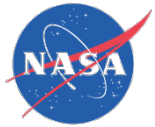


# **DEPENDENCE OF AEROMACS INTERFERENCE ON AIRPORT RADIATION PATTERN CHARACTERISTICS**

## **Abstract**

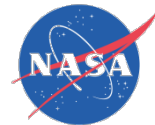
AeroMACS (Aeronautical Mobile Airport Communications System), which is based upon the IEEE 802.16e mobile wireless standard, is expected to be implemented in the 5091-5150 MHz frequency band. As this band is also occupied by Mobile Satellite Service (MSS) feeder uplinks, AeroMACS must be designed to avoid interference with this incumbent service. The aspects of AeroMACS operation that present potential interference are under analysis in order to enable the definition of standards that assure that such interference will be avoided. In this study, the cumulative interference power distribution at low earth orbit from AeroMACS transmitters at the 497 major airports in the contiguous United States was simulated with the Visualyse Professional software. The dependence of the interference power on the number of antenna beams per airport, gain patterns, and beam direction orientations was simulated. As a function of these parameters, the simulation results are presented in terms of the limitations on transmitter power required to maintain the cumulative interference power under the established threshold.



# **Dependence of AeroMACS Interference on Airport Radiation Pattern Characteristics**

**Jeffrey D. Wilson,  
NASA Glenn Research Center**

ICNS 2012 Conference 24-26 April 2012



# AeroMACS Interference Issues

- AeroMACS (Aeronautical Mobile Airport Communications System)
  - Airport ground communications for next generation air transportation systems.
  - To be implemented in 5091-5150 MHz frequency band.
  - Must avoid interference with mobile satellite service (MSS) feeder uplinks.
- Interference Modeling
  - Performed with Visualyse Professional software.
  - Simulated configurations of AeroMACS antennas at 497 major airports in contiguous US.
  - Calculated resulting aggregate power at low earth orbit.
  - Determined limits on AeroMACS transmissions from airports so that the threshold of interference into MSS is not exceeded.



# Interference Analysis Modeling

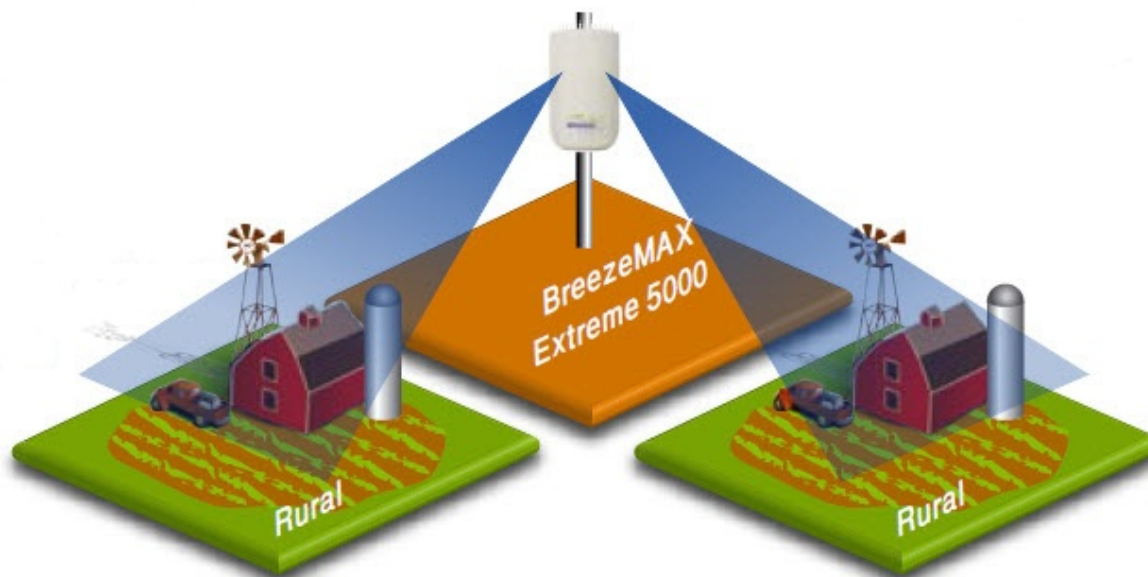
## Modeling Procedure with Visualyse Professional:

1. Define antenna gain profiles.
2. Locate transmitters and receivers.
3. Specify bandwidth and frequency of carriers.
4. Set up propagation environment (basic transmission loss in free space, ITU-R P525).
5. Assign transmitter power (135 mW).
6. Define links between transmitters and receivers.
7. Specify output desired, run, and analyze results.

