PulseTRAK™
Solving the Lidar Multipulse Challenge

Innovative new lidar technology significantly increases collection efficiency and data quality

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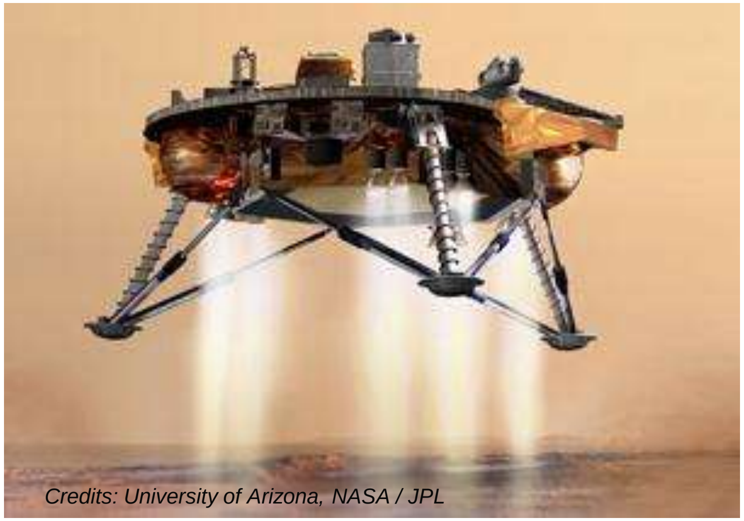
Sistemas Integrados de Lidar y Cámaras

Múltiples Plataformas

Acerca de Optech

"De las profundidades del oceano hasta la superficie de Marte"

Dr. Allan I. Carswell*
Fundador & Chairman de Optech

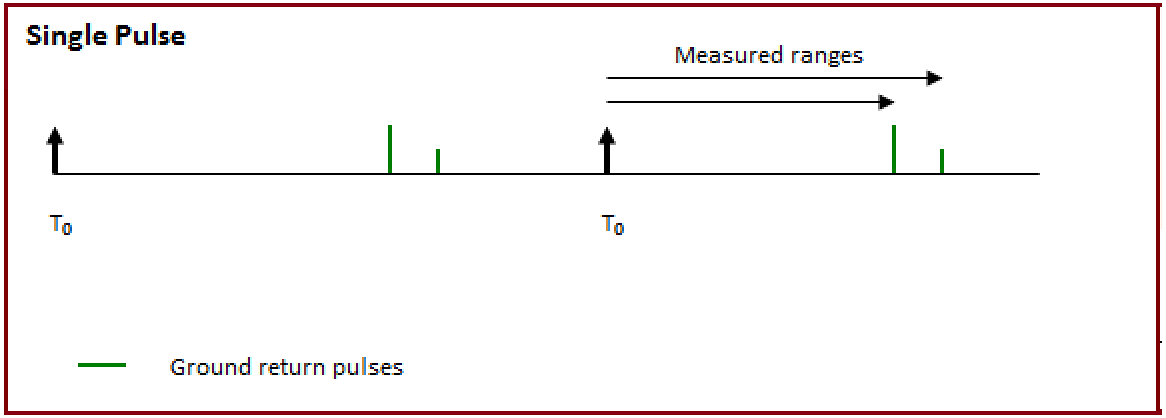


Una compania global que disena, fabrica, integra, desarrolla, y da soporte a sistemas sofisticados de sensores activos y pasivos que operan en tierra, agua, en el aire y en el espacio

Presentation Summary

- Pulse Principles
  - TOF versus SNR
- Blind Zones
  - Impacts to blind zone thickness (beams, scanner types, scan angle, hardware variations, atmospherics)
- Multipulse Technologies
  - FMP, MPiA versus CMP, MTA
  - Impacts to data density and efficiency of collection
- A Multipulse Replacement
  - PulseTRAK™ development objectives
  - Zero blind zones
  - Swath Tracker mode
  - PulseTRAK™ planning example
- Conclusions

Pulse Principles: Signal Measurement



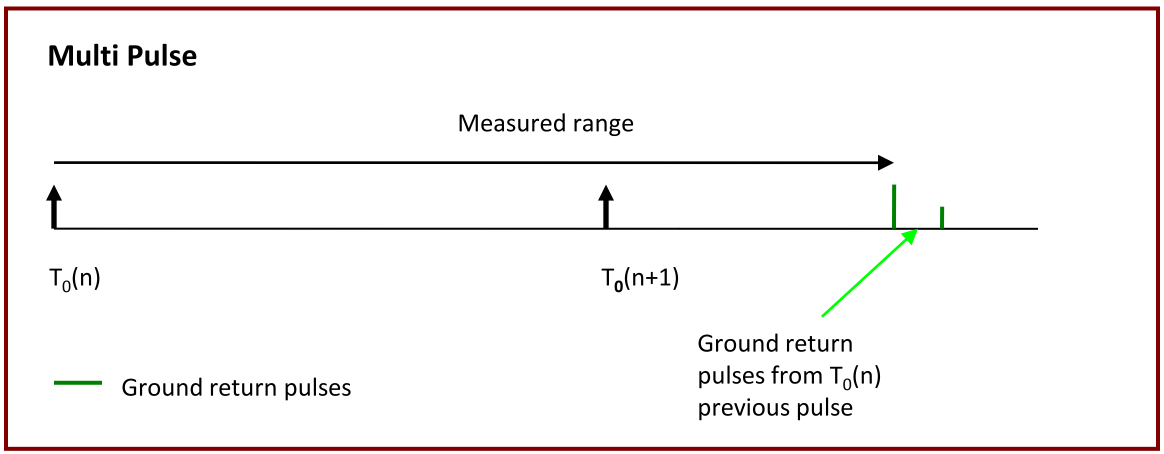
$$D = \frac{T \times c}{2}$$

D = distance (m)

T = time (sec)

c = 3×10^8 m/sec

Output signal recorded and timed, then signal return detected *prior* to next pulse emitted. Time-of-flight limited.



Output signal recorded and timed, then signal return detected *after* next pulse emitted. Now signal-to-noise limited.

Pulse Principles: Multipulse

- “Multipulse” is the ability to track, identify and measure more than one emitted laser pulse in the air

