

Interference Analysis Status and Plans for Aeronautical Mobile Airport Communications System (AeroMACS)

Interference issues related to the operation of an aeronautical mobile airport communications system (AeroMACS) in the C-Band (specifically 5091-5150 MHz) is being investigated. The issue of primary interest is co-channel interference from AeroMACS into mobile-satellite system (MSS) feeder uplinks. The effort is focusing on establishing practical limits on AeroMACS transmissions from airports so that the threshold of interference into MSS is not exceeded. The analyses are being performed with the software package Visualyse Professional, developed by Transfinite Systems Limited. Results with omni-directional antennas and plans to extend the models to represent AeroMACS more accurately will be presented. These models should enable realistic analyses of emerging AeroMACS designs to be developed from NASA Test Bed, RTCA 223, and European results.



Interference Analysis Status and Plans for Aeronautical Mobile Airport Communications System (AeroMACS)

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Introduction

AeroMACS

- Aeronautical Mobile Airport Communications System (AeroMACS) is being developed to provide next-generation broadband, networked communications for airport surface applications – safety critical, non-critical and advisory (ATC, AOC, AAC, airport operations)
- AeroMACS is based on IEEE 802.16e/802.16-2009 standards
- RTCA Special Committee 223 is working to develop standards for AeroMACS, an “aviation profile” derived from the IEEE 802.16
- Key technical parameters are under investigation, such as security issues, channelization of the 5091-5150 MHz allocation, interference issues, transmit power limitations, etc.



Introduction

AeroMACS Interference Analysis

- The work described in the presentation addresses interference issues for the AeroMACS standard under development within RTCA SC-223
- AeroMACS transmit power limitations need to be determined in order to prevent interference from AeroMACS into other existing systems
- An analytical capability is needed to enable NASA to contribute technically to this effort:
 - Enable required analyses to be performed in coordination with other organizations, within an RTCA sub group
 - Complementary to other capabilities that will be employed, such as the Mitre-CAASD models
 - Provide validation of results, increase confidence level for key results
- This presentation describes NASA Glenn Research Center's progress in developing and validation this capability



AeroMACS Interference Issues

- Relevant 5091- 5150 MHz in-band systems that need to be considered:
 - Aeronautical Radionavigation Service (ARNS)
 - Aeronautical Mobile Service (AMS) (Aeronautical Security (AS))
 - Aeronautical Mobile Telemetry (AMT)
 - Aeronautical Mobile (Route) Service (AM(R)S)
 - Fixed Satellite Service (FSS) (Mobile Satellite Service (MSS) feeder uplink)
- Issue of immediate interest is interference from AeroMACS into the MSS feeder uplink
- This effort will focus on establishing practical limits on AeroMACS transmissions from airports so that the threshold of interference into MSS is not exceeded



Interference Analysis Modeling (1)

Interference modeling is being performed with Visualyse Professional Version 7 software from Transfinite Systems Limited (UK)

Modeling Procedure:

1. Define antennas

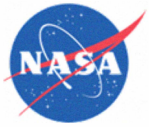
- Single beam, multiple beam, spot beam patterns
- Beam shape can be circular, elliptical, or shaped with user-defined gain dependence on azimuth and elevation angles

2. Locate stations

- Locations of transmitters and receivers
- Types: Earth, Mobile, Maritime, Aeronautical, GSO Satellite, non-GSO Satellite

3. Specify carriers

- Frequency, bandwidth, polarization
- Spectrum masks to calculate adjacent channel and out of band interference levels



Interference Analysis Modeling (2)

Modeling Procedure (continued):

4. Set up propagation environment

- Choose loss model from ITU-R menu
- Can include rain attenuation, atmospheric losses

5. Set up links

- Connect stations
- Form communications paths by combining stations carriers, propagation, interference criteria
- Types: fixed, receive, transmit, dynamic

6. Set up interference paths

- Select victim link(s)
- Select interfering link(s)

7. Specify output desired, run, and analyze results

- Detailed statistics
- Visual, graphical output
- Monte Carlo runs with varying parameters