# AeroMACS Antennas

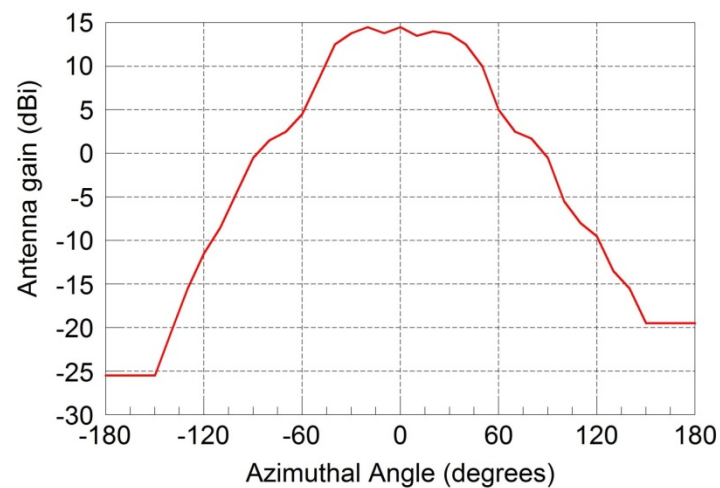
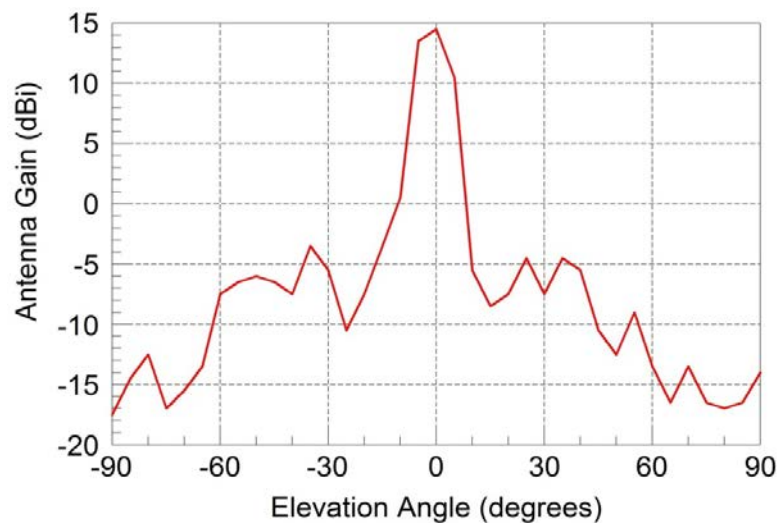
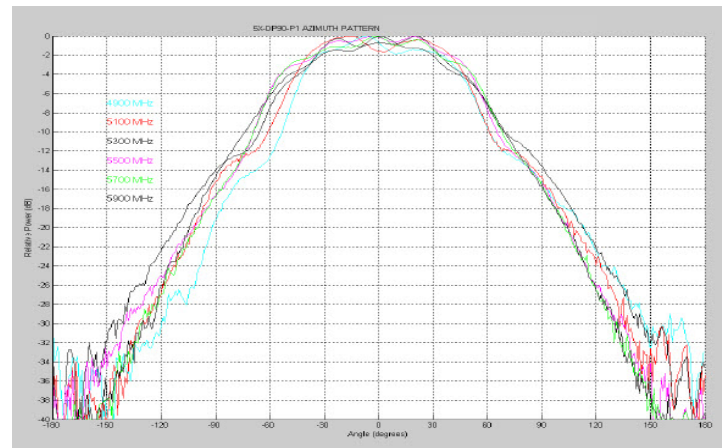
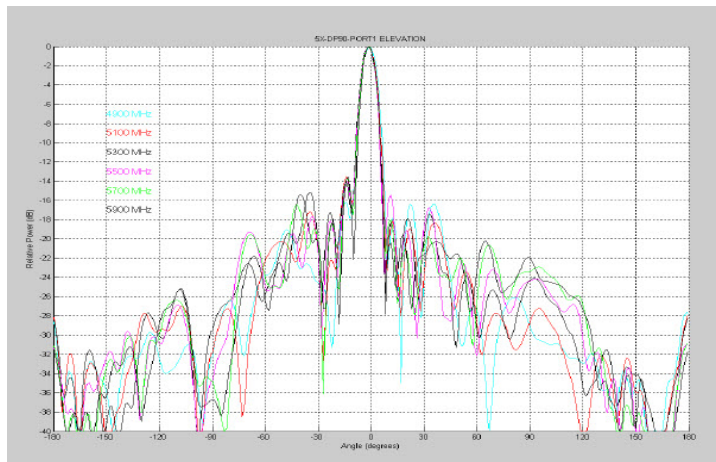
## Alvarion BreezeMAX Extreme 5000

