye alt 12289.42 km
Google earth




# Waikato Region: Population 416,000
# Density: 1-4000 per sq km

West Coast
NZ Average
Auckland Region
AKL/WLG Urban

Cost/Complexity

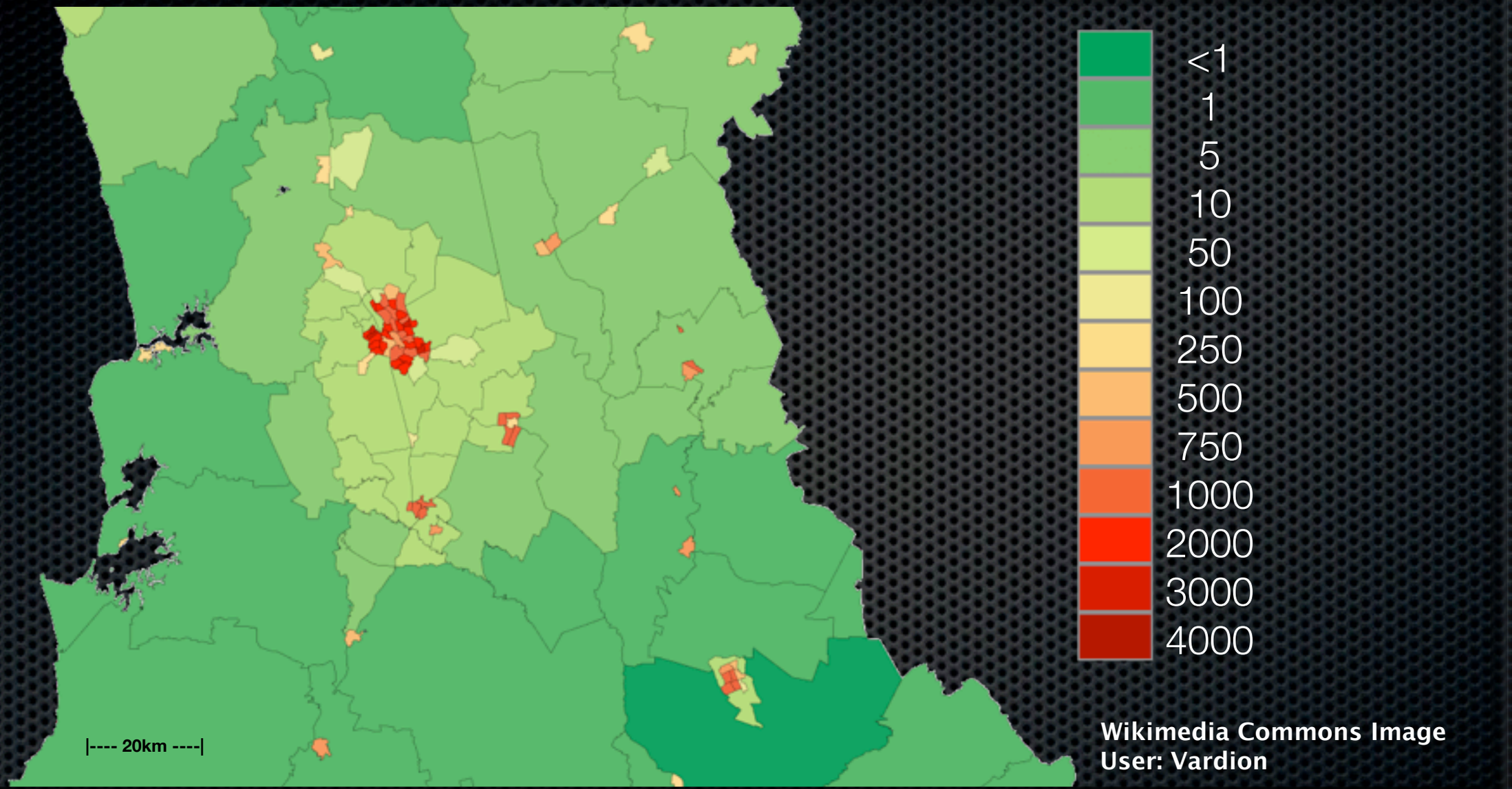
100
90
80
70
60
50
40
30
20
10
0

Fixed Wireless
ADSL
Cable Modem
Fibre Optic
Satellite

**Wireless**
**Satellite**
**Fibre**

0.1
1
10
100
1,000
10,000
100,000

**Lower ← Population Density → Higher**




# Waikato Region: Population 416,000
# Density: 1-4000 per sq km

# Summary: Terrestrial broadband only economic for <50 people / $km^2$

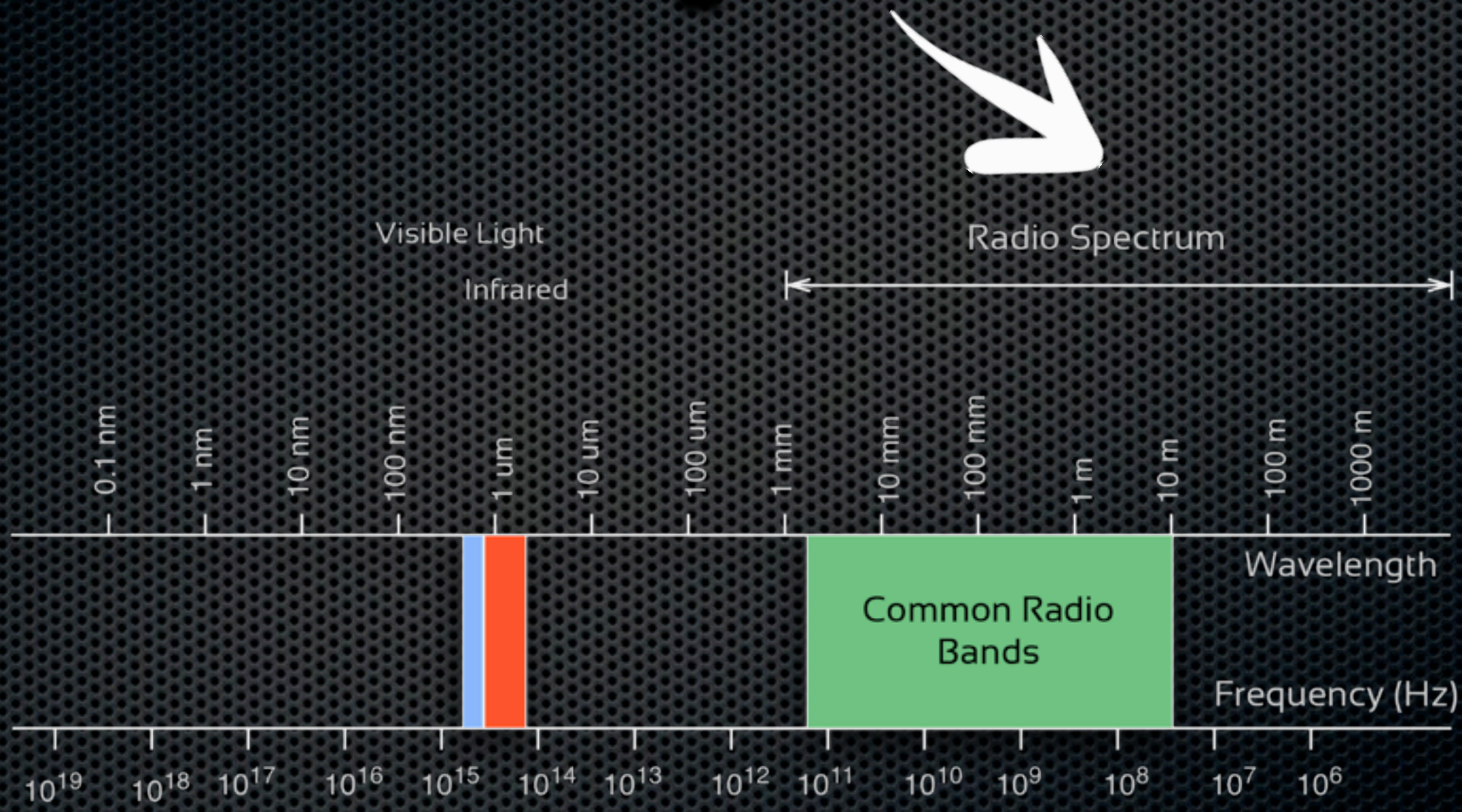
# New Zealand invests $300M in Rural Broadband 2011-2016