Benchmark Case

Reference: Hoh, Gheorghisor, and Box, 2005, Feasibility Analysis of 5091-5150 MHz Band Sharing by ANLE and MSS Feeder Links, MITRE-CAASD Report MP 05W0000083

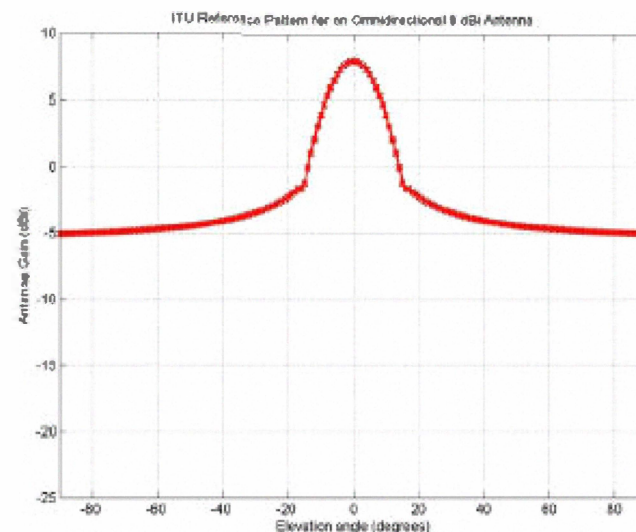
Key Aspects:

- Investigated co-channel interference from ANLE (Airport Network and Location Equipment / now referred to as AeroMACS) system to non-geostationary mobile-satellite-service (MSS) feeder uplinks
- Assumed one transmitter with omni-directional antenna at each of 497 major airports in contiguous United States
- Worst case scenario: all transmitters on 100% of time
- Calculated aggregate interference power at LEO from each airport antenna:

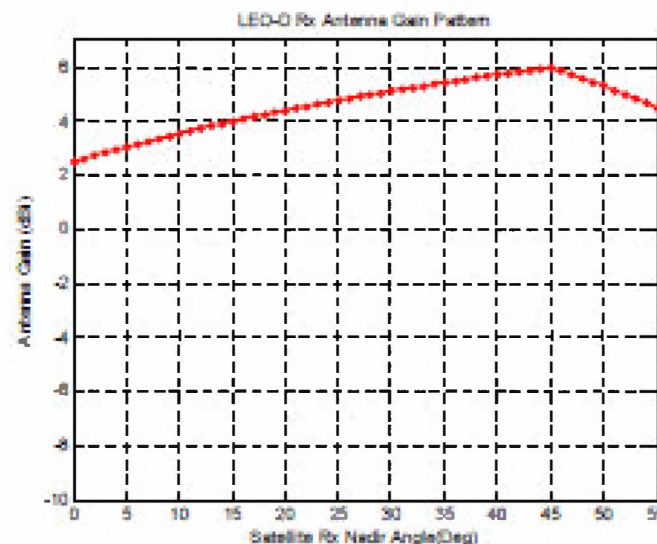
$$P_r(\text{dBW}) = P_t + G_t - L_c + G_r - L_{\text{free}}(d) - L_{\text{feed}} - L_p + B_f - 30$$

Benchmark Parameters *(from Hoh, et al.)*

- P_t = transmitter power
= 38.6 dBm (8.6 dB = 7.2 W)
- G_t = transmit antenna gain
= 8 dBi peak (see figure)
- L_c = cable/line loss = 1 dB
- G_r = receive antenna gain
= 6 dBi peak (see figure)
- L_{free} = free-space path loss (dB)
- L_{feed} = feed loss = 2.9 dB
- L_p = polarization discrimination = 1 dB
- B_f = bandwidth factor
= $10 \cdot \log(B_{\text{LEO}}/B_{\text{ANLE}})$
= $10 \cdot \log(1.23/20) = -12.1$ dB
- d = distance between transmitter and LEO satellite receiver = (1414+ km)