- Gain = 15 dBi
- Azimuth Beamwidth =  $80^{\circ}$ , Elevation Beamwidth =  $8^{\circ}$



from [www.alverion.com](http://www.alverion.com)

# AeroMACS Antenna Gain Profile





# 497 Transmitter Locations





# Antenna Transmission

- AeroMACS antennas transmit over 5-MHz channels.
  - Consider channel centered at 5100 MHz.
  - One of 11 channels available over 5091-5150 MHz band.
- Each antenna beam transmits -8.7 dBW (135 mW).
  - Cumulative interference power calculated at LEO (1400 km).
  - Determine 'hot spot' where aggregate interference power a maximum.
  - Adjust transmitted power so that 'hot spot' is at threshold interference power.
  - Threshold interference power = -157.3 dBW ( $1.86 \times 10^{-16}$  W): corresponds to 2% increase of MSS satellite receiver's noise temperature.

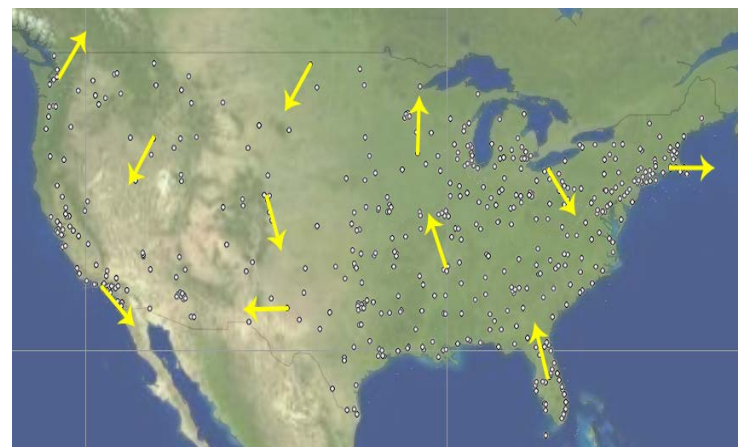


# Random Antenna Orientation Cases

## Case 1

One antenna beam at each airport:

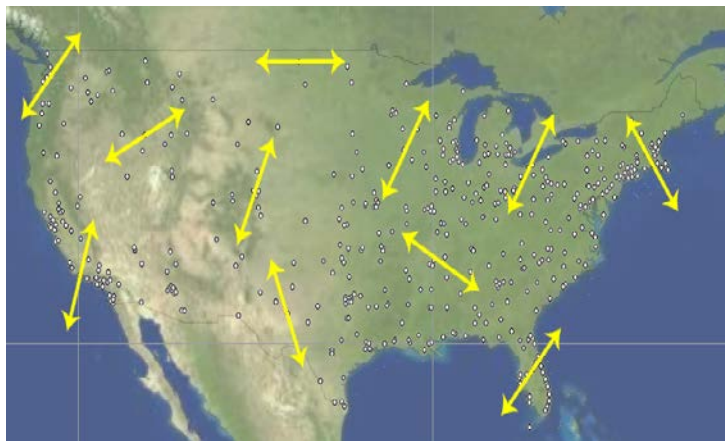
- Since each airport has a different layout of runways and buildings, random beam orientations are assumed.
- Most airports will likely require one or two beams.
- Larger airports may require three or four beams.
- Consider several orientation cases:



# Random Antenna Orientation: Cases 2a, 2b

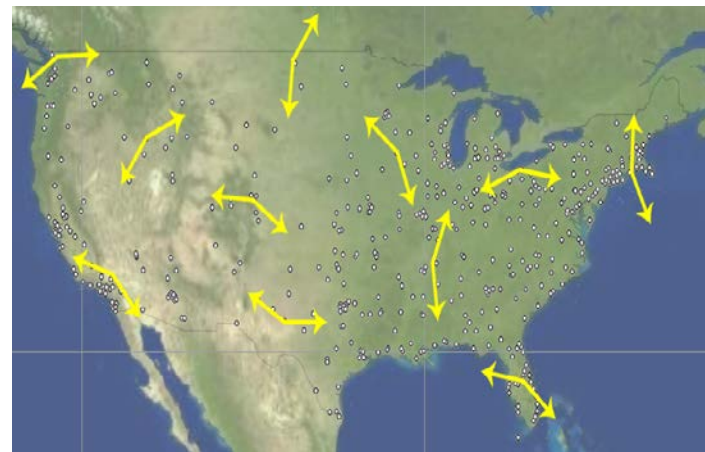
## Case 2a

Two antenna beams separated by  $180^\circ$  at each airport:



## Case 2b

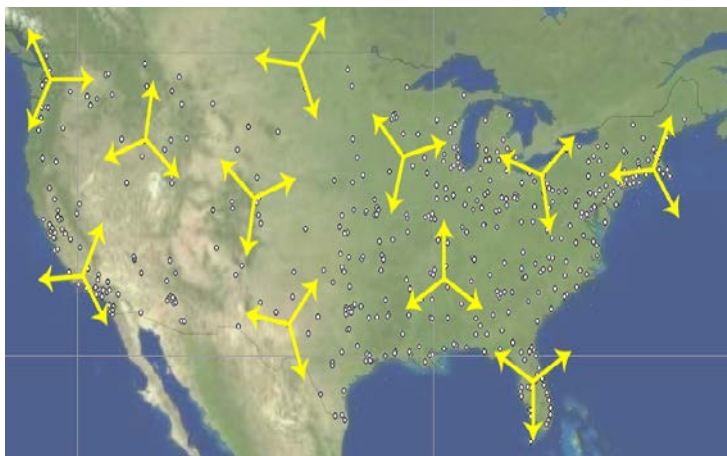
Two antenna beams separated by  $120^\circ$  at each airport:



# Random Antenna Orientation: Cases 3, 4

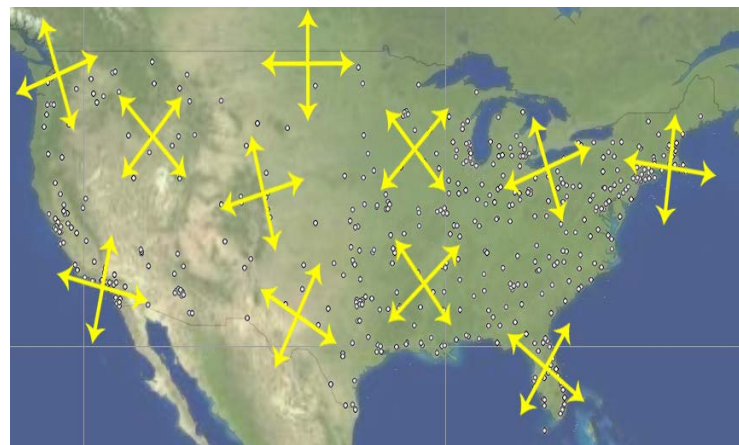
## Case 3

Three antenna beams separated by  $120^\circ$  at each airport:



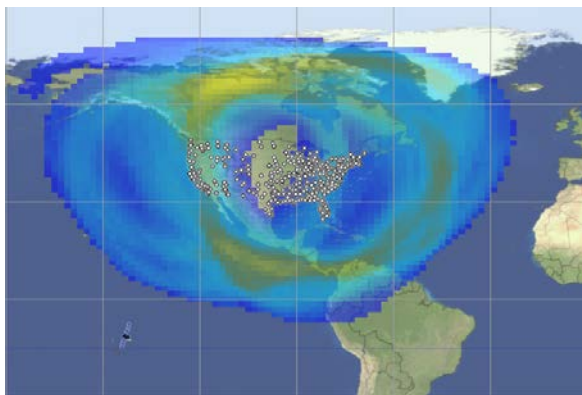
## Case 4

Four antenna beams separated by  $90^\circ$  at each airport:

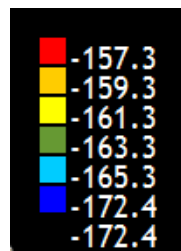
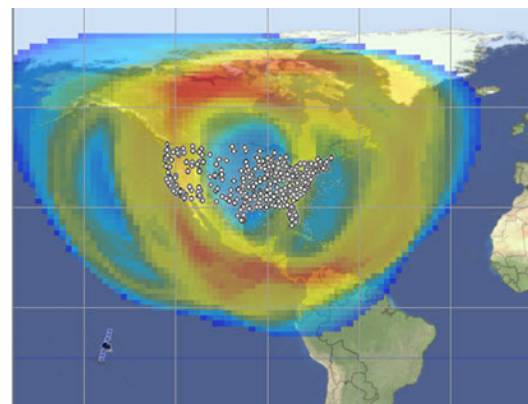


