

Single Photon LiDAR: The logical next step in airborne LiDAR mapping

Why is Single Photon LiDAR (SPL) so revolutionary?

- Lower-power laser and highly sensitive detection to achieve accurate range measurement
- 100 optical channels respond to each laser shot, achieving 6.0 MHz effective pulse rate
- Developed for earth-to-satellite range-finding
- Technology accessible to Leica Geosystems through acquisition of Sigma Space in 2016
- Lowers cost per acquired data point

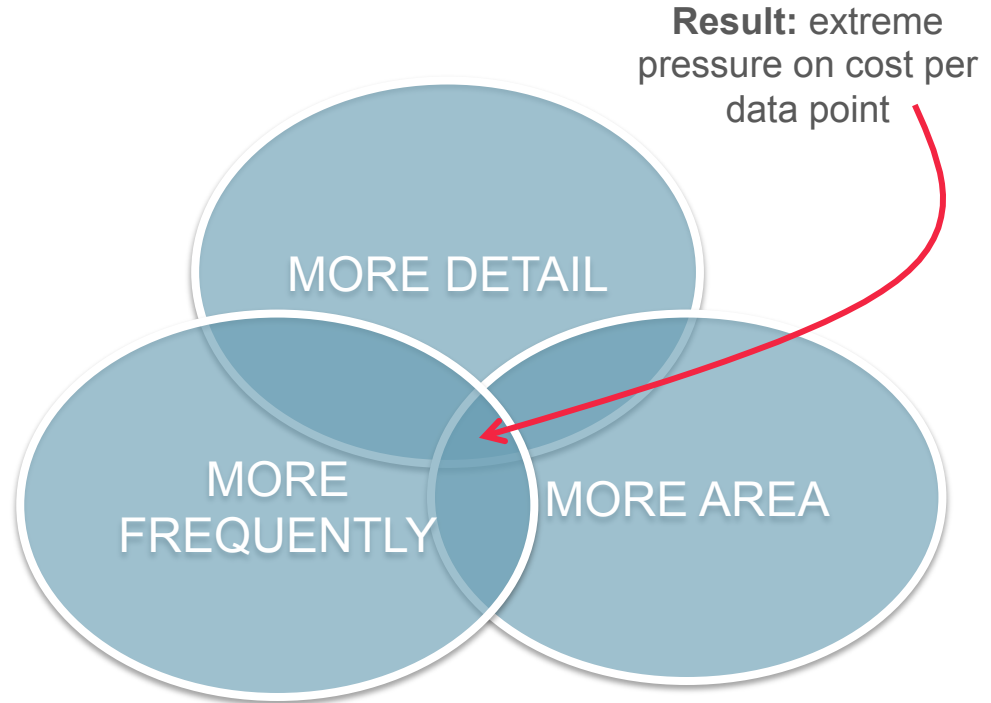


- when it has to be **right**

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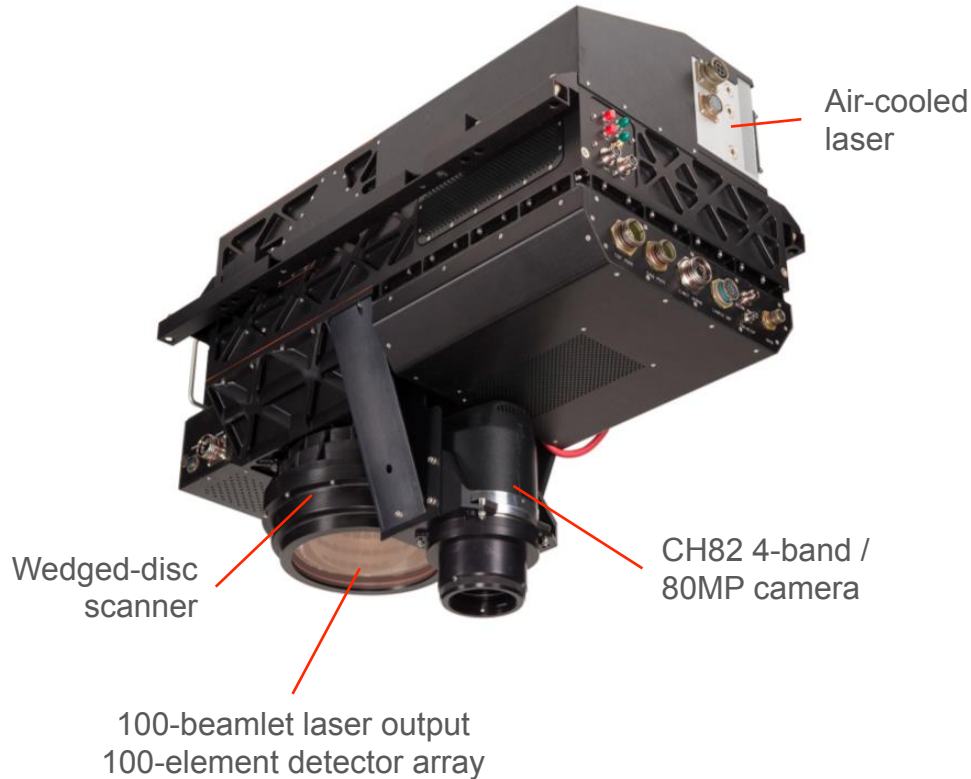
Motivation to develop SPL Technology