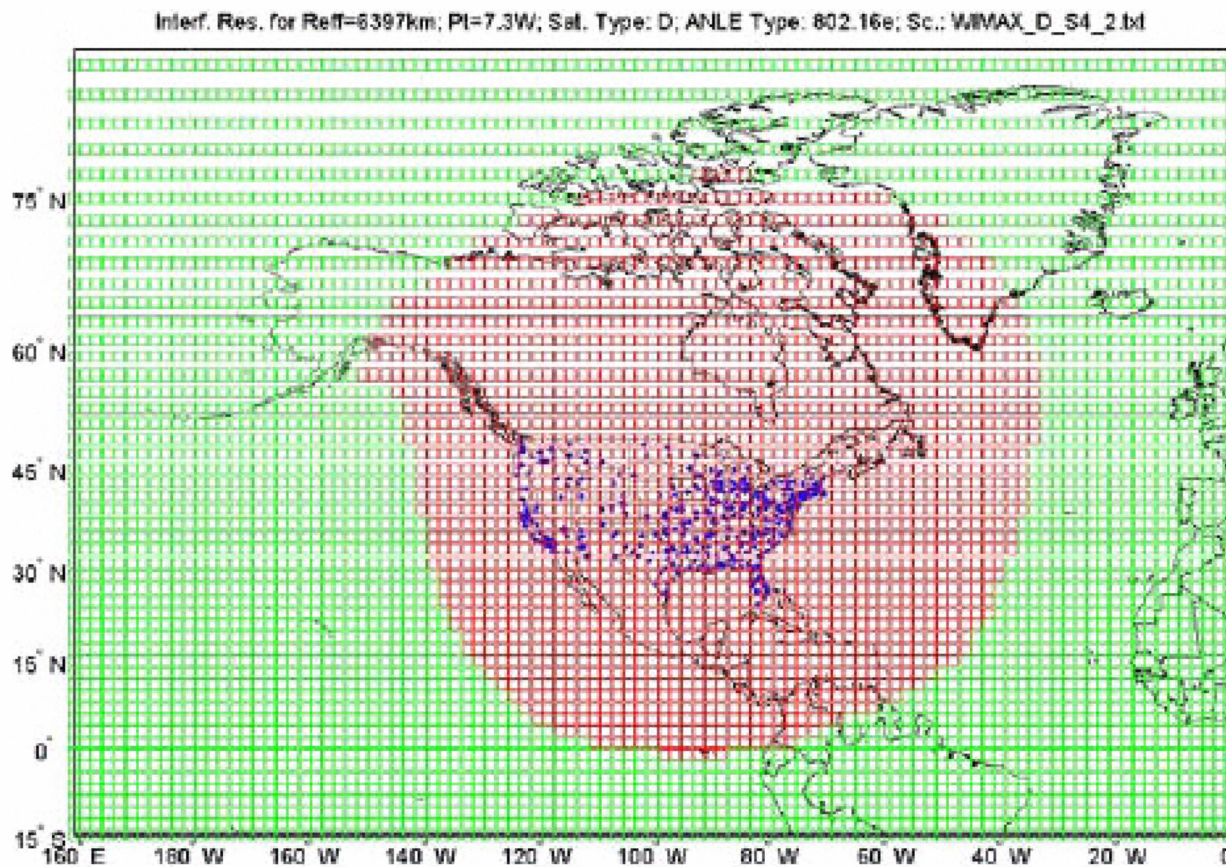


Transmit antenna gain pattern



Receive antenna gain pattern

Benchmark Results *(from Hoh, et al.)*

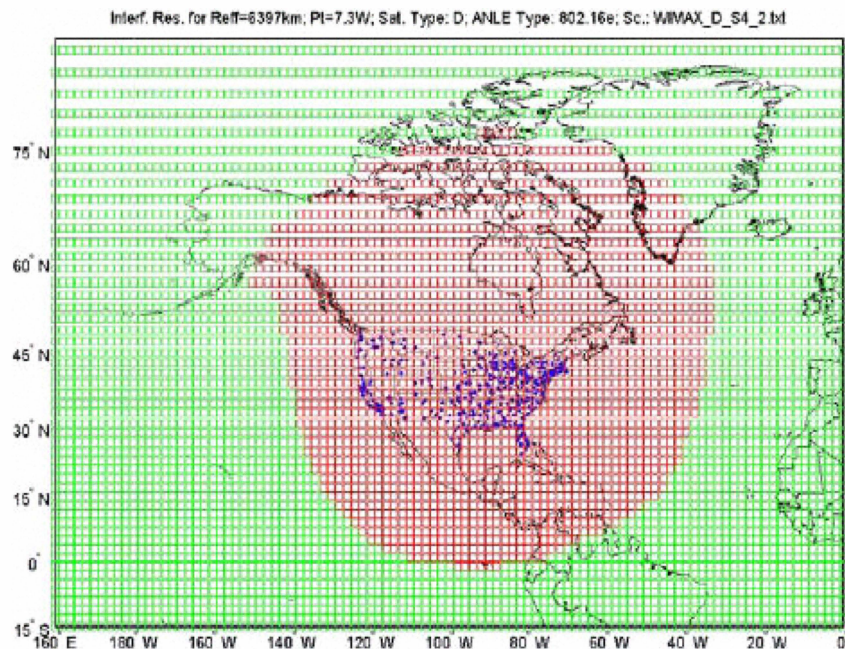


- Aggregate interference power at LEO (1414 km) from 497 airports
- Threshold (- 155.5 dBW) exceeded in red area*
- Maximum interference power of -150.0 dBW at 67° N 104° W