Image Credit: http://commons.wikimedia.org/wiki/User:Dschwen

# 45,000 households in New Zealand are still economically excluded.

# What can we do to make broadband more economic for <50 people / $km^2$ ?

# Radio Spectrum




# Electromagnetic Spectrum

# Not All Spectrum is Equal

Frequency

2.4GHz: Wi-Fi

2.1GHz: 3G

1.8GHz: 2G & LTE

900MHz: 3G

700MHz: LTE

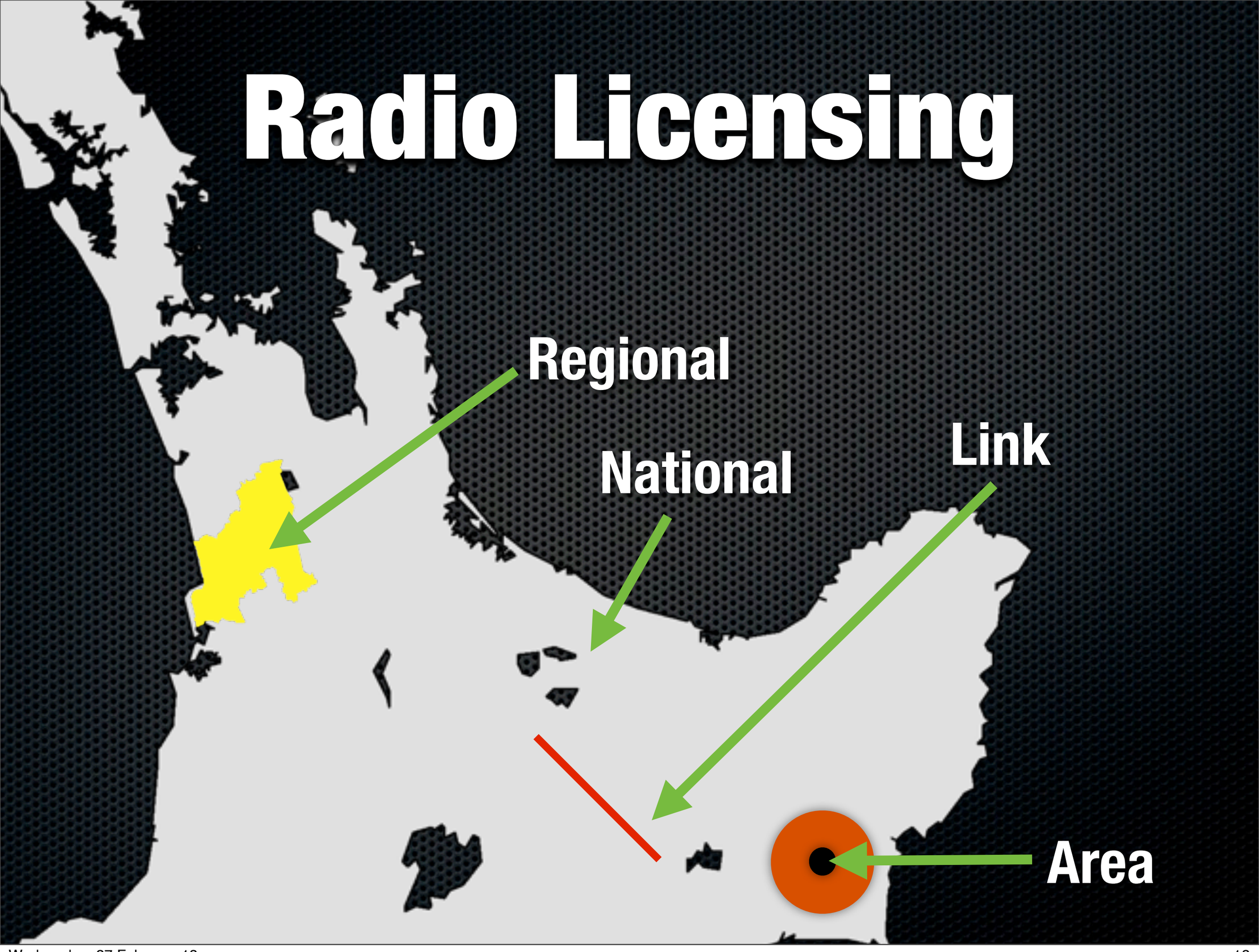
500-700MHz: UHF Television

