Design Tradeoffs and Challenges of Omnidirectional Optical Antenna for High Speed, Long Range Inter CubeSat Data Communication

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Omnidirectional Optical Antenna

- Compact Dual Axis mirror
- High FPS Camera-Optics System for AOA Detection
- Data Processing Unit and Laser Drivers

System: Cube

System: Sphere

- MEMS Based telescope System
- High Speed APD for AOA Detection
- Data Processing Unit and Laser Drivers

Preliminary Prototype
Transmitter design parameters

- COTS Component Availability
- Distance
- Beam Profile
- Beam Size
- Scanning Mirror Parameters
- Pointing Accuracy
- Peak Irradiance

OOA Transmitter Optimization
Transmitter design optimization

**Beam Radius**

- Effect of Initial Beam Size to Scanning Mirror Size Ratio on Far Field Beam Radius.

**Peak Irradiance**

- Effect of Initial Beam Size to Scanning Mirror Size Ratio on Far Field Peak Irradiance. The Scanning Mirror is at 45° w.r.t. Laser Beam Axis.
Transmitter design optimization

Peak Irradiance vs Scanning angle

Figure. Peak Irradiance Variation Due to Mirror Scanning Angle for Different Initial Transmit Beam Size. 15mm Diameter Scanning Mirror with ±25° Mechanical Scanning Capability is Used in the Simulation Model.
Transmitter design optimization

Effective Communication Beam Region and Width

Figure. Effective Communication Beam Region (ECBR) at 50km for a 1W Laser at the Receiver Due to Different Initial Transmitter Beam Size.

Figure. Effect of Laser Peak Power on Effective Communication Beam Width (ECBW) at 50km.
Transmitter design optimization

Vibration Tolerance

Fig. Angular Disturbance Tolerance due to Random CubeSat Vibration, Position and Tracking Inaccuracies.
Summary

Transmitter Design
- Initial Beam Size
- Transmitter FOV
- Available Power
- Laser Divergence
- Available Optics

Far Field
- Distance
- Beam Size
- SNR requirement
- Irradiance

Mechanical Design
- Available Space
- Component Weight

Scanning Mirror
- COTS availability
- Size
- Speed
- Small Step Angle
Applications

Space

CUBESATS with OOA in Formation Flying and Data Realying.
Applications

Ground

Post Natural Disaster Temporary Hybrid Rapidly Deployable Network

Standalone High Speed Secure Data Transfer Network (Video Streaming, Photo sharing)

Photo source: Google
Questions

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Back Up Slides
Transmitter Design

- Compatible to mirrors with small (≤ 7°) scanning angle
- Transmitter and receiver aperture need to be different.

- Compatible to mirrors with large scanning angle (> 20°)
- Transmitter and receiver aperture need to be different.
Transmitter design optimization

Figure. ECBW at Different Communication Distance for Different Initial Laser Power and Laser Beam Size.

Figure. Angular Disturbance Tolerance due to Random CubeSat Vibration, Position and Tracking Inaccuracies.