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

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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.

Methods:
• To determine the gain at a chosen az/el point, \( (az_0, el_0) \), 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:
    \[ X = \sin(az)\cos(el), \quad Y = \sin(az)\sin(el), \quad Z = \cos(az) \]
  • Compute Euclidean distance from chosen point \( (X_0,Y_0,Z_0) \) to all measured points \( (X,Y,Z) \)
    \[ d = \sqrt{(X_0-X)^2 + (Y_0-Y)^2 + (Z_0-Z)^2} \]
  • Collect all measured points that are within a given distance from \( (X_0,Y_0,Z_0) \). These points are near the point \( (az_0,el_0) = (X_0,Y_0,Z_0) \). Distance represented in degrees along the sphere.

• Near-Point-Mean (NPM)- gain at \( (az_0,el_0) \) = arithmetic mean of gains of near point gains. (Brownlow, E., 2007)
• Near-Point-Percentile (NPP)- gain at \( (az_0, el_0) \) = p-th percentile of near point gains. (Brownlow, E., 2007)
• Determine the gain at every az/el point \(-180\leq az\leq 180\), \(-90\leq el\leq 90\)

Results:
fig 1-4: Measurements on the “sphere” about the X-51; Measurements on the Azimuth / Elevation Plane

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.

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