- Decision-making that affects larger and larger areas
- Decision-making that requires more detailed and more consistent data
- Decision-making that demands frequent updates at manageable cost



- when it has to be **right**

Continued Development of SPL Technology

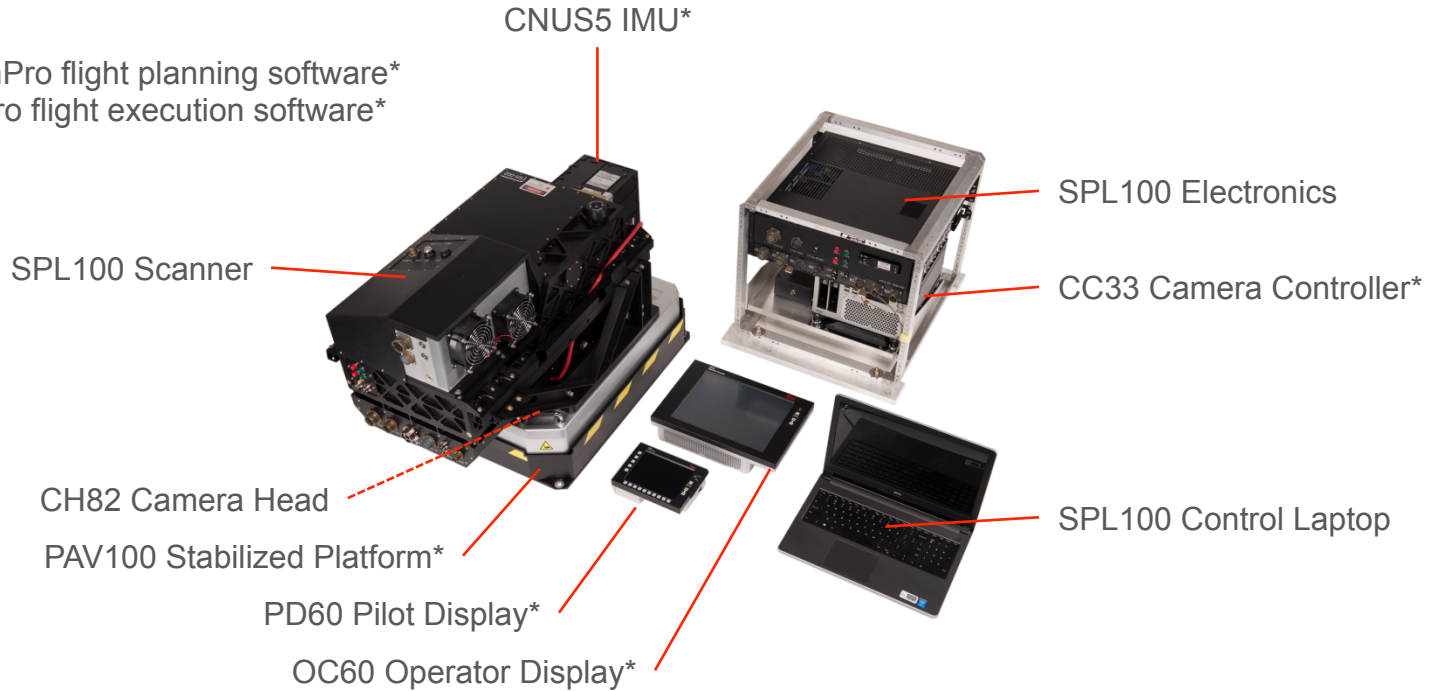


- Retains key design elements
- Improved range accuracy, borrowing techniques refined in years of linear-mode LiDAR use
- Return-signal intensity data in LAS output
- Integrated medium-format camera (RCD30)
- ~34 L x 21 W x 24 H inches, including stabilized platform and medium-format camera
- Improved workflow using HxMap processing platform

System Configuration

Also:

- MissionPro flight planning software*
- FlightPro flight execution software*



* Leica Geosystems Common Sensor Platform

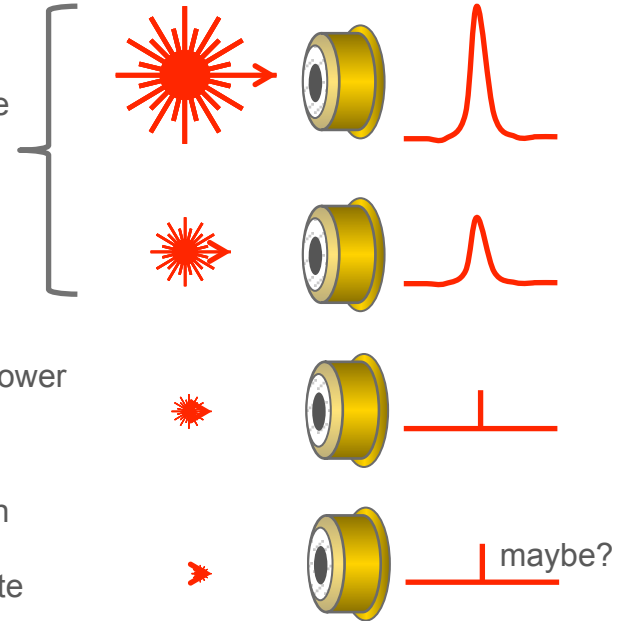
Airborne LiDAR Constituent Technologies

Detection Methodology

Linear (conventional) → the more photons that come back, the stronger the indicated return signal (i.e., intensity proportional to reflectivity)

Single Photon → like linear-mode, but with much higher amplification and lower laser outputs required

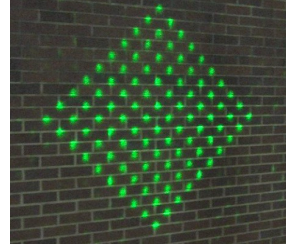
Geiger-mode → very little laser output required, but “probabilistic” detection (...if one photon hits the detector, you might get a detection...but then the detector has to be “quenched” before the next laser shot is fired; accumulate data from many shots to pull target range out of noise)



Summary of LiDAR technologies

Parameter	Technology		