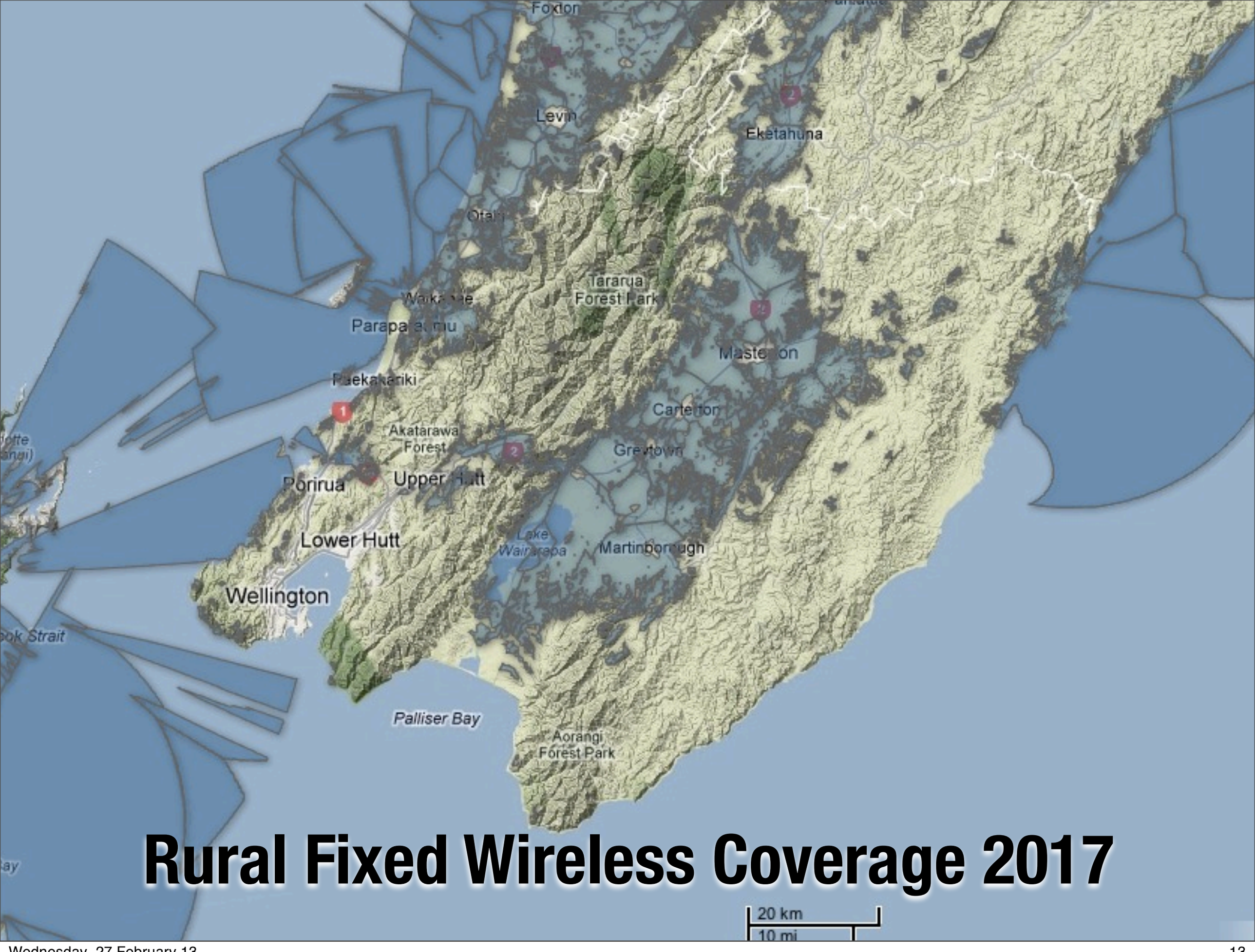
100MHz: Radio

Greater Penetration

Antenna Size

# Radio Licensing





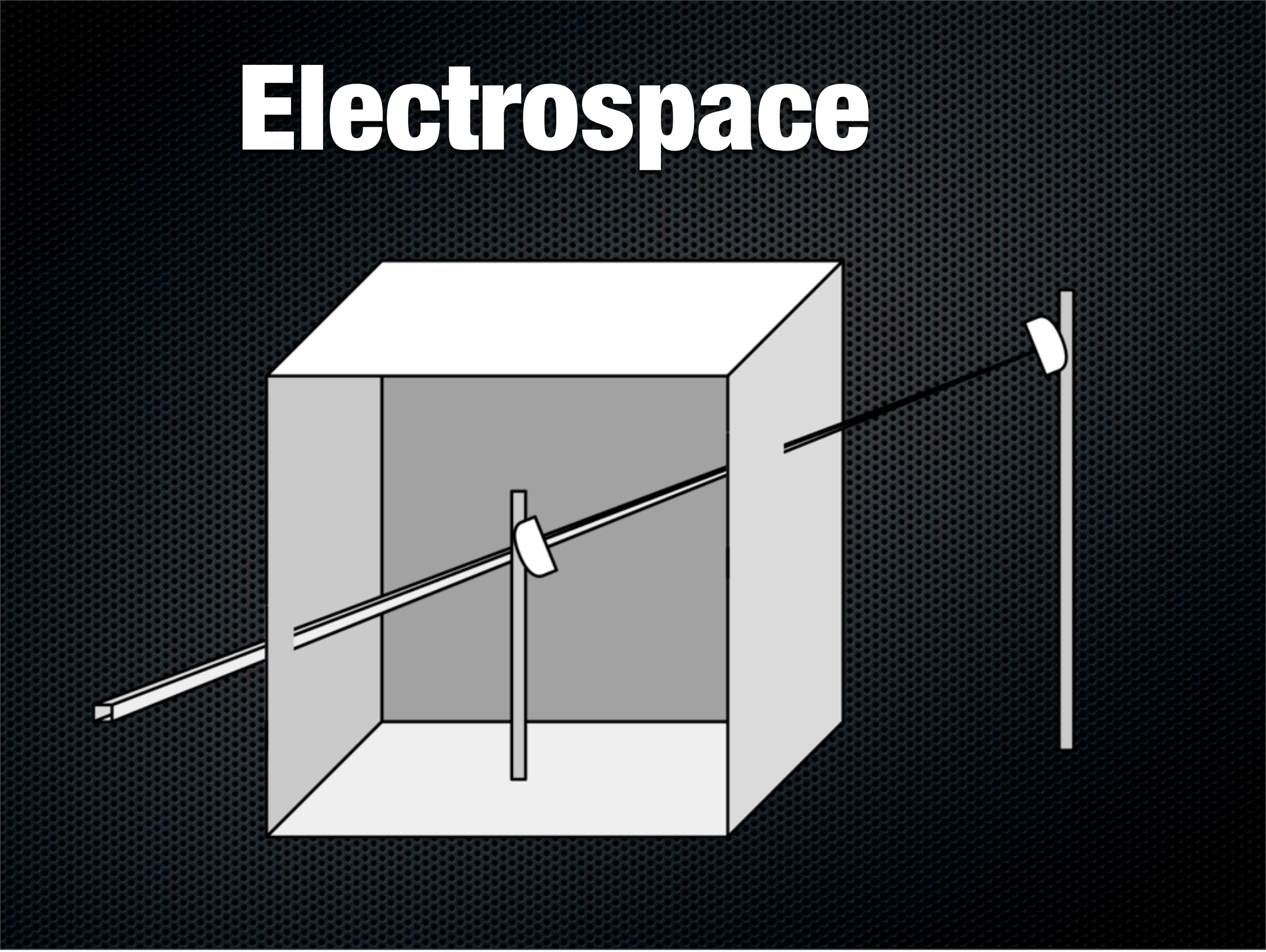

# Rural Fixed Wireless Coverage 2017

# We're doing it wrong.

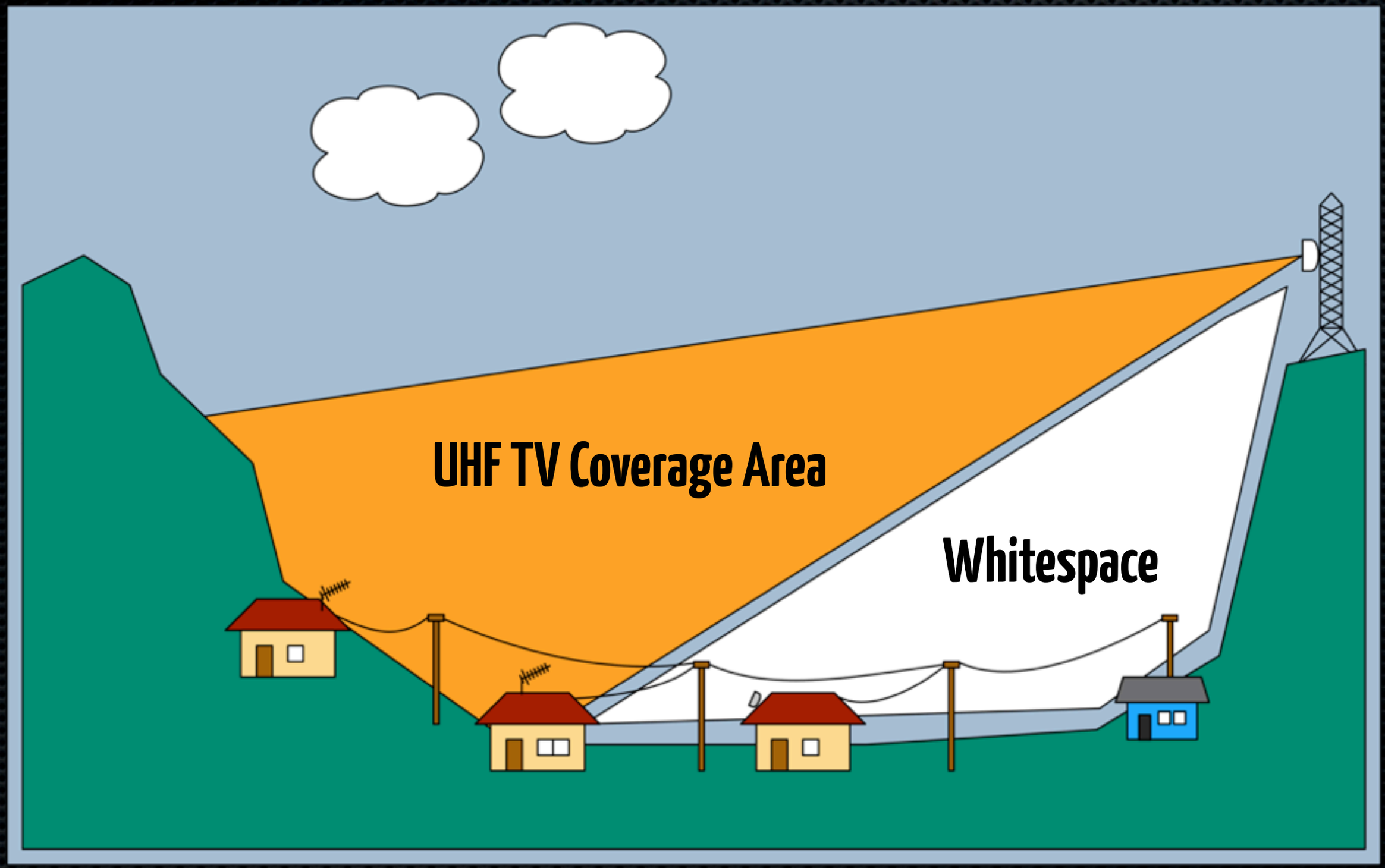
# The Electrospace Model* of Radio Spectrum Reflects The Reality of Modern Radio Applications.

See Matheson (2011)
"The Technical Basis for Spectrum Rights: Policies to Enhance Market Efficiency"