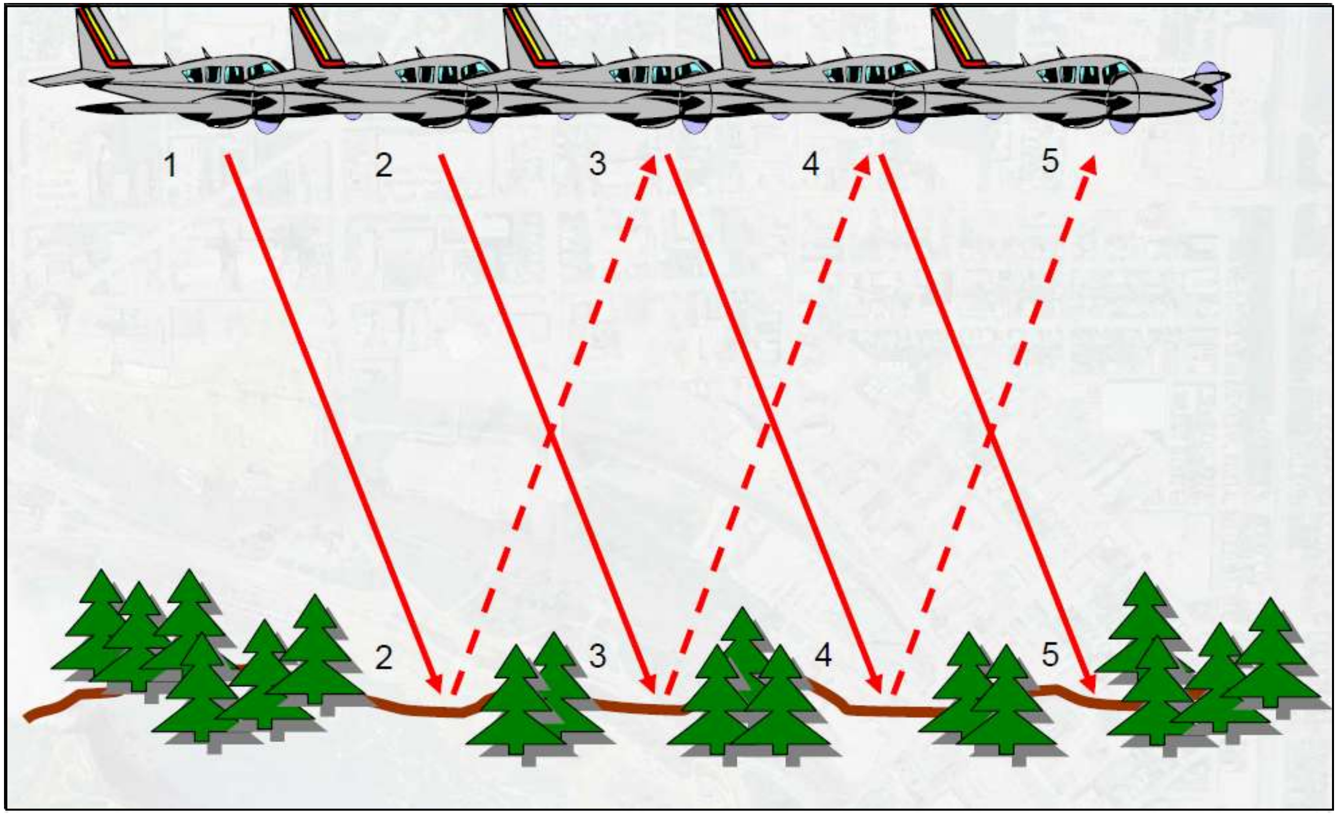


Image courtesy of Leica GeoSystems

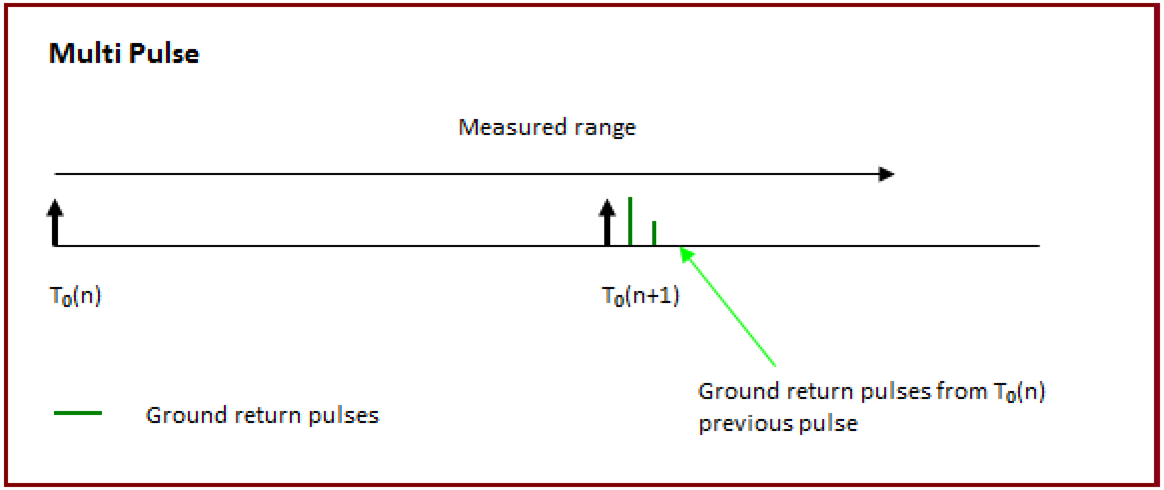
A History of Multipulse: Decade 1

- Decade 1 (1995-2004) – Constrained by single pulse TOF
  - ALTM 3033
    - 3000 m = 20 µs < 33 kHz
  - ALTM 2050 (higher PRF, lower altitude)
    - 2000 m = 13.3 µs < 50 kHz
  - ALTM 3070 (higher PRF OR higher altitude)
    - Included new TIM design
  - ALTM 3100
  - Not just Optech…the entire industry was assuming this phantom constraint
  - ALTM Gemini
    - Included new TIM to remove single pulse TOF constraint

A History of Multipulse: Decade 2

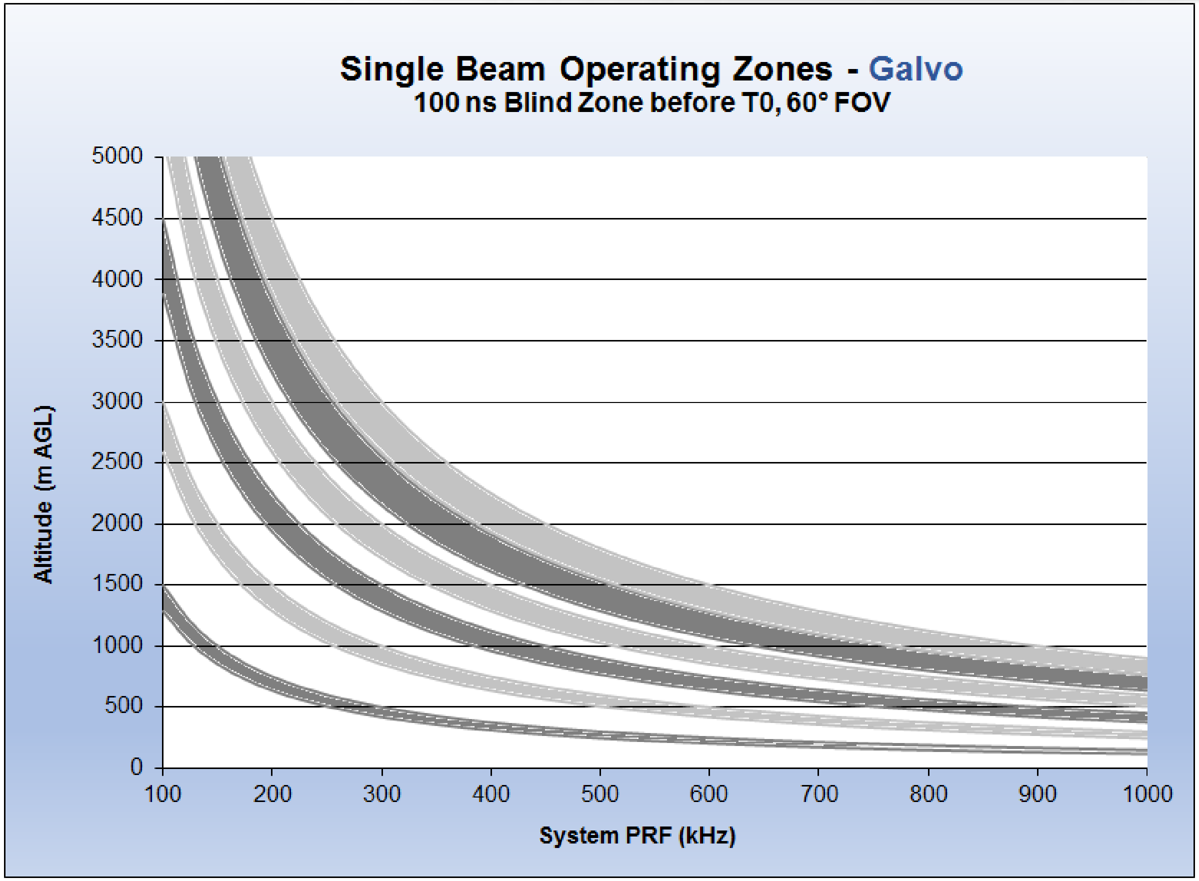
- Decade 2 (2006-2014) – Constrained by Blind Zones (time interval shortly before and after laser firing)
  - Again- Not just Optech - the entire industry was observing this phantom constraint.
  - Optech developed Fixed and Continuous Multipulse technology (CMP™)
  - Leica developed MPiA
  - Riegl developed MTA and PRF “modulation”
- Decade 3 (2015-   ) –Blind Zone constraint removed
  - Optech releases Galaxy with PulseTRAK™

Pulse Principles: Blind Zones



If fly too close to altitude zone that corresponds to T_0 (n+1), then confusion regarding outgoing pulse vs. return pulse (blind zone)