	Linear-Mode LiDAR (e.g. Leica ALS80)	Single-Photon LiDAR (e.g. Leica SPL100)	Geiger-Mode LiDAR (e.g. Harris Intelli-Earth)
Effective pulse rate	1.0 MHz	6.0 MHz	10.2 MHz @ 20x oversampling
Laser output per "pixel"	Lots	Less	Least
Number of returns per outbound laser pulse	4 - ∞	∞	1
Intensity data	12+ bits	~4-bits	~4-bits (quasi-intensity)
Accuracy (RMSE _z)	3-5 cm	6-10 cm	10 cm
Minimum vertical inter-return separation	0.5 – 0.7 m	0.2 m	Single return only on single shots, but <1.0m using multiple laser shots in same area
Wavelengths used	532 / 1064 / 1550 nm	532 nm, but detectors available up to 900 nm	1064 nm, but 532, 1550 nm feasible
Size (approx. excluding UAV types)	~0.2 m ³	~0.2 m ³	~1.0 m ³
Typical flying height	100 - 5000 m AGL	2000 - 4000 m AGL	4000 – 11000 m AGL

Single Photon LiDAR Summary



- Uses a 10 x 10 array of laser beamlets
 - Each beamlet is 25 cm on the ground, total area is a 5m x 5m spot on the ground
- Returns from individual beamlets are imaged into a pixelated detector
- Each pixel output is input to one channel of a Sigma-built high resolution (< 100 psec), multi-stop timer to form a 3D image on each pulse. Individual images are mosaicked together by the aircraft motion and an optical scanner.
- A high speed scanner is synchronized to the laser pulse train. The transmitter and receiver share a common telescope and scanner.
- Channel recovery time (detector plus electronics) is only 1.6 nsec (or ~ 20 cm)
- System operates in full day light and can record multiple events per pixel channel per shot.

