Determining the X-51 Antenna Gain Pattern Using Near-Point Approximation

Erich Brownlow, Melissa Dominguez, Kelly Jiang

Department of Mathematics and Statistics

Introduction:

- **The radiation gain pattern of a receiving antenna is defined as the angular dependence on incoming signal amplification.**

Purpose:

- **Given a set of test data, approximate and visually represent the antenna gain pattern of the X-51 for all possible azimuth (az) and elevation (el) angles.**
- **Data given as triplets: {az, el, gain}**
- **Az angle: horizontal angle off the boresight of the aircraft**
- **El angle: vertical angle off the boresight of the aircraft.**
- **Measured points cover the "imagined" sphere about the aircraft.**

Fig. 1: Measurements on the "sphere" about the X-51

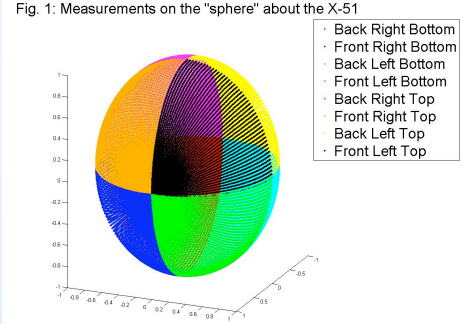
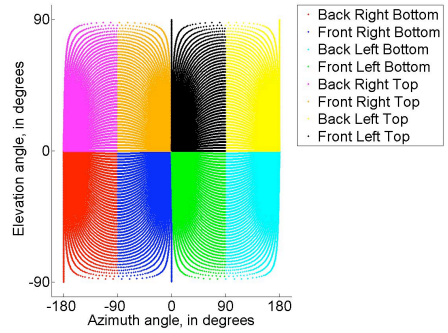


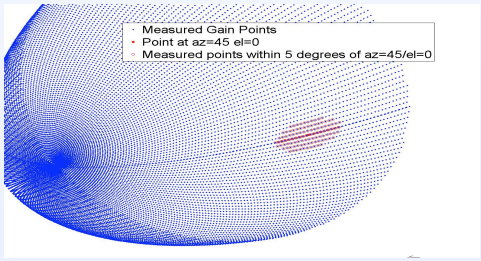
Fig. 2: Measurements on the Azimuth / Elevation Plane



Methods:

- **To determine the gain at a chosen az/el point, {az0,el0}, find the measured points "near" that point. How do we do that?**
- **Assuming the points all lie on the unit sphere (radius=1) convert from spherical to Cartesian coordinate system:**
- **X = sin(az)*cos(el) , Y = sin(az)*sin(el) , Z = cos(az)**
- **Compute Euclidean distance from chosen point (X0,Y0,Z0) to all measured points (X,Y,Z)**

  = ((X0-X)^2 + (Y0-Y)^2 + (Z0-Z)^2)^(1/2)
- **Collect all measured points that are within a given distance from {X0,Y0,Z0}. These points are near the point {az0,el0} = {X0,Y0,Z0}. Distance represented in degrees along the sphere.**



Results:

Fig 3: NPM Method / gains within 5 deg.

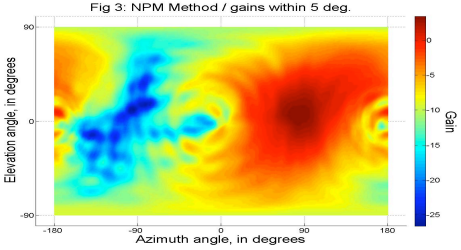
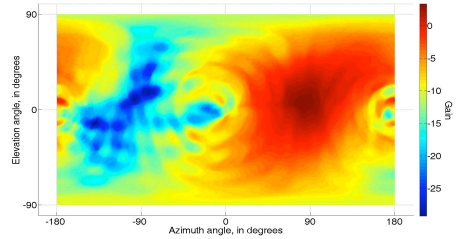


Fig 4: NPP Method 25th%-ile / gains within 5 deg.



- **Near-Point-Mean (NPM)- gain at {az0,el0} = arithmetic mean of gains of near point gains. (Brownlow, E., 2007)**
- **Near-Point-Percentile (NPP)- gain at {az0, el0} = p-th percentile of near point gains. (Brownlow, E., 2007)**
- **Determine the gain at every az/el point**

  -180<=az<= 180

  -90<=el<=90

Fig 5: NPM Method / gains within 10 deg.

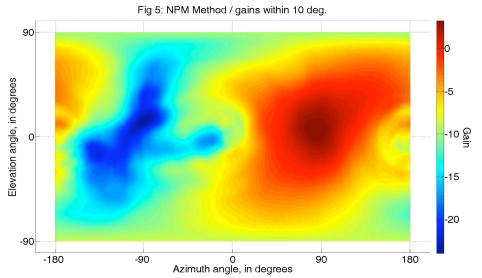


Fig 6: NPP Method 25th%-ile / gains within 10 deg.

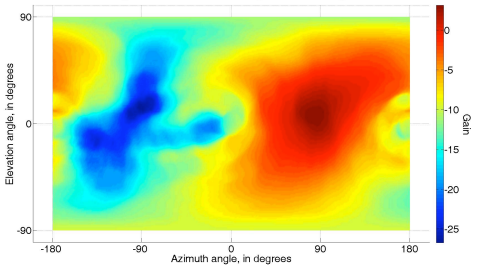
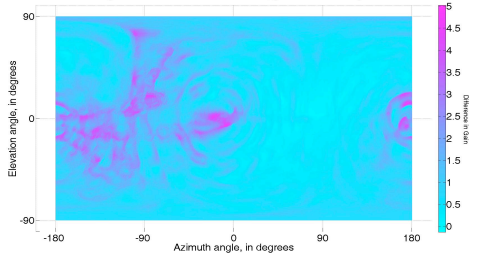


Fig 7: NPM - NPP Difference in Gain, gains within 10 deg.



Summary:

- **Methods are easy to understand but are computationally intensive.**
- **Using 65,429 measurement triples to determine gain at 65,341 distinct az/el points.**

Conclusion:

- **Fig 7 shows that the NPP Method is more conservative, and this is preferred.**

Acknowledgements:

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