



# **Presentation to RABC: Impact of Outdoor Wi-Fi in 5150-5250 on Globalstar Operations**

February 26, 2015

# Overview

---

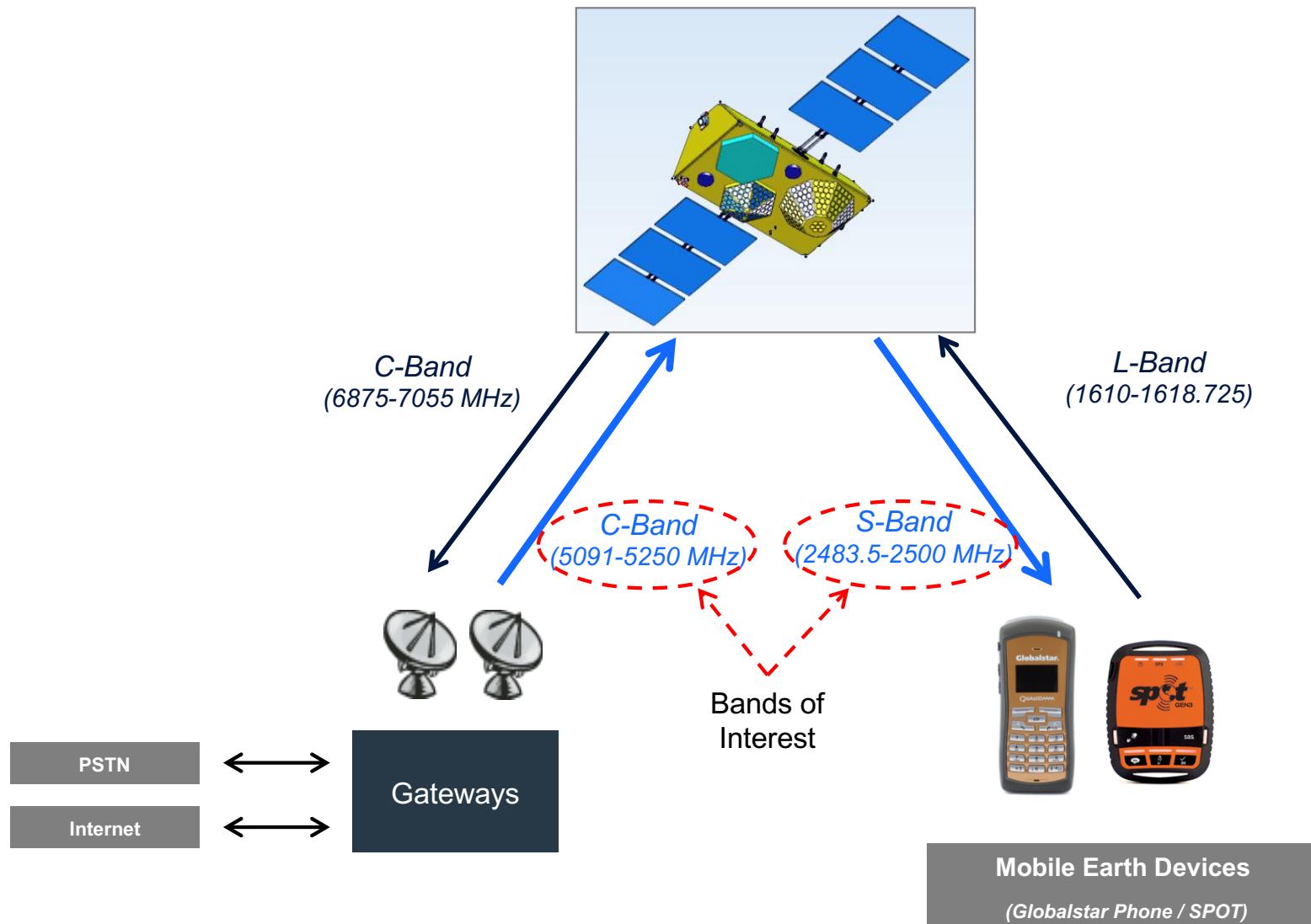
- 1) Globalstar Background
- 2) Impact on Globalstar Operations
- 3) Conclusions
- 4) Addenda
- 5) Appendices

# 1) Globalstar Background

---

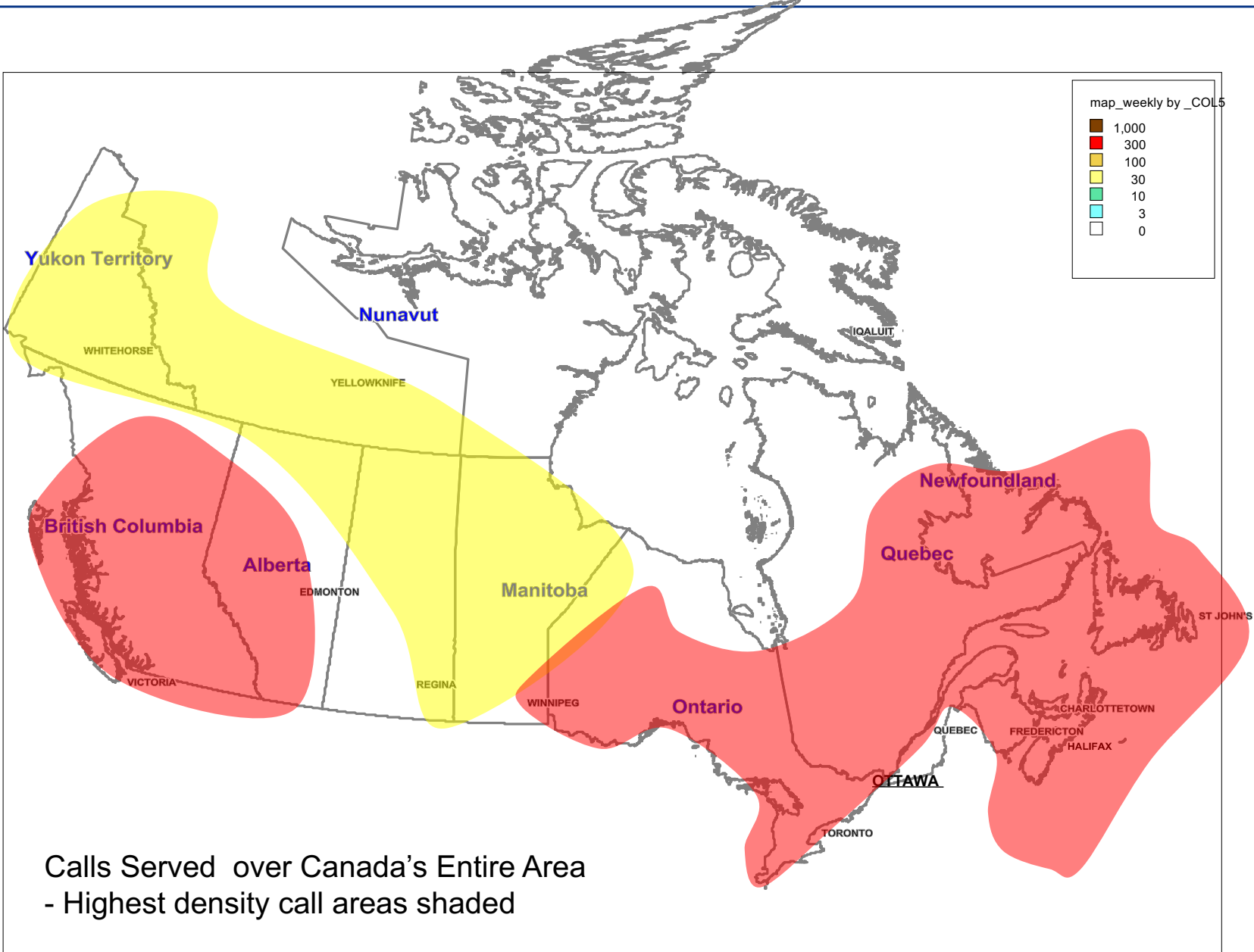
# Globalstar bent-pipe architecture

The Globalstar Network has a “bent-pipe” architecture and the “brains” of the System are located on the ground. The Network can be easily upgraded to ensure that customers always have the most technologically advanced mobile satellite services.