# Electrospace

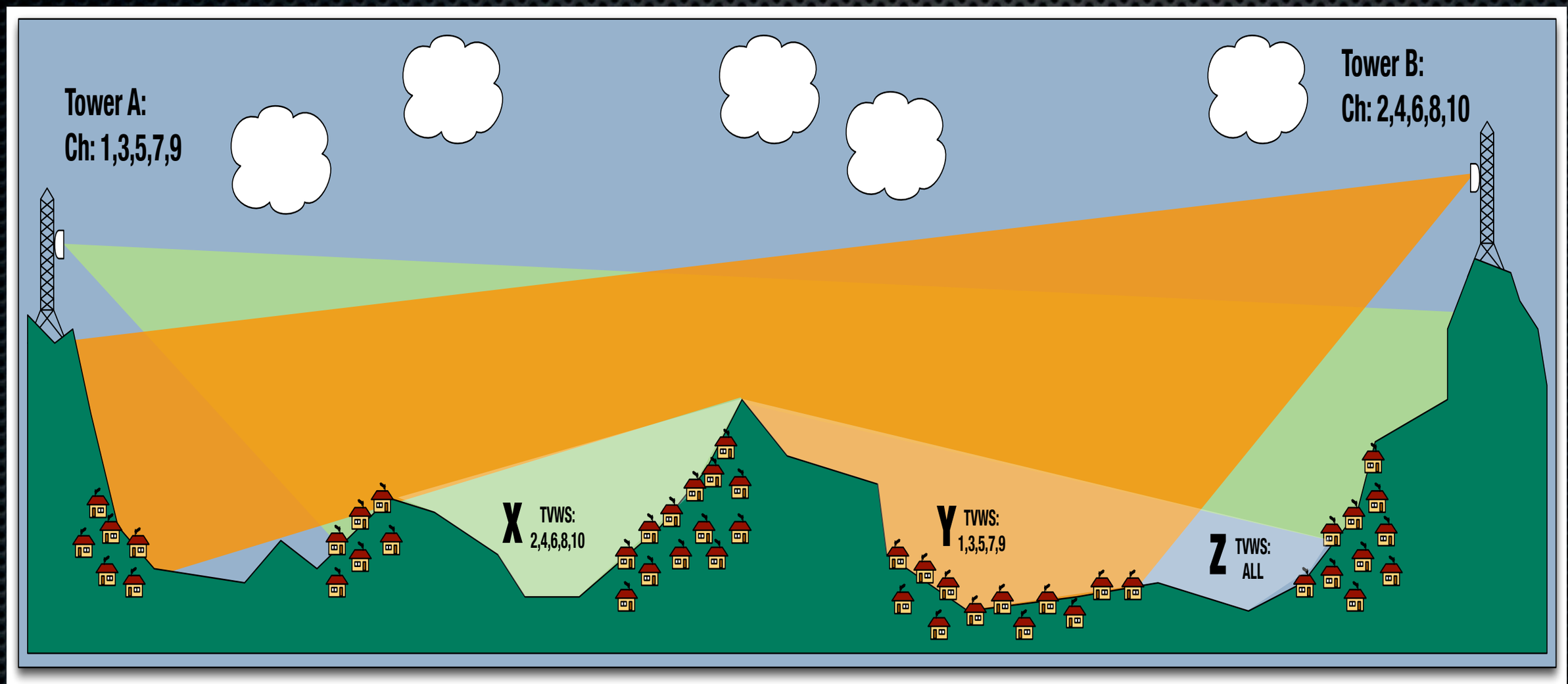


# Where & when there's no signal in an Electrospace, we have Whitespace.

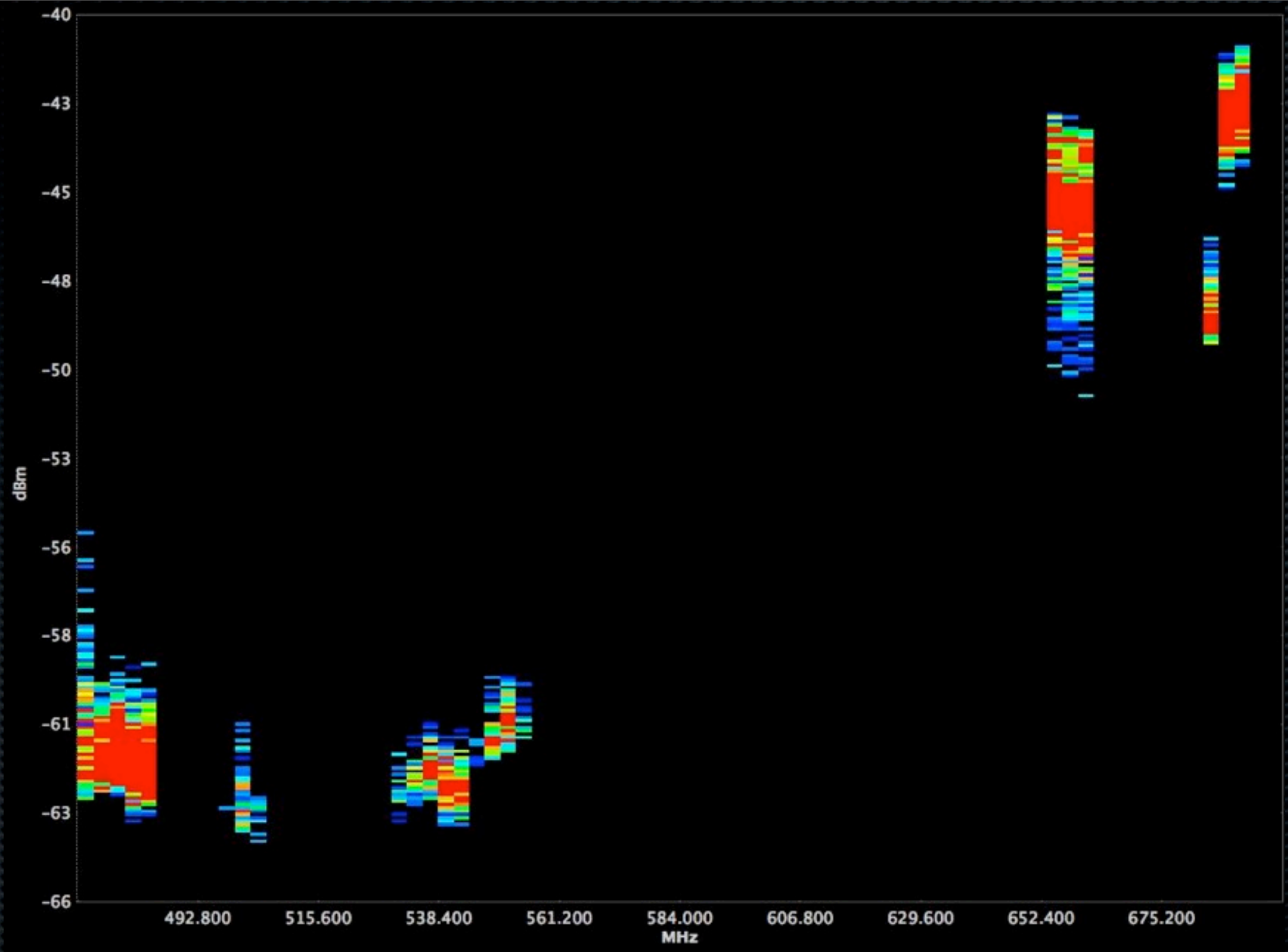



# Whitespace: A Simple Example

# Typical TV Broadcast Configuration



# How does this look to a Spectrum Analyser?




# Wellington, New Zealand UHF Broadcast Spectrum, 30-08-11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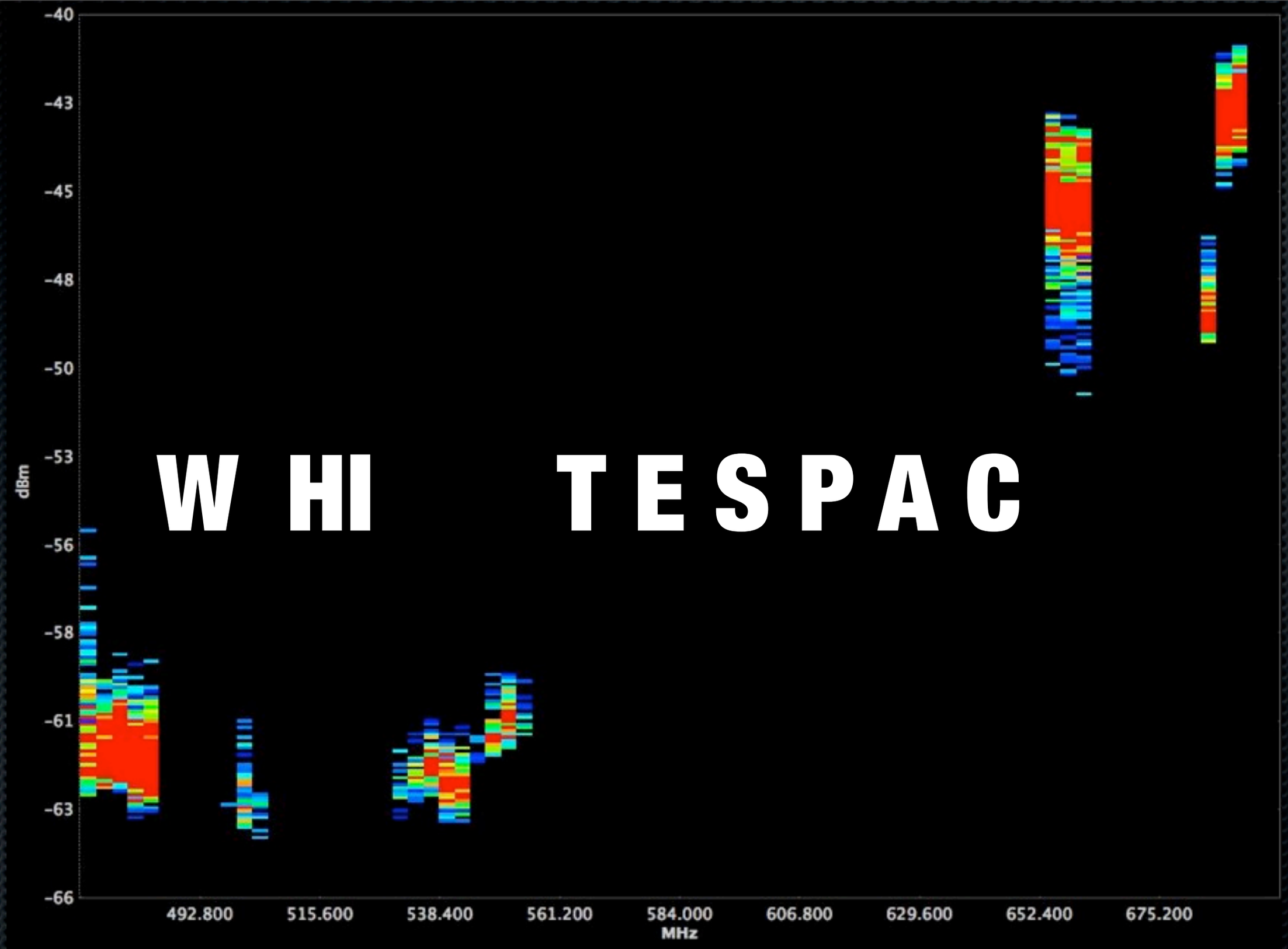
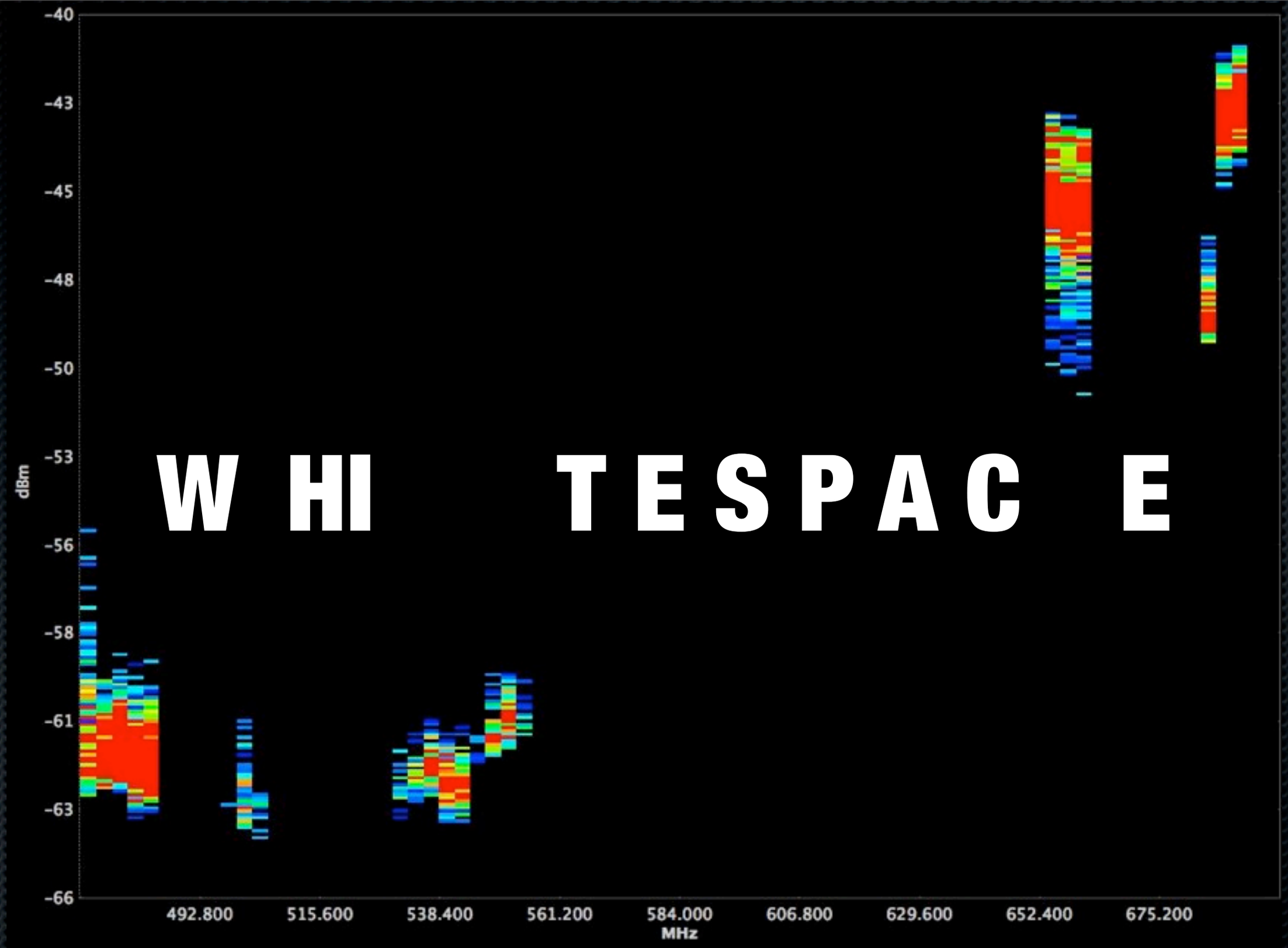



