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# Modeling GPS Adaptive Nulling Receivers

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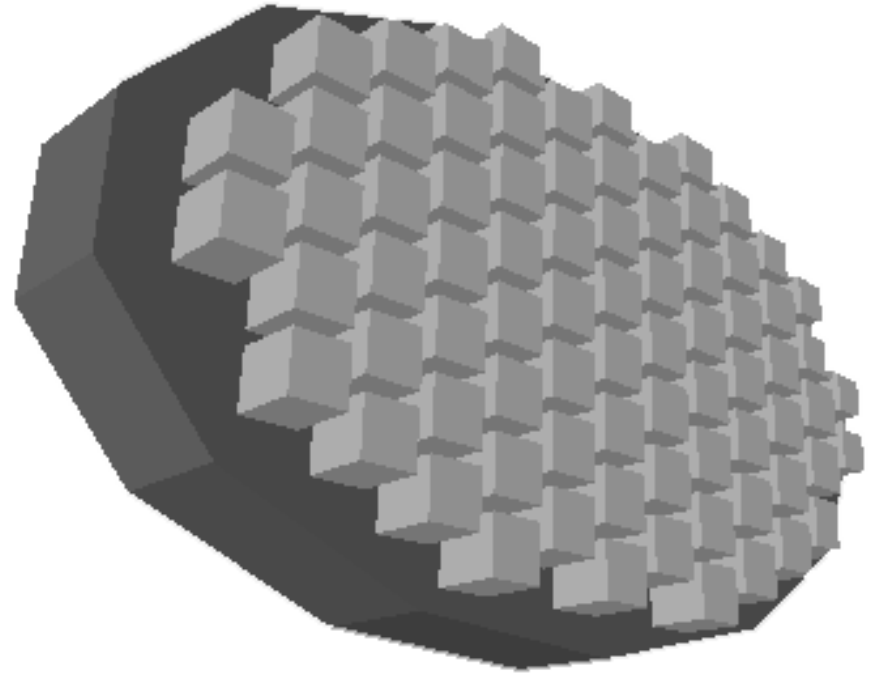
# Satellite Software



