Laser Applications for Space Navigation

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Laser Applications for Space Navigation

- Planetary LIDAR
- Laser Optical Cross Link Measurement
- Rendezvous Missions
- Landing (Planetary, Asteroid, Comets)
Planetary LIDAR Navigation Background

- Deep space missions carry onboard at least one laser altimeter (laser range finder):
  - Scientific research (shape, topography ..etc)
  - Aid to navigation (greater proximity to target)

- The shape of the pulse that returns after reflection on the surface contains information about the roughness (topography) of the lighted area. The information is used to construct a 3D model of the terrain.

- The time of flight of the return signals contain information useful for proximity and/or docking operations.
Optimization

- The selection of the components to construct an optimum system is paramount
  - Type of laser (solid state, fiber ..etc) - (pulse duration, pulse rate, pulse energy ..etc)
  - Type of detector (PIN detectors, APD, Geiger mode ..etc) – (pixel size, number of pixels, dark current, quantum efficiency ..etc)
  - Optics (aperture size, optical elements, ensquared energy, MTF ..etc)
  - Beam steering (solid state, Risley prisms ..etc)
  - Beam forming optics
  - Operation issues (FoR, FoV, resolution ..etc)
Synthetic Imagery and Mission Performance Assessment Computational Tool (SIMPACT)

- Adsys Controls proprietary modeling and analysis tool
- The model covers all major expected conditions:
  - The physical features of the instrument (parameters, specifications and transmitter-detector characteristics);
  - The features of the environment where the instrument will operate (radiation degradation, etc.);
  - The physical features of the target surface (bidirectional reflectivity distribution function).
- Incorporates mission dynamics (sensor orbital dynamics, observed object dynamics, LOS jitter)
- Generates synthetic imagery and optical signal data
- Incorporates signal/image processing algorithms
- Executes dynamic simulations
Model Parameters

• Input Parameters
  - Laser Energy per Pulse
  - Laser pulse width
  - Laser pulse repetition rate
  - Receiver efficiency
  - Instantaneous Field of View (IFOV)
  - FPA pixel size/pitch
  - Dark current
  - Electronic noise
  - Laser Wavelength
  - Laser size in detector pixels
  - Transmission efficiency
  - Aperture diameter
  - Surface BRDF
  - FPA quantum efficiency
  - FPA nonuniformity
  - ROIC noise

• Output
  – SNR vs Range
  – GSD vs Range
<table>
<thead>
<tr>
<th>Range to Target</th>
<th>Active Pixels</th>
<th>Pixel Footprint</th>
<th>Illuminated Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1: 0.8 - &gt; 22 km</td>
<td>4 x 4</td>
<td>4m x 4m</td>
<td>16m x 16m</td>
</tr>
<tr>
<td>Mode 2: 27 - 800 m</td>
<td>32 x 32</td>
<td>0.4m x 0.4m</td>
<td>9.6m x 9.6m</td>
</tr>
<tr>
<td>Mode 3: 1 - 30 m</td>
<td>128 x 128</td>
<td>4cm x 4cm</td>
<td>5.5m x 5.5m</td>
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A simulation model that takes into consideration all the major conditions regarding the design of a lidar system as a laser altimeter and an aid in navigation and proximity operations has been developed, validated and verified.

The model allows design optimization of the system components.