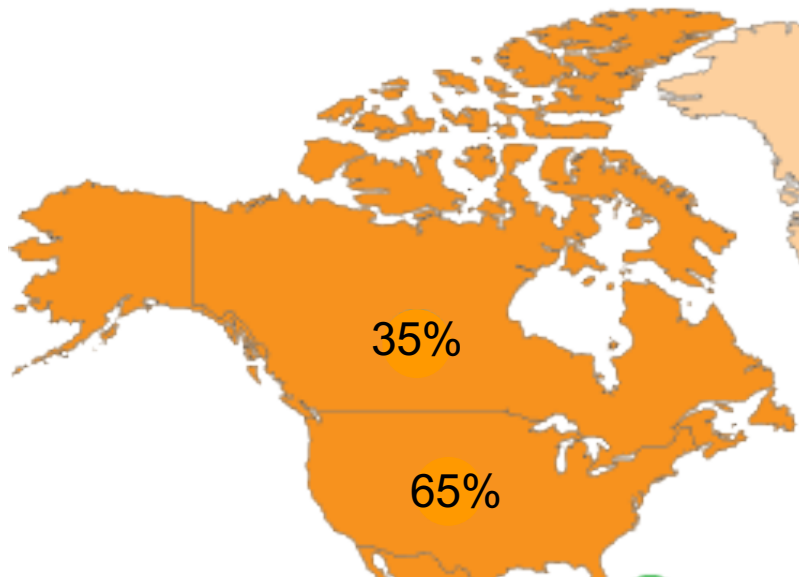
# Canadian Call Density (Simplified)

Call density below is for the period February 2, 2015 to February 8, 2015 (Detailed view is proprietary)

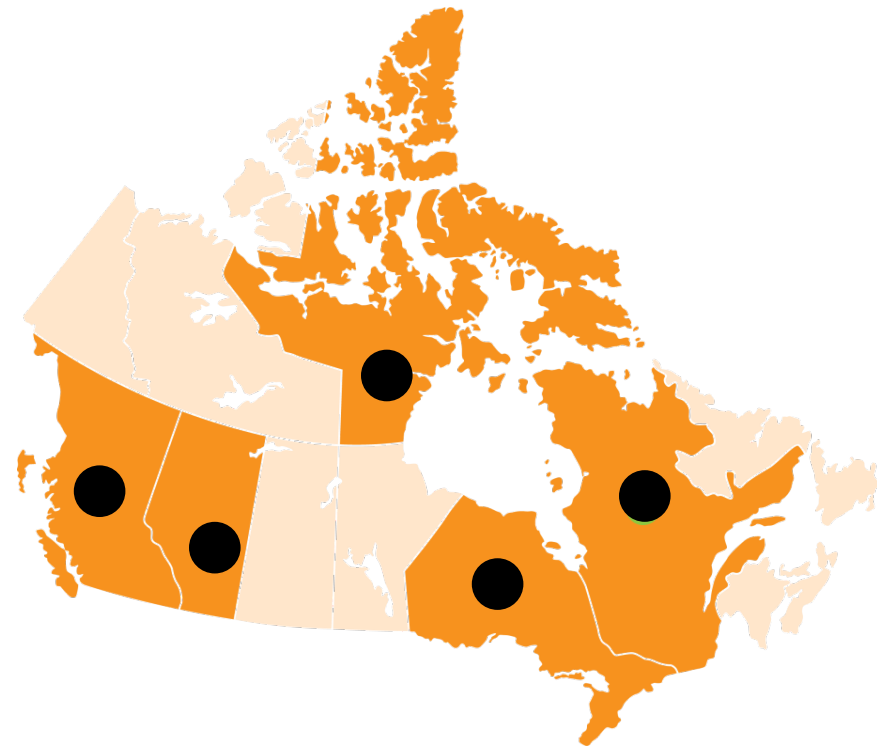


# Canadian SPOT Product Rescues

Approximately 35% of North American  
SPOT Product Rescues  
Take Place in Canada



Top 5 Canadian Rescue Locations



## 2) Impact on Globalstar Operations

---



# Background

## FCC 14-30 Rulemaking on Wi-Fi Operations in 5150 - 5250 MHz

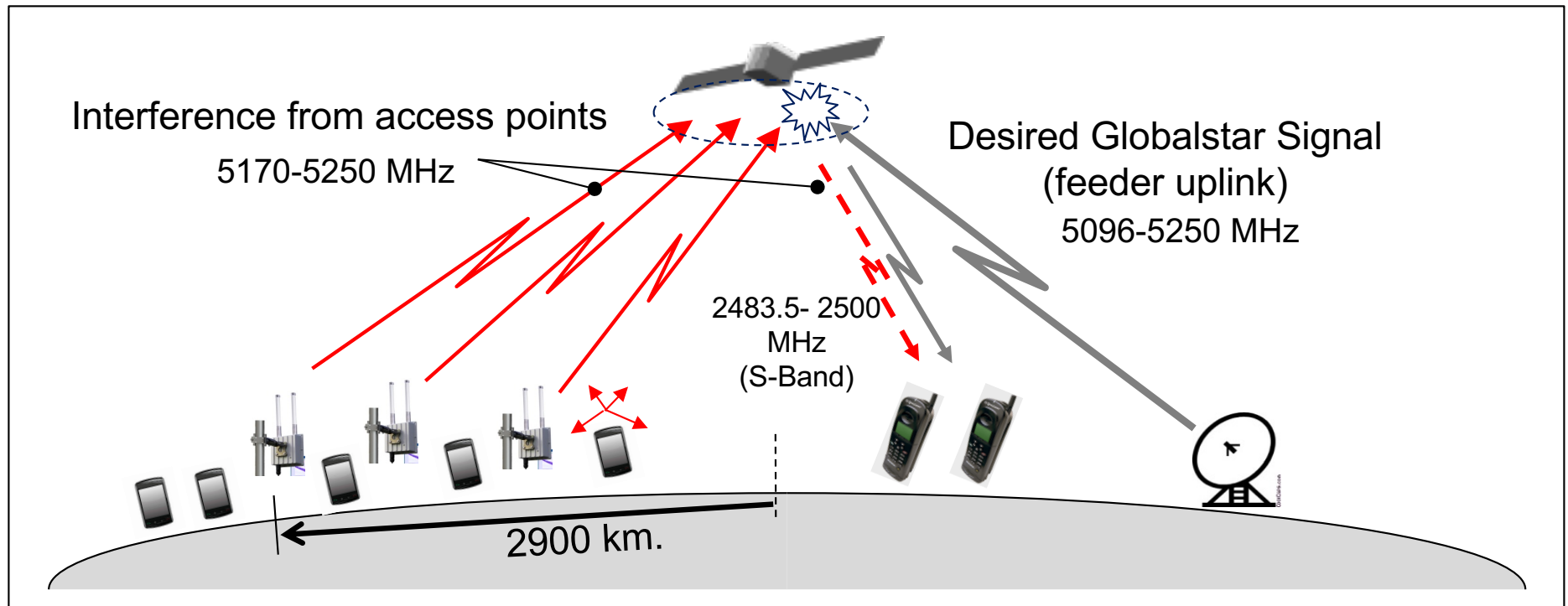
- Outdoor Access Point Deployment Allowed, Subject to Antenna Gain Restrictions to Protect Globalstar\*
  - 1 W conducted power with max 6 dBi antenna gain (4 W max EIRP)
  - 125 mW max EIRP for radiation above 30 degrees elevation
- FCC Notification Requirement for Deployments > 1000 APs
  - Companies must submit letter acknowledging that should harmful interference occur, **they will be required** to take corrective action
  - (FCC's enforcement authority a key element in the rulemaking allowing outdoor operations)
- FCC Explicitly Recognizes
  - Globalstar has capability to monitor noise level increases at its satellites
  - Globalstar will report changes and impact on operations