# Aggregate Interference Power at 1400 km

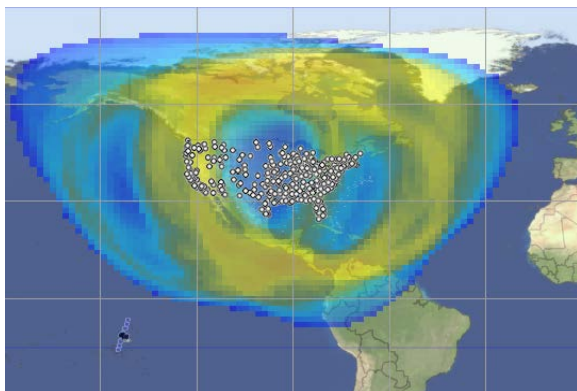
Case 1:



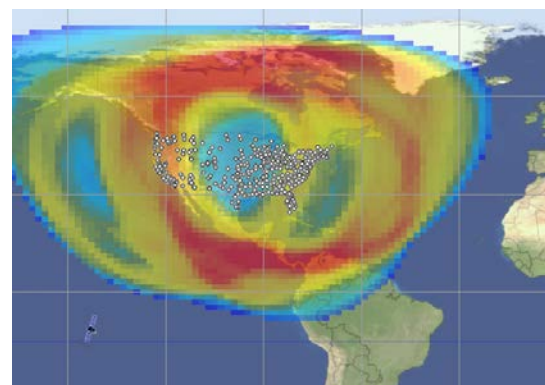
Case 3:



Case 2a:



Case 4:



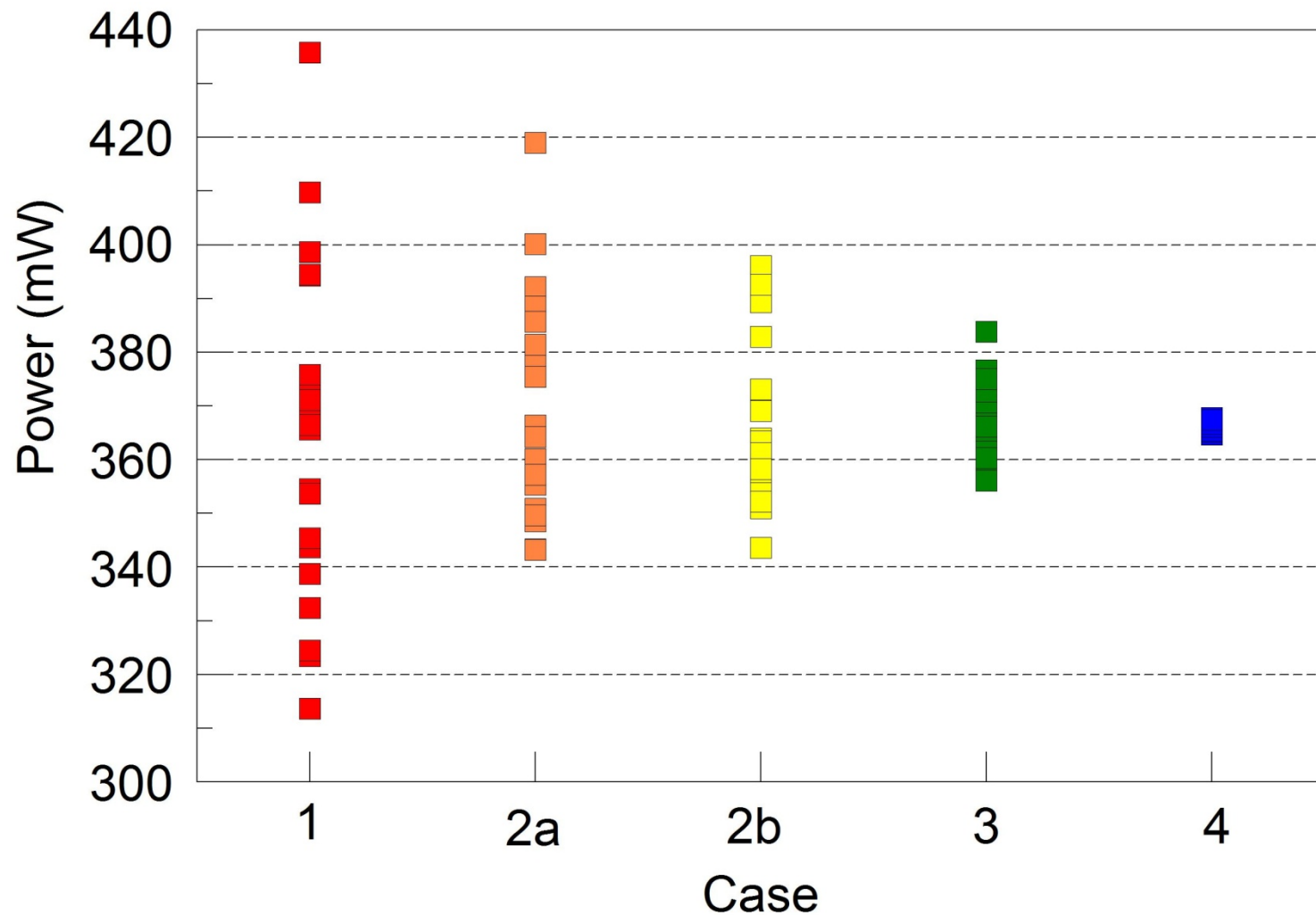


# Threshold Interference Power

- Submitted 20 runs with different randomizations for each case
- Determined location of maximum aggregate interference power.
- ('Hot spot' for each run was in northern Canada).
- Calculated total power transmitted per airport to reach threshold interference power -157.3 dBW at 'hot spot'.
- Example: Case 1, Run 19
  - Transmitting -8.7 dBW at each airport results in maximum aggregate interference power of -161.7 dBW at 67° N, 105° W.
  - Since we are 4.4 dBW under threshold, we can transmit  $-8.7 + 4.4 \text{ dBW} = -4.3 \text{ dBW}$  ( 372 mW ) at each airport.



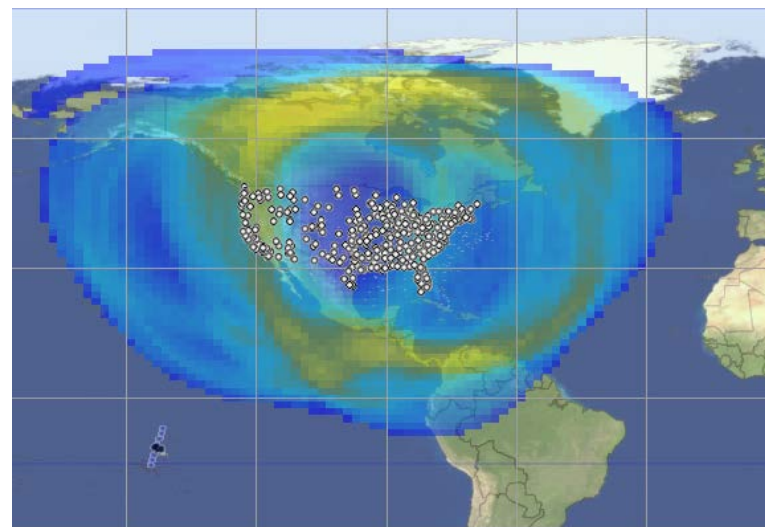
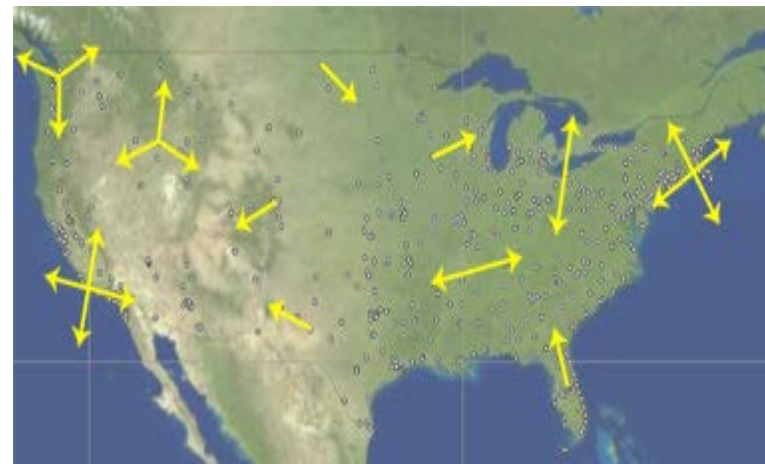
# Transmitted Power / Airport to Reach Threshold





## Variable Airport Size: Case 5

- Divide airports into size categories based on 2009 passenger boardings.
  - 10 Very Large (LAX, JFK) : model with 4 beams.
  - 18 Large (SEA, SLC) : model with 3 beams.
  - 33 Medium (CLE, MEM) : model with 2 beams.
  - 436 Small (GRB, GNV) : model with 1 beam.
- Assume each beam transmits equal amount of power.





