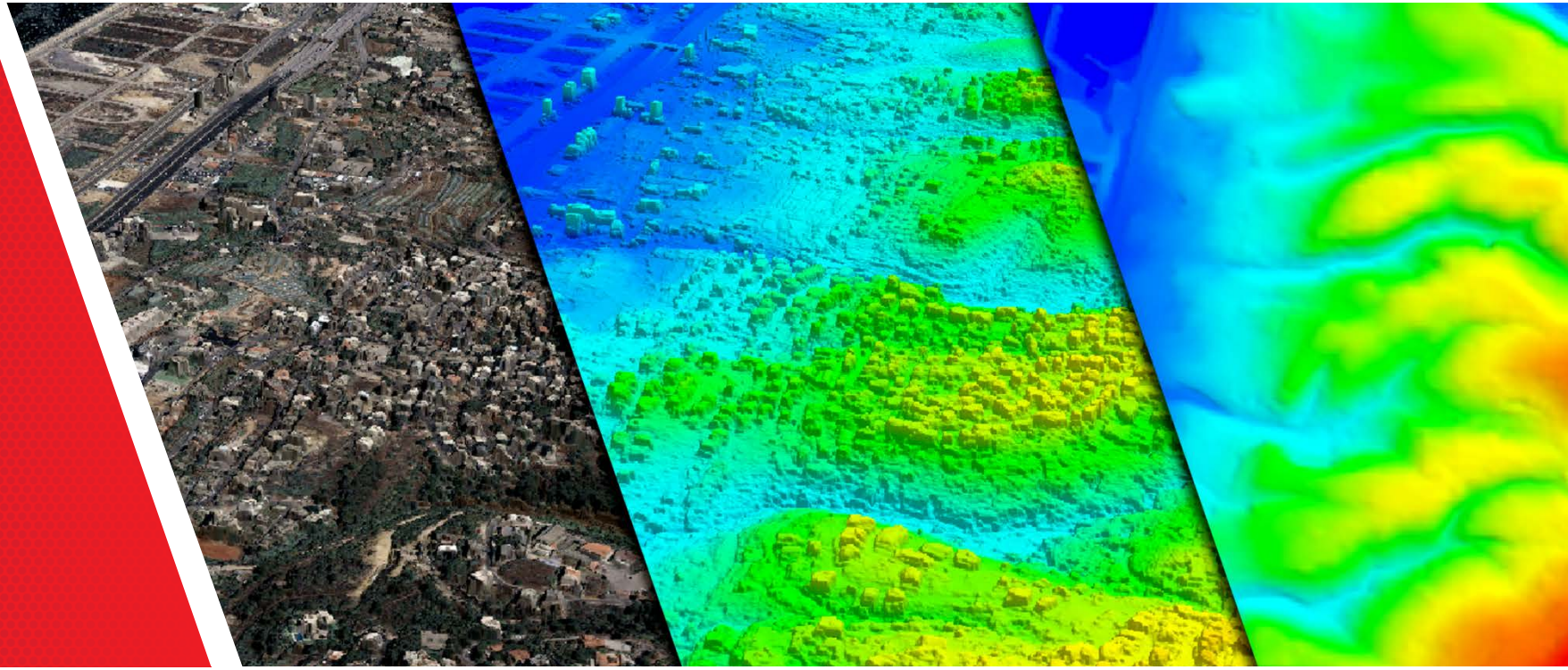
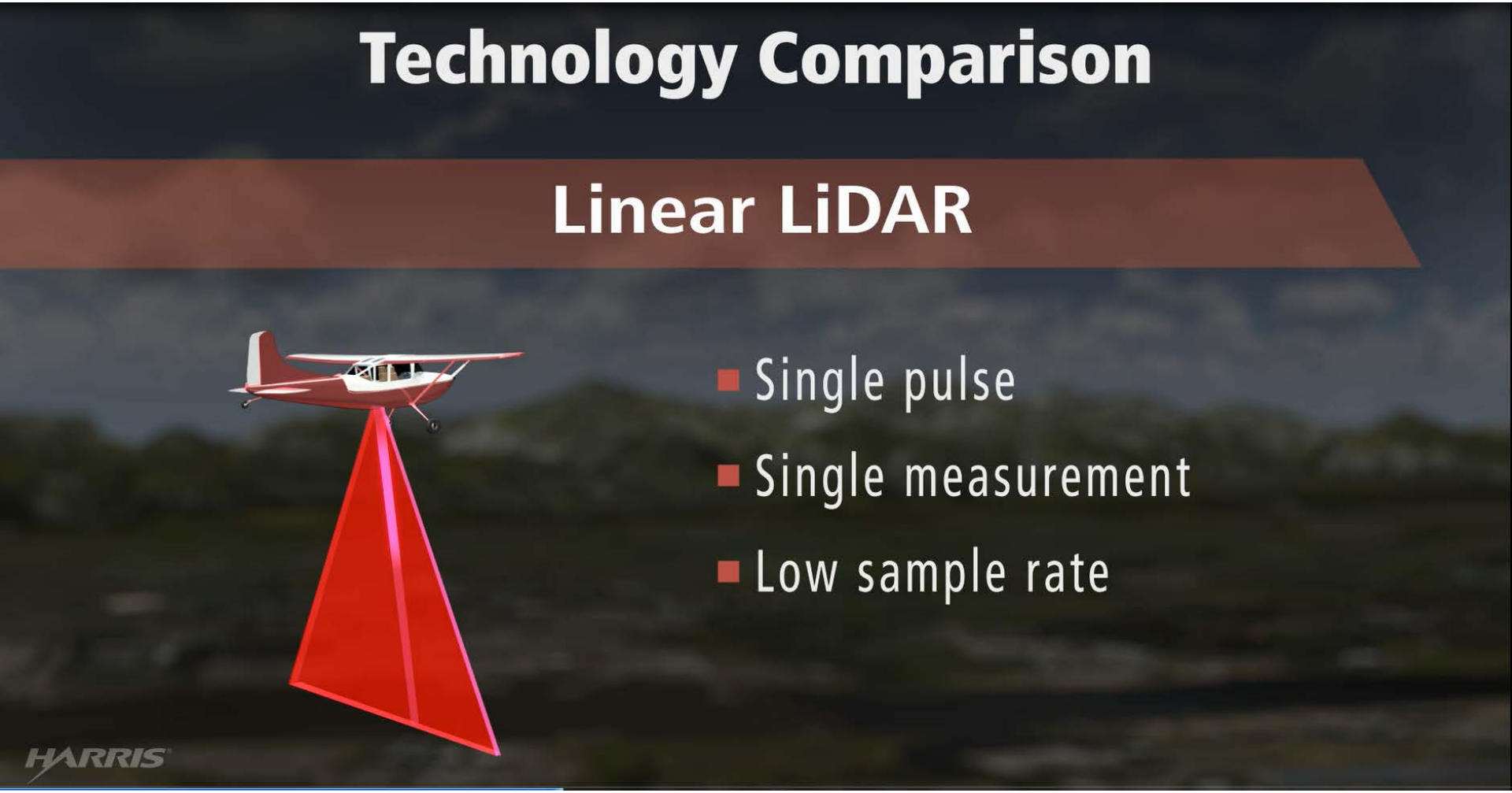