# Wellington, New Zealand UHF Broadcast Spectrum, 30-08-11

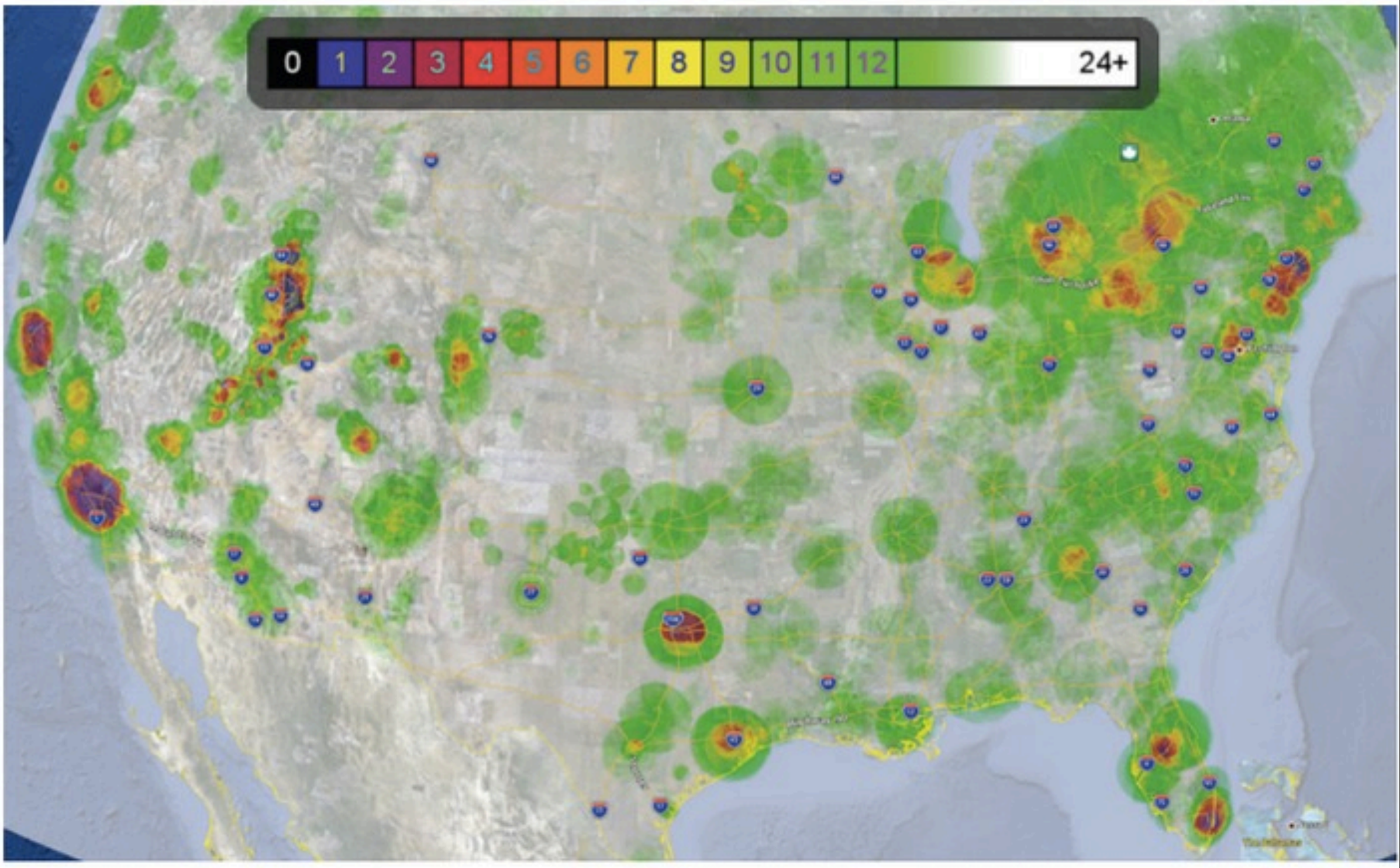



# Wellington, New Zealand UHF Broadcast Spectrum, 30-08-11

# Wellington's Not Special

# It's Like That Everywhere

# TV White Space Channel Availability



# Why are we not using Whitespace right now?

# How can we use whitespace without breaking existing services?

How can we use whitespace without **breaking** existing services?

# Cognitive Radio

# Cognitive Radio

- Aware
- Adapts
- Senses
- Interacts

# And it's real.

# IEEE 802.22 is the first Wireless Regional Area Networking standard.

# IEEE 802.22 delivers fixed wireless broadband using Cognitive Radio in TV Whitespace Spectrum

# IEEE 802.22
# Protects Primary Users

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# IEEE 802.22 Protects Primary Users Using Geolocation & Spectrum Databases

