Space Geodesy Project (SGP) Colocation considerations and Radio Frequency Interference (RFI) Mitigation Techniques

L. M. Hilliard Lawrence.M.Hilliard@NASA.gov, Beaudoin, Christopher, cbeaudoin@haystack.mit.edu
Corey, Brian, bec@haystack.mit.edu
Petrachenko, William, Bill.Petrachenko@nrc-cnrc.gc.ca

1NASA Goddard Space Flight Center, Greenbelt MD, USA
2 MIT Haystack Observatory, Westford MA, USA
3 National Research Council Canada

www.nrc-cnrc.gc.ca
Space Geodesy Project (SGP)

- Modeling the GGAO environment and VLBI2010 susceptibility before & after the trees came down
- Measuring the DORIS Beacon, and the NGSLR radars in South, radar masks & DORIS path loss provide mitigation
- Measuring 12m side lobes with a standard gain horn simulator ≥100m away
- Mitigate RFI with masks, filtering, and shielding
RF Compatibility Methodology
Measurement of Transmitter Radiation Properties

- DORIS and SLR radar power levels were measured using S and X-band standard gain horn antennas.
- SLR Radar Power Level Measurement Memo:

http://www.haystack.mit.edu/geo/vlbi_td/BBDev/037.pdf
High pass filter in current configuration of GGAO VLBI front end

- New configuration will adapt gain and filtering to low end of the band

- Prior to use of pre amp filter
- Isolated S-band harmonic distortion generation to a stage between the LNA and the fiber
antenna gain vs. angle between 12-m boresight and transmitter. The data have been binned by angle into 40 bins equispaced in log(angle). The 4 "curves" are:
- **red**: 100th percentile in each bin (i.e., max gain)
- **green**: 90th percentile
- **blue**: 50th percentile (i.e., median gain)
- **black**: ITU-R SA.509 standard for the 90th percentile of the far-field gain of a large antenna.

12 m Sidelobe views it peripherally in the North

Beacon in the East
Sidelobe Measurement of 12 meter antenna - with beacon deployed near NGSLR LHRS phase center
Comparison to ANSI sidelobe envelope

Figure 1: ITU-5009 antenna sidelobe envelope model incorporated in numerical RFI-compatibility studies.
Absorber/reflector Material Evaluation: X-band

Transfer Coefficients (Absorber/reflector Combinations)

DG/Black attenuation is > 40 dB

DG/Silver attenuation is below the noise floor = short on port 1 or port 2
S11 & S22 Comparison of thin Reflector materials

- S11 & S22 Comparison of AL100 (Silver) and Laminated MW Absorber (Black):
  - P1: Absorber (EC SF-9.5)
  - P2: Reflector

**Amplitude-Dark Gray absorber**

**Black Reflector**

**Amplitude- Dark Gray absorber**

**Silver Reflector**
ANW-75 absorber material characteristics

- **ANW-75**
  - Reflectivity range (>20 dB) >2.4 GHz
  - Thickness: 2.9 cm
  - Weight: 0.80 kg/piece
  - Density: 0.07 g/cm³
Configuration for Radar Shield experiments

- From preliminary ground tests the best combination of attenuation and back reflection is at $35^0$. 
Sidelobe Measurement of 12 meter antenna - with beacon deployed near NGSLR LHRS phase center.
Radar absorber/reflector barrier design and test – Mob7 radar platform
DORIS beacon characteristics

- DORIS barrier must be considered for two frequencies
- Barriers modeled for 6 degrees in azimuth and elevation

Graphs showing antenna gain for 2GHz and 400 MHz channels.
S-Band (DORIS frequency) shielding effectiveness

- http://www.feko.info/
  - Physical Optics and Uniform Theory of Diffraction

- at 5m, the linear dimension of the square barrier was $2 \times 5 \times \tan(6\text{deg})$
  - 1 meter
- 20m the square barrier was $2 \times 20 \times \tan(6\text{deg})$
  - 4 meters
Material Analysis: S-band

- Eccosorb SF-2.0
- Thicker material wedged between waveguide launchers
- 4” x 4” sample
Material Evaluation: S-band

- Eccosorb SF-2.0
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Sgray Black attenuation is > 30 dB
Sgray Silver attenuation is > 50 dB
## Tradeoffs to RFI Mitigation Techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Current Implementation</th>
<th>Current results/limitations</th>
<th>Next steps</th>
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<tbody>
<tr>
<td>Masking</td>
<td>MOBLAS 7/ 20° NGSLR / 30° VLBI/ 40° and 30°</td>
<td>May 16th geodetic test lost targets due to mask</td>
<td>Masks will be removed when absorber/reflector go up</td>
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<tr>
<td>Filtering</td>
<td>3.9 GHz highpass filter immediately preceding the fiber transmitter</td>
<td>Broadband system cannot form baselines with legacy S-band channels</td>
<td>Combination of high pass filter and isolation w/ tailored dynamic range. Notch at 9.41 GHz under consideration</td>
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<tr>
<td>Shielding</td>
<td>Radars are blocked by GGAO buildings</td>
<td>Radar platform guard rail occupies space. Metal guardrails re-resonate</td>
<td>Deliberate shielding must control back reflection</td>
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<tr>
<td>Absorbing</td>
<td>No absorber currently deployed</td>
<td></td>
<td>Cover guard rails</td>
</tr>
<tr>
<td>Shielding/Absorbing</td>
<td></td>
<td>Further experiments necessary. 35 degree above horizontal experiment – must be all - weather</td>
<td></td>
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