Airborne LiDAR
Geiger Mode vs. Traditional Linear

Mike Fuller
Geospatial Account Manager
Michael.Fuller@Harris.com

The Linear System

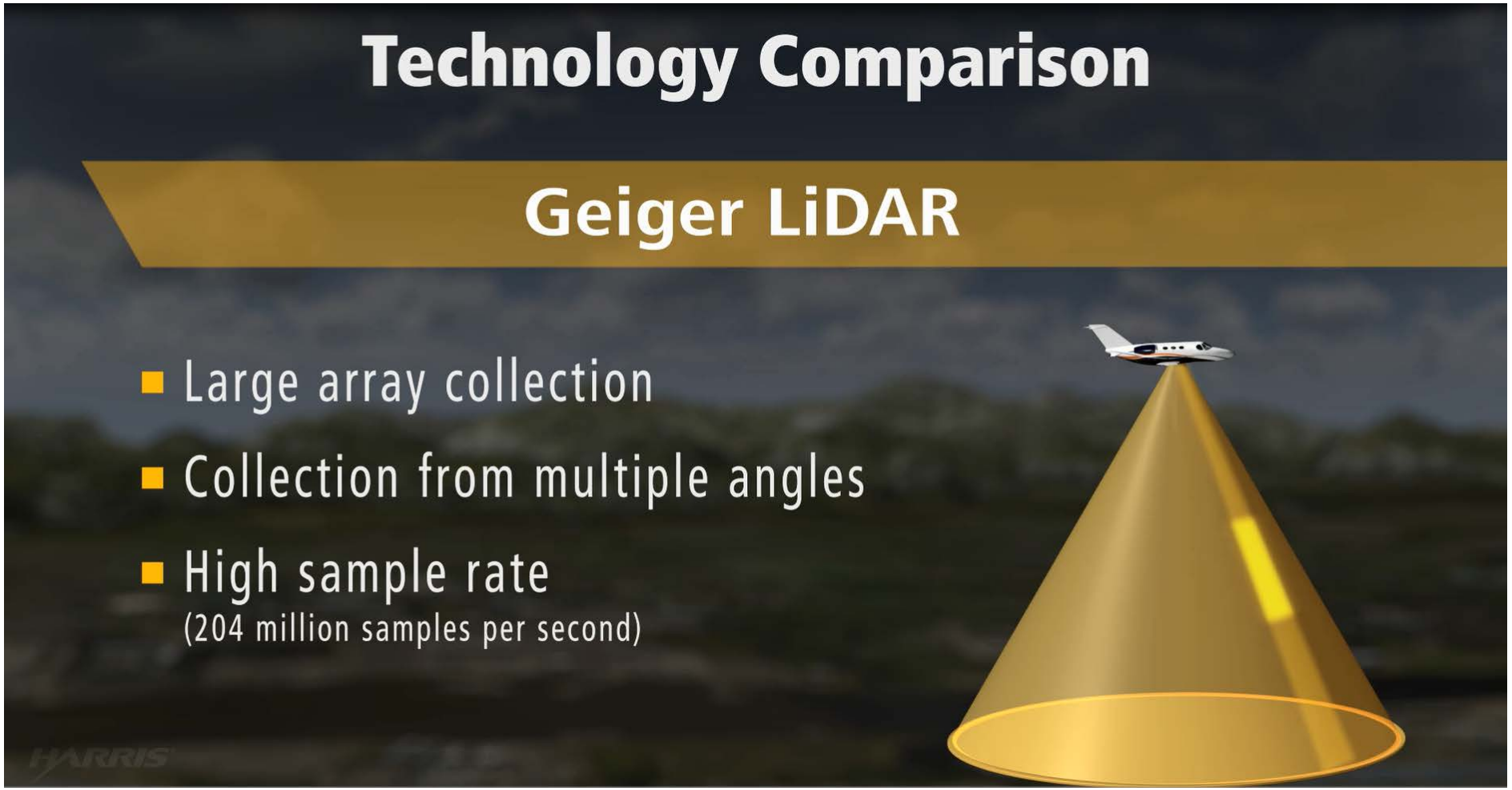


Approximately 500KHz for single scanner designs

Limitations of existing technology

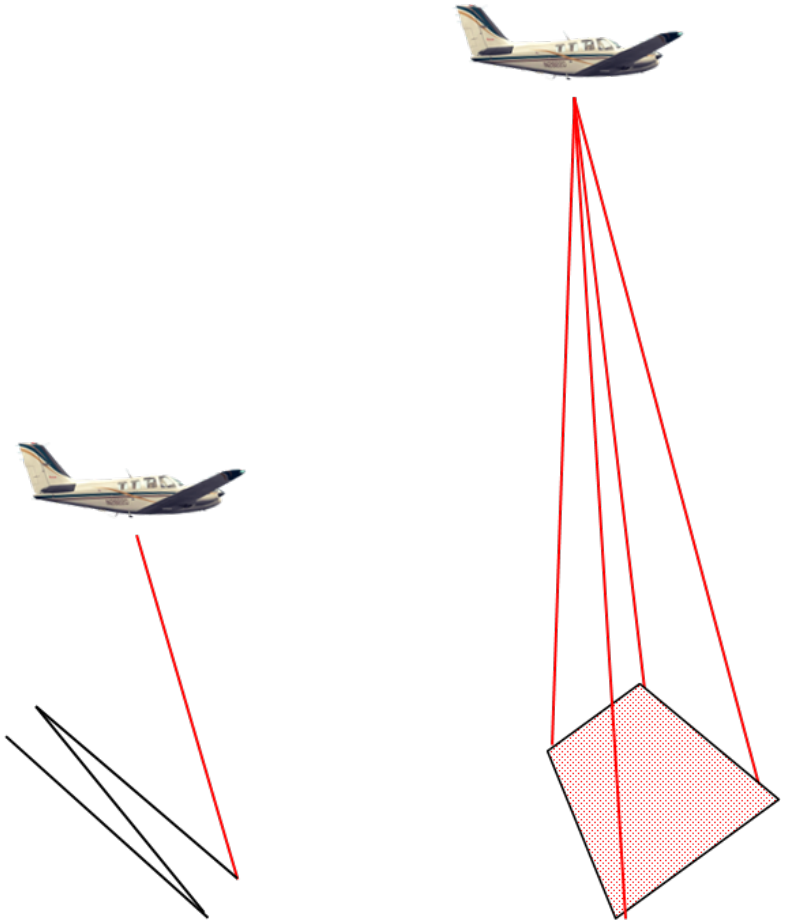
- Cost prohibitive for high resolutions
- Has inherent data occlusions
- Foliage penetration is limited
- Limited-range resolution (target separation)
- Low-sensitivity, high-power system