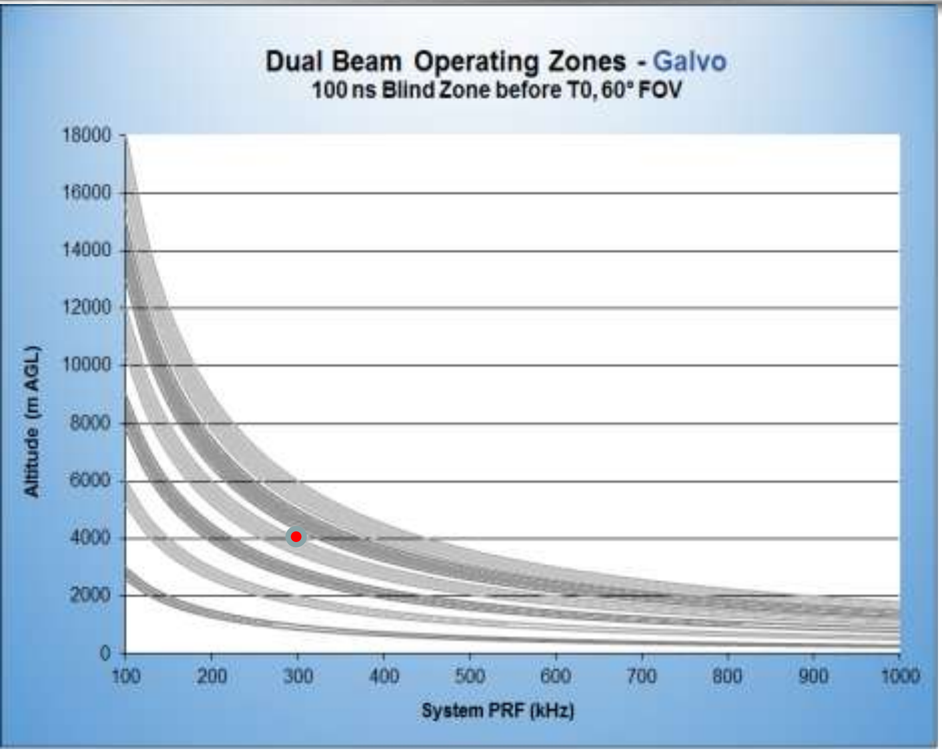
Blind Zones: Altitude versus Thickness

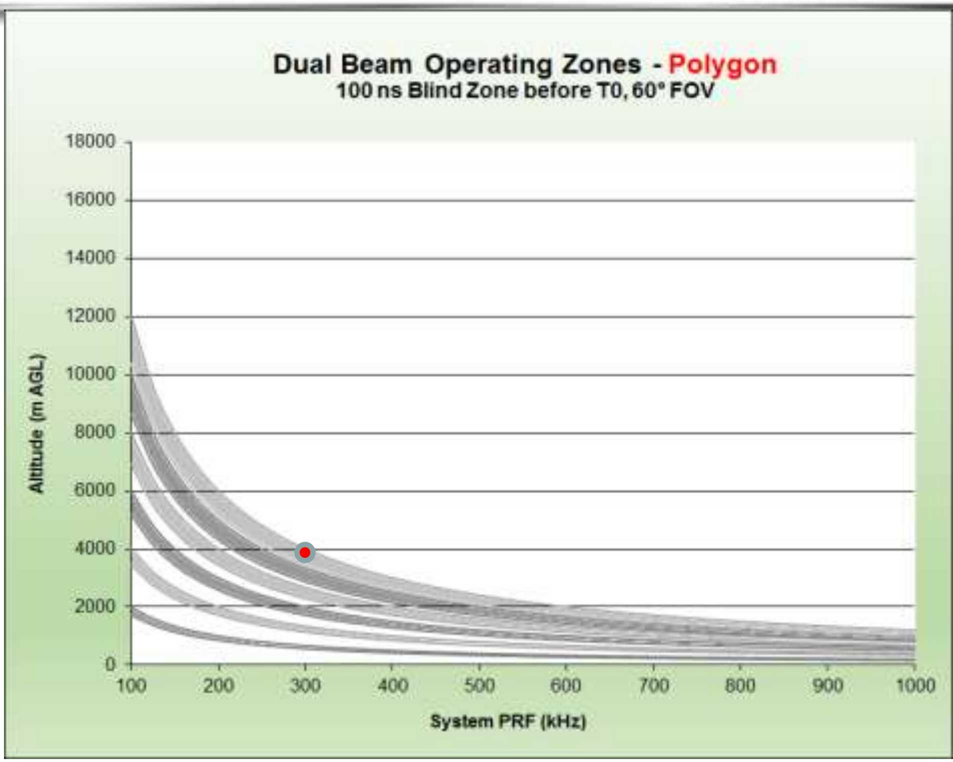


Blind zone thickness increases with altitude

- Operational envelope decreases with increasing altitude and PRF

Blind Zones: Zones versus Scanner Types

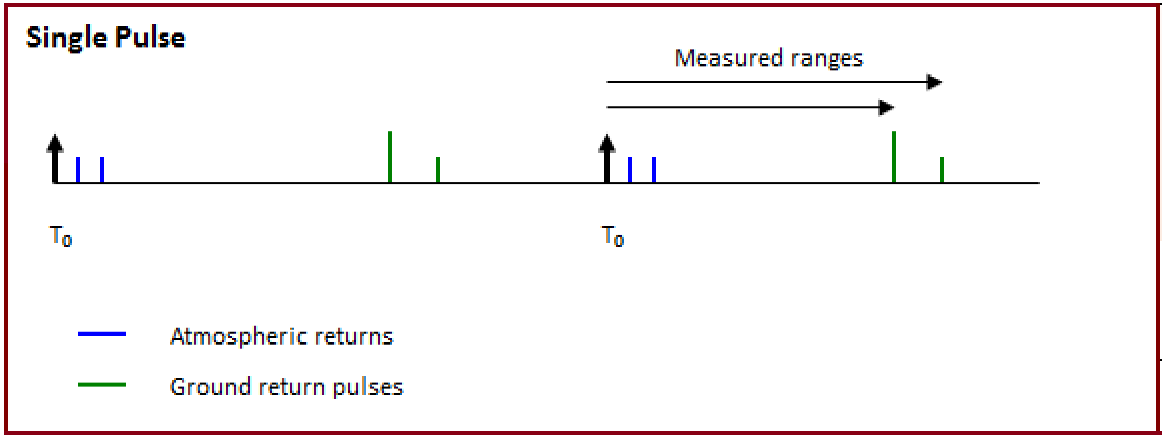




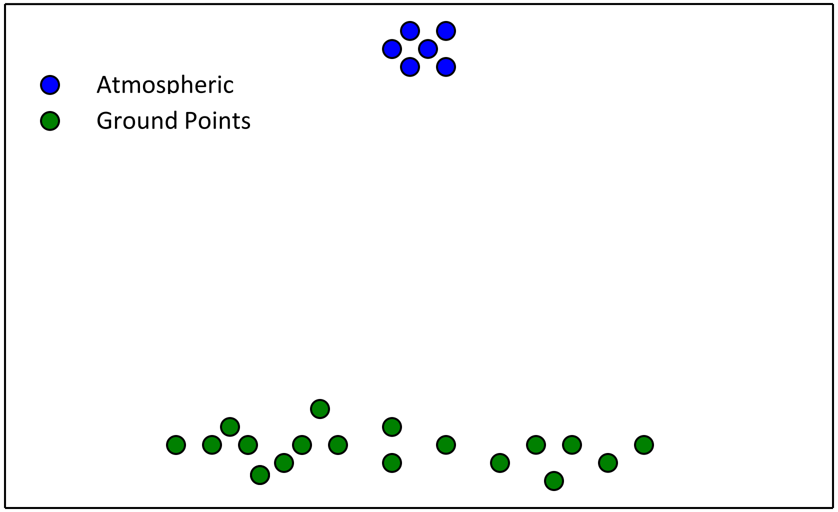
Polygon scanners have 33% more blind zones to navigate, compared to galvometric scanners

- A consequence of having to use a higher advertised (emission) PRF to achieve an effective (ground) PRF for equivalent density
- Increased number of blind zone “scars” in the terrain model, relative to galvometric scanners