*Note threshold definition has since been tightened to -157.3 dBW corresponding to 2% increase of satellite receiver's noise temperature

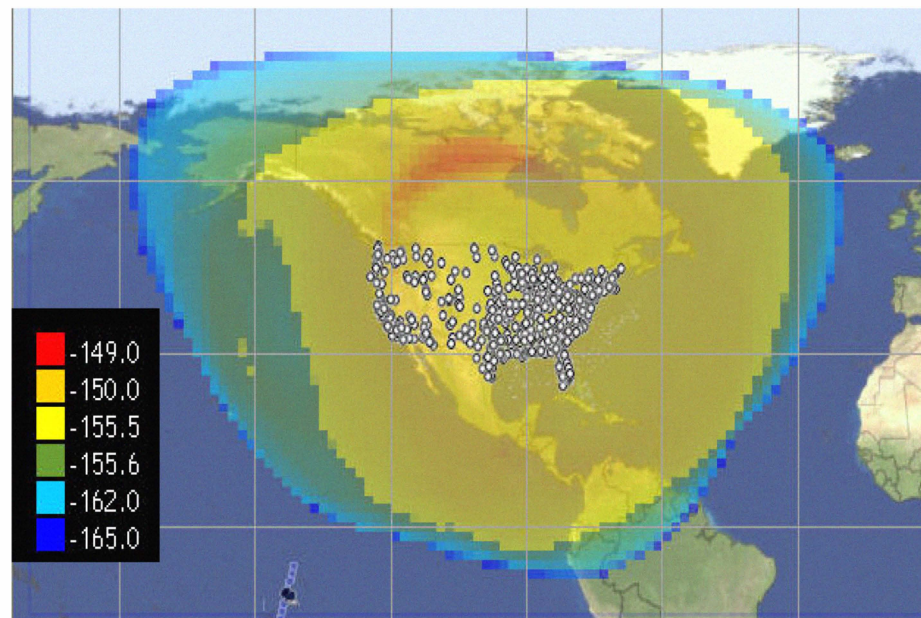
Visualyse Results Comparison

Hoh, et al.:



- Red/green border = threshold
- Max interference = -150.0 dBW
- Max location = 67° N 104° W