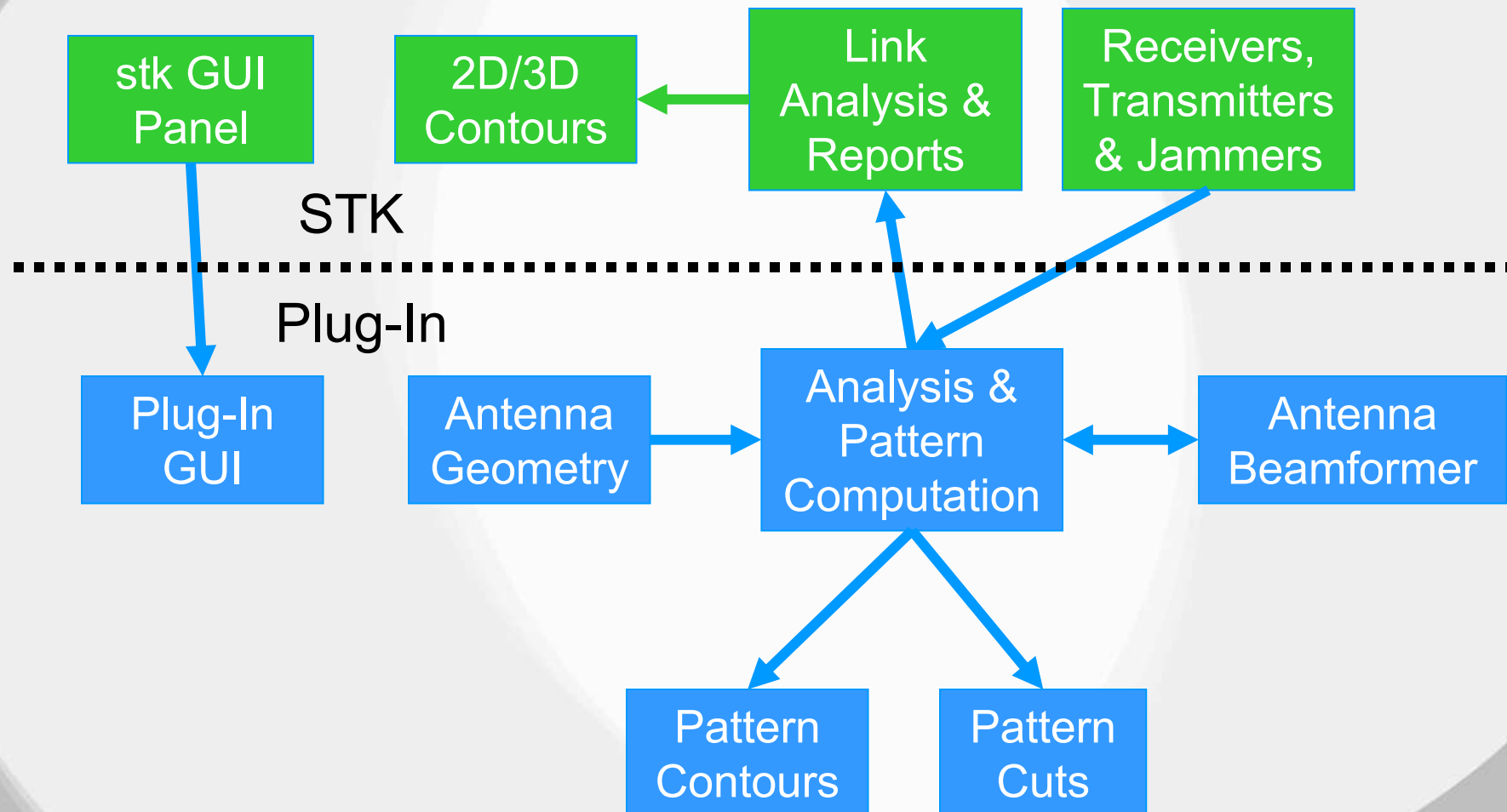
- AGI business partner specializing in antennas
- Develops antenna modeling software (SATSOFT)
- Developing a series of antenna plug-ins for stk & ntk
- [www.satsoft.com](http://www.satsoft.com)
- Contact Ken Sherman (*sales at satsoft dot com*)

# Overview

- Plug-In Architecture
- Array Design
- PA GUI
- Nulling Algorithms
- Null Formation
- Scenarios
- Results
- Future Work
- Conclusions



# Antenna Plug-In Architecture



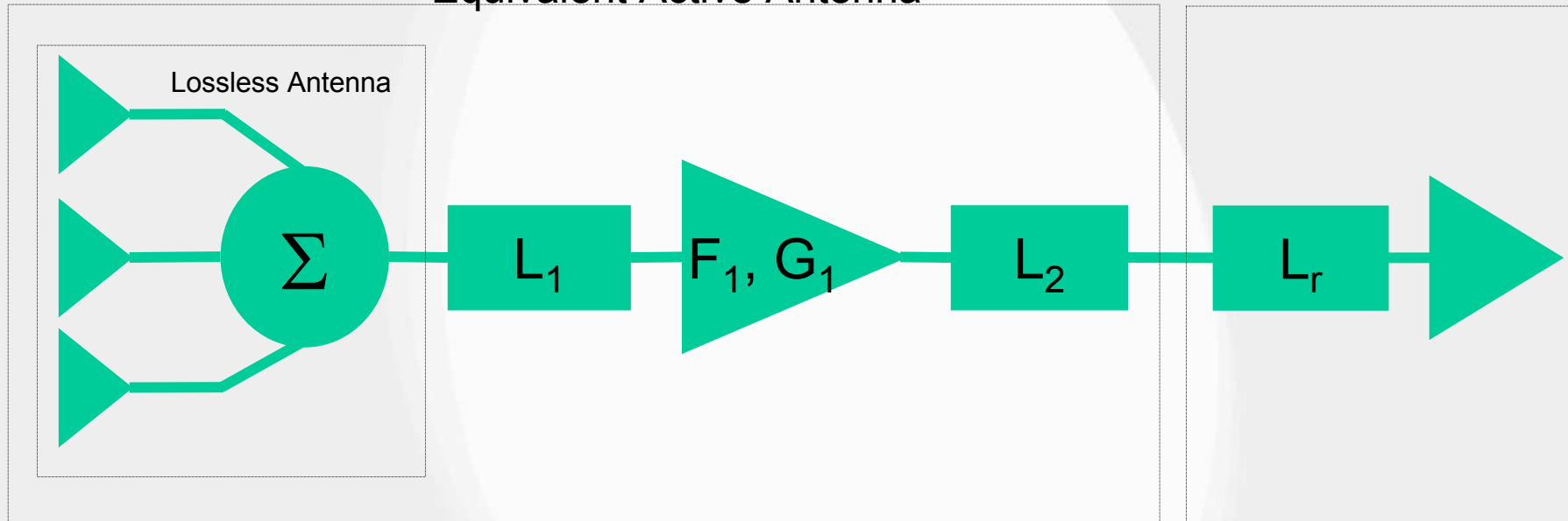
# Wide Range of Antennas Supported by Plug-In