*\* also power spectral density requirement*



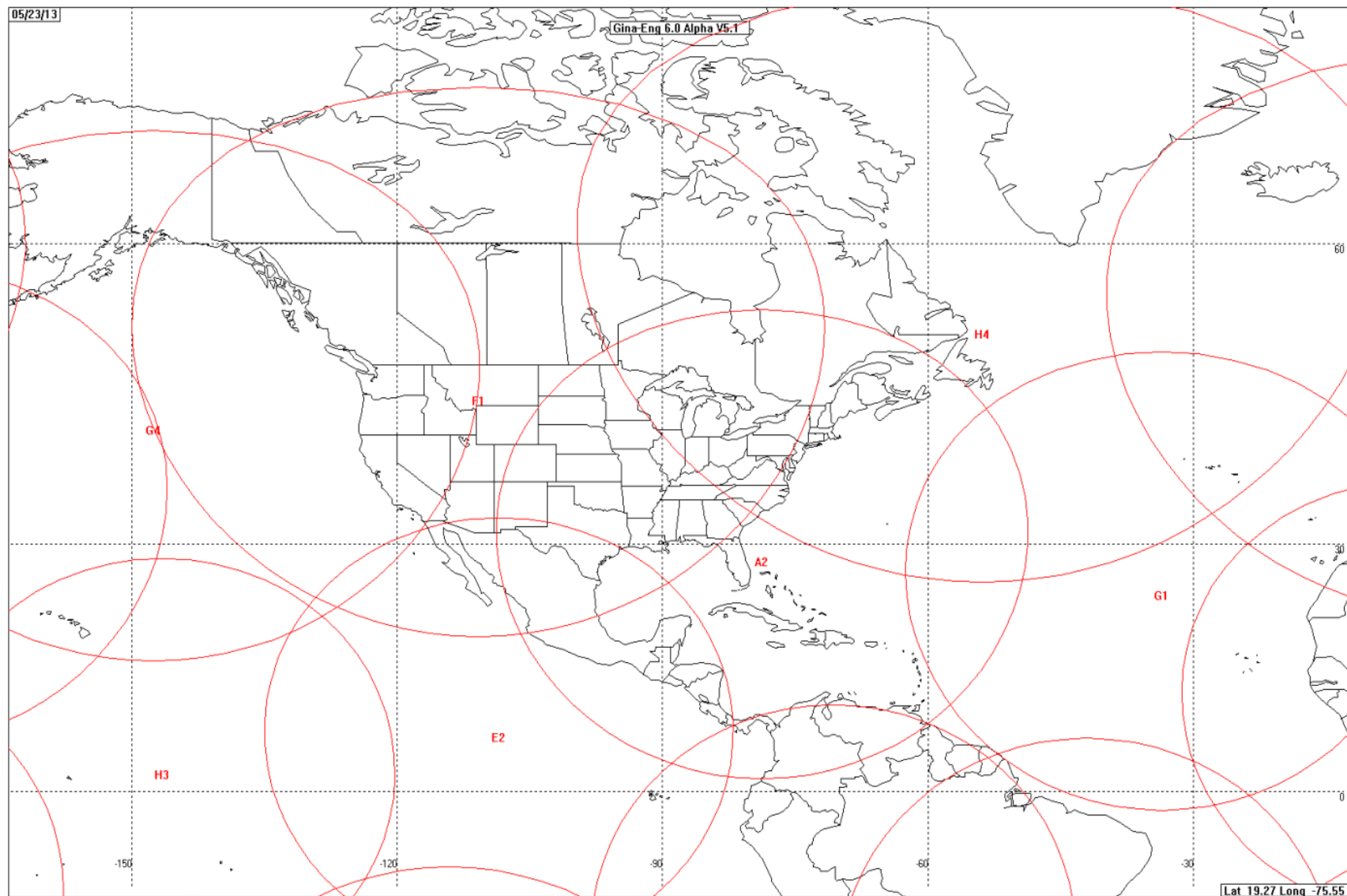
# 5150-5250 MHz Interference Scenario

- All outdoor unlicensed APs visible to Globalstar's satellites create interference at satellite receiver
- All access points within a circle of 5,800 km diameter on earth's surface create interference



# Representative Receive Antenna Footprints for GSAT Feeder Uplink

All Wi-Fi Access Points within the Footprint Contribute to Uplink Interference



# Inputs to FCC Rulemaking

## Analysis of Impact of Outdoor Wi-Fi in 5150-5250 MHz on Globalstar Operations

- Impact to Globalstar Considered

(Impact assessment with and without antenna gain restrictions considered)

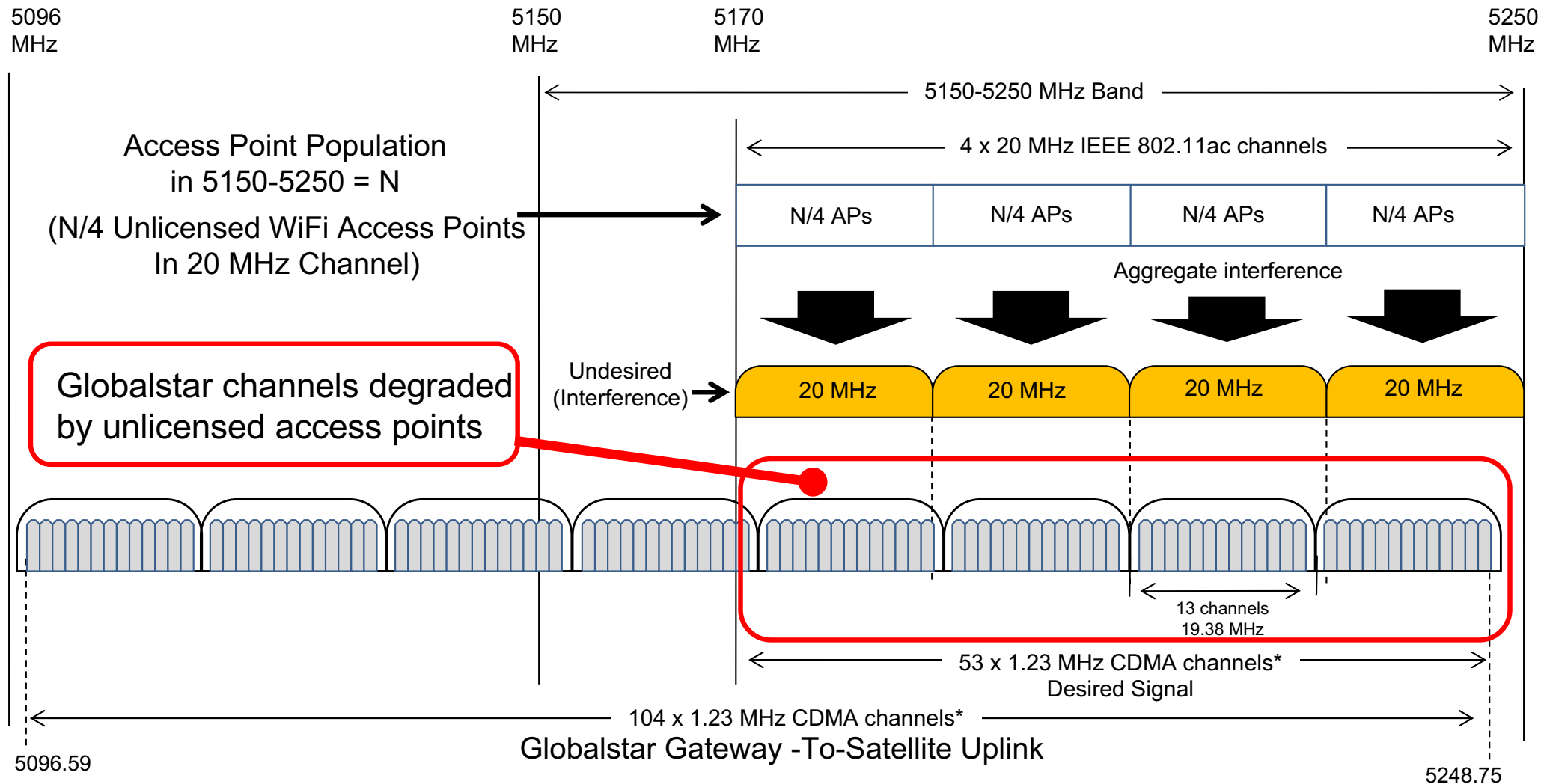
- Feeder Uplink (Noise Rise) and Downlink Noise Rise
- User Downlink (CDMA Capacity Reduction Due to Increased Downlink Interference)
- User Downlink (Coverage Degradation)
- Downlink: Capacity Degradation Due to Finite Satellite RF power.
  - Access Point interference “steals” RF power due to Globalstar “bent-pipe” architecture

- Key Elements in Impact Analysis

- Number of Outdoor Access Points in 5150-5250 MHz
- Access Point Characteristics (power, antenna gain, duty cycle)
- Propagation Characteristics
- Satellite and Access Point Geometric Relationship