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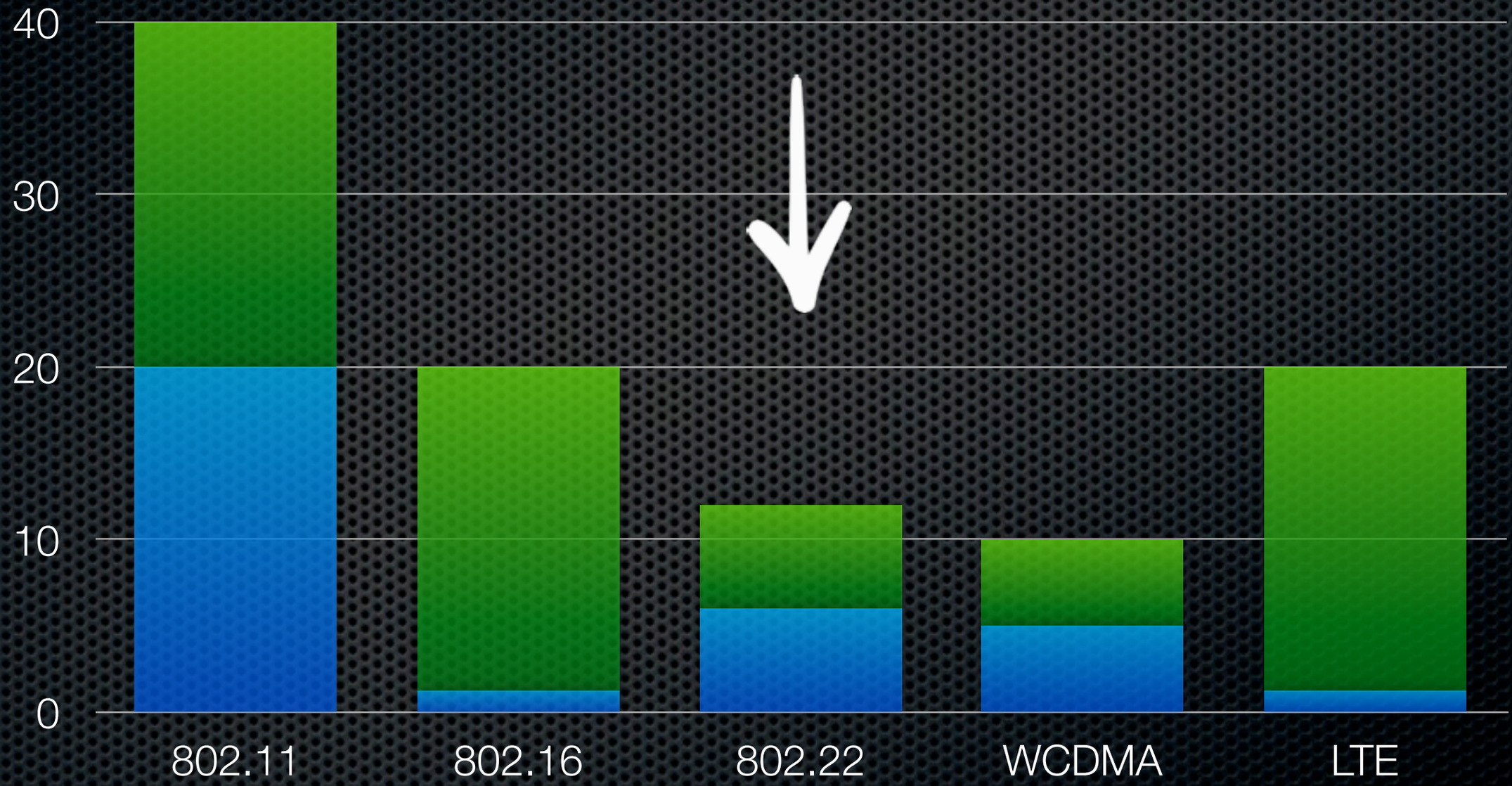
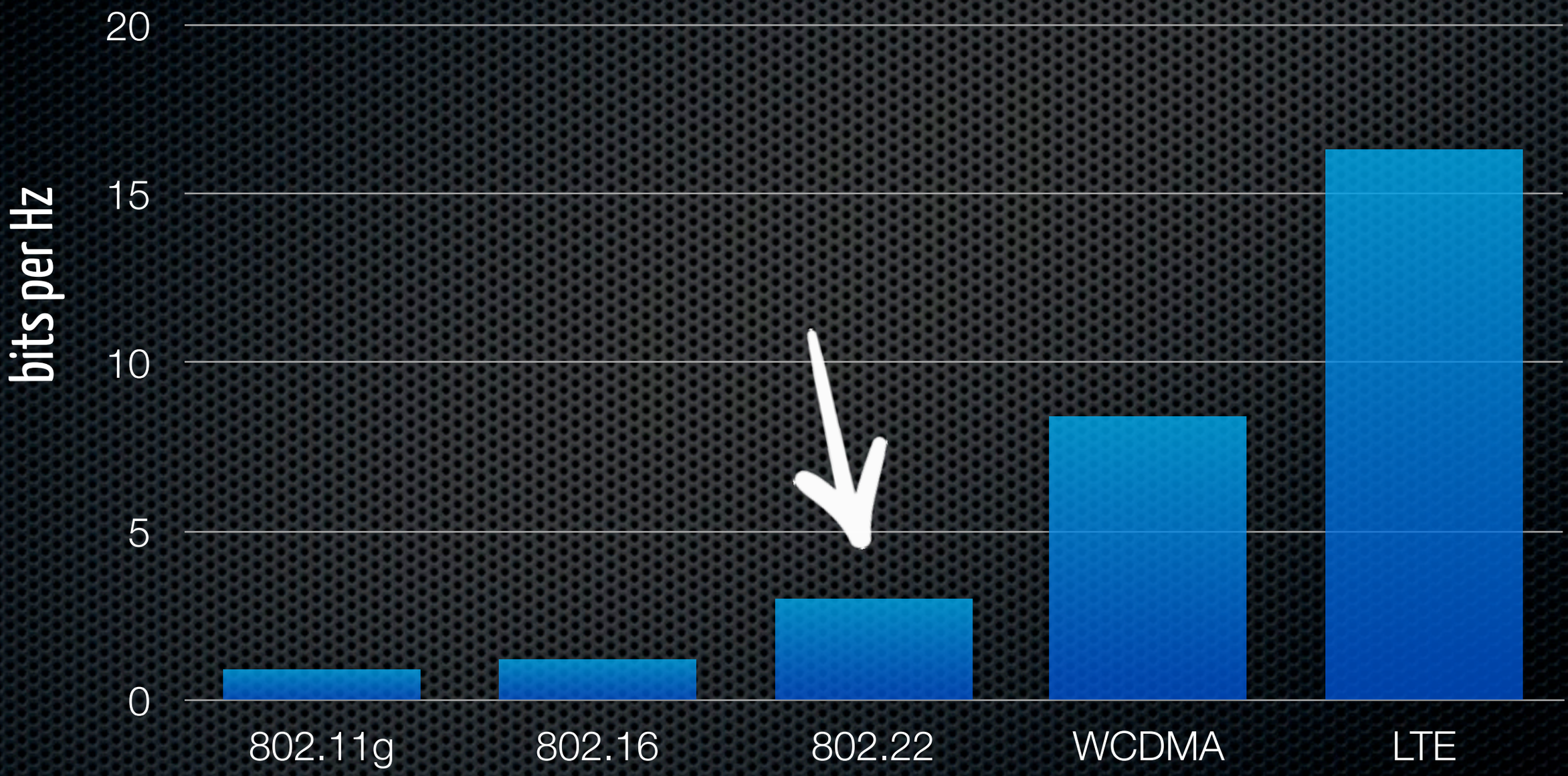
# IEEE 802.22
# Protects Primary Users
# Using Geolocation &
# Spectrum Databases
# And Spectrum Sensing