- Active & passive receiving antennas
- Active & passive transmitting antennas
- Beam steering and nulling
- Arbitrary polarization (LP, CP, etc)

# Active Receiving Antenna

Equivalent Active Antenna

Receiver



$$t_e = (l_1 - 1)t_0 + (f_1 - 1)l_1 t_0 + (l_2 - 1) \frac{l_1}{g_1} t_0$$

$$g_{ckt} = \frac{g_1}{l_2} \quad g_a(\theta, \phi) = \frac{g_{lossless}(\theta, \phi)}{l_1}$$

$$f_e = 1 + \frac{t_e}{t_0}$$

# Features of Phased Array Plug In



- Quickly design arrays for any receiver or transmitter in stk & ntk
- Planar, linear, and cylindrical (conformal) array geometries
- Circular, elliptical, and polygonal apertures
- Shaped beam phase and/or amplitude synthesis
- Adaptive nulling
- Taylor circular, rectangular, and Baylis low sidelobe aperture tapers
- Several element models
- Linear & circular polarization

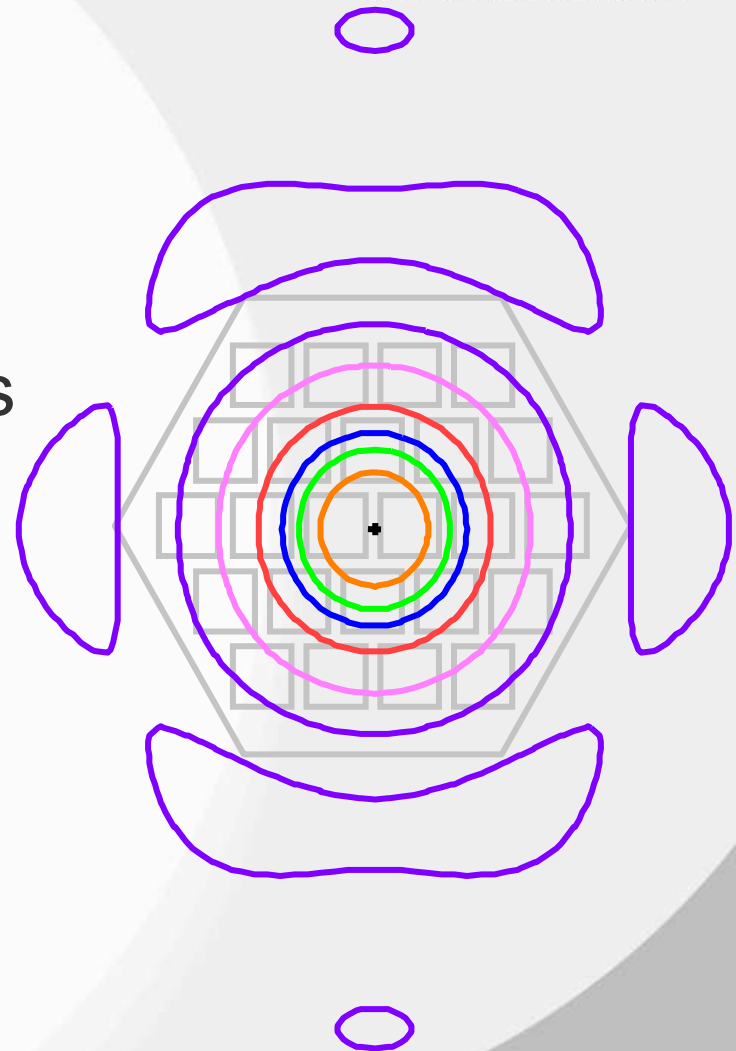
# Designing & Analyze the Array

Define:

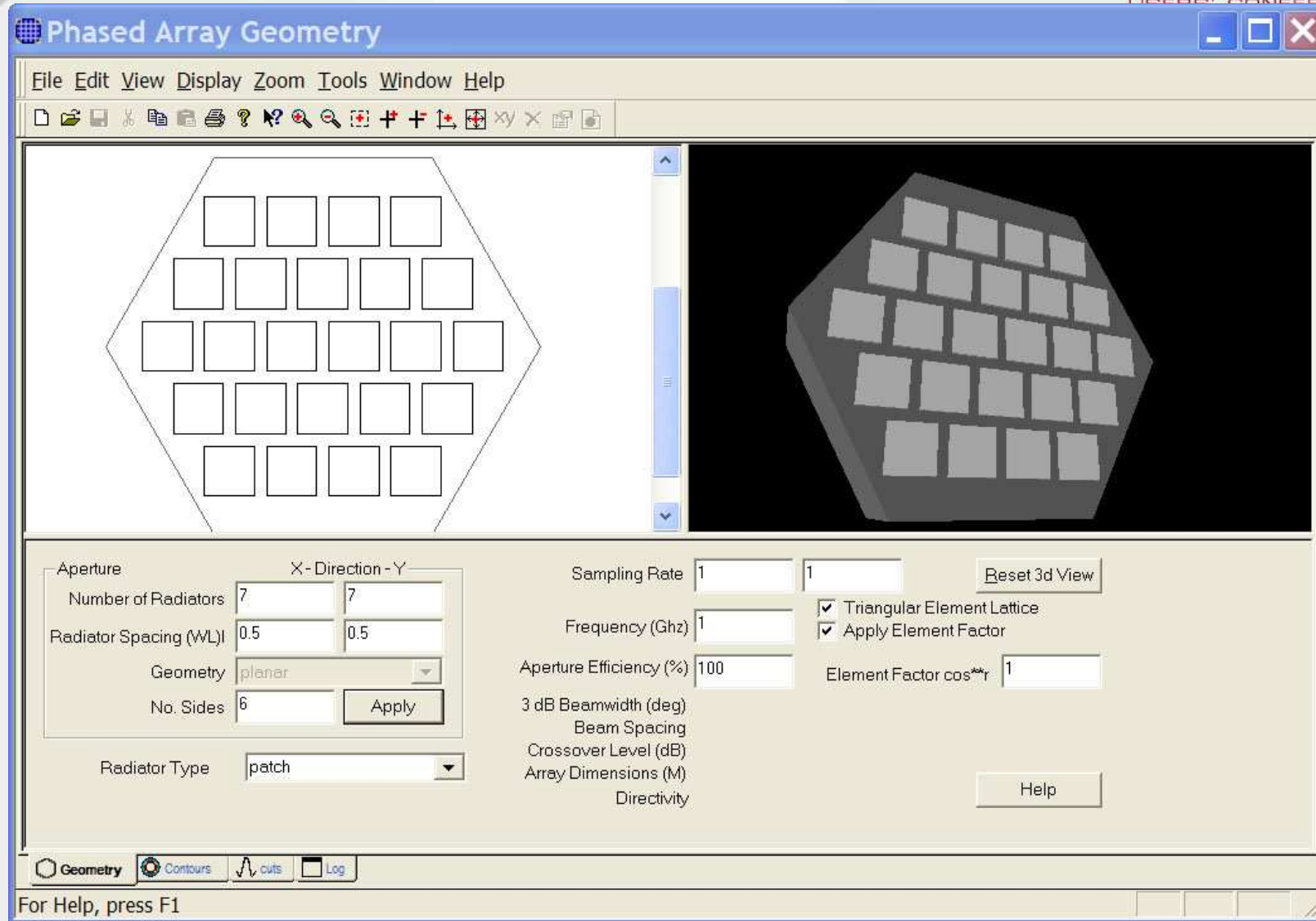
- Size & shape of aperture
- Number & position of elements
- Type of radiating elements
- Nulling algorithm, if any