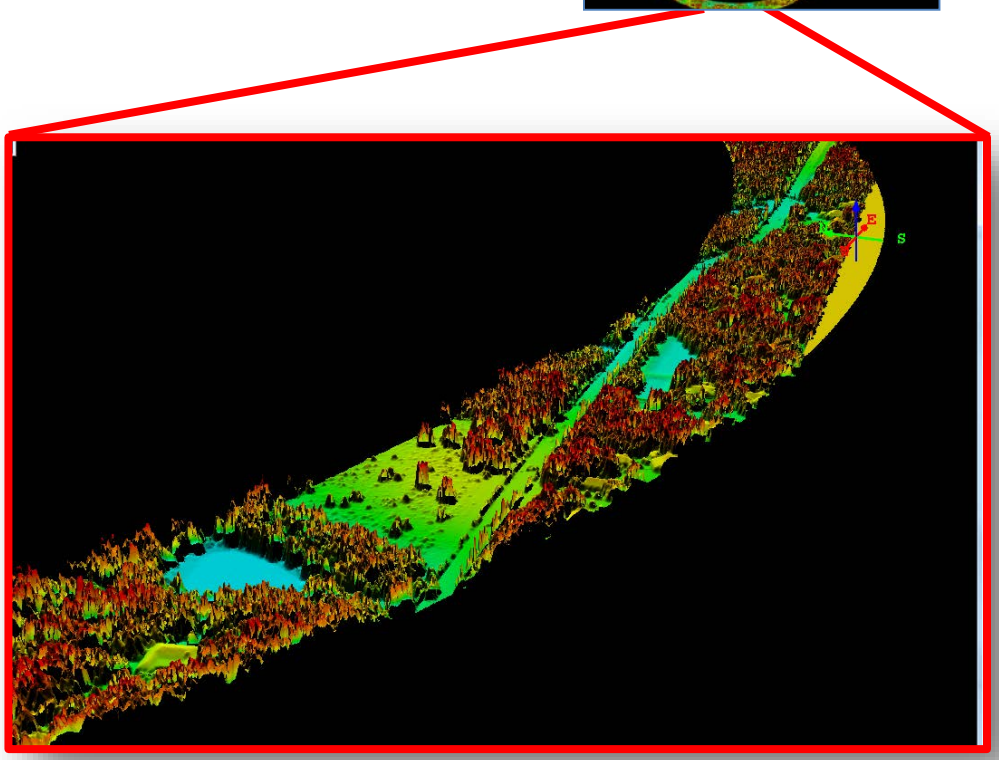
The Geiger-mode System



200MHz vs. 500KHz

Geiger-mode vs. today's technology

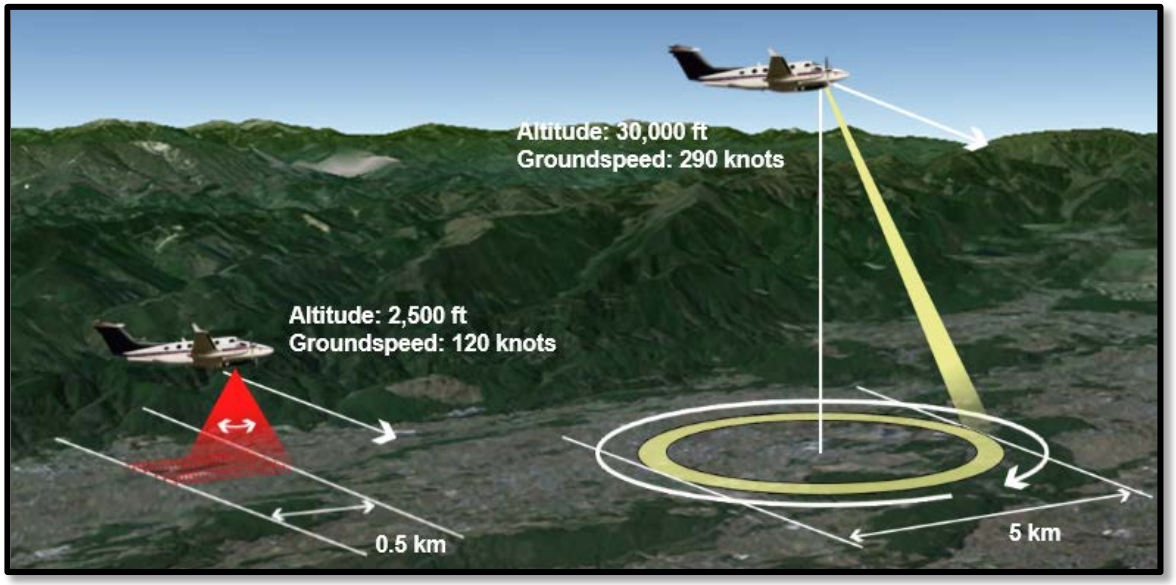




Geiger-mode sensors sample the same spot on the ground multiple times

Geiger-mode superior capabilities

- High-sensitivity
- Low-power system
- Higher-resolution
- More accurate data
- Large-aperture Palmer scanner
- Multi-pulse-in-the-air
- Automatic range gate control



Geiger-mode flies higher and collects faster than current sensors

Why is Geiger-mode superior?

- Improves speed of collection
- Increased data density (resolution) at lower cost
- Improves foliage penetration
- Reduces shadows/voids
- Higher accuracy with robust bundle adjustment
- Improved range resolution (separation)

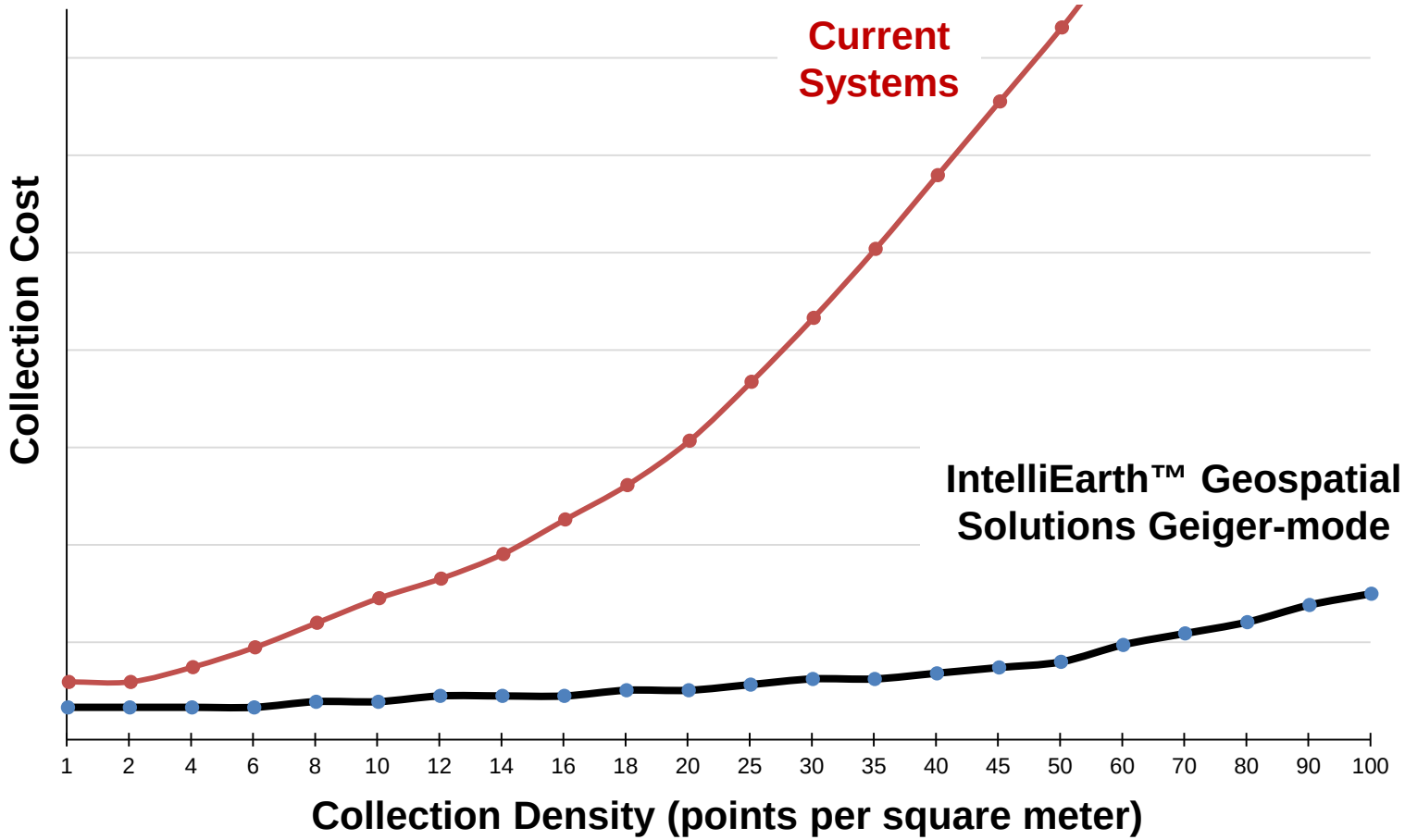
Large-area, high-density collection leads to new users and opportunities