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Single Photon LiDAR

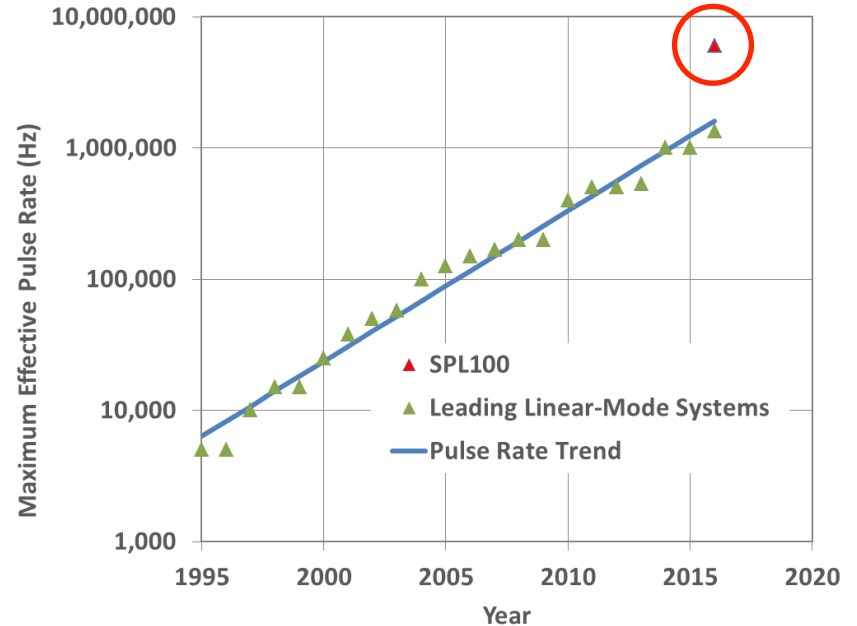
The logical next step for large area LiDAR terrain mapping

Large-area mapping driven by cost per data point

- Dictates high effective pulse rates
- Ability to fly high enough to cover wide swaths, while maintaining high pulse rates

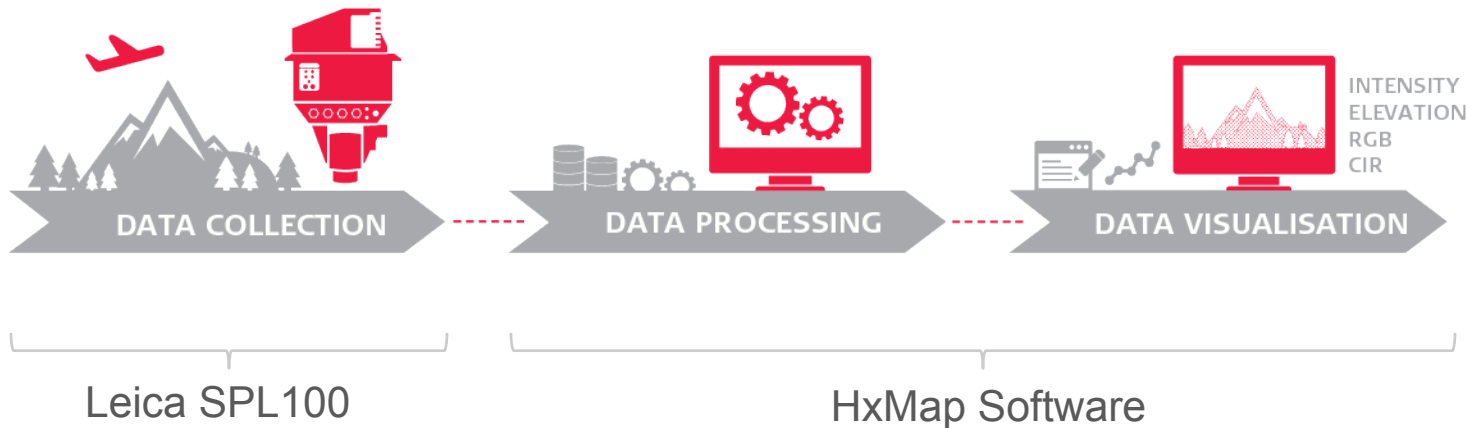
Current technology has allowed a doubling of pulse rate roughly every two years