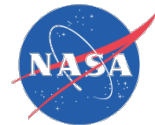
## Case 5 Results

- Submitted 20 randomized runs.
- Worst run results:

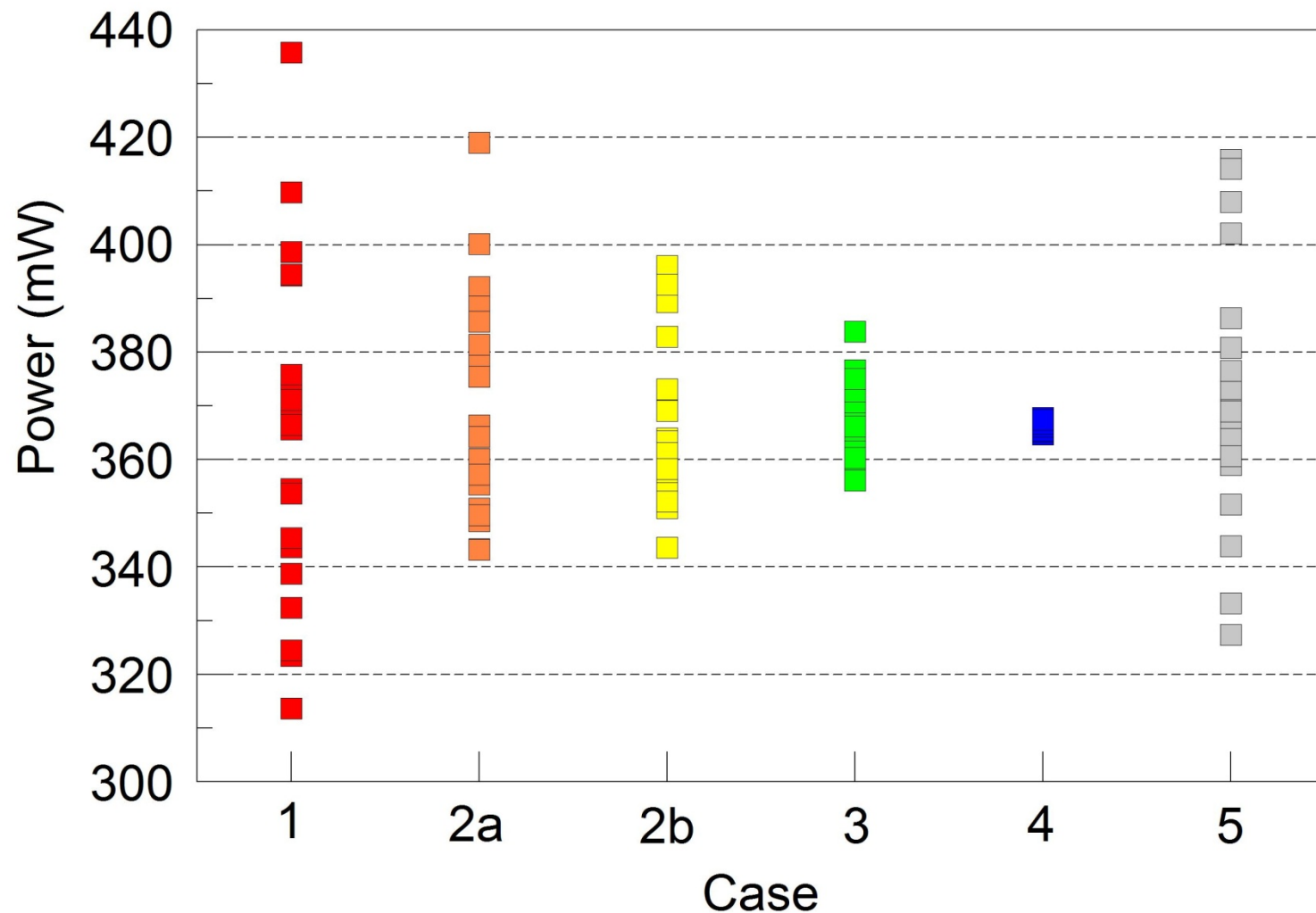
Airport Size	Allowable Transmitted Power
Very Large (10)	1092 mW
Large (18)	819 mW
Medium (33)	546 mW
Small (436)	273 mW

- Total transmitted power / 497 = 327 mW/airport.