# So how does IEEE 802.22 compare?

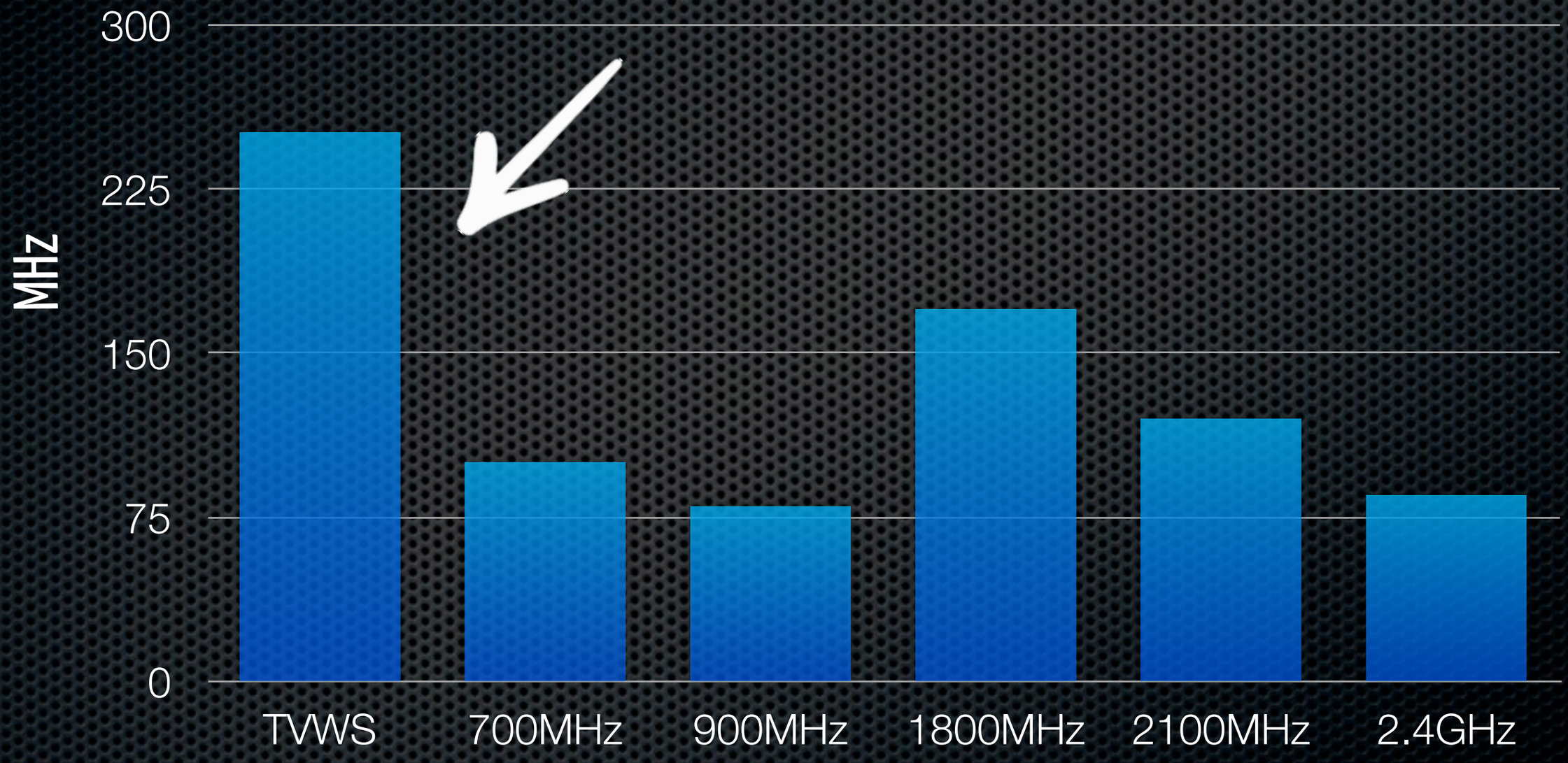
# 802.22 Channel Size: 6MHz



# 802.22 Spectral Efficiency



# Spectrum Availability



# What About In Real Life?

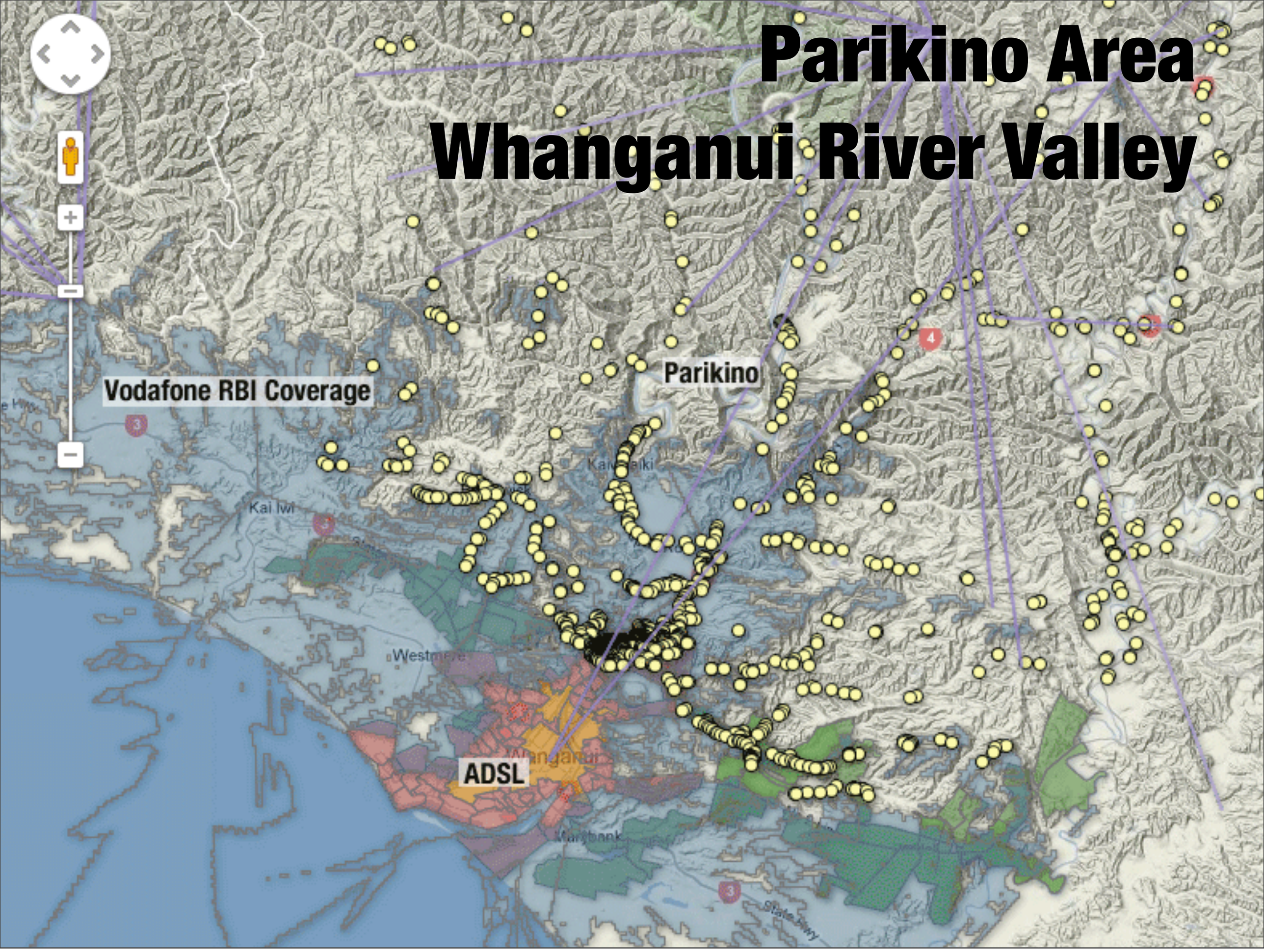
# Wi-Fi vs TVWS Community Studies

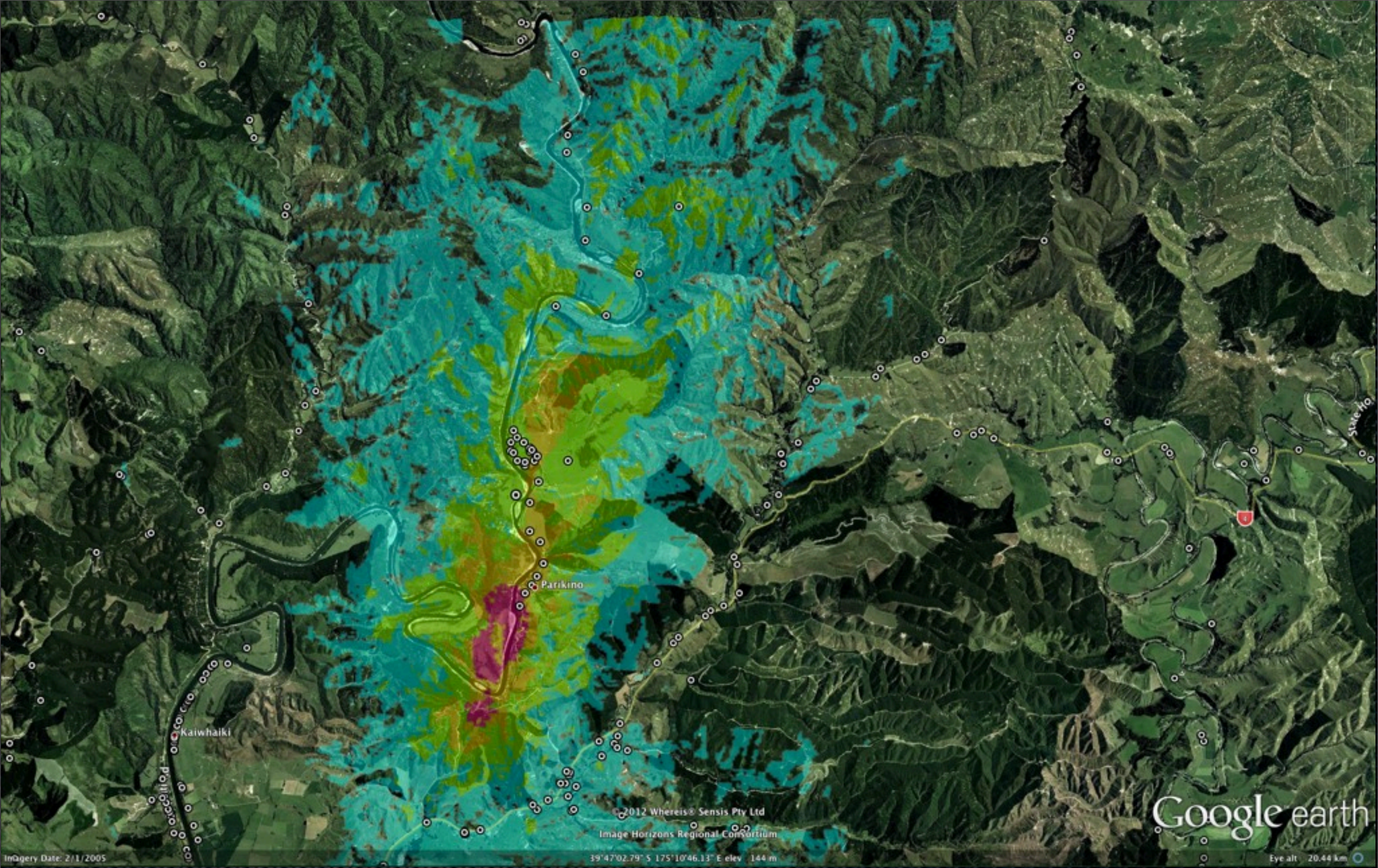
- Three Rural New Zealand Communities
- Modeled with Awe WinProp at 25M
- Same Emitted Power for Both Technologies
  - (4 Watts EIRP)
- Like for Like Subscriber Antenna Sizes