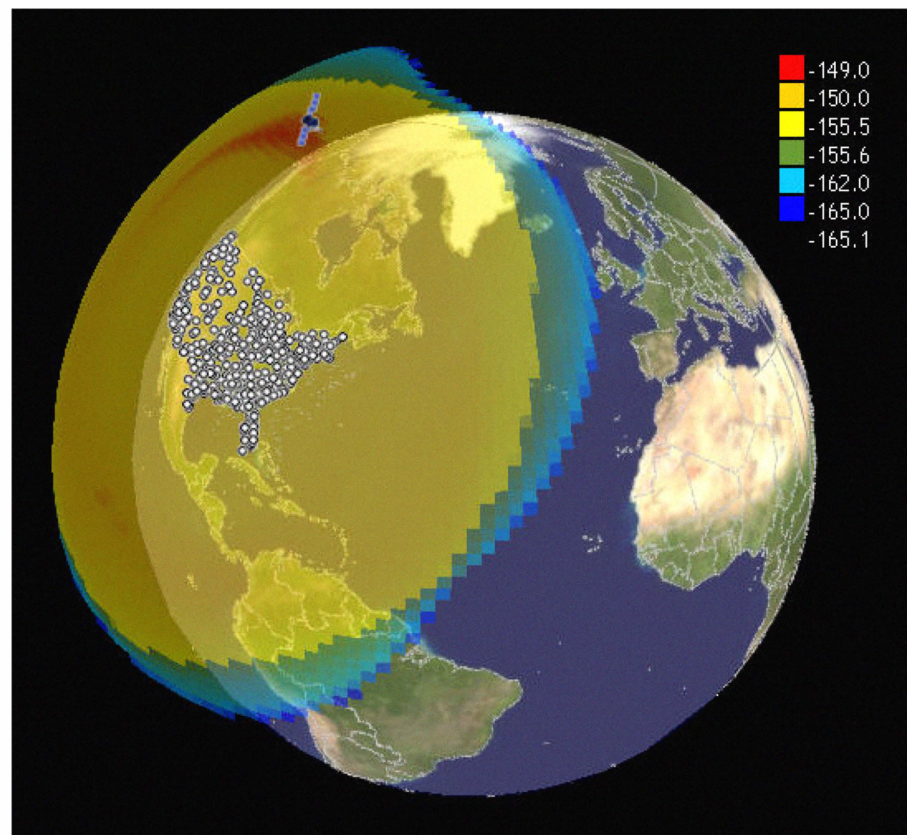
Visualyse:



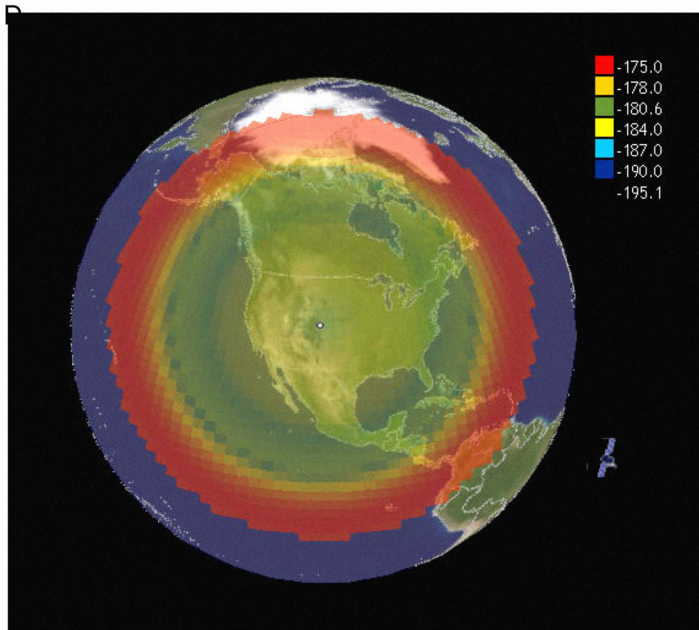
- Yellow/green border = threshold
- Max interference = -149.3 dBW
- Max location = 64° N 105° W

Visualyse Global View

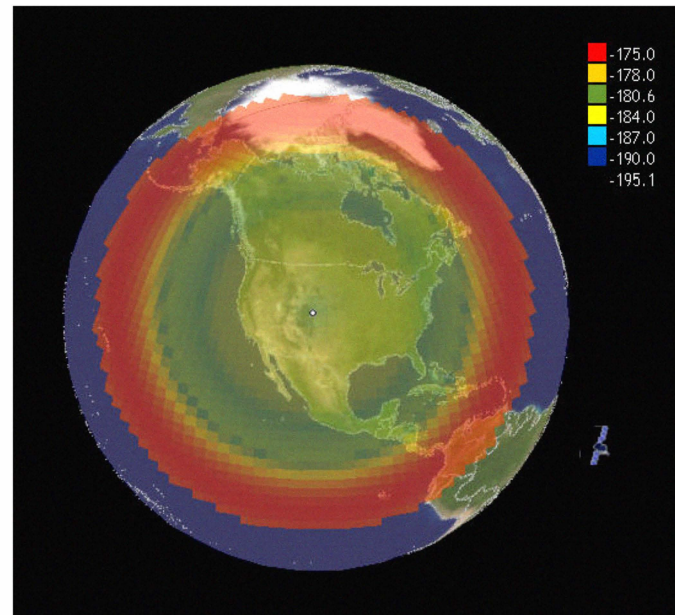
- Corresponding global view shows widespread area of threshold violation (yellow and red) in this worst case scenario
- Confirms need to investigate sectoral antennas as in MITRE-CAASD study
(Gheorghisor, Hoh, and Leu, et al., 2009, Analysis of ANLE Compatibility with MSS Feeder Links, MITRE-CAASD Report MTR090458)
- Max interference power over northern Canada and secondary max over Central America due to maximum transmitting gain of antennas in horizontal direction