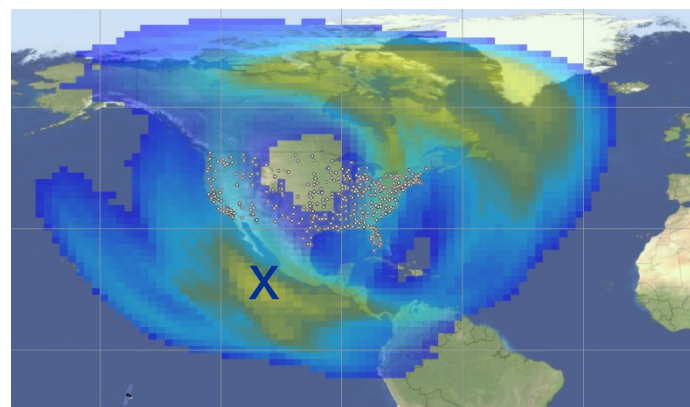
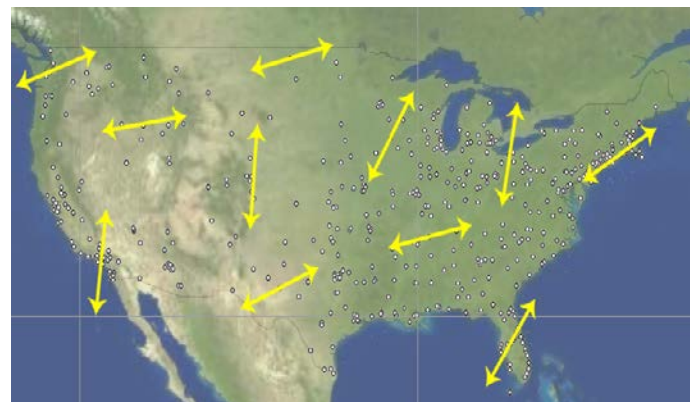


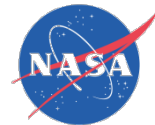
# Transmitted Power / Airport to Reach Threshold



# Semi-Random Antenna Orientation

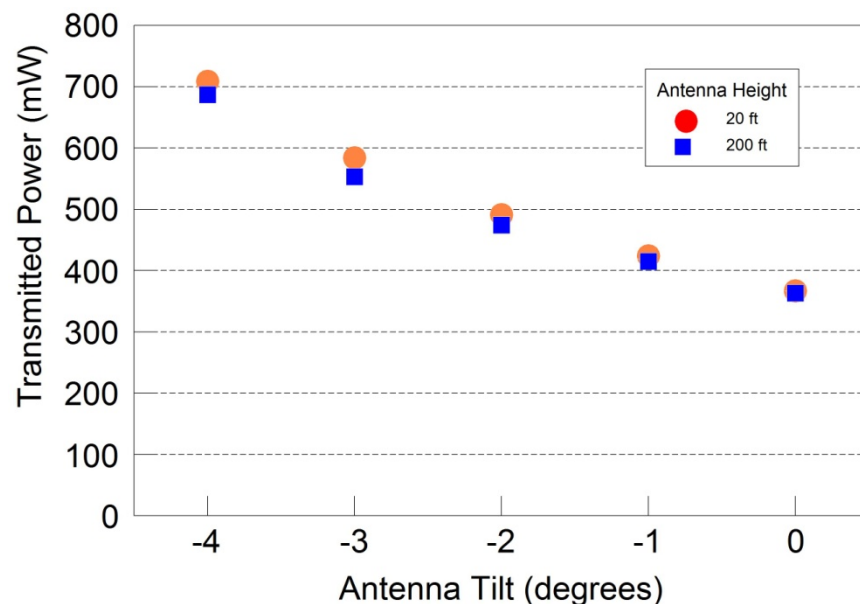
- Beam directions likely not completely random.
- Airplanes prefer to takeoff and land into wind.
- Prevailing wind in US primarily from south and west.
- Assume an extreme case with two oppositely oriented beams at each airport with all beams oriented in SW/NE quadrants.
- Results from 20 runs:
  - “Hot spots” located over Pacific west of Mexico.
  - Avg. run allows 176 mW/airport
  - Worst run allows 151 mW/airport





# Antenna Height / Tilt Effects

- Examined a specific run with 4 beams (Case 4).
- Allowable transmitted power virtually independent of antenna height.
  - Similar results with 20 ft and 200 ft antennas.
  - Antenna height negligible compared to 1400 km LEO height.
- Allowable transmitted power strongly increases as downward tilt increases.
  - However reflection effects not modeled.
  - Need further work to verify.





# Conclusions

- Modeled aggregate interference from 497 airport AeroMACS antennas at LEO (1400 km).
- Of 120 runs with randomized beam orientations, worst run allows 314 mW to be transmitted from each airport.
- Of 20 runs with semi-randomized beam orientations in SW/NE quadrant, worst run allows 151 mW /airport.
- Positioning of AeroMACS base station antenna beam directions and degree of randomness will have significant impact on allowable power.
- Downward tilt should increase allowable power.
- Future work needed to add subscriber effects.
- Expect 150 – 300+ mW allowable per airport for each of eleven 5-MHz channels.