GNSS Antenna Technology Development at the Jet Propulsion Laboratory

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GNSS Radio Occultation Workshop
Pasadena, CA
7 April 2009

Government sponsorship acknowledged.

Outline

- Anticipated occultation antenna requirements
- Physics-based antenna limits
- Trick to get around the limits
- Some results from JPL's actively steered, multi-beam, phased array antenna

Occultation Antenna Needs

(Similar for GNSS Surface Reflections

- High gain toward multiple occulting and clock difference satellites
- Moderate gain available over a large field of view for orbit determination.
- Low antenna temperature. Low loss antenna element and minimizing gain toward the earth (a 300 K black body).
- Track frequencies with the best signals for RO

Physics-Based Antenna Limits

- For an antenna with 100% efficiency, the product of gain and field of view (FOV) is 4 PI Steradians.
  - *Integral of (Gain * FOV) = 4*PI *efficiency*
  - Ex: Gain of an omnidirectional antenna is == 1 (0 dBi, 0 dB relative to isotropic)
- Therefore, a high gain antenna **must** have a narrow field of view. (*Gain of 10 with 50% efficiency can cover at most 4 PI/20 SR*)
- This does not allow a single high-gain occultation antenna to track satellites to the earth's limb over a wide range of azimuths, and to track clock-difference satellites at positive elevations.

Trick to Get Around the Limits

- An array of elements can be used.
  - Each element has moderate gain, and a corresponding wide field of view.
  - These elements are phased to steer a narrow/high-gain beam in the desired direction (*at each frequency*)
  - This is done in parallel digital firmware so that N beams are steered toward N satellites
    - Each of these beams satisfies the equation:
      Gain * FOV = 4*PI *efficiency
    - When all N beams are included, the equation becomes:
      Gain * FOV = N*4*PI *efficiency
  - JPL developed a patented beam-steering system using the hardware and software embodied in a GPS receiver.

Results from JPL's Actively Steered, Multi-beam, Phased Array Antenna

: 4 LHCP and 4 RHCP antennas installed on the aircraft

Results from JPL's Actively Steered, Multi-beam, Phased Array Antenna

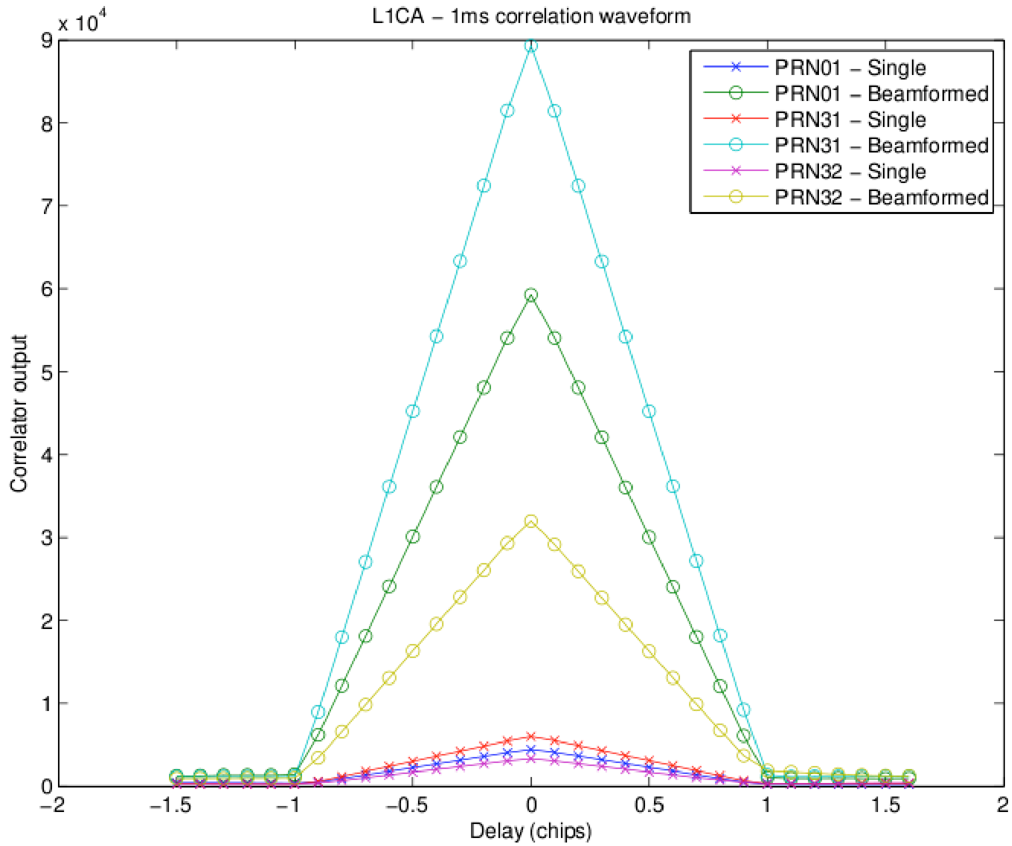

Figure 1: RSS of correlation waveform before and after L1 beamforming. Three simultaneous beams were formed pointing at PRN1,PRN31 and PRN32 with 16 antennas

Conclusion

- A multi-beam actively-steered phased array GNSS antenna has been designed and tested
  - Ground tests confirm expected SNR gain
  - Aircraft tests demonstrate ability to direct beams from a dynamic platform
  - Multi-frequency: tracked GPS CA, P(Y)1, P(Y)2, L2C and L5(from WAAS), Galileo E1 and E5A signals from GIOVE-A and GIOVE-B. This demonstrates steering multiple beams at three frequencies.
- This active array technology is ready for insertion into occultation missions