# Globalstar Interference Scenario

## Band plan View with 20 MHz Wi-Fi Channels

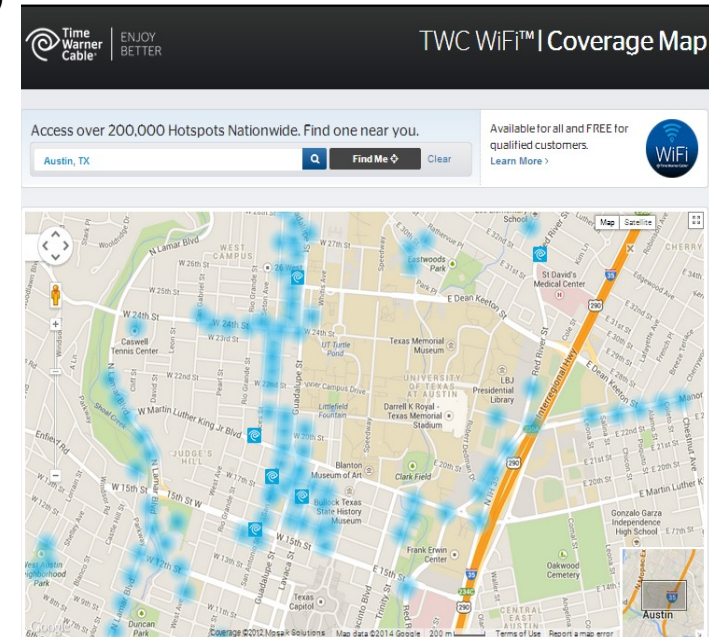


\* Transmitted in right- and left- handed circular polarizations

# Number of Outdoor Unlicensed Access Points in 5150-5250 MHz

## High-Density, Nationwide Outdoor Deployments

- 16 AP/km-sq (urban area) for each deployment (E.G. Austin, TX; Mountain View, CA)
- ~4.4 Million APs for each deployment (276,000 km<sup>2</sup> U.S. urbanized area)
  - Canada urbanized area is **22,943.50 km<sup>2</sup>** ( adds ~ 10% to U.S. number)
- 4 Nationwide Deployment Entities
  - (1) Cable Operator
  - (2) National Wireless Operator-1
  - (3) National Wireless Operator-2
  - (4) Non-Operator Entities
    - Non-Defense Government Ministries
    - Defense
    - Provincial and Local Government (e.g. Law Enforcement, Muni-WiFi)
    - Commercial, Industrial (e.g. theme parks, business campus)
- Considering All 12, 20 MHz Channels Available at 5 GHz and 2.4 GHz
  - 4 channels in 5150-5250
  - 8 additional channels (3 @ 2.4 GHz; 5@ 5 GHz)
  - Then → 1/3 of APs Deployed in 5150-5250 MHz



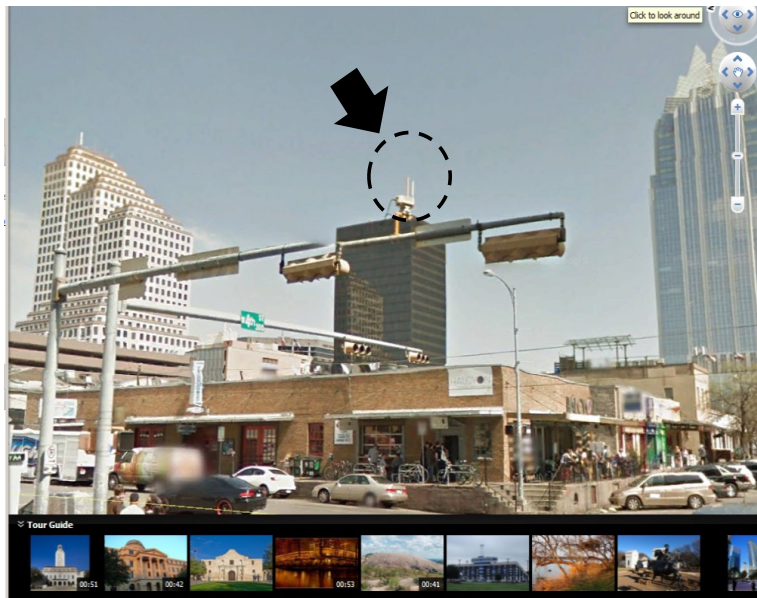
*APs in Austin, TX*

Impact Analysis  
uses 1M APs per 20 MHz

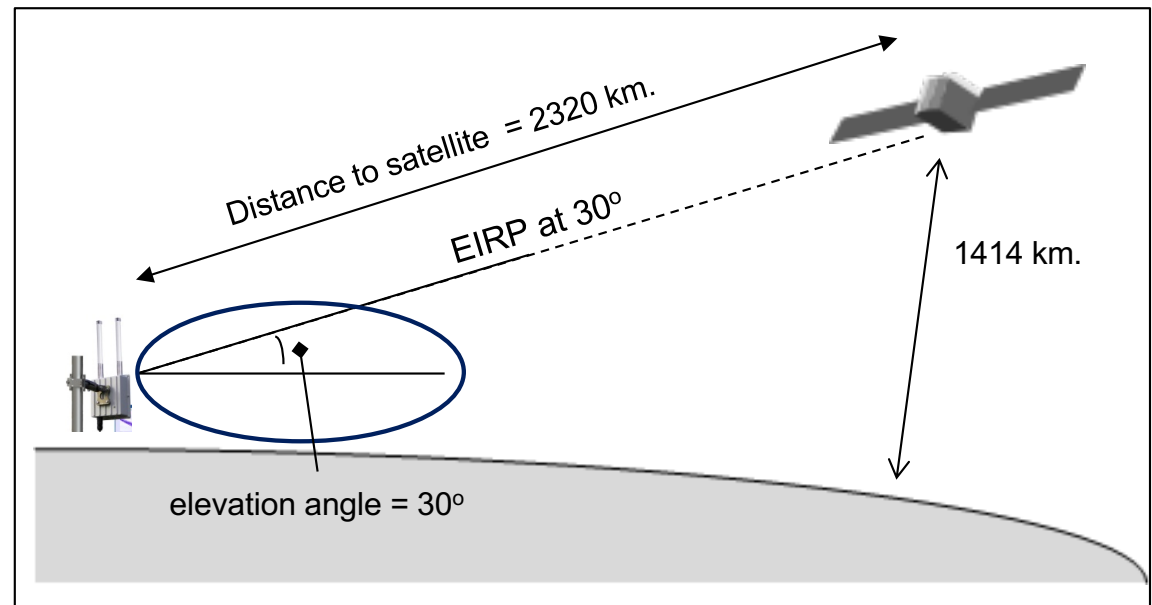
AP in 5150-5250 MHz = 5.8 million or (1.4 m per 20 MHz)  
= 4.4M<sub>per deployment</sub> × 4<sub>deployments</sub> × 0.33<sub>fraction of AP in 5150-5250</sub>

# Access Point Characteristics

- Representative Characteristics and Scenario for FCC Interference Analysis\*
- Used to show impact of antenna gain restrictions
- Yields results consistent with dynamic analyses with similar AP assumptions