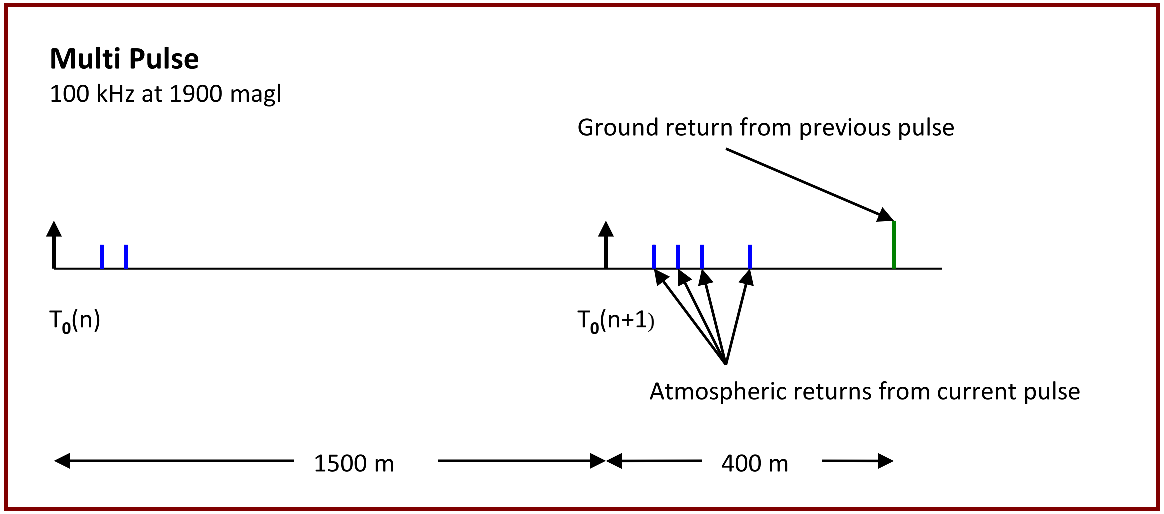
Pulse Principles: Atmospherics (Single Pulse)



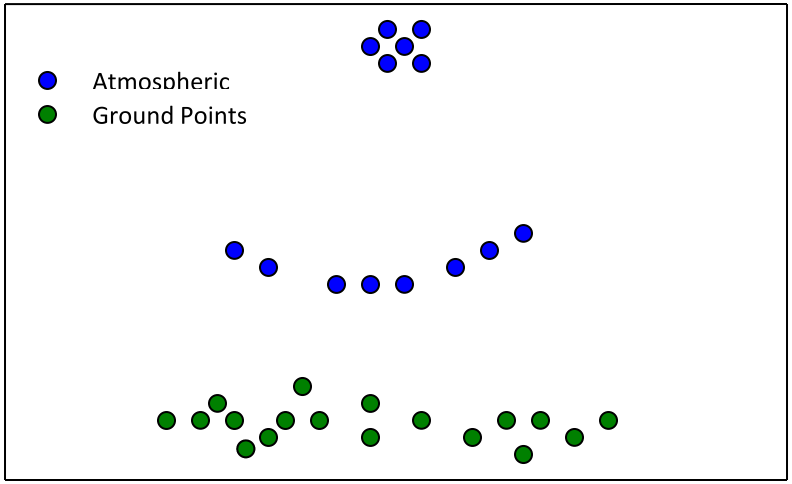
Location of atmospheric returns relative to outgoing *single-pulse*.



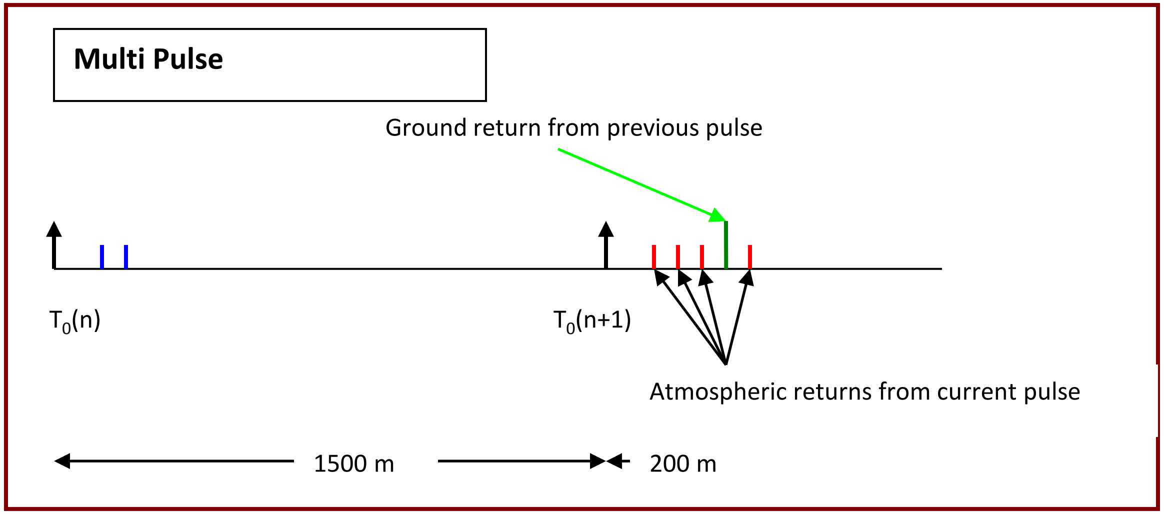
Pulse Principles: Atmospherics (Multipulse)



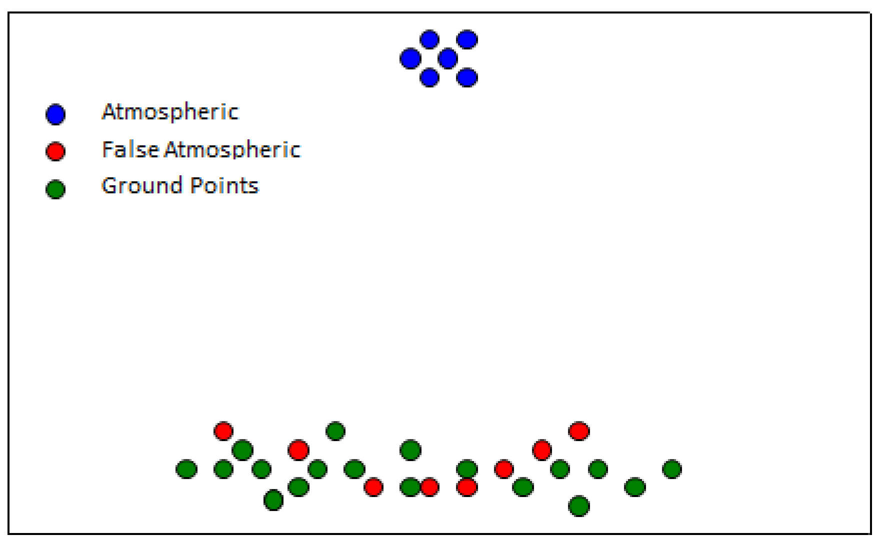
Location of atmospheric returns relative to outgoing *multi-pulse.*



Pulse Principles: Atmospherics (Multipulse)

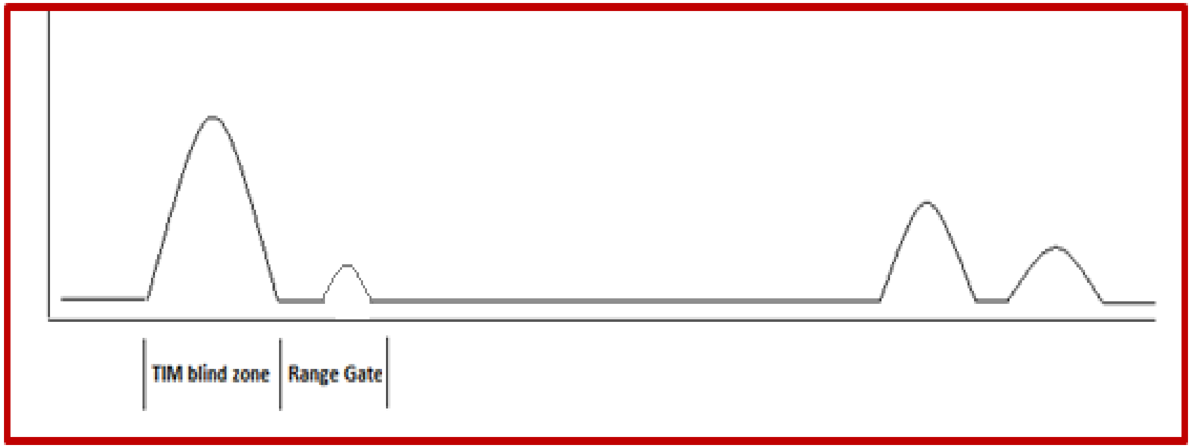


Impact of atmospherics on ground data relative to outgoing *multi-pulse.*



Blind Zone Thickness: Atmospherics

- Blind Zone thickness is often a function of additional range gate to exclude near-field returns (atmospherics)
- Atmospherics can have a significant impact on data quality and necessary post-processing filtering
- Manufacturers will adjust the size of the blind zone based on sensor susceptibility to atmospherics



Multipulse Solutions

Blind zones are problematic when trying to collect data in high relief environments, or when flying at high altitudes with high PRF