SPL100 breaks pulse rate barriers a 6.0 MHz effective pulse rate



Leica RealTerrain

Single Photon LiDAR (SPL) with a highly-efficient workflow



HxMap unified post-processing workflow

- Unified post-processing workflow for all Leica Geosystems LiDAR and imaging airborne sensors
- Processes imagery from SPL100 scanner and built-in RCD30 medium-format imager... in a single application
- Accelerates data delivery with distributed processing
- Creates output in industry-standard formats and wide variety of projection systems



HxMap Modules for RealTerrain

Enabler

Enabler, Workflow Manager, Projection Engine



Provider

Ingest, Raw QC



Core LiDAR

AutoCalibration, Color Encoding, Registration,
Point Cloud, Data Metrics



Core Image

APM, AT, InfoCloud, Ortho, Mosaic



3D Modeller Basic

City Modeller, Texture Mapper, 3D Editor



3D Modeller Advanced

Building Finder, 3D Mesh



SDK

Developer's Kit

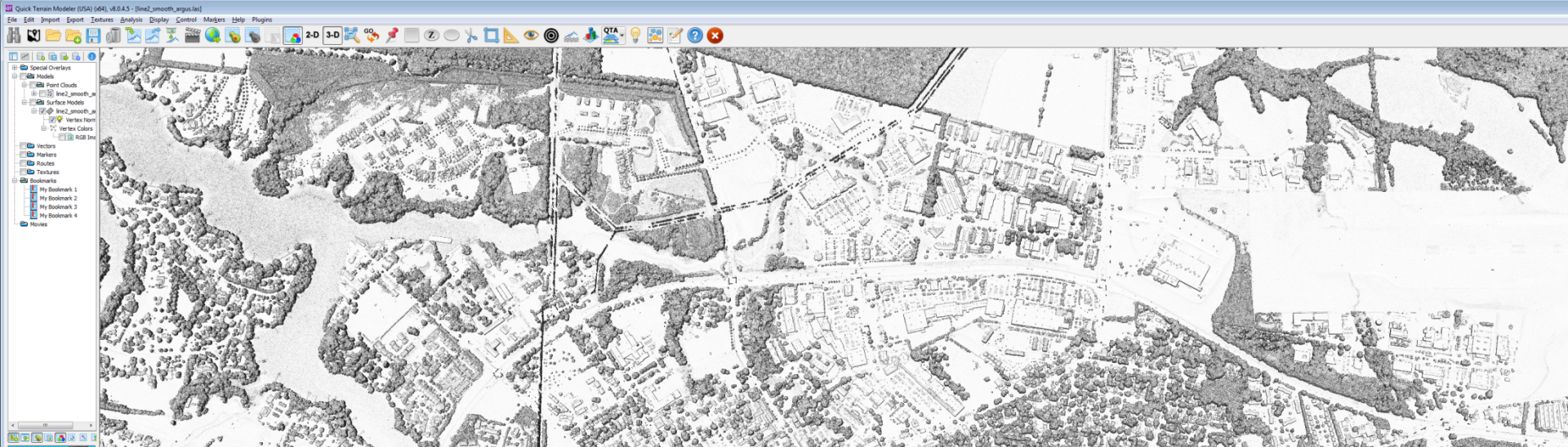


● = Standard ○ = Optional



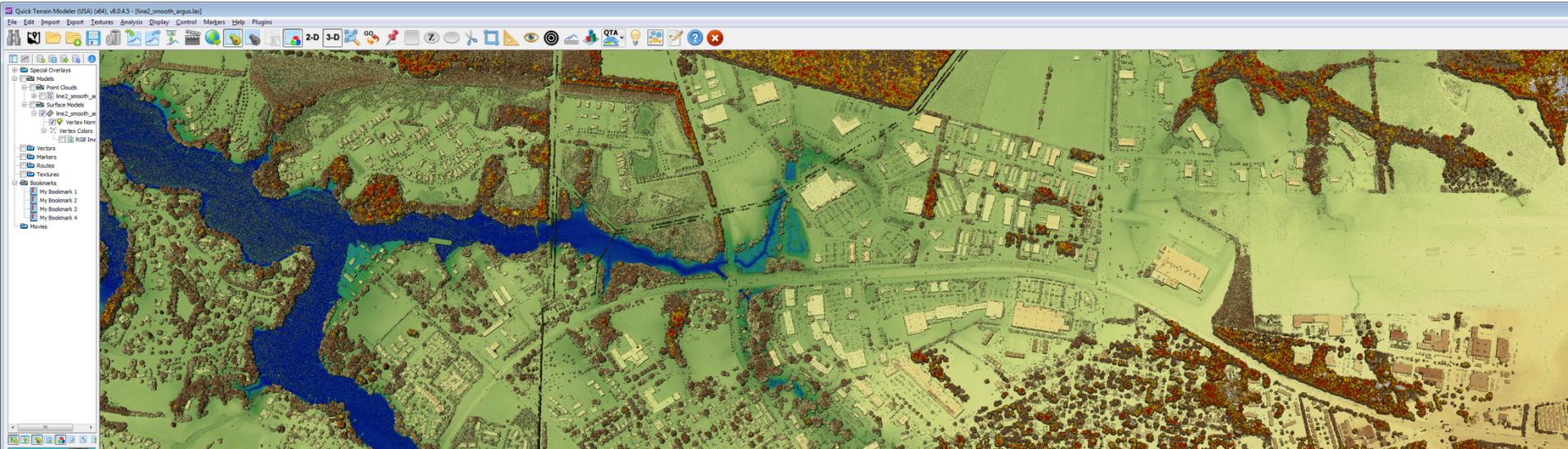
Capture & deliver dense LiDAR & Imagery