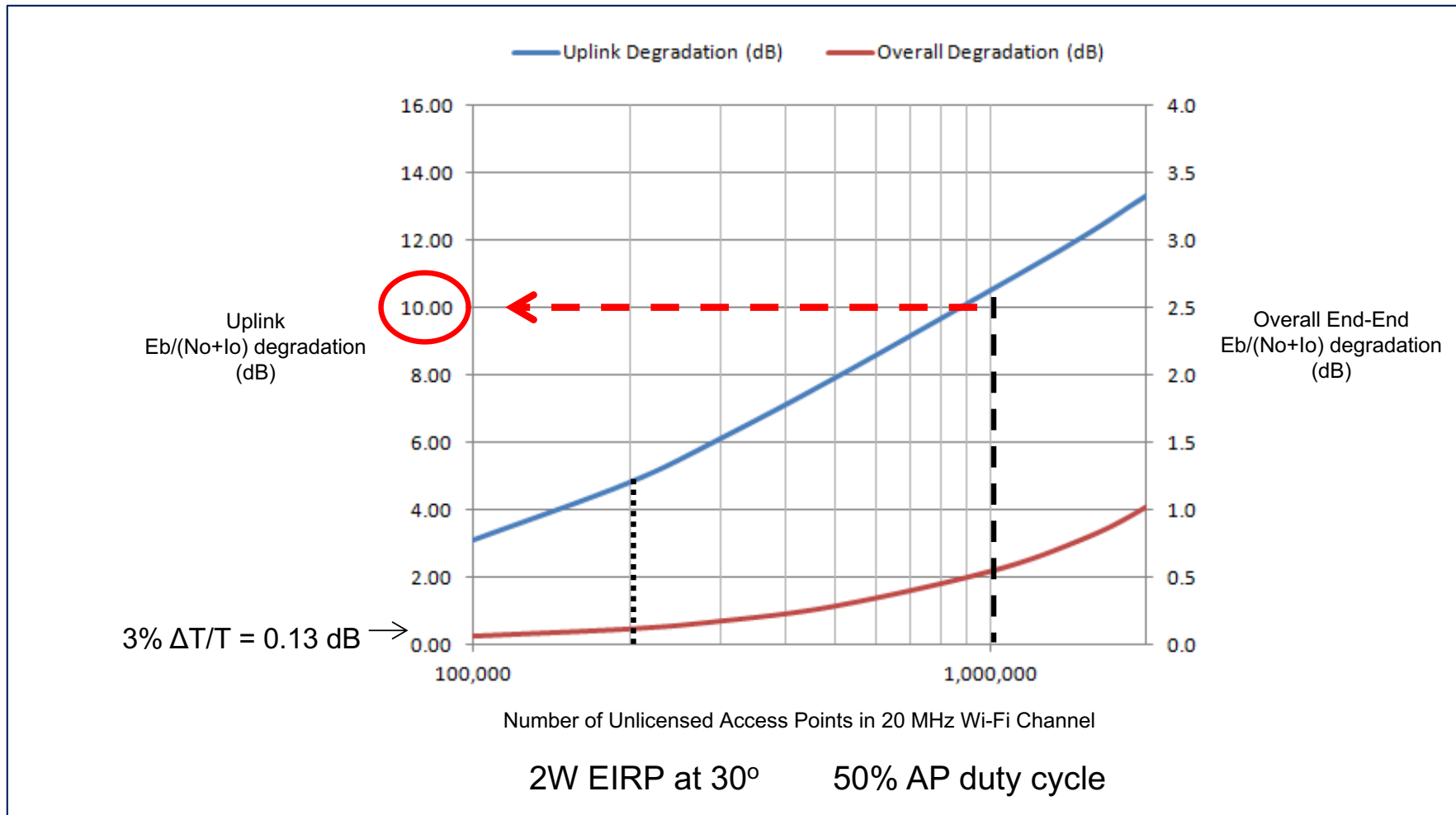
Austin, TX Outdoor Urban Deployment



\* Scenario used by NCTA in November 2013 FCC Filing

## Analysis Result 1: Uplink and End-to-End Globalstar Degradation vs Number of Access Points

Without Antenna Gain Restrictions, 1 M Access Points in Wi-Fi Channel Degrade Uplink by 10 dB and Degrade End-End by 0.5 dB, Degrading Downlink CDMA Capacity



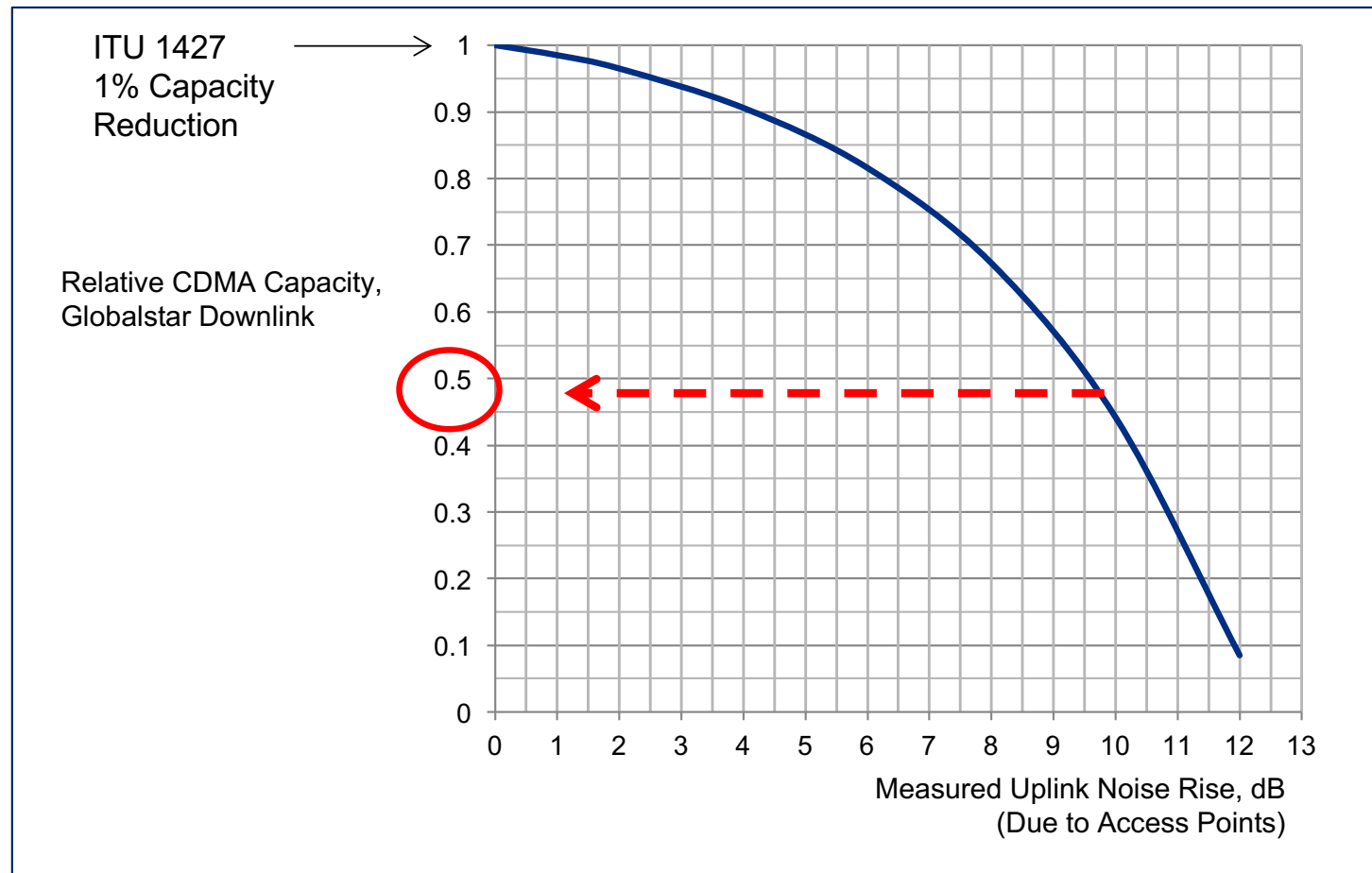
(Without Antenna Restrictions, U.S. Rules Would Have Allowed Max. 4 W EIRP for Outdoor APs)



## Analysis Result 2: Globalstar Capacity Reduction vs. Uplink Noise Rise

Based on End-to-End –(uplink/downlink)– approach

- 10 dB Noise Rise Produces 50% -55% Capacity Reduction.
- This would occur without antenna gain restrictions