- Data gaps will occur when the terrain crosses a blind zone

Manufacturers have developed several methods to try and overcome this blind zone constraint:

Optech CMP (October, 2006)

- Solves for blind zone data gaps (now referred to as a pulse transition zone)
- Does not maintain planned density in the transition zone (~90%)
- In-air implementation does not impact post-processing times or in-air visualization

Leica MPiA (December, 2006)

- Does **not** solve for blind zone data gaps
- Must plan around the MPiA blind zones (prevents use of high PRF in high relief environments)

Riegl MTA (January 2012)

- Solves for MTA transition zone data gaps
- Does not maintain planned point density in the MTA transition zone (~50%)
- Smaller transition zones than CMP
- Post-processing solution required

Multipulse Replacement: PulseTRAK™

PulseTRAK™ was designed to remove the stigma of multipulse and provide wholly consistent point data throughout the complete sensor operating range

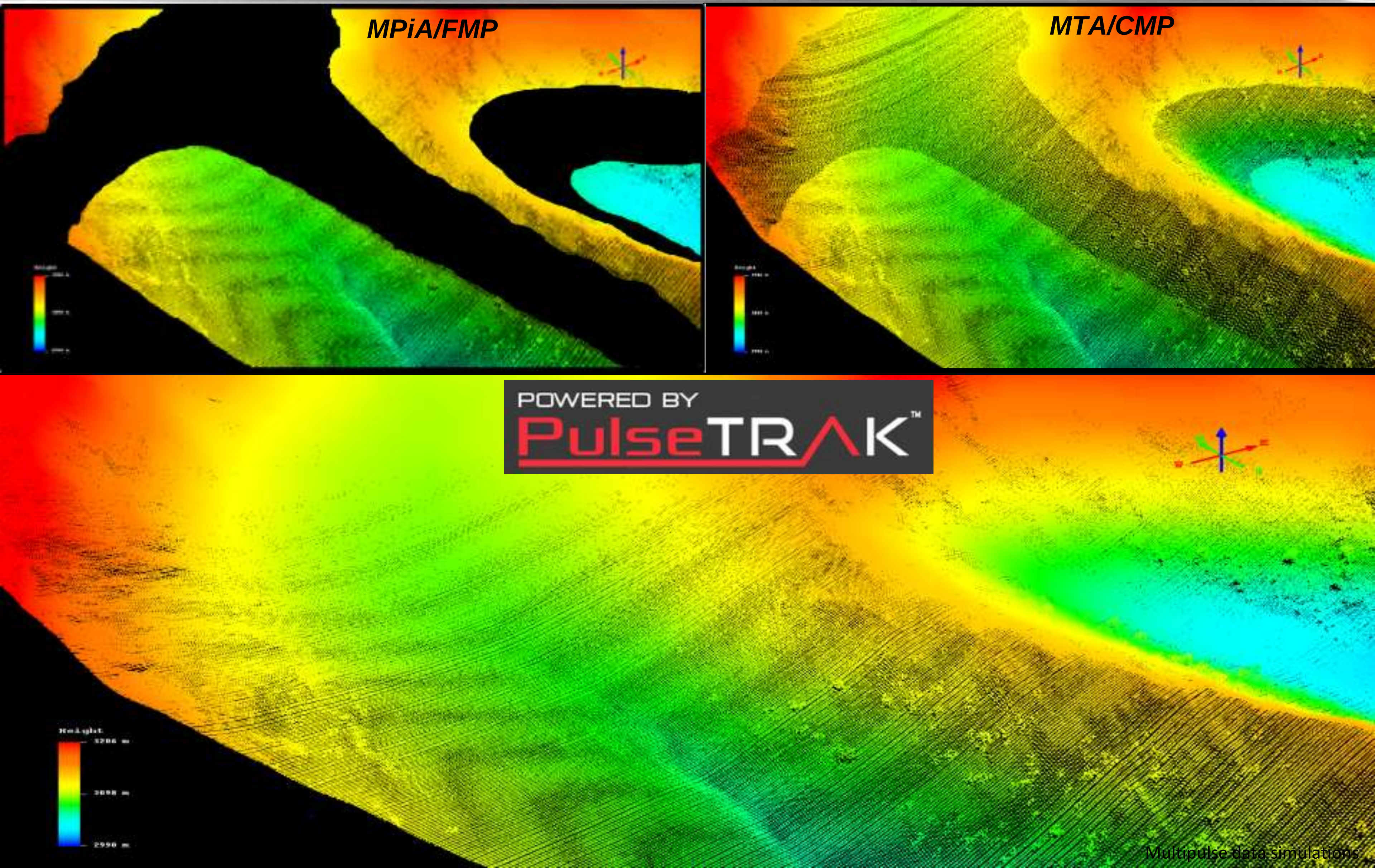
Development Objectives:

- Maintain complete coverage across multipulse transition/blind zones
- Maintain consistent point density across zones
- Eliminate the impact of atmospherics in ground model results
- Provide complete collection freedom across all terrain types
- Not impact post-processing times
- Be able to observe coverages in realtime
- Simplify mission planning

GALAXY™

With PulseTRAK™ technology — No more compromises!

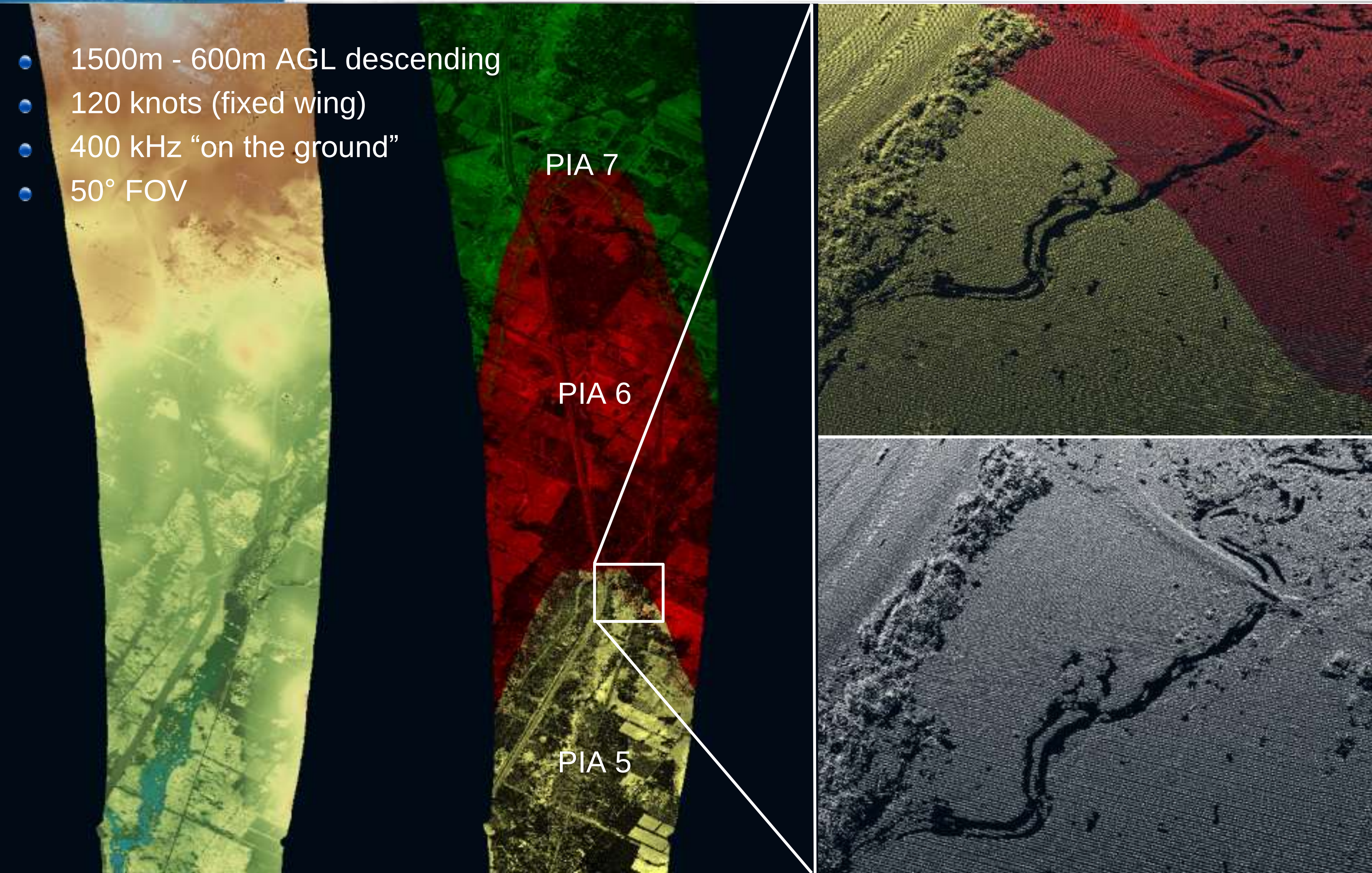
PulseTRAK™ = Seamless Operating Envelope