Speed of collection metrics @ 8PPM

8 points/m2 Collection	Current Linear Mode	Flash (Linear Array)	Photon Counting PMT	Harris Geiger-mode Sensors
Altitude (AGL)	150 - 1500m	500-2000m	1000-8500m	4000-11000m
Field of View	45-60°	5-10°	10-40°	30°
Flight Speed	50-100 kn	200-250 kn	100-200kn	200-450kn
Laser Power	200-500mW	120-400mW	1-2W	20-40W
PDE	N/A	N/A	10-15%	25-40%
Pulse Width (Resolution)	1 - 10 ns	5 - 10 ns	700-900ps	300-600ps
Timing Jitter (Precision)	50-500ps	50-500ps	50-100ps	250-500ps
Pulse Repetition Frequency	100 - 800kHz	20-30Hz	20-35kHz	50-90kHz
Detector Count	less than 10	16k	100	4096
Ground Samples/Second	100k-800k	325k-500k	200-350k	200M-400M
Return Surface(s)	1,4,Full Waveform	1, Multiple	Multiple	Multiple
Area Coverage Rate (w/ desired overlap)	**50-180km^2/hour**	**40-160km^2/hour**	**170-500km^2/hour**	**1000-1600 km^2/hour**
Operational Maturity	**20-25 years of airborne operation; Evolutionary Improvements**	**Limited operations in airborne mapping; Technology undergoing incremental improvement**	**< 5 years in experimental mapping operations; Emerging technology undergoing rapid improvement**	**5-10 years in defense operations mapping hundreds of thousands of km^2; Over 15 years in experimental use; Emerging technology undergoing rapid improvement**

Geiger-mode sensors can collect 5x,10x, etc. with increased density

Reduced Cost at Higher Resolutions



Efficiency gains keep costs down at higher collection densities

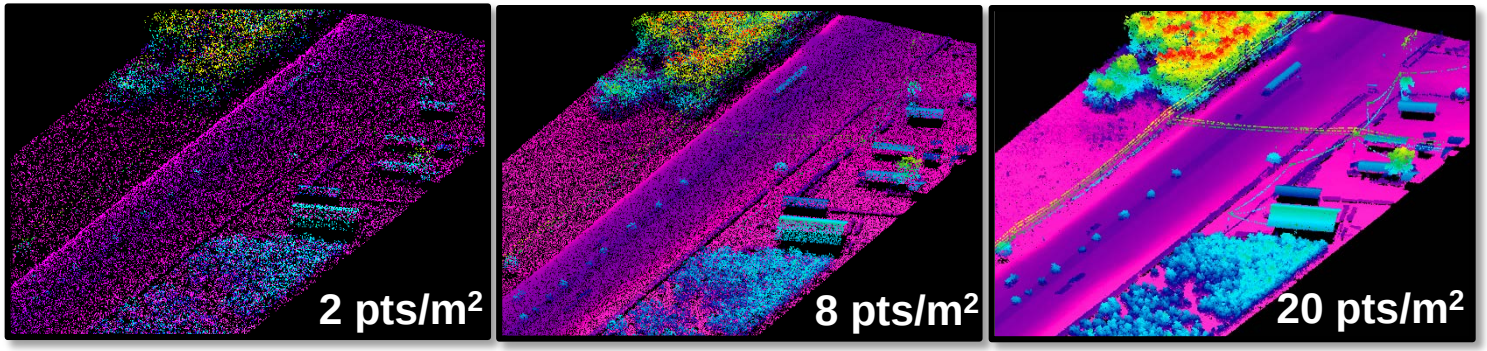
Collection example comparison at 8 ppm

Superior Performance

	Linear LiDAR	Geiger LiDAR
Density (points per meter)	8	8
Instantaneous Coverage Rate (mi^2/hr)	50 ← 17X →	850
RMSEz (cm)	9.25	9.25
Altitude (AGL ft)	3,200	27,000
Swath Width (ft)	3,300	16,000
Ground Speed (kts)	90	290

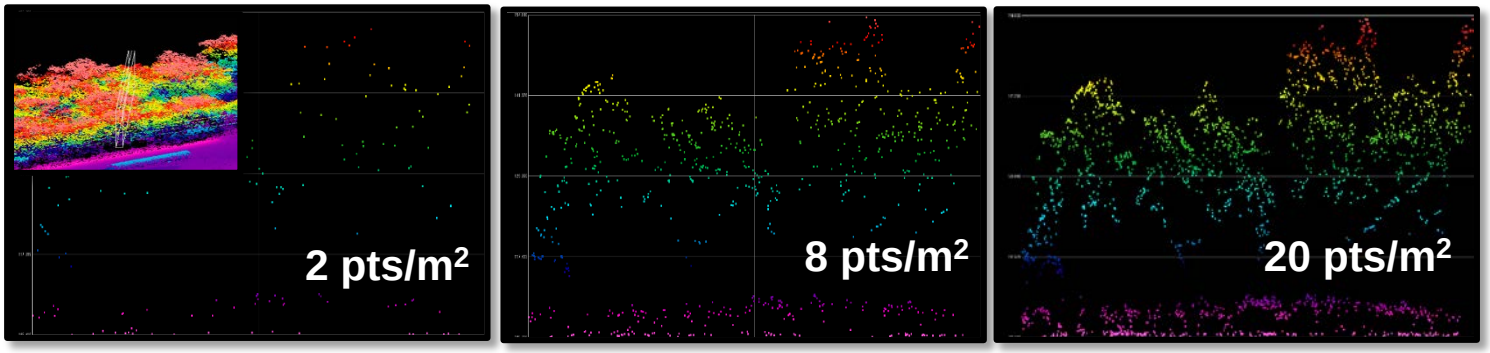
Higher the density greater the payback

Why do higher densities matter?