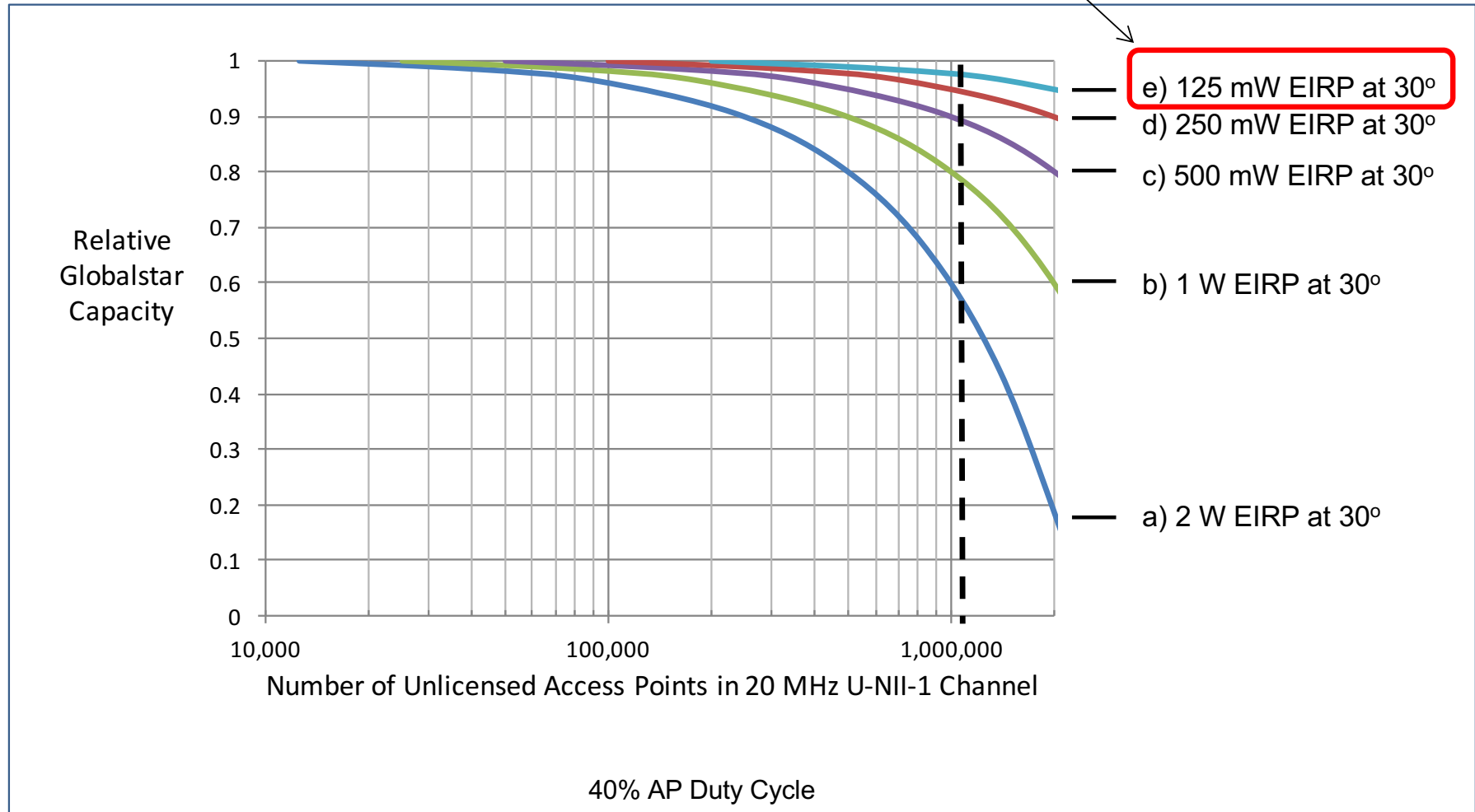


\*assessment without antenna gain restrictions



### Analysis Result 3: Impact on Globalstar CDMA Downlink Capacity -- Effect of Different Antenna Gain Restrictions

Limiting EIRP at Elevation Angles  $> 30^\circ$  will Result in Small Degradation to Globalstar Capacity



(Without Antenna Restrictions, U.S. Rules Would Have Allowed  
Max. 4 W EIRP for Outdoor APs)

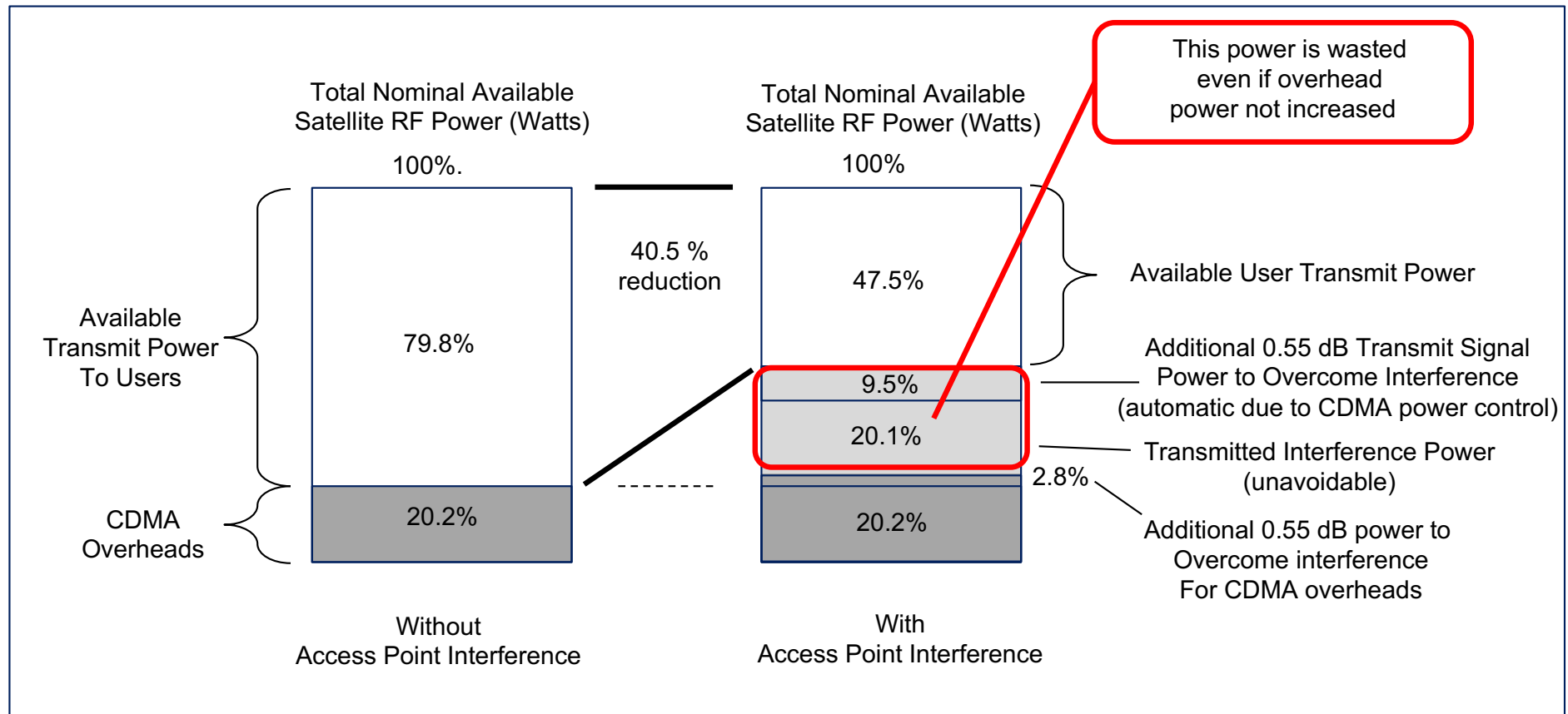
## Impact on Downlink RF Power Available for User Communications

---

- Total RF Power Available is limited, used for
  - User Communications to Handheld devices
    - # users supported directly related to RF power available
  - CDMA Communications Overheads (fixed)
    - Pilots, Synchronization, Paging Channels
- Additional Uplink Interference “Steals” RF Power Available at Satellite
  - Additional interference is retransmitted on downlink (bent-pipe)
  - Additional RF power required to overcome degraded Signal to Noise plus Interference
    - Additional RF power required to transmit CDMA overheads
    - Additional RF power required to transmit user communications

## Analysis Result 3: Globalstar RF Power Availability and Corresponding Capacity Degradation

Impact of 1M APs in 20 MHz WiFi Channel, 50% Duty Cycle, 2 W EIRP.  
(This Impact would occur if there were no antenna gain restrictions)



- 1 million access points in a 20 MHz IEEE channel cause a **40% reduction** in available RF power at the satellite, reducing user capacity by same amount.
- This effect occurs independently (but does not add to) CDMA capacity loss.

