LEO-Based Hybrid RF-Optical Data Relay Network Architectures

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Remote Sensing & the Downlink Bottleneck
DATA CREATION INCREASING - LATENCY REQUIREMENTS DROPPING

Data products are getting more data intense:

Spatial Resolution

Spectral Resolution

Temporal Resolution

New Instruments

- Spatial Resolution: 5 m → 50 cm
- Spectral Resolution: 3 bands → 30 bands
- Temporal Resolution: Week of Jan 1st
- New Instruments: Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday

100x 10x 7x

New applications are driving stringent latency requirements:
Data Downlink Today:

High spatial/spectral/temporal resolution imagery: **Intensive data transfers**

Time per day available for downlink to global ground terminal network: **2-3 Hours**

Time between image capture and analysis: **Hours to days**
IMPACT OF ASI DATA RELAY NETWORK

Access to Data Offload

- **Hours**
  - 40%
  - 50%
  - 60%
  - 70%
  - 80%
  - 90%
  - 100%

- **Days**
  - 10%
  - 20%
  - 30%

Latency to Ground

- **Real-Time**
  - Mi nut es
  - 40%
  - 50%
  - 60%
  - 70%
  - 80%
  - 90%
  - 100%

- **RF**

Total throughput

- **Geo gr ap h y l i m i t s l at en cy t o**
  - 10s of min to hours
  - Geography limits latency to <40%

- **High Res Multi-spectral**
- **SAR**
- **Hyperspectral**

Asset Tracking

Weather Forecasting
**Analytical Space (ASI)** is building a network of data relay satellites in Low Earth Orbit that use **optical downlink** to provide **high-throughput, low latency** data downlink service for remote sensing satellite operators.
HYBRID RF/OPTICAL DATA RELAY

ASI Data Relay Solution

1. Client **images** while over land
2. Client **crosslinks** to co-orbital ASI satellites over the ocean
3. ASI **downlinks optically** over land (with RF backup)

Land
30% of Earth’s Surface

Ocean
70% of Earth’s Surface
CAPABILITY EVOLUTION

Store & Forward

Low-latency Routing
BENEFITS FOR REMOTE SENSING SATELLITES

**Greater Efficiencies**
- Higher asset utilization
- Smaller asset base

**New Capabilities**
- New data products

**Store & Forward**

**Low-latency Routing**
- Dynamic tasking
- Near-real-time data delivery
IMPACT OF ASI DATA RELAY NETWORK

% Access to Data Offload

- 40%
- 50%
- 60%
- 70%
- 80%
- 90%
- 100%

Latency to Ground

- Days
- Hours
- Minutes
- Real-Time

Asset Tracking
Weather Forecasting

Total throughput

RF
ASI Network

High Res Multi-spectral
SAR
Hyperspectral

High Res Multi-spectral
SAR
Hyperspectral
**Mission Goals**

**Deployable Antenna**
First to deploy very high-gain antenna on a commercial nanosatellite platform to enable duplex LEO operations

**Laser Downlink System**
First to demonstrate high-speed commercial laser downlink, surmounting many technical barriers

**Satellite Crosslink**
First to establish high-data rate commercial nanosatellite relay communication
July 13th, 2018

- Successful deployment from the ISS!
- Multiple contacts!
- Commissioning initiated!
**BETA MISSION - RADIX - TIMELINE**

**Start building Radix**

The team begins assembly of the Radix platform.

**March 2017**

**March 2018**

**Launch**

Radix launches out of Wallops, VA on the CYGNSS CRS OA-9E ISS resupply mission.

**May 2018**

**Handover of Radix**

Satellite construction complete after only 1 year!

**July 2018**

**Deployment and Commissioning**

Radix is successfully deployed and commissioned. Preparations for key subsystem tests and technical demonstrations in progress.

ASI has a wide variety of Beta partners

- **Entity**: Government, Commercial, Academic
- **Orbits**: ISS, SSO, numerous altitudes
- **Nations**: A variety of countries around the globe
- **Mission**: Earth observation, technical demonstration, science missions
- **High Demand**: Waitlist of interested technical demonstration parties
GOAL: First to Demonstrate High-Speed Commercial Laser Downlink

Thermal Management
First to effectively manage the large thermal load on a commercial nanosatellite.

Power Management
First to manage the high power requirements for high-speed optical comms on a commercial nanosatellite.

Size Constraint
First to reduce a high-speed optical terminal to a form-factor suitable for commercial nanosatellites.

Pointing Accuracy
First to combining coarse and fine pointing mechanisms on a commercial nanosatellite platform to effectively close an optical link to ground.
GOAL: First High-Gain Deployable Antenna on a Commercial Nanosatellite

High Gain
A 0.5m dish on a 6U cubesat - nearly 2x the largest dimension of the satellite. Scalable to 1.0m.

Wide Frequency Range
Capable of communication in designated Earth Observation S-Bands. Technology demonstrated will pave the way to a high-gain dual-band X and S-Band antenna.

Size Constraint
Reduced the undeployed form factor to ~1U.
GOAL: First to Transmit Payload Data via a Commercial Nanosatellite Crosslink

**Backwards Compatible**
Wide band antenna coupled with software defined radios allow for satellite crosslinks using their existing, on-board downlink systems.

**High Data-Rate**
High gain antenna, a robust data-handling computer and massive on-board storage allow for relay communication of data-dense payload data.

**Orbital Flexibility**
Lower altitude, yet close enough to establish high gain connections - acts as a “virtual ground station” capable of working with satellites from a group of different orbits.
Analytical Space, Inc.’s Upcoming Missions

Technical Demonstration Completion
Wideband antenna coupled with software defined radios allow for satellite crosslinks using their existing, on-board downlink systems.

Second Relay Satellite
An improved relay satellite with improved capabilities - suitable for relay operations - is scheduled to launch in H2 2019.

Networked Relay
A partial network capable of low-latency routing will launch in 2020.
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