Perform:

- Static pattern analysis



# Phased Array User Interface

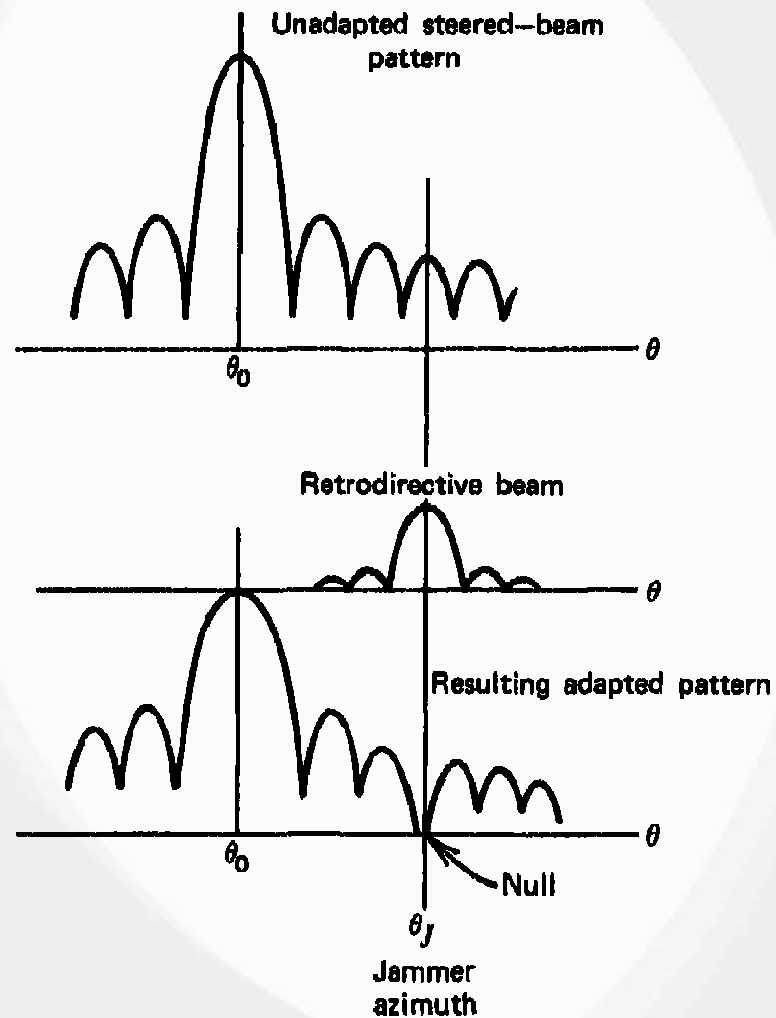


# Adaptive Nulling Algorithms



- LMS steepest descent