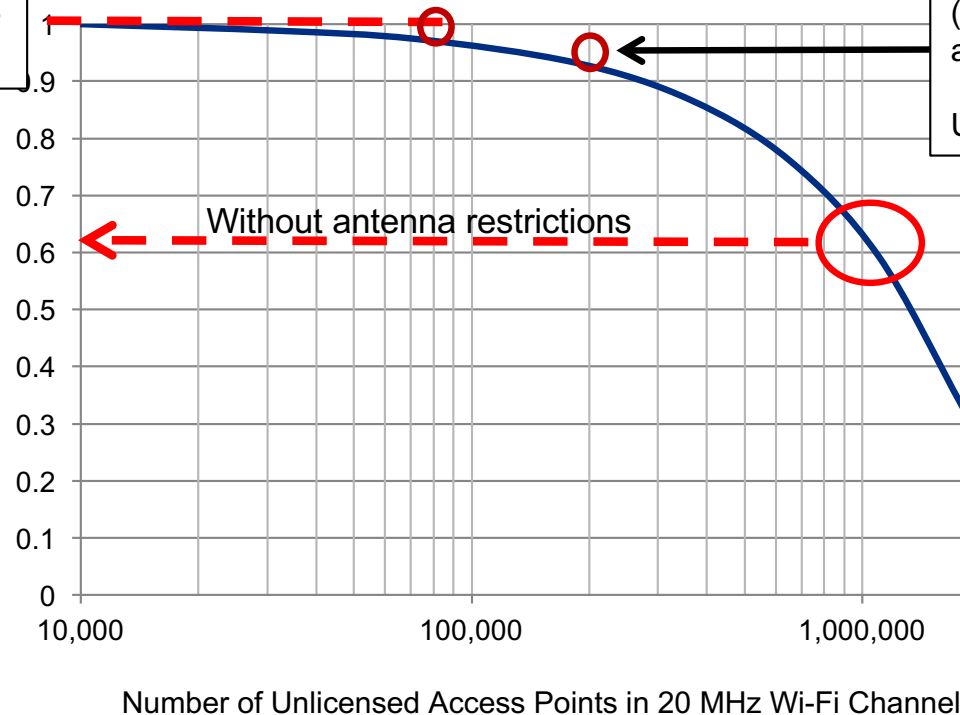
\*assessment without antenna gain restrictions

## Analysis Result 4: Globalstar RF Power and Capacity Degradation vs Number of Access Points

### 1M AP's in 20 MHz Cause 40% Reduction in RF Power And Corresponding Reduction in Capacity\*

Approx. capacity if 125 mW EIRP  
(1 M U.S. APs)

Relative  
RF User Power  
Available  
(Relative Capacity)



Approx. capacity if 125 W EIRP  
(1M U.S. APs) and 100k Canada APs  
at 2 W EIRP at 30°.

Unacceptable Harm to Globalstar

Number of Unlicensed Access Points in 20 MHz Wi-Fi Channel

- 50% Duty Cycle
- 2 W EIRP at 30°

- Limiting EIRP at Elevation Angles > 30 will Result in Small Degradation to Globalstar Capacity
- Without Antenna Gain Limitations in Canada, Canada AP will add proportionally more interference (9dB) more than their U.S. counterparts.

\*assessment without antenna gain restrictions

# Comparison of Globalstar /Roberson and NCTA Analyses

---

- **Impact Areas**

- NCTA Analysis Ignores Impact on Satellite Downlink RF Power (and Capacity)

- **Analysis Approach and Assumptions**

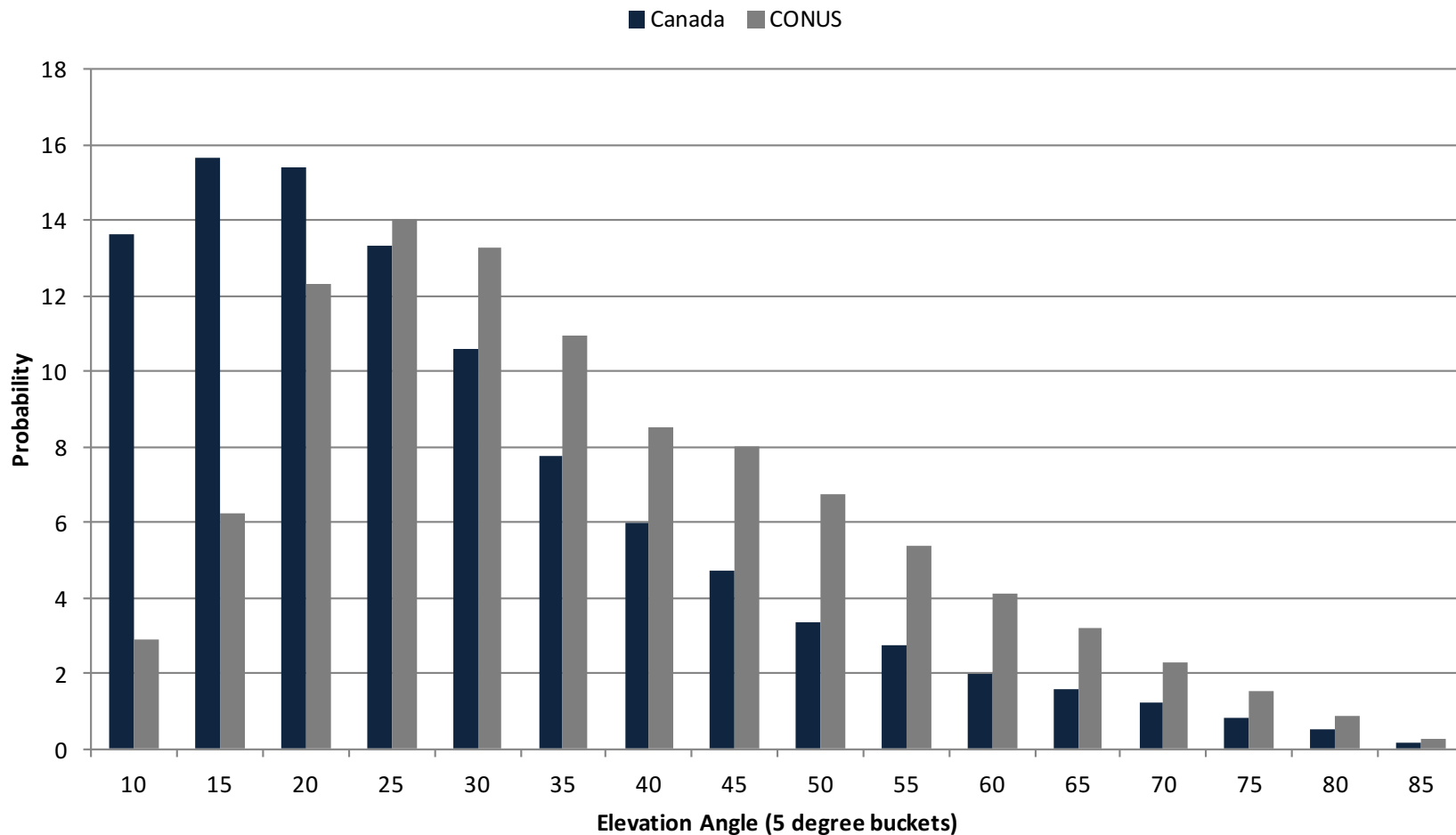
- Significantly Fewer Outdoor Access Points in NCTA Analysis
    - Globalstar/Roberson Projects 1M APs visible in each Wi-Fi channel (4 national deployments), AP density 16 /km-sq
    - NCTA assumes only 1 nationwide deployment and lower AP density
  - Lower AP Power Level in NCTA Analysis
    - ~ 250 mW EIRP at 30°

## Differences Between Canada and U.S.

Canada has higher proportion of low elevation angles to Globalstar user devices

Lower Elevation Angle → Less Downlink Margin → Greater Impact on Globalstar

### Probability Distribution for User Elevation Angle: Canada & CONUS



# Analysis Summary

---

- **If Outdoor Operation Were Allowed in 5150-5250 MHz without restriction and without recourse to enforcement**
  - Millions of outdoor access points will be deployed in 5150-5250 GHz band in North America without oversight
  - Without Restrictions, Outdoor APs at 4 W EIRP will Significantly Degrade Globalstar Operations
    - 30 dB greater interference than ITU-R 1427 recommendation
    - 10 dB increase in uplink (Interference + Noise)
    - 10-50 % Globalstar capacity reduction for downlink channels CDMA capacity
    - 40% degradation in available satellite RF transmit power and corresponding capacity degradation
    - Degraded Globalstar user coverage / availability
- **Antenna Gain Restrictions Reduce Degradation to Globalstar**
- **At Minimum, Canada Should Implement Antenna Gain Restrictions at Least as Great as U.S.**