Interference Power for Single Airport Model



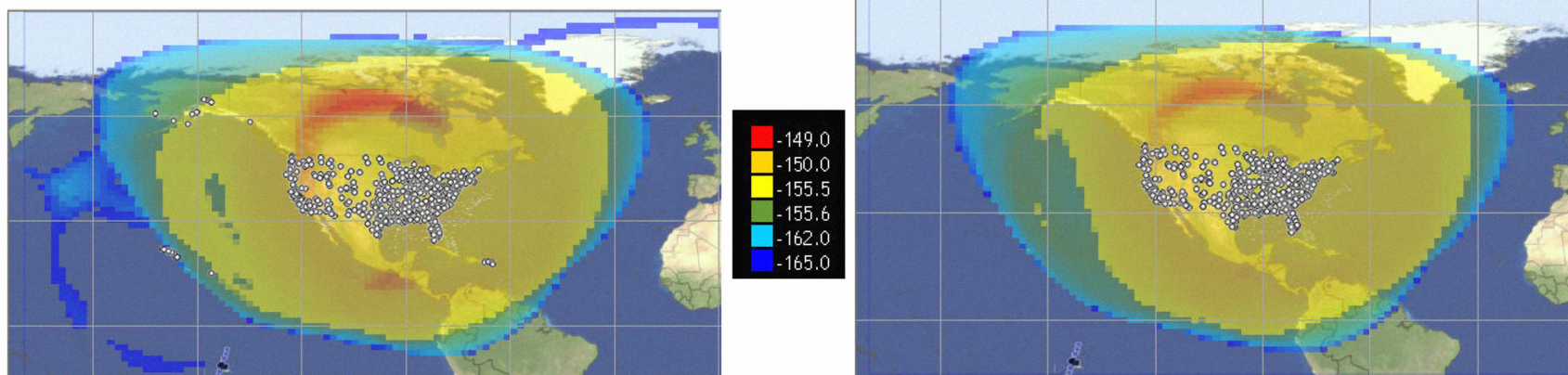
Denver (sea level)



Denver (5431 feet)

- Max interference power -175.5 dBW in both
- Station elevation (1.6 km) not very important at LEO (1414 km)