- Howells-Applebaum
- Sample Covariance Matrix Inversion

# Forming a Pattern Null

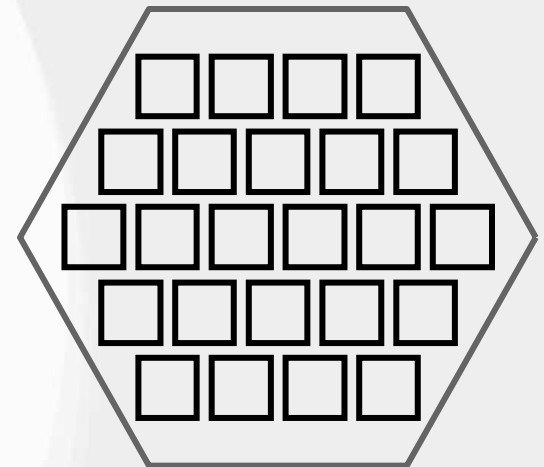
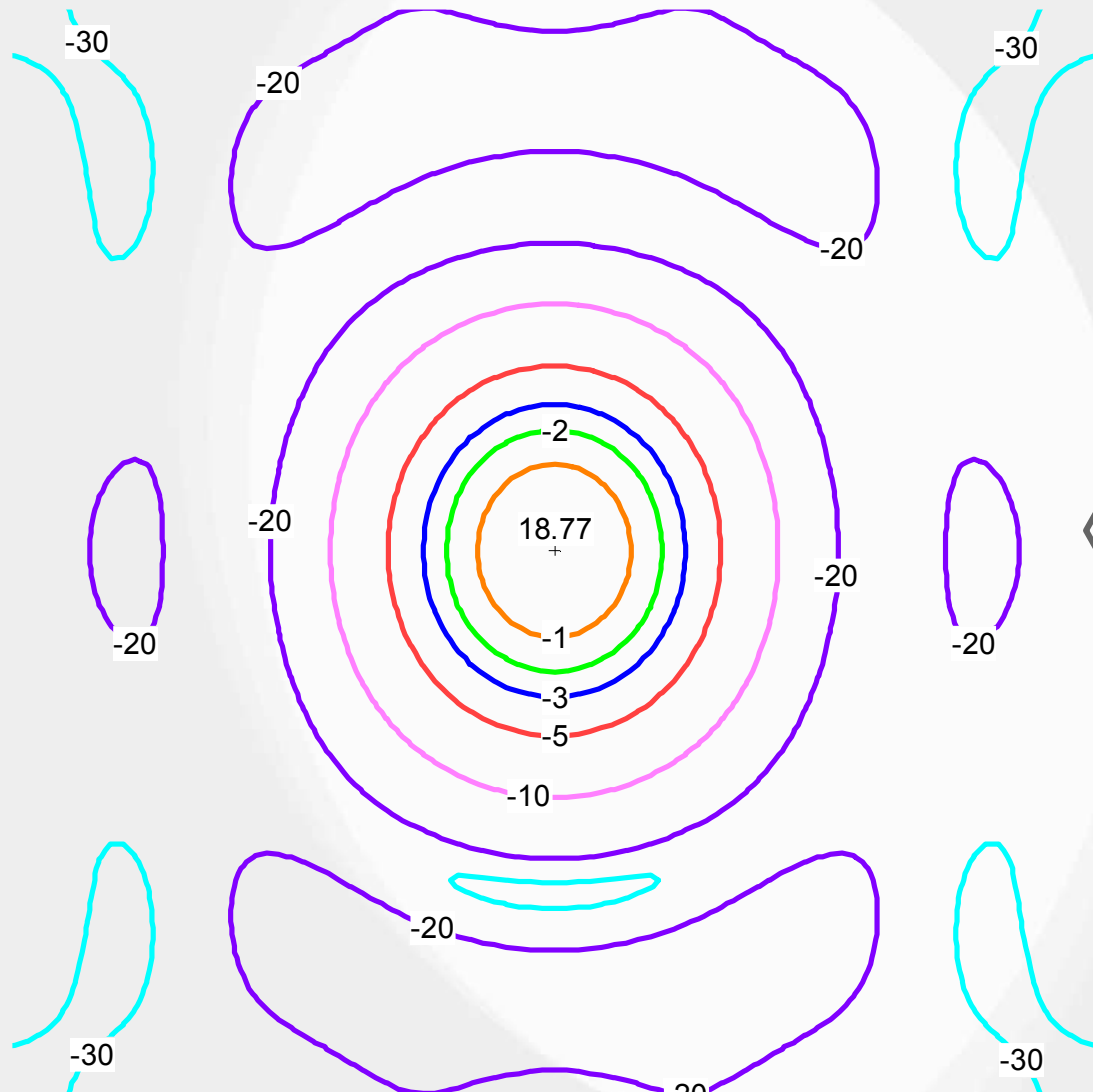