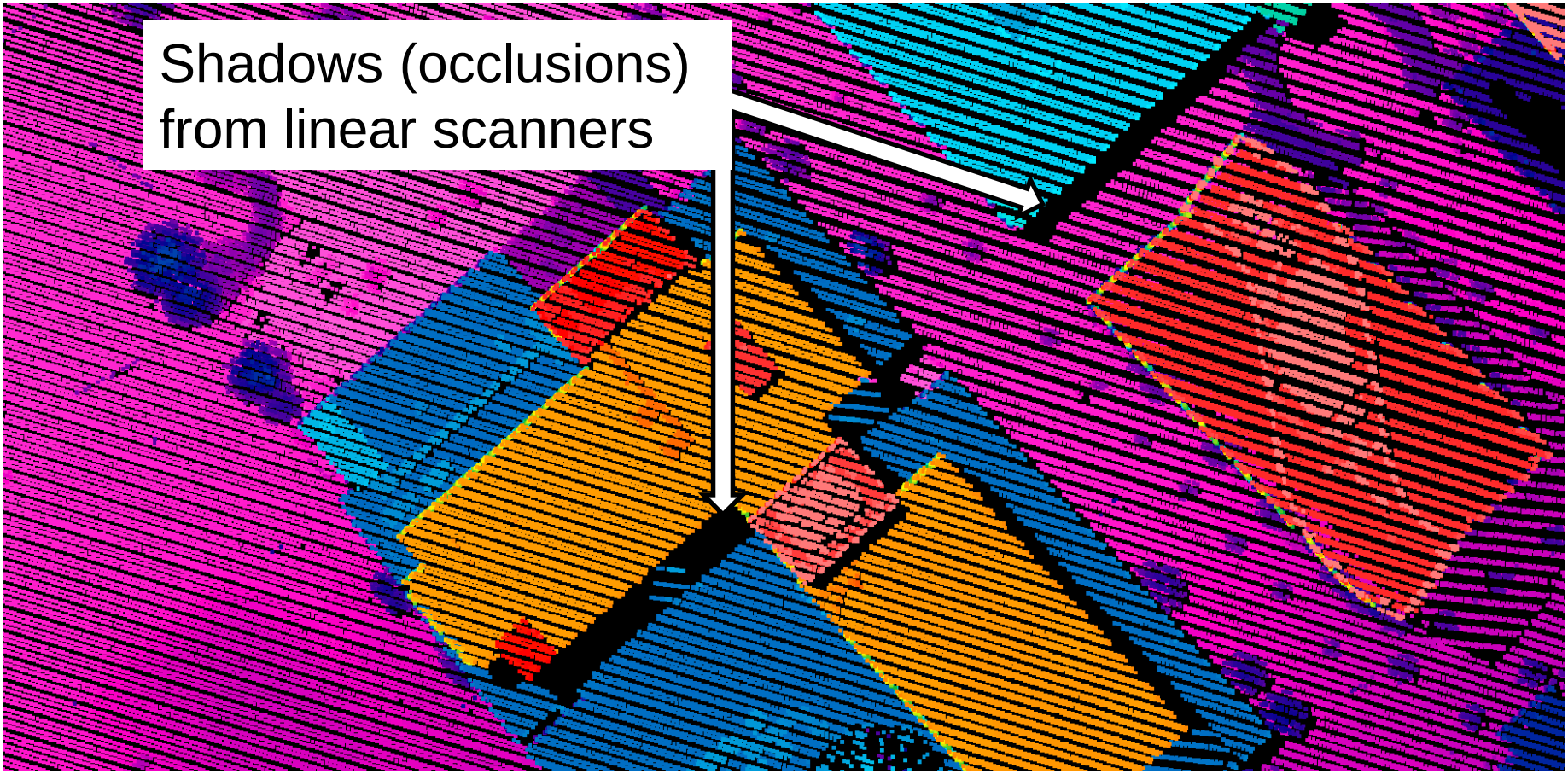
Infrastructure details better defined

Improves foliage penetration to better sample bare earth



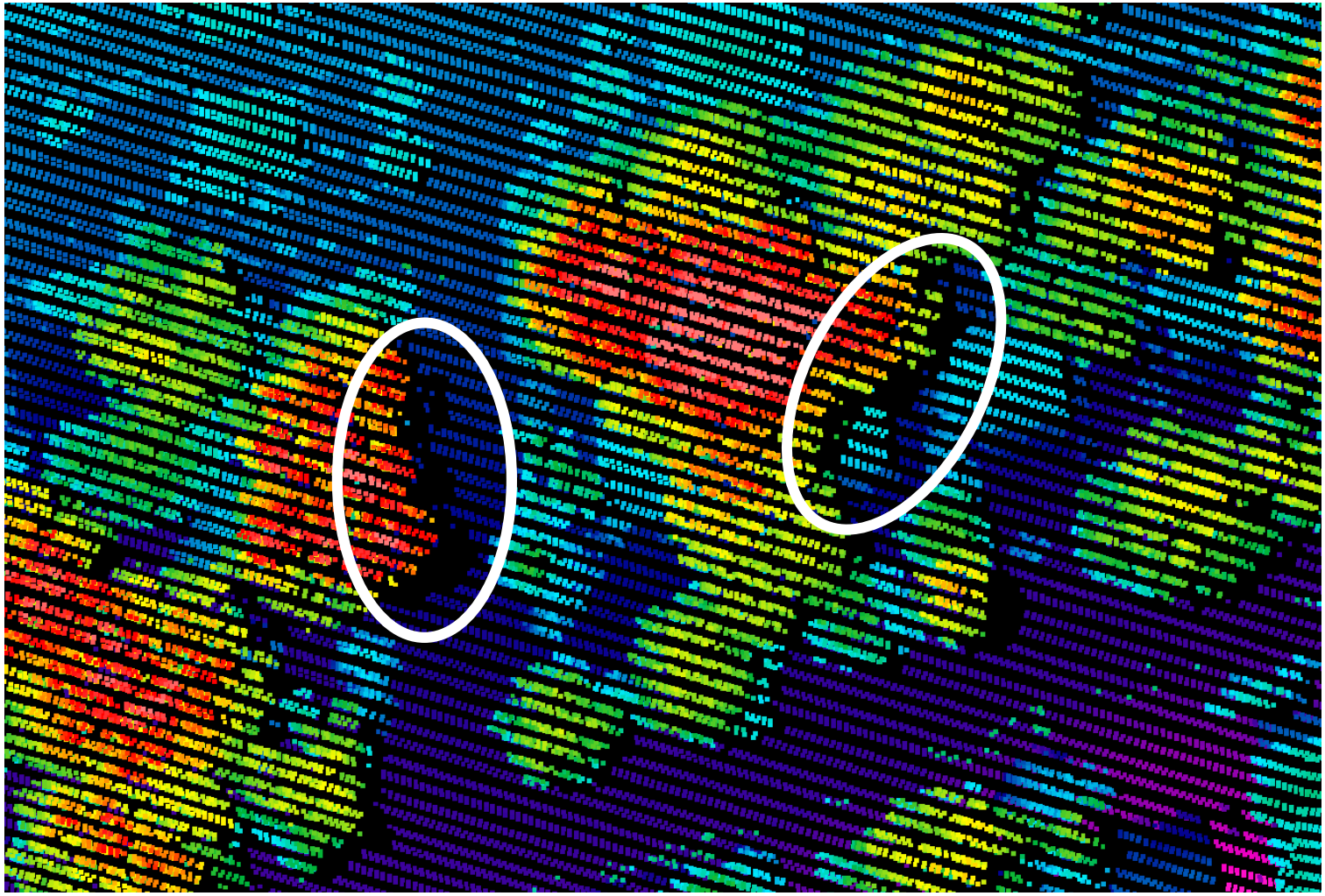
Improves accuracy and enables a high level of automation