Interference Power for 703 Airports Model

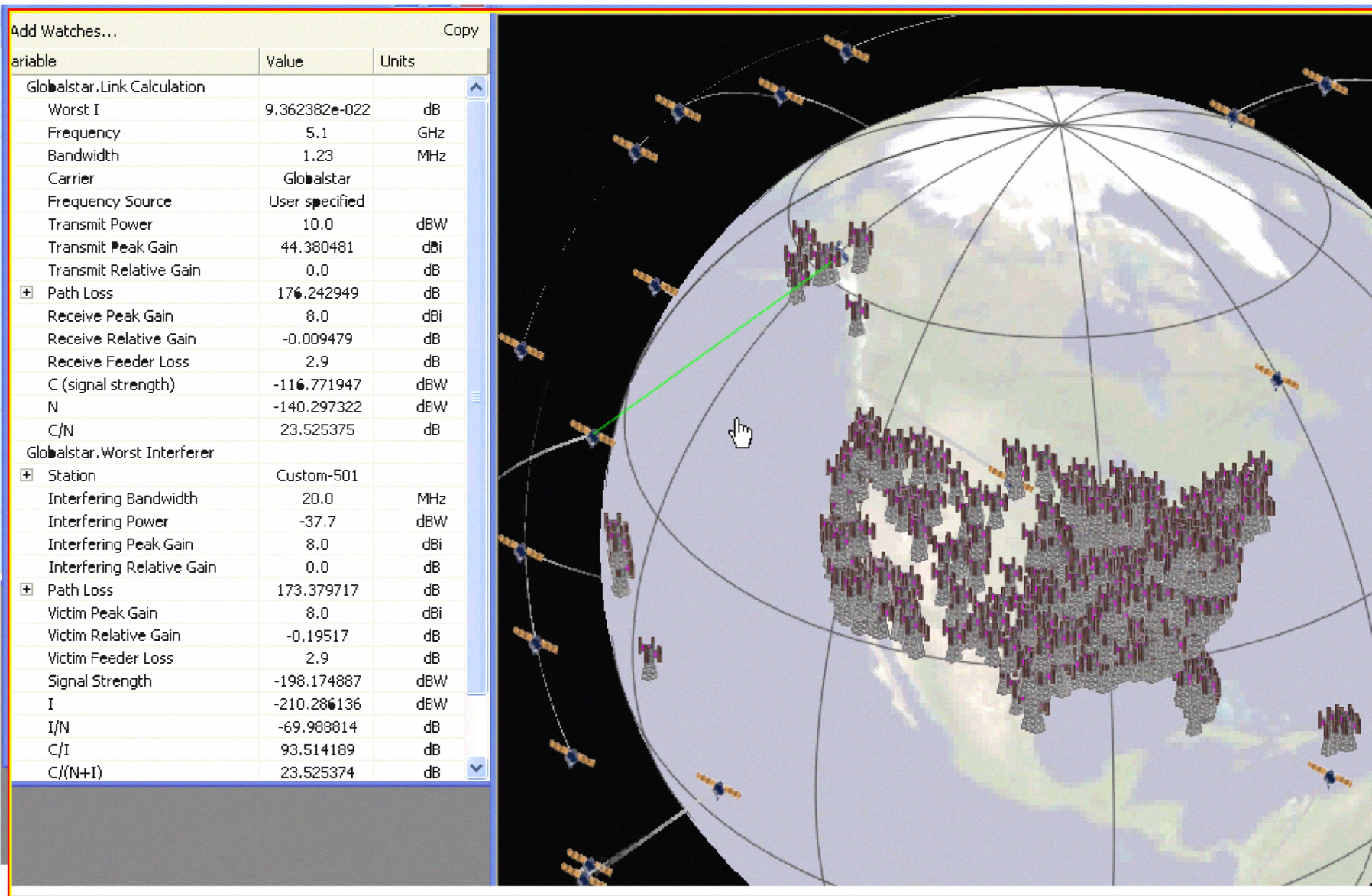


703 Airports

497 Airports

- Model includes 703 FAA towered airports and heliports, including Alaska, Hawaii, and Caribbean, from FAA data base
 - More than the 497 airports considered in *Hoh, et al.*
- Interference threshold violation extends further into Pacific.
- Maximum interference power increases only by 0.3 dBW.

Wasilla Globalstar Uplink Movie





Future Plans

- Year 2010 plans to increase complexity and realism of interference models:
 - Multi-sector antennas.
 - Airport surface network with multiple base and subscriber stations.
- Year 2011 and beyond potential plans:
 - Interference from AeroMACS into adjacent frequency bands.
 - Co-channel and adjacent band interference into AeroMACS.
 - Geographically close AeroMACS implementations.
 - Multiple stations, frequency re-use, and multipath signal propagation effects in single airport.



Conclusions

- Need to establish practical limits on AeroMACS transmissions from airports so that the threshold of interference into MSS and other C-band systems is not exceeded
 - Enable the development of standards under RTCA SC-223
- Analyses have been started with Visualyse, a powerful and flexible interference analysis software tool.
- Visualyse results with omni-directional antenna transmitters agree very well with results from MITRE-CAASD.
- Near term plans to improve model realism with multi-sector antennas and subscriber stations.