Shaded relief for building outline identification



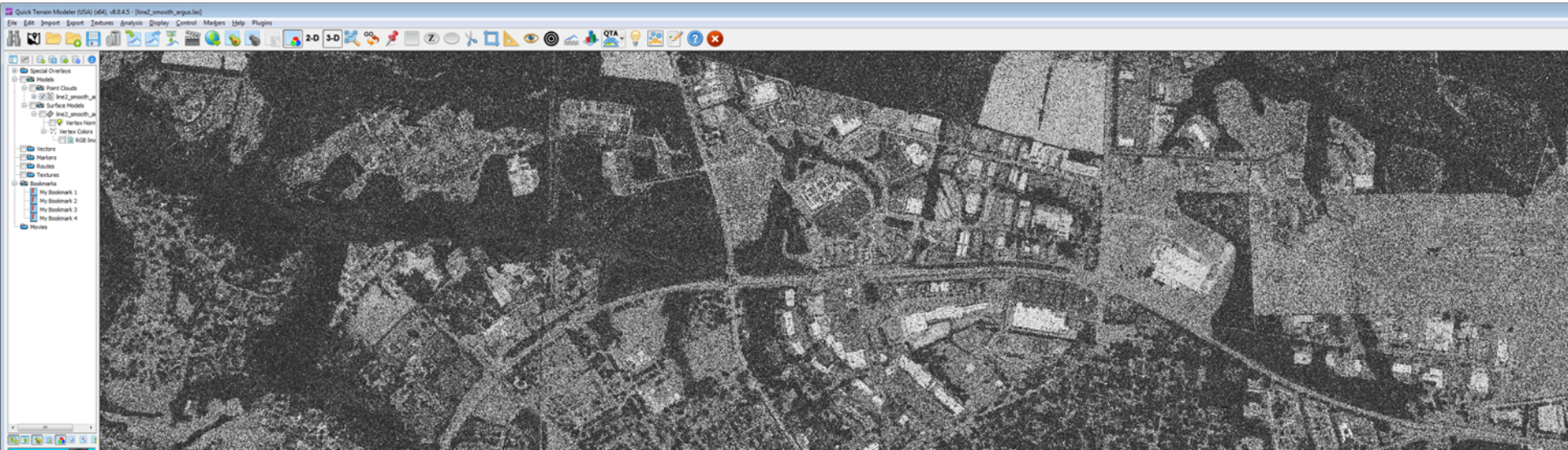
Capture & deliver dense LiDAR & Imagery

Color by elevation



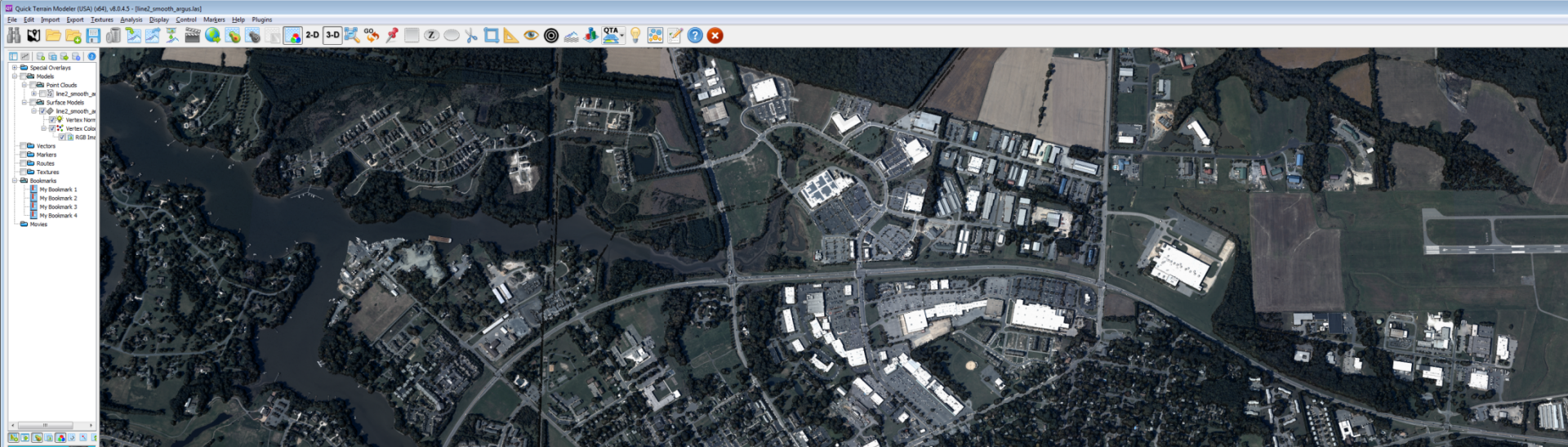
Capture & deliver dense LiDAR & Imagery

Gray-scale by intensity for enhanced classification



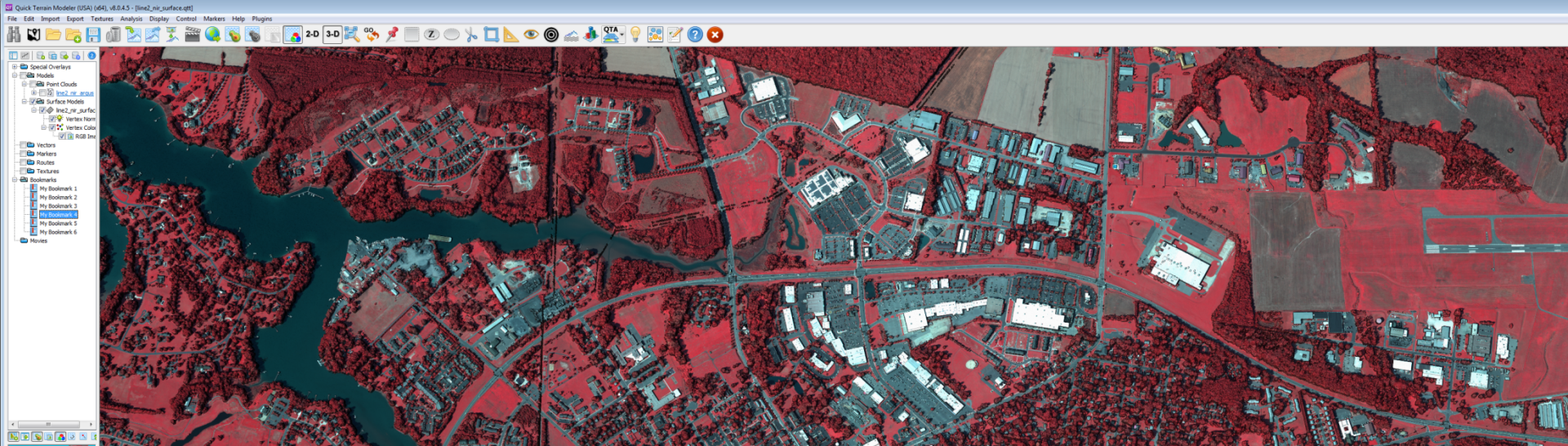
Capture & deliver dense LiDAR & Imagery

Natural color point cloud for easy object identification

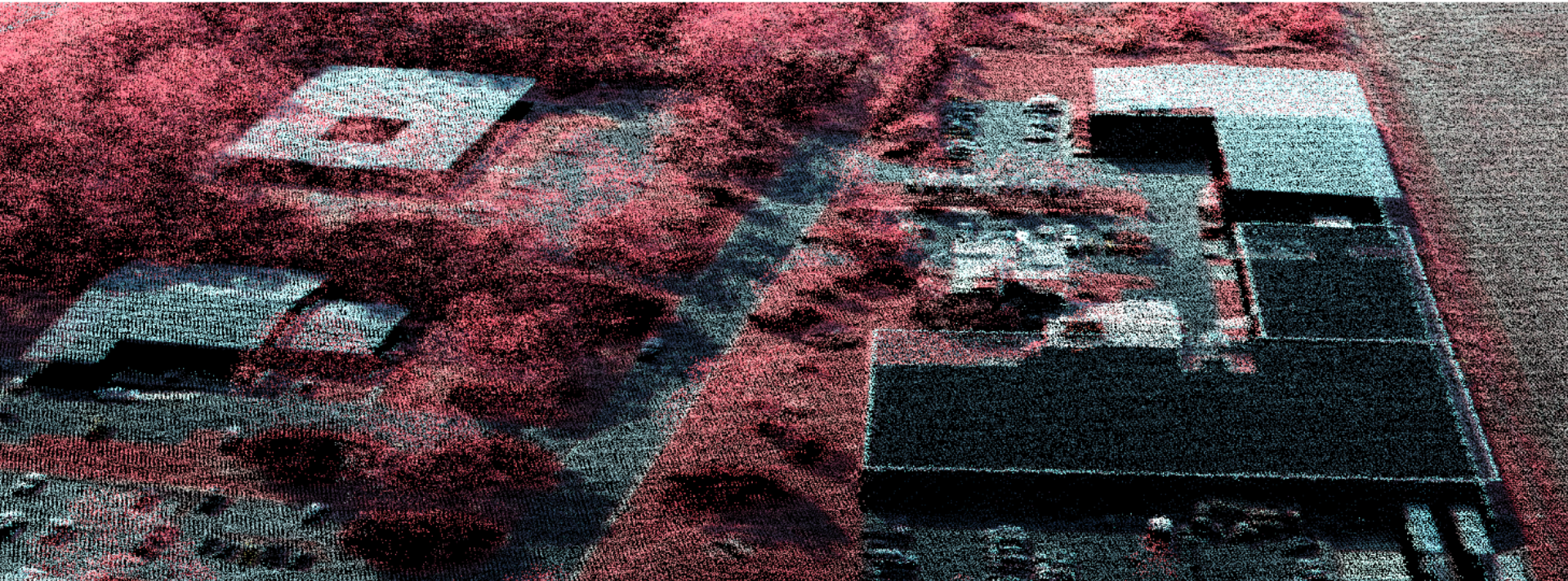


Capture & deliver dense LiDAR & Imagery

False-color infrared for vegetation classification



Leica RealTerrain: be efficient



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Conclusions

RealTerrain is a solution designed for wide-area LiDAR mapping applications

The HxMap workflow is up to the task of processing the vast amounts of data from SPL100

Single-photon LiDAR continues to exist as another tool in the LiDAR mapping toolkit

RealTerrain is accessible via a variety of business relationships, depending on job project location and requirements