Why oversampling and 360° look matters



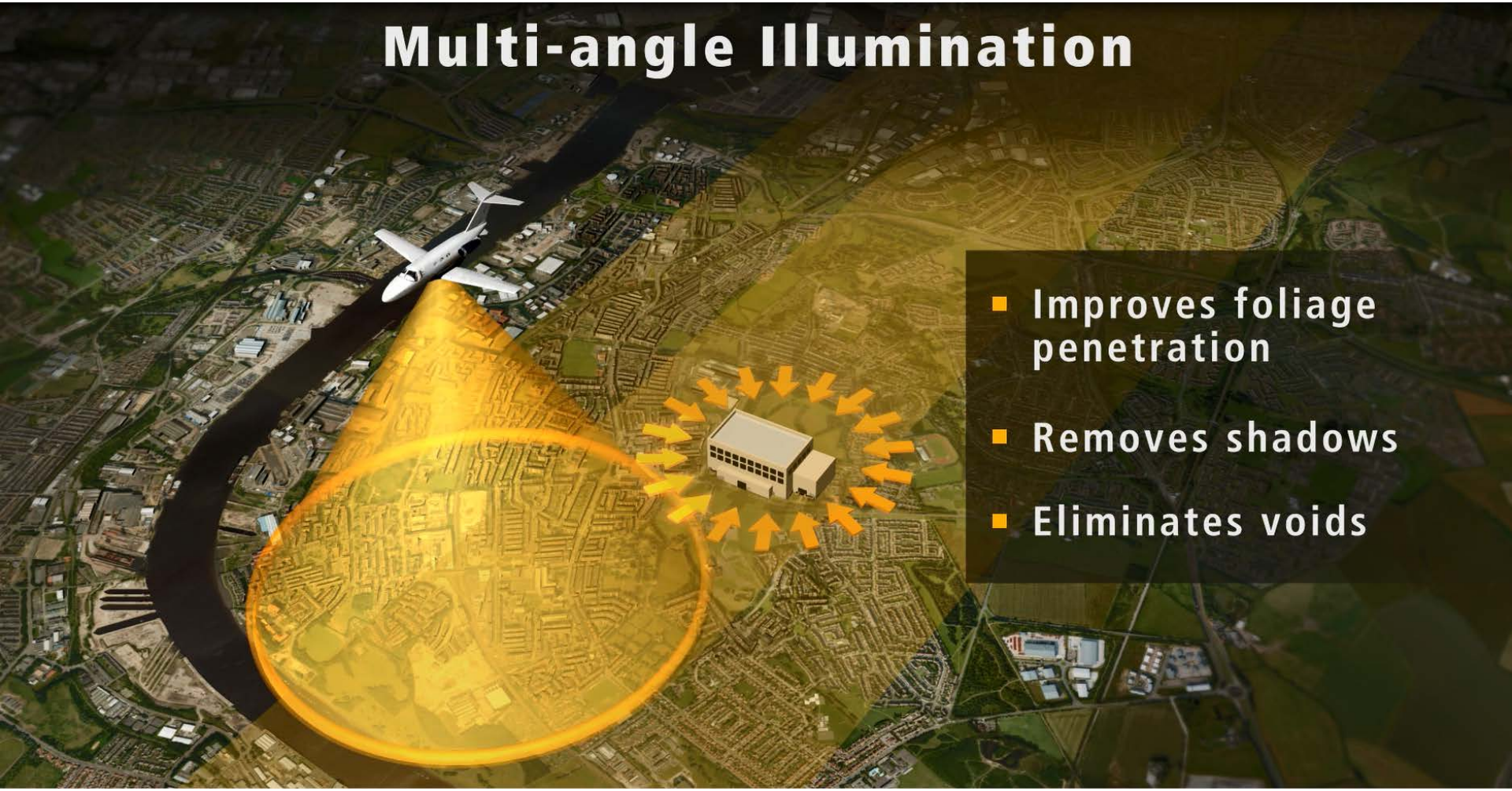
Why oversampling and 360° look matters

Vegetation Shadows (occlusions) from linear scanners



Eliminates the accordion effect

Solution 360° look and oversampling



How to improve accuracy?

Aggregating data requires accurate swath alignment

Utilize latest INS/GPS

Utilize horizontal and vertical ground control points

50% overlap swaths

Perform bundle adjustment via data tie points correcting both horizontal and vertical alignment from multiple look angles.

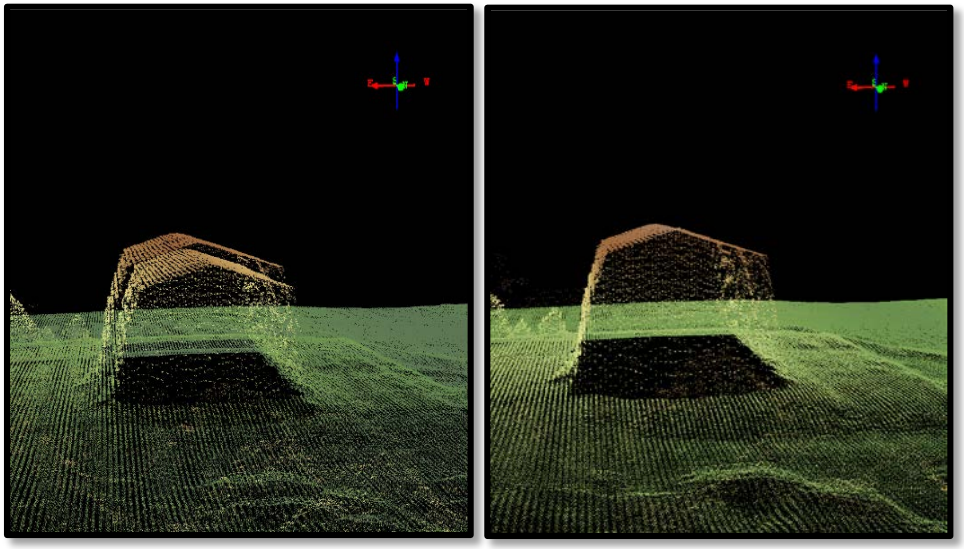
Note: (This is both sensor and process specific)