# Parikino, Whanganui River Valley

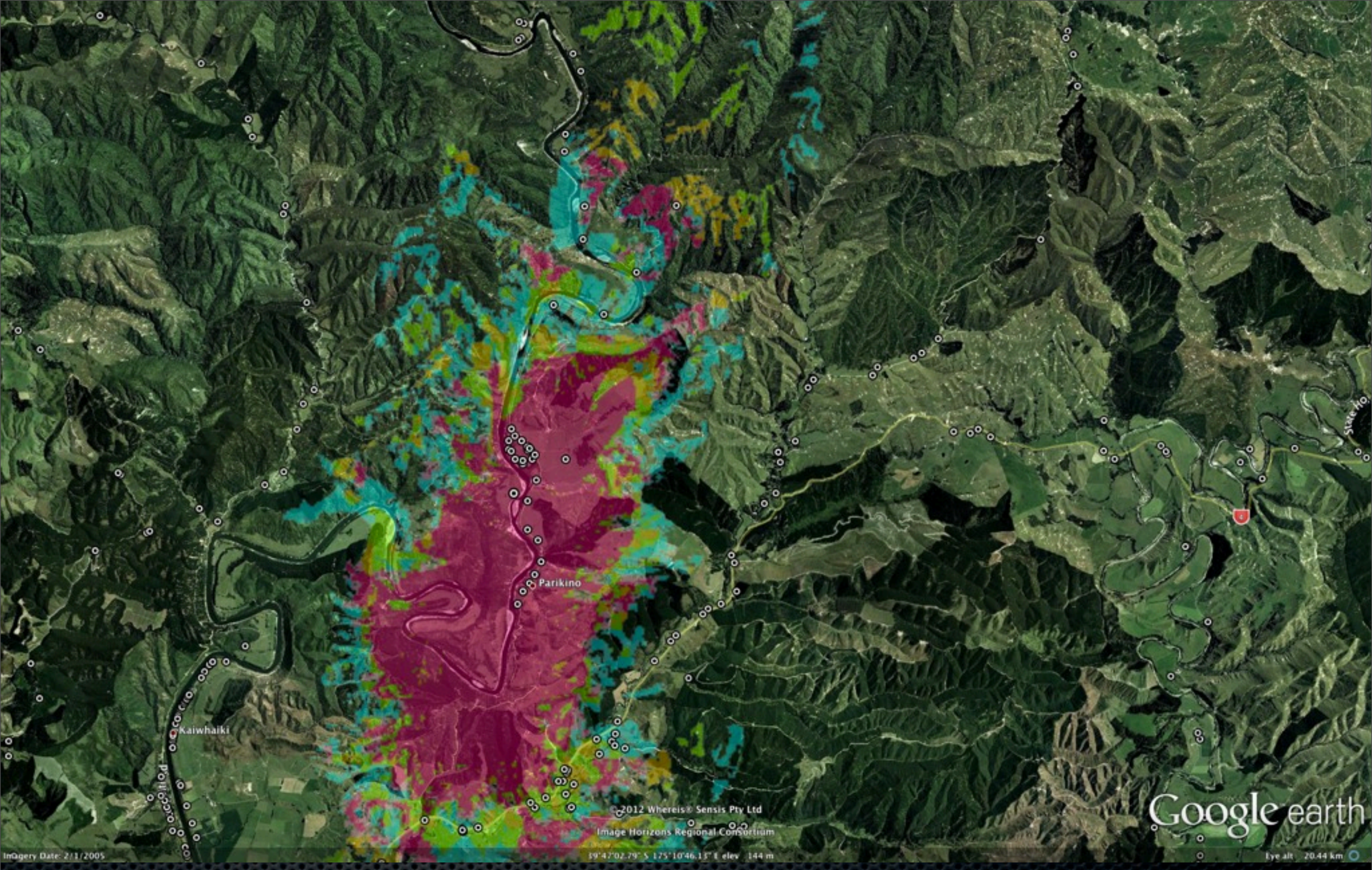
Image Copyright 2012 Google Retrieved from http://maps.google.com/ on 6 August 2012

# Parikino Area
# Whanganui River Valley



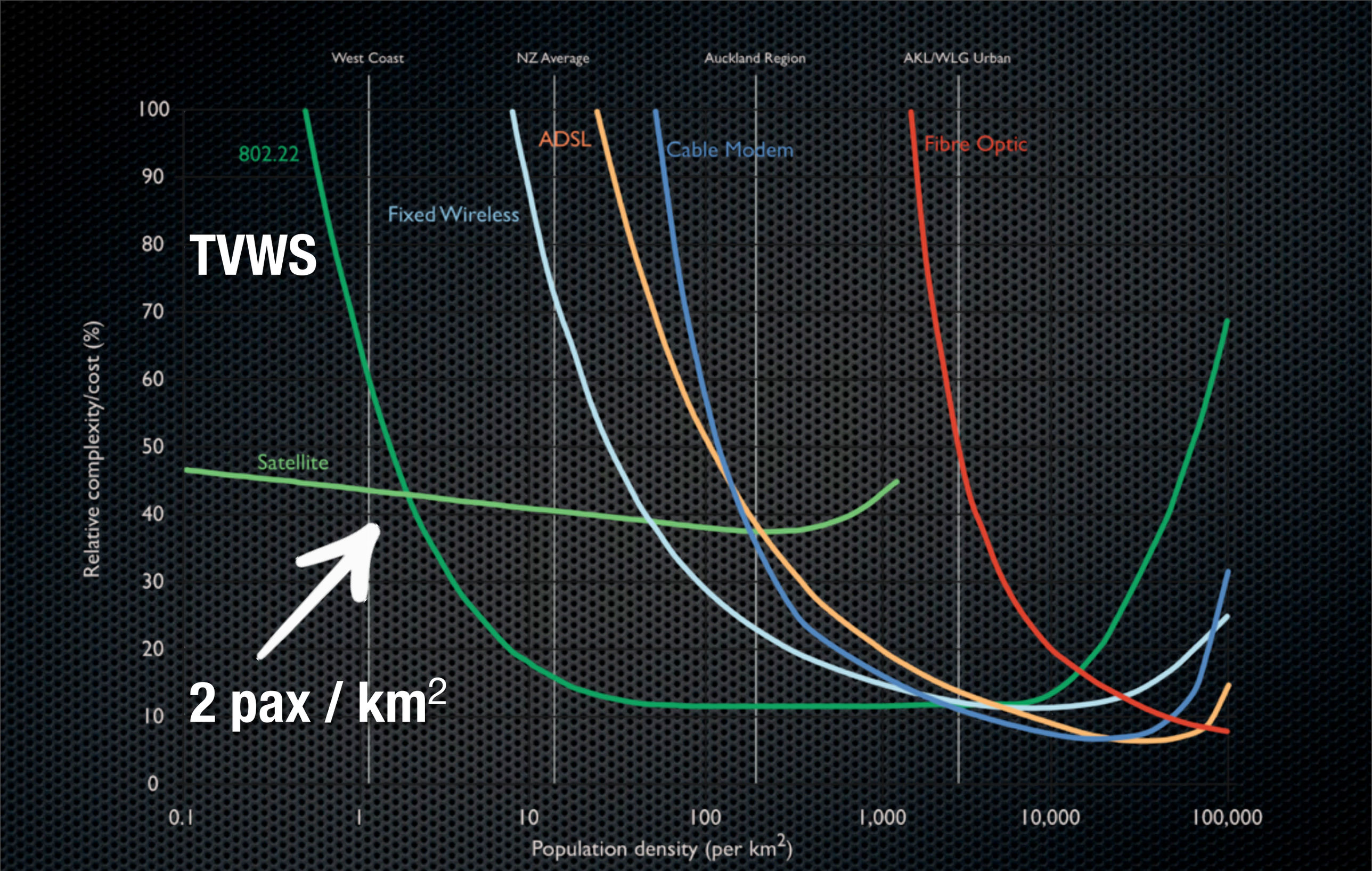



# Parikino on Wi-Fi: 18 Houses Ok




# Parikino on TVWS: 28 Houses Ok

# Cognitive Radio in TV Whitespace Has Real Potential for Rural Broadband




# It changes the economics of rural wireless

# Trials are on in Singapore, UK, US.

# Expect hardware in 2-3 years

**Paper available:**

**http://tinyurl.com/bph5amf**

**or**

**https://internetnz.net.nz/system/files/pages/2012/telco2_whitespace_study_community_examples_final.pdf**

# Thank You!

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