AIRBORNE GEIGER MODE LIDAR - LATEST ADVANCEMENTS IN REMOTE SENSING APPLICATIONS

RANDY RHOADS
Geospatial Industry Manager
Harris Company Information

- HQs in the US
- Offices in 125 countries
- Global Customer Base
- Advanced, technology-based solutions for government and commercial customers
World leader in next generation Geiger LiDAR technology.

Advantages

- Wide Area Mapping
- Greater Point Density
- Higher Cost Effectiveness
- Better Precision/Accuracy
Collection Simulation Comparison (8ppm)

Linear LiDAR VS Geiger LiDAR
# Collection Metrics at 8ppm

## Superior Performance

<table>
<thead>
<tr>
<th>Metric</th>
<th>Linear LiDAR</th>
<th>Geiger LiDAR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density</strong> (points per meter)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><strong>Instantaneous Coverage Rate</strong> (mi²/hr)</td>
<td>50</td>
<td>850</td>
</tr>
<tr>
<td><strong>RMSEz (cm)</strong></td>
<td>9.25</td>
<td>9.25</td>
</tr>
<tr>
<td><strong>Altitude (AGL ft)</strong></td>
<td>3,200</td>
<td>27,000</td>
</tr>
<tr>
<td><strong>Swath Width (ft)</strong></td>
<td>3,300</td>
<td>16,000</td>
</tr>
<tr>
<td><strong>Ground Speed (kts)</strong></td>
<td>90</td>
<td>290</td>
</tr>
</tbody>
</table>

Efficiency gains keep costs down at higher collection densities.
Higher Efficiencies at Higher Resolutions

Collection Cost vs. Collection Density (points per square meter)

- Linear Systems
- Geiger-mode

Higher the resolution, greater the payback
Solution: Multi-Look and Oversampling

Multi-angle Illumination
What makes Geiger Mode so Different

Geiger-mode sensors sample the same spot on the ground multiple times
GmAPD Multi-Look/Multi-Pulse Collection

Multi-look approach

• 4096 measurements per laser flash
• 50,000 flashes per second
• Approx= 205 million elevation measurement per second

• Every spot illuminated 100’s of times

• The dozens of photon detections are processed to determine the real objects

• Programmable Forward/Sidelap
Improved Accuracy Results

Aggregating multi-look data requires highly accurate alignment

Required input:
• Utilize high grade INS/GPS
• Utilize horizontal and vertical GPS ground control objects
• Opposing 50% overlap sorties create four looks

Process:
• Perform horizontal/vertical bundle adjustment via GPS tie points
• Perform auto tie point registration from multiple look angles

True photogrammetric bundle adjustment provides higher accuracy
SBET refined to produce final Aggregate Points

Multi-Swath Alignment via Sensor Based 3D Photogrammetric Bundle Adjustment

Enables Rigorous Accuracy Statements per Point

Sensor-based adjustment enables per point accuracy statements
Benefits of Geiger-mode LiDAR

- Dramatically improves speed of collection
- Higher density (resolution) at lower cost
- Improves foliage penetration (Better terrain information)
- Multi-look reduces shadows and voids (Higher quality)
- Robust bundle adjustment (Higher accuracy)
- Enterprise production (Improved Delivery/Schedule)

Large-area, high-density collection leads to new adopters and opportunities
8 points per meter: Higher Point Density enables accurate decisions

- Nearly mirrors existing high precision survey data.
Why do higher densities matter?

Improves accuracy and enables a high level of automation

Infrastructure details better defined

Improves foliage penetration to better sample bare earth

2 pts/m²

8 pts/m²

20 pts/m²
How can Geiger LiDAR help The Netherlands?

40 points per meter (~15cm GSD)
- King Air B-200
- 42,508 sq. km
- 400 km²/hr ACR
- Assuming only 4.5 hours on station and 50% weather delays

<table>
<thead>
<tr>
<th>Area (km²)</th>
<th>Traditional LiDAR Mapping</th>
<th>Harris Geiger-Mode LiDAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flight Hours</td>
<td>Days</td>
</tr>
<tr>
<td>42,508</td>
<td>1700</td>
<td>755</td>
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</table>

Makes nationwide mapping at high density possible
Charlotte NC (20PPM)

Uses: Urban Planning / Smart City / Infrastructure / Security
20pts/m² Geiger LiDAR downtown w/ intensity
20pts/m² Geiger LiDAR Suburbia w/ intensity
Roof-Top Geometry from LiDAR Example
Solar Panel Site Assessment

