A Foliage Penetration Imaging Radar System

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Physical Scale Modeling Radar Measurements

**Field Measurements:**
- can be costly
- non-covert
- threat target may not be available

20.5 feet

234-354 MHz

**Scale Model Measurements:**
- less costly
- controllable environment
- covert
- models built from intelligence data
- rapid response

Scaled radar wavelength: 30 mm

8.2 GHz - 12.4 GHz

7 inches

Radar wavelength: 1.05 m
Physical Scale Modeling
Requirements

1. **Scale wavelength by same factor as model**
   For 1/35\(^{th}\) scale models: UHF/VHF (300 MHz) --> X-Band (10 GHz)

2. **Build a scale model with properly scaled materials**
   Metallics --> high reflectivity metal coatings (Al, Cu, etc.)
   Non-metallics --> same $\varepsilon'$ + i $\varepsilon''$ as full scale component
- Frequency Coverage: 8.2-12.4 GHz
- Monostatic Radar Configuration
- Horn/Lens configuration ≈ 35 dB gain
- Polarization: Linear (H or V)
- 35 dB Dynamic Range
Antenna Beam Profile

Phase S11 10.3 GHz

-200
-150
-175
-200

Position (in)

Magnitude S11 10.3 GHz

-45
-44.5
-44
-43.5
-43
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6

Position (in)
## 2-Way Beam Spot Characteristics

<table>
<thead>
<tr>
<th>Freq. (GHz)</th>
<th>BW (°)</th>
<th>Horizontal Pol.</th>
<th>Vertical Pol.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Spot Size (inches)</td>
<td>Mag. Roll-off (dB)</td>
</tr>
<tr>
<td>8.2</td>
<td>6.88</td>
<td>9.45</td>
<td>.23</td>
</tr>
<tr>
<td>10.3</td>
<td>5.48</td>
<td>8.11</td>
<td>.52</td>
</tr>
<tr>
<td>12.4</td>
<td>4.57</td>
<td>7.66</td>
<td>.68</td>
</tr>
</tbody>
</table>

- Spot size defined over region of 22.5° phase roll-off
- Less than 1 dB magnitude roll-off at all frequencies
- Targets are contained within smallest spot size
System Linearity

- Predicted RCS
- Spot size at upper-band limits maximum dimensions of target
- Energy density at lower-band limits minimum dimensions of target

\[ \sigma_{dBsm} = 10 \log_{10} \left( \frac{4\pi A^2}{\lambda^2} \right) \]
Agreement with GTD Predictions

**6.375" Square Plate**

- **RCS (dBsm)**
- **Aspect Angle (°)**
- **Measured 10 GHz Data**
- **GTD Prediction**

**8x6" Plate**

- **RCS (dBsm)**
- **Aspect Angle (°)**
- **Measured 10 GHz Data**
- **GTD Prediction**