### 3) Conclusions

---



# Conclusions

---

- Studies have shown that outdoor RLAN operation at 1W with the >30 deg elev Antenna restriction would still exceed the ITU harmful interference level into the MSS satellite network
- Studies to date have been based on many assumptions on the total RLAN AP roll out/density along with their overall duty cycle with no guarantee that they would not be exceeded in the future.
- Studies of the impact of outdoor RLANs have been based on the specific Globalstar network design, impact on other satellites may be different.
- Studies have shown that outdoor RLAN operation with antenna restrictions would result in reduced interference into Globalstar's Satellite end to end performance, whatever RLAN assumptions are made.
- Outdoor RLAN operation in Canada should take into account the following:
  - Access Point Antenna Gain Restrictions for elevations > 20 deg
  - Registration of AP Locations for Deployments > 1000 Units
  - Development of a threshold level on the allowable uplink interference into the Globalstar satellite receiver.(Note: without determining if the Cdn AP's are causing the interference)
  - Specific mitigation measures Unlicensed AP Operators must take to reduce interference.
- Globalstar is ready to fully cooperate in any future Canadian consultations to develop the appropriate regulatory constraints on the RLAN operation while protecting the Globalstar satellite network

## 4) Addenda

---

# Globalstar satellite constellation

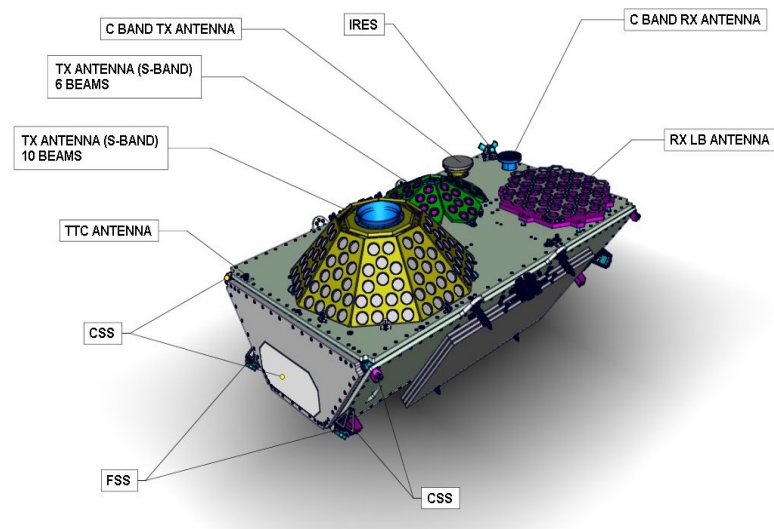
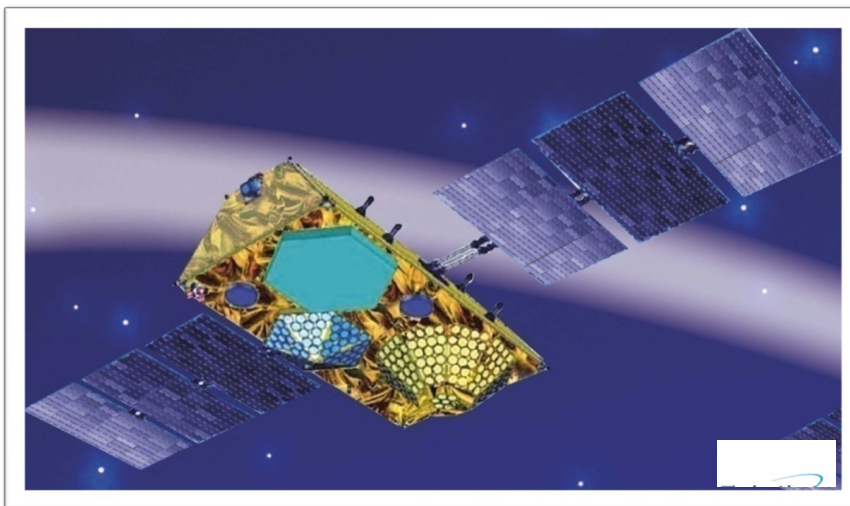
## How are satellites configured?

- Current second-generation satellite constellation – 8 planes, 3 satellites each; 114-minute orbit period. Additional first-generation satellites also provide service
- 70 S to 70 N latitude coverage; minimum two satellite coverage in temperate zones
- High signal quality and availability – multiple satellite coverage reduces fading and blocking, dynamic power control for changing conditions, coherent combining increases signal strength

## How does the constellation work?





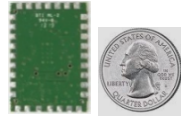

- Satellite constellation communicates with the gateway antennas that pass calls by reflecting the signals from the users' terminals to the gateway
- As a satellite acquires a signal from a subscriber, the subscriber is authenticated by the serving gateway and then the connection is established and the call completed by way of the public switched telephone network to a terrestrial wired or wireless subscriber
- Data connections are made in a similar manner to voice calls except that in the case of a Simplex data message the connection is established via the internet.

## Second-generation satellite diagrams



# Globalstar's select product portfolio –all available in Canada

Globalstar has a full product suite supporting both one-way and two-way communications beyond the range of traditional cellular services.

	Duplex		SPOT		Simplex	
	GSP 1700 / SPOT Global Phone	Sat-Fi	SPOT Gen3	SPOT Trace	STX3	SmartOne B
Image						
Features	<ul style="list-style-type: none"> <li>• Portable two-way satellite phone with full voice and data capabilities</li> <li>• While the GSP-1700 targets the commercial market segment, the SPOT Global phone is consumer-focused</li> </ul>	<ul style="list-style-type: none"> <li>• Connects any Wi-Fi enabled device to Globalstar's satellite network for voice and data services beyond the range of cellular networks</li> <li>• Targets boaters, emergency responders, oil &amp; gas workers, miners, ranchers etc.</li> <li>• Later version will be targeted towards the mass consumer market</li> </ul>	<ul style="list-style-type: none"> <li>• Flexibility to outdoor enthusiasts to send pre-defined messages &amp; GPS coordinates while off the grid</li> <li>• Battery life 2x SPOT 2 – enhanced customization features – smaller form factor</li> <li>• USB for line power eliminates need for battery replacement</li> </ul>	<ul style="list-style-type: none"> <li>• Traces the path of anything, anytime, anywhere for consumer assets</li> <li>• Key applications include theft prevention</li> <li>• Extreme Tracking offered at \$99.99 per year</li> </ul>	<ul style="list-style-type: none"> <li>• World's smallest M2M transmitter</li> <li>• Enables VARs and OEMs to develop smaller, more efficient M2M solutions</li> <li>• Applications include wide range of assets including LPG tanks, water tanks, vehicles, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Designed for the intelligent management of powered and non-powered fixed and movable assets</li> <li>• Provides solution for engine runtime reporting and major fault monitoring for portable construction equipment as well as tracking intermediate bulk containers, vehicles and boats</li> </ul>

# Globalstar ground stations

## Gateway ground stations on six continents – including two gateways in Canada



\* Globalstar retains 30% equity interest  
 \*\* Globalstar retains 49% equity interest



High River Gateway (Canada)



Smith Falls Gateway (Canada)

# Appendices

---

# CDMA Capacity Reduction on Globalstar Downlink

(Relationship used to compute End-End  $E_b/(N+I)$ )

1) Access point interference  $I_a$  degrades uplink

$E_b/(N_0+I_0)$   
relationship  
for satellites  
acting as  
Repeaters\*



$$\boxed{\frac{E_b}{N_0 + I_0}_{MIN, \text{ovr}}} = \left[ \left( \frac{E_b}{N_0 + I_0 + I_a} \right)_{up}^{-1} + \left( \frac{E_b}{N_0 + I_{0,red}} \right)_{dn}^{-1} \right]^{-1}$$

2) Since overall CDMA performance must be maintained

3) Inherent CDMA interference  $I_0$  on downlink must be reduced.

4) Reducing CDMA inherent interference → Globalstar Capacity Reduction

\*Satellite Communication Systems, p. 117, M. Richharia, McGraw Hill, Second Edition, 1999.