Uses: Solar Panel House Candidates
Enabling the Digital Oilfield
Transmission and Distribution

Maps Both Systems In Single Collect

Provides Highly Homogenous High-Density Accurate Data
Utilities

Fully classified to customer specifications
Transportation

Uses: DOT ROW mapping / asset management / autonomous vehicles
20pts/m² Geiger LiDAR overpass w/ intensity
Forestry

Uses: Harvest maturity (value) / biomass / Fire Risk (models) / other analytics
Line of Sight (LOS) – Tower to Tower Profile

**Main antenna height:** 3

**Div. delta height:** 3

**Station:** STAT_1159
**Antenna:** ANTEENA_MW
**Azimuth (x/y):** 344.2°
**Equipment:** FA38-3150P-13GHZ
**Site:** FTX166778
**Longitude:** -121.468119
**Latitude:** 30.415494
**Altitude:** 33 ft + 0 ft
**Tower:** 10.0 ft

**Main antenna height:** 3

**Div. delta height:** 3

**Station:** STAT_1160
**Antenna:** ANTEENA_MW
**Azimuth (x/y):** 164.2°
**Equipment:** FA38-3150P-13GHZ
**Site:** FTX1662371
**Longitude:** -121.500111
**Latitude:** 36.469544
**Altitude:** 79 ft + 0 ft
**Tower:** 10.0 ft

**Number:** 1494/1493
**Dist extremity 1:** 1.93 mi
**Dist extremity 2:** 1.93 mi
**DTM height:** 13.1 ft
**Corrected height:** 15.0 ft
**EL height:**
**DEM height:**
**Total height:** 15.0 ft
**Line of sight height:** 43.0 ft
**Ellipsoid height:** 24.2 ft
**Clutter:**

**Link name:** STAT_1159 – STAT_1160
**Length:** 3.06 (3.86) mi/2986 pts/6.8 ft
**Line of sight Main. A / Main B:** 0 % / -1.8 ft (13000 MHz)
**Line of sight Main. A / Div. B:**
**Line of sight Div. A / Main B:**
**Line of sight Div. A / Div. B:**

**Options:**
**Optimize:**
**View:**
**Diversity:**

**Ok** | **Cancel**

Technology to Connect, Inform and Protect™
# Summary (Tower Location)

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Actual</th>
<th>Terrain Set 1 (USGS) 30m</th>
<th>Terrain Set 2 (IFSAR) 5m</th>
<th>Terrain Set 3 (Satellite DSM) 1m</th>
<th>Terrain Set 4 (LiDAR) &lt;1m</th>
</tr>
</thead>
<tbody>
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</table>
High Altitude at High Resolution =
Fly once
Use for many applications
Recently Assessed Accuracies

Results from Independent QAQC Assessment – April 2016

Delta Z (Squared) : Rmse table

<table>
<thead>
<tr>
<th>Material</th>
<th>Rmse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>0.0786 ft.</td>
</tr>
<tr>
<td>Asphalt</td>
<td>0.0583 ft.</td>
</tr>
<tr>
<td>Dirt Parking</td>
<td>0.0261 ft.</td>
</tr>
</tbody>
</table>

Compared to the 2015 Lidar this 2016 QL-1 Lidar has much less noise on the road areas tested.
The percent of tin edges under 6cm:
2015 Phase _III ranges from 82% to 89%
2016 Phase_IV ranges from 99.97% to 100%
Questions?

Randy Rhoads
Geospatial Industry Manager
Randal.Rhoads@Harris.com
+1 321-727-4278
Commercial Geospatial Products

2D Imagery Products

Digital Elevation Models

3D Urban Models

Vector Feature Extraction

Vast experience in multiple products from Space/Air/Land/Sea
Future Repository (One stop shopping!)

IntelliEarth™ Marketplace

Elevation
- Satellite
- SAR
- Airborne LiDAR
- Mobile LiDAR
- Terrestrial LiDAR

Imagery
- Satellite
- Airborne Ortho/Oblique
- Mobile

Products & Services
- Topographic
- Urban Models
- Roads
- Impervious
- Land Cover
- DEMS
- DSMS
- Forestry
- Utility
- Flood Risk
- Fire Risk
- Many Others

Increase value to customers through off the shelf availability and SAS