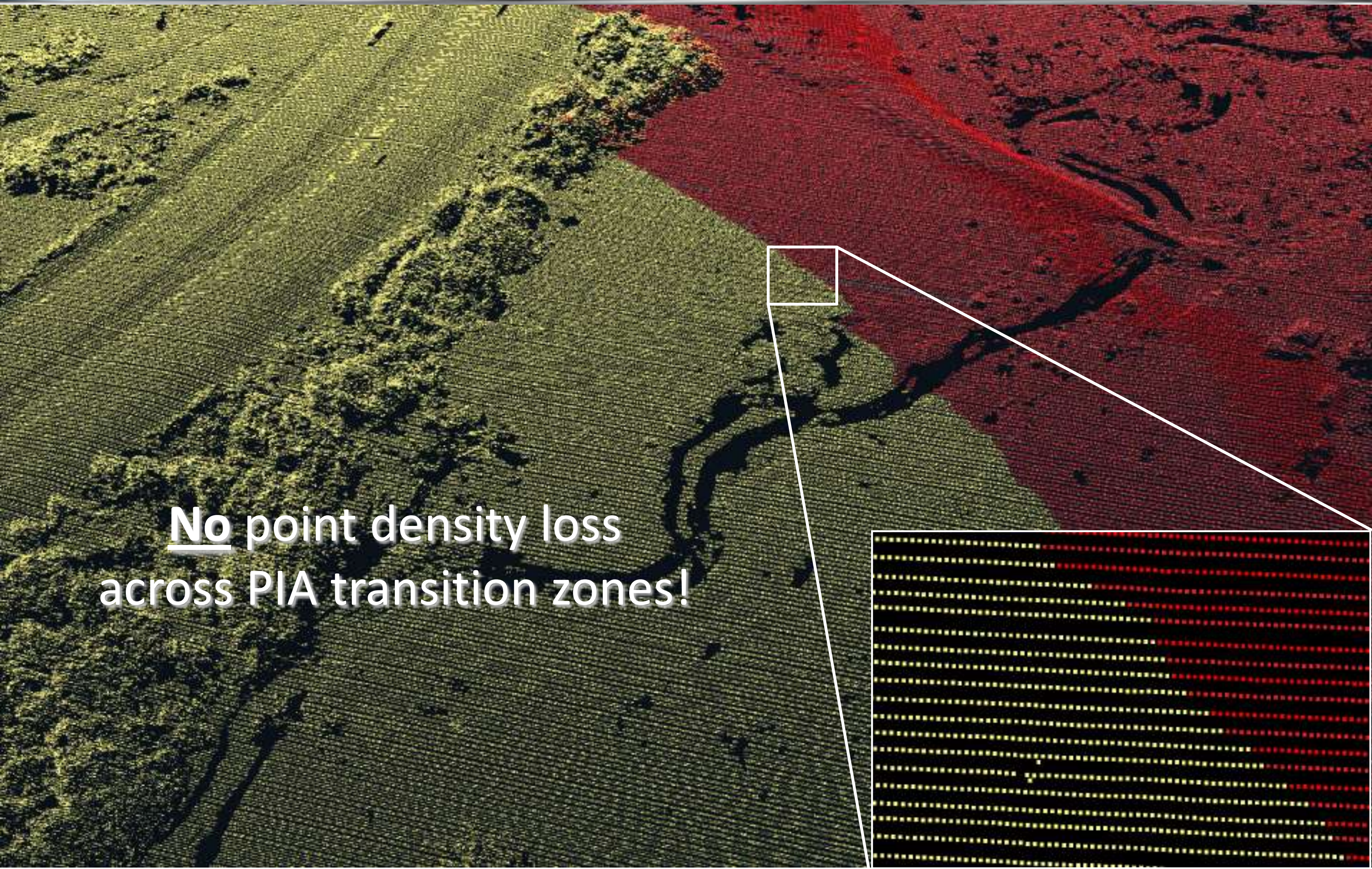
Multipulse data simulations

PulseTRAK™: Collection Example

- 1500m - 600m AGL descending
- 120 knots (fixed wing)
- 400 kHz “on the ground”
- 50° FOV



PulseTRAK™: Collection Example

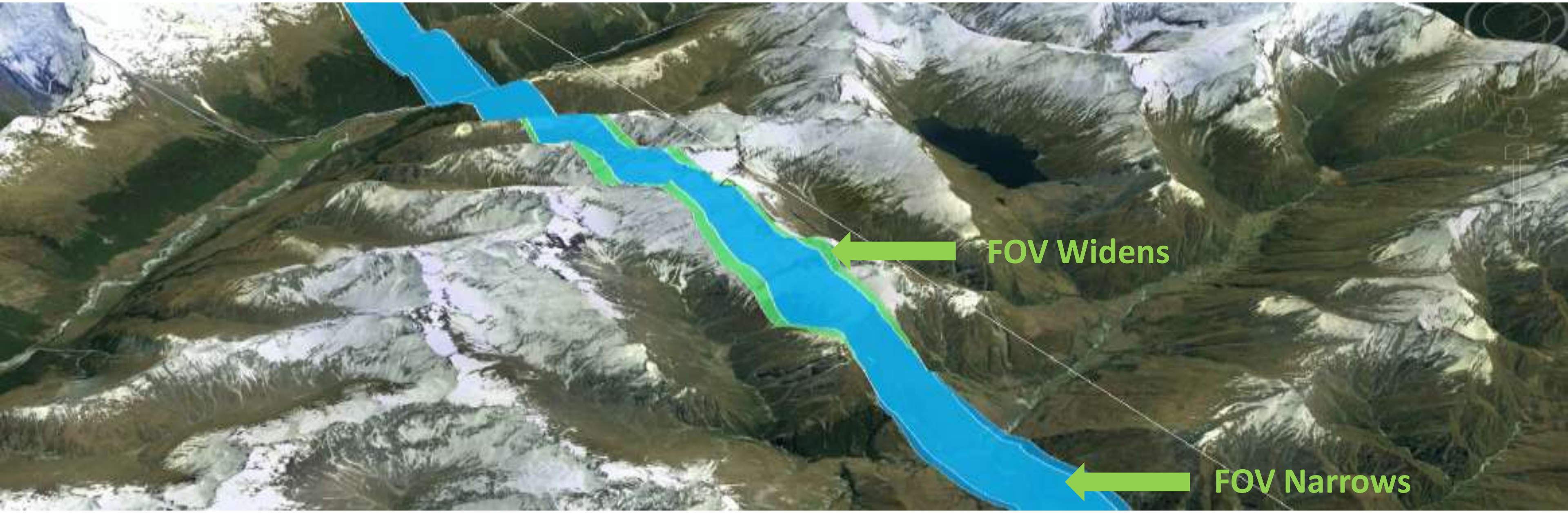


SwathTRAK™: Leveraging PulseTRAK™ Advantage

An industry exclusive! Dynamic FOV maintains fixed swath over ground in complex terrain

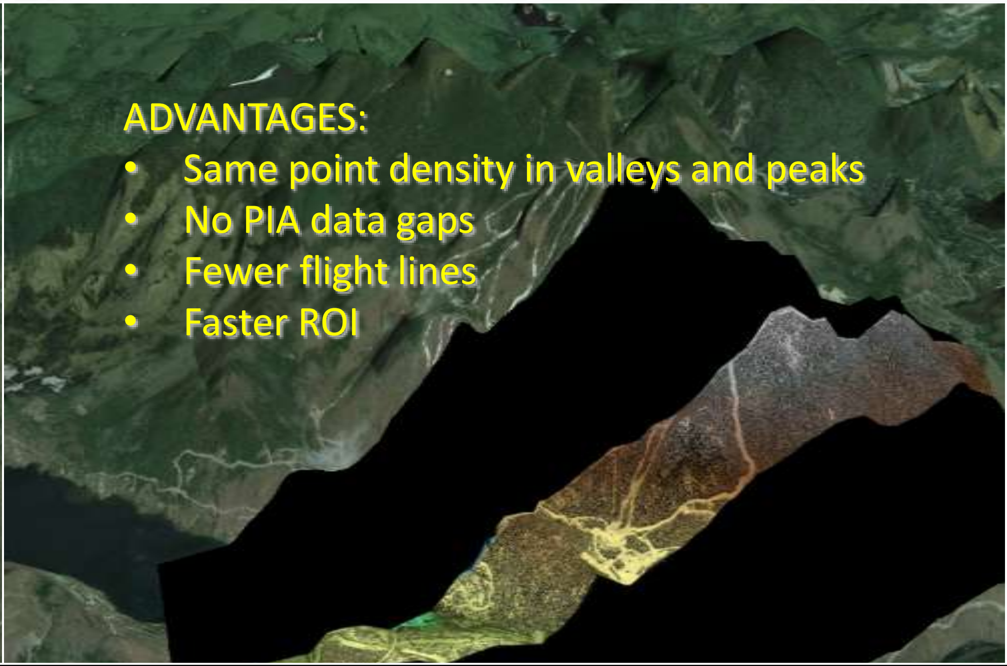
Benefits:

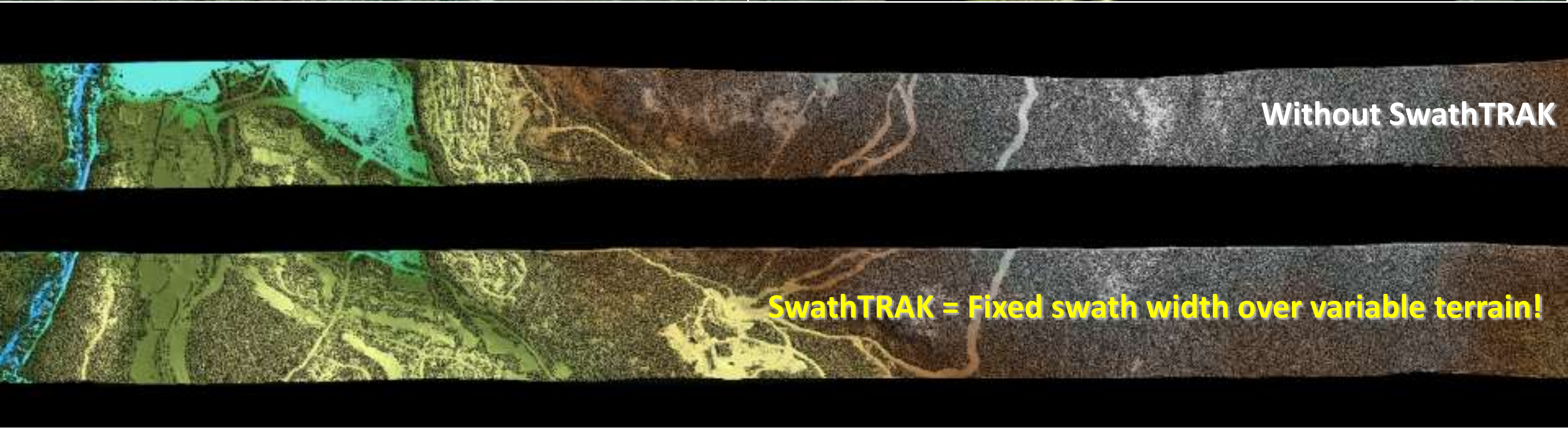
- Maintain XY point distribution, even in variable terrain conditions
- Maintain same point density, on peaks and valleys
- Produce constant-width flight lines, with less sidelap requirement
- Reduce number of flight lines and increase area coverage rates
- Simultaneously solve for platform roll effects