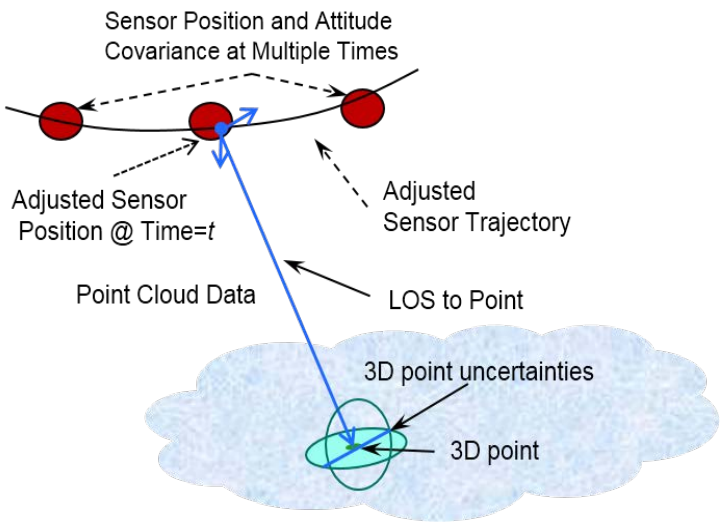
True photogrammetric bundle adjustment to provide higher accuracy

Accuracy improves with rigorous bundle adjustment

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

Enables Rigorous
Accuracy Statements per Point



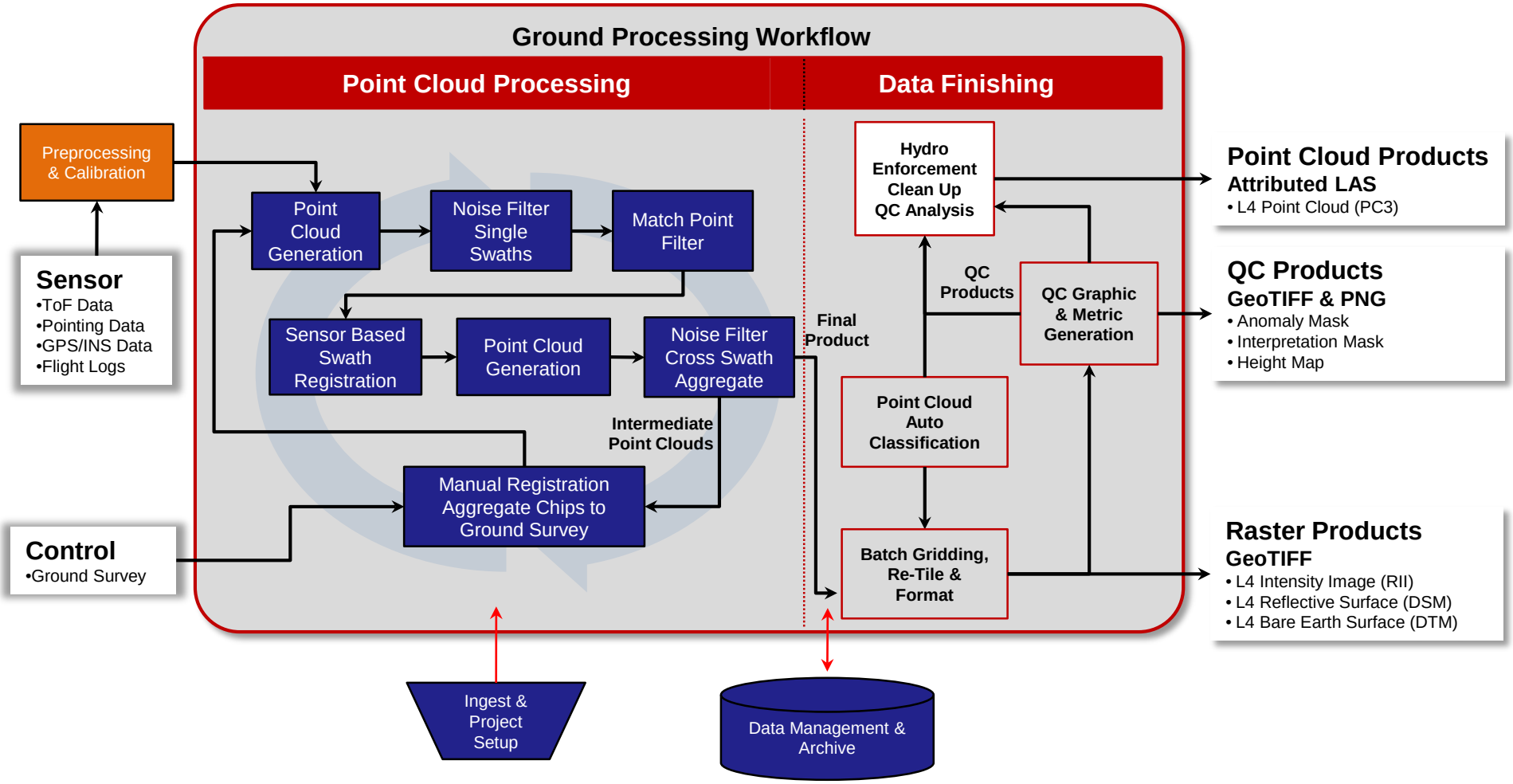


Sensor-based adjustment enables per point accuracy statements

What to do with all this data?

- Not for the workstation in raw form
- Terabytes to petabytes in data management and processing
- Requires high-speed, distributed, multi-core processing
- System has been highly evolved over 15 years
- Sorties are processed in <24 hours
- Total solution requires innovations in both hardware and software

Automated GmAPD LiDAR Processing…

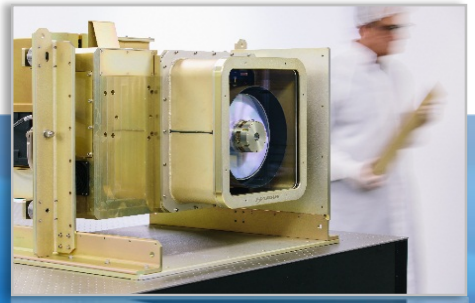


Increased ground automation is critical for reducing production costs

Geiger-mode is the key to reduced cost and higher quality data

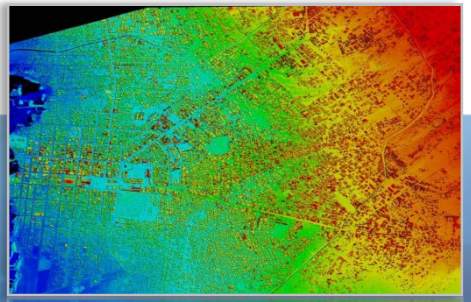
Geiger-mode Sensors to Increase Acquisition Rates