# STK Scenarios

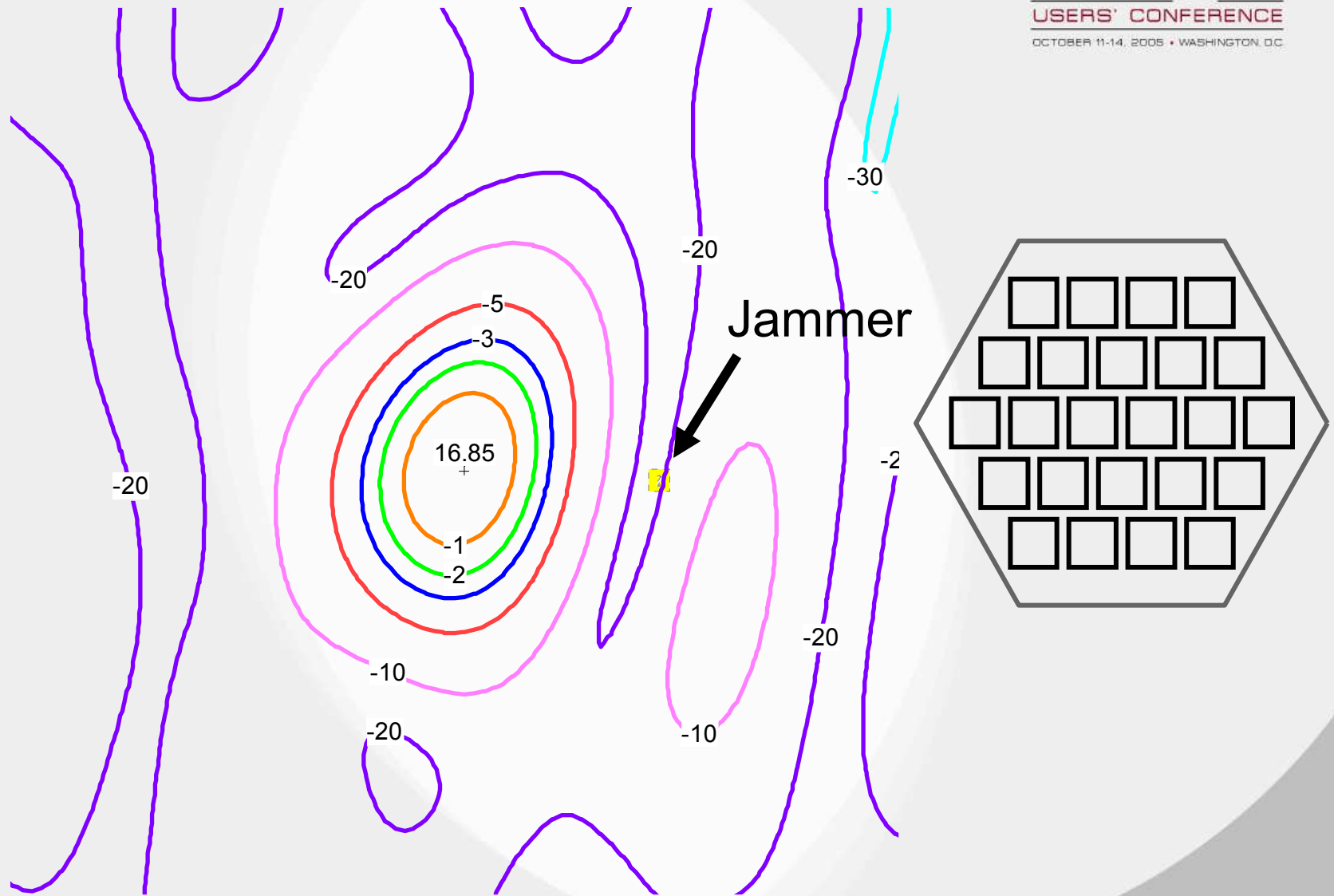


- SATCOM Link with Jammer on Airplane
- GPS receiver with single jammer

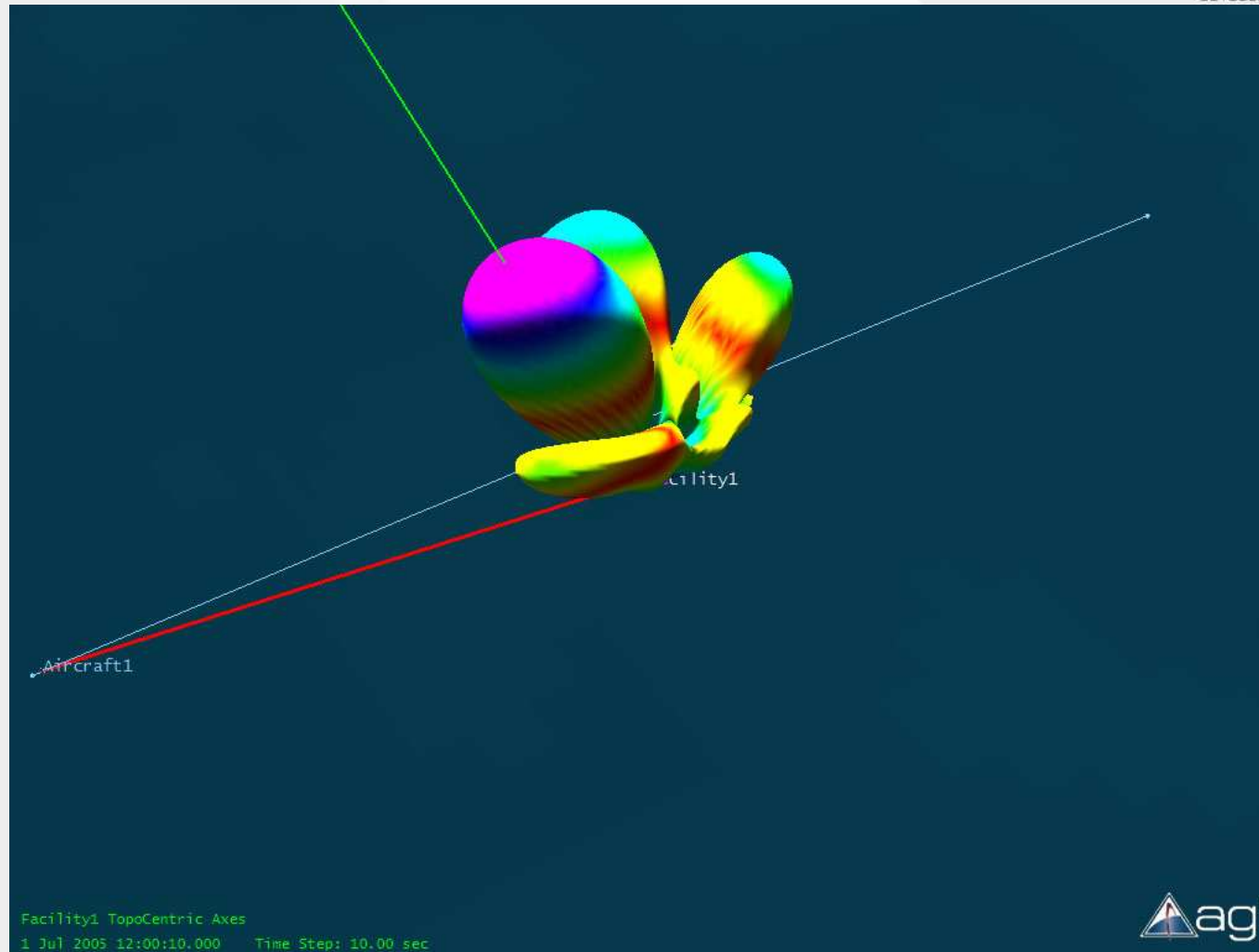
# Un-Adapted Pattern



# Adapted Pattern



# 3D Antenna Pattern



# Future Work

- Phased array digital beamformer
- Phased array interface to future stk/radar module
- Reflector model (physical optics)
- Wire antenna model (moment method)
- Scripting (nulling algorithms, etc)

# Conclusions

- Flexible antenna plug-in architecture for stk & ntk
- New phased array plug-in under development
- Improvement of s/n by nulling a jammer
- Future work

## Challenges:

- Accurate gain = pattern integration = cpu time
- Providing visual feedback
- Easy-to-use but comprehensive GUI