- Higher Altitudes
- Wider Swaths
- Lower Laser Power
- Higher Density
- Decreased Shadowing



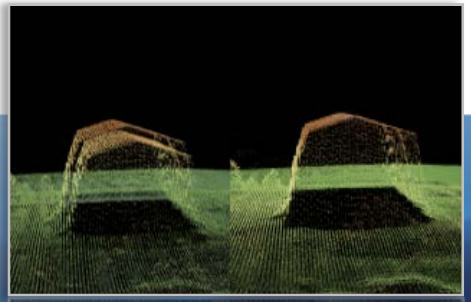
Automated Production to Reduce Hands-on Analyst Time

- Large Areas
- LiDAR Production Management
- Point Classification
- Value-Added Products



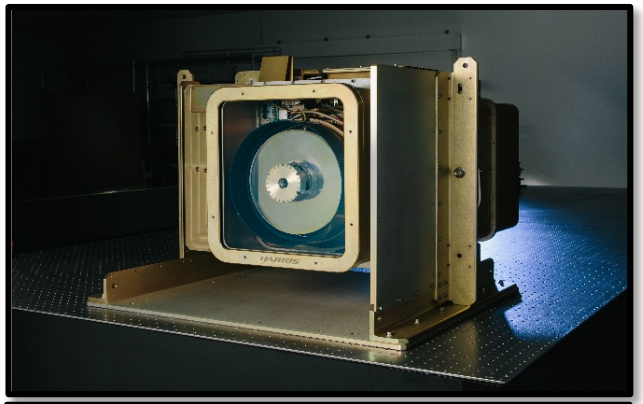
Improved Registration and Quality Control for Accurate Products

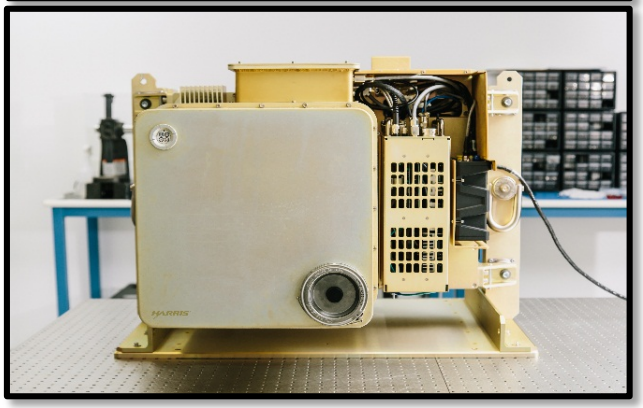
- Automated QA/QC
- Swath Alignment via Bundle Adjustment
- Integrated Ground Control Locking



Built on Harris' 15 year Geiger-mode production legacy

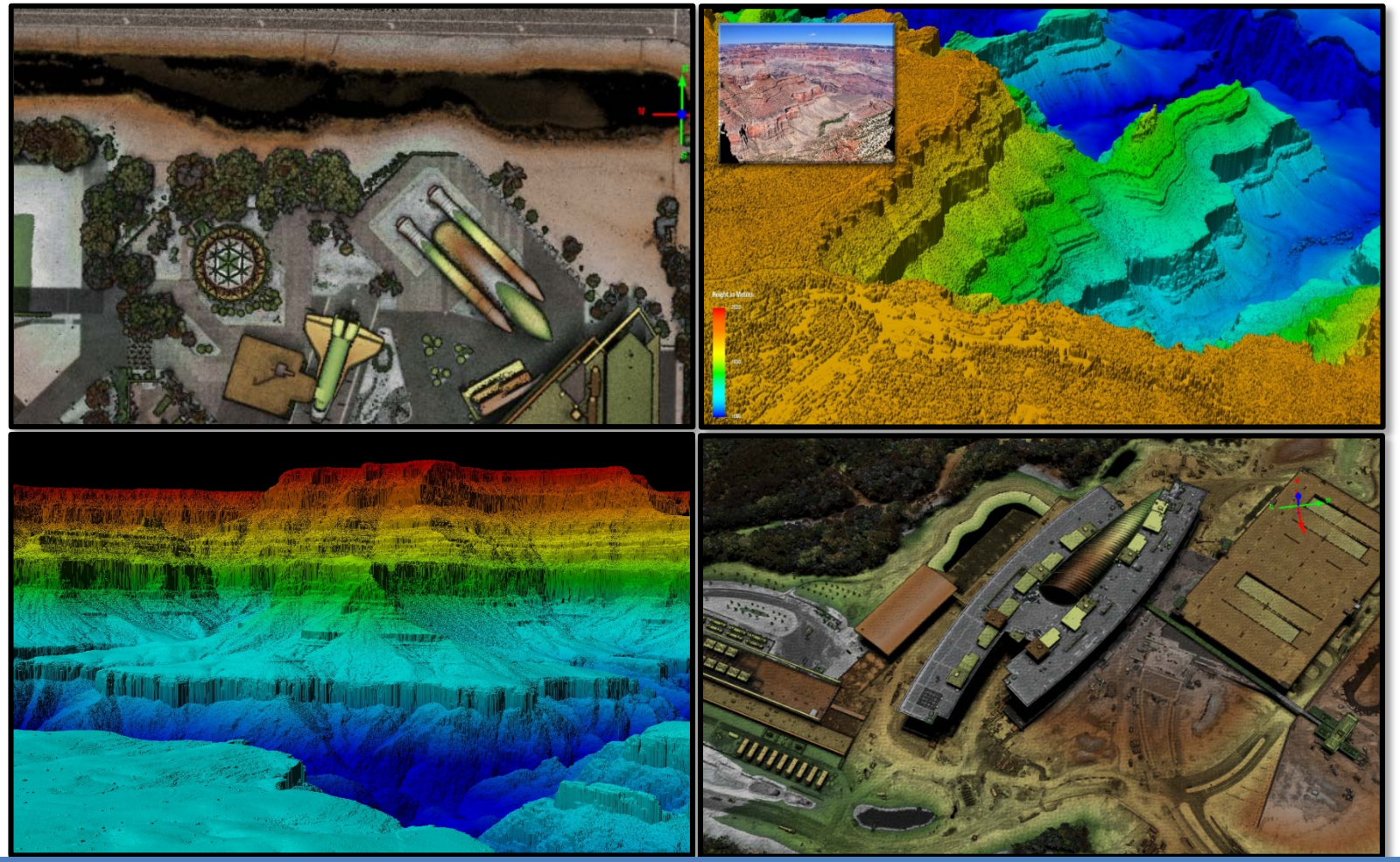
IntelliEarth™ Geospatial Solutions
Geiger-mode (GmAPD) LiDAR sensor





Built specifically for wide-area, high-density collection

Examples



Proven workflows have produced hundreds of thousands of kilometers of high-quality data

Applications

Exploration & Production

- Seismic Survey Planning
- Seismic Processing
- Well Site Planning
- Logistics
- Design & Construction

Pipeline

- HCA and Class Location Analysis
- Right of Way Encroachment
- Overland Spill Modeling
- Design & Cost Estimates
- Route Planning

Questions

Questions?

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