SwathTRAK = OFF   SwathTRAK = ON

SwathTRAK™ = EFFICIENCY



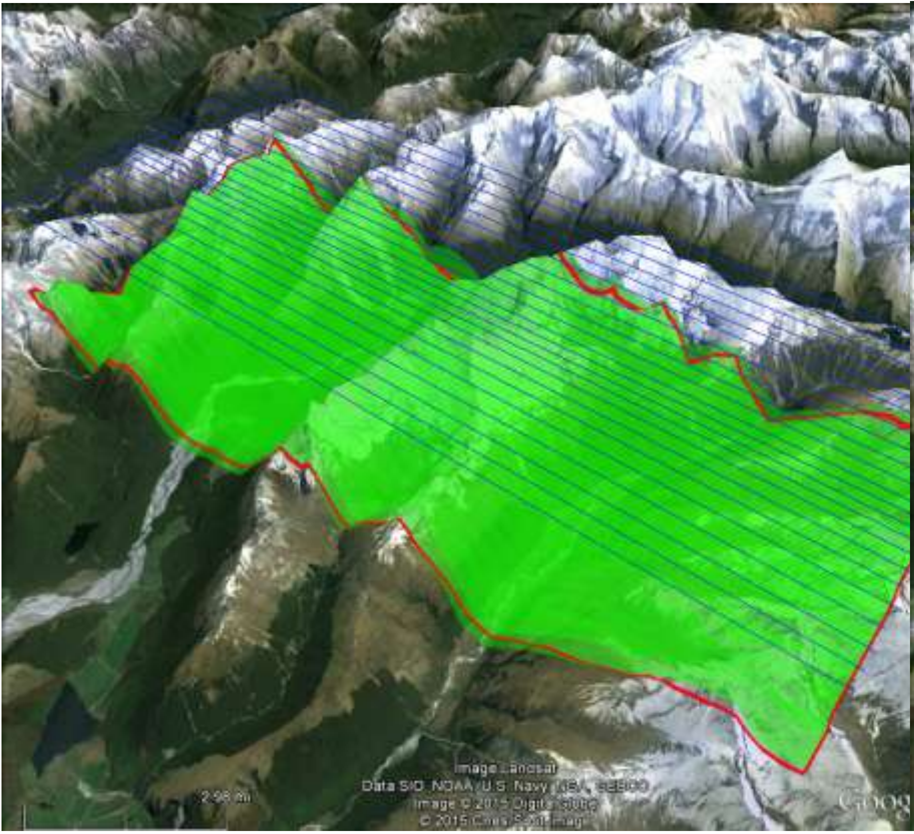


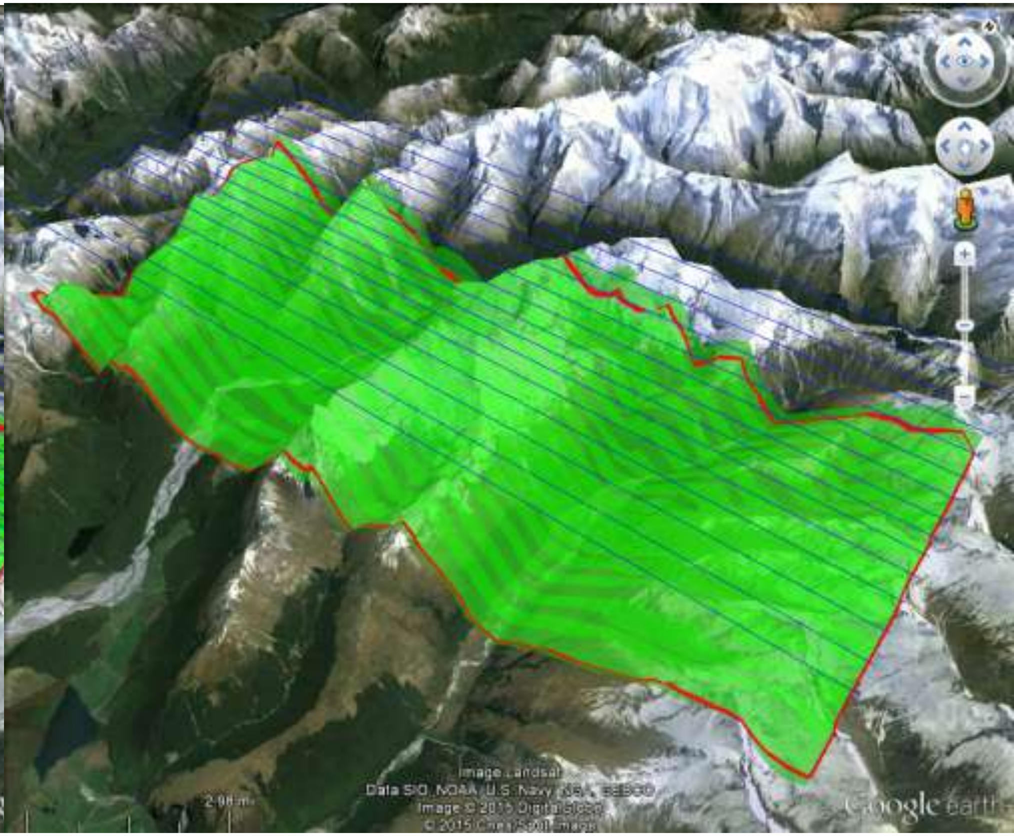
SwathTRAK: Planning Example

- Swath Tracker mode = OFF
- 22 lines
- 4:30:00 = 270 mins

- Swath Tracker mode = **ON**
- 15 lines
- 03:11:00 = 191 mins

~30% more efficient than fixed FOV

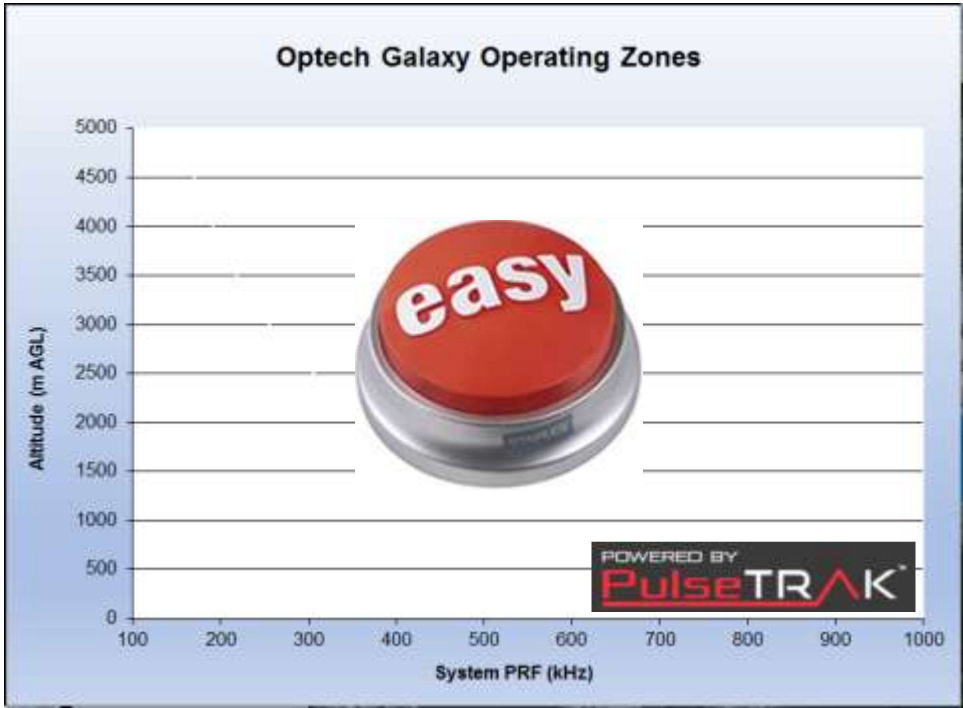




PulseTRAK and SwathTRAK Conclusions

A significant technology advancement for airborne laser scanning that:

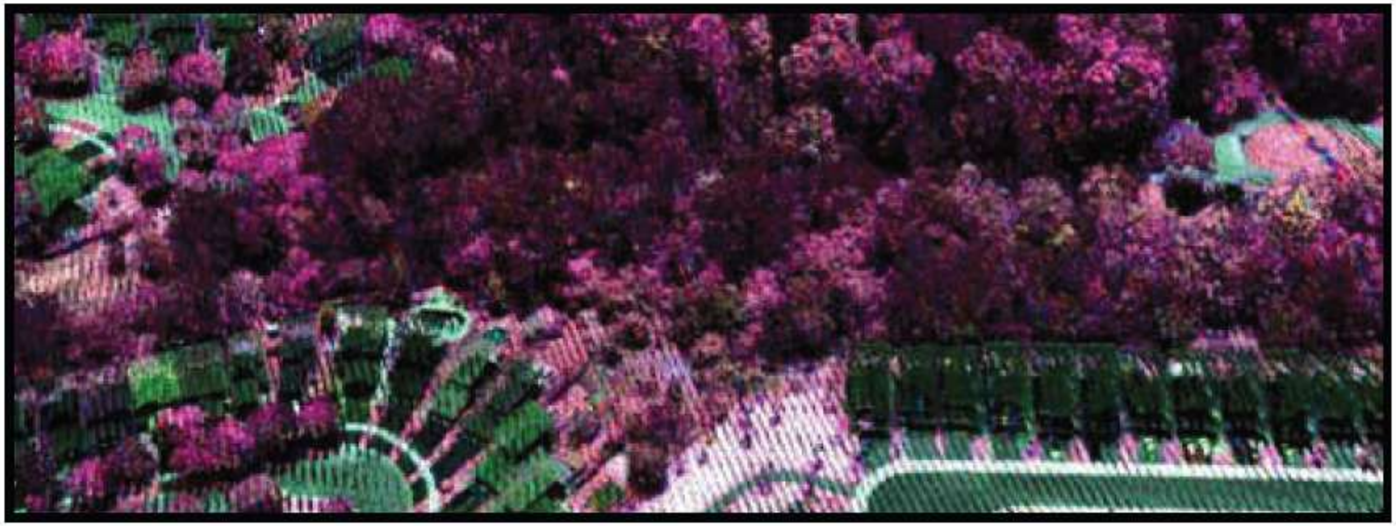
- Leverages higher pulse rates at higher altitudes
- Can produce high sample rate data across Multipulse transition zones with no density decrease
- Can provide more consistent point density in high-relief terrain, compared to fixed FOV sensors
- Can significantly increase ROI and area coverage rates in high-relief terrain, compared to fixed FOV sensors



Titan – Multispectral lidar point clouds

Titan – Applications

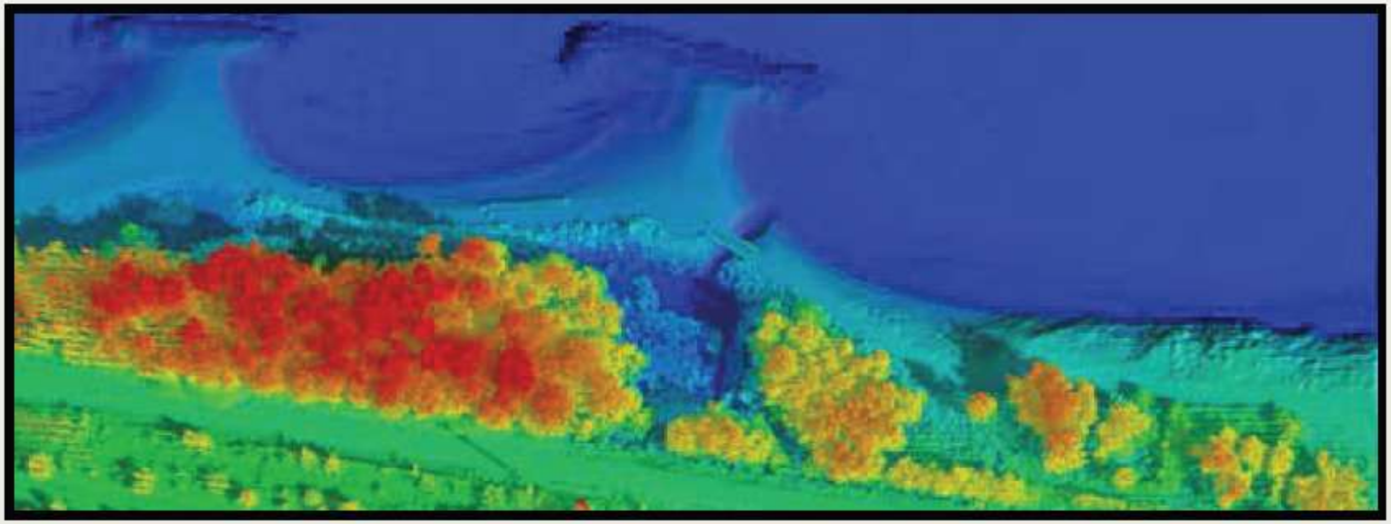
3D land cover classification:
Significantly improve land cover classification accuracies with 3D multispectral intensity analysis



Vegetation mapping:
Map vegetative differences for environmental, forestry and agricultural applications day or night, with high precision and accuracy

Titan – Applications

Shallow-water bathymetry:
Collect seamless data sets across the land-water interface with Titan's water-penetrating green channel for clear shallow water bathymetry and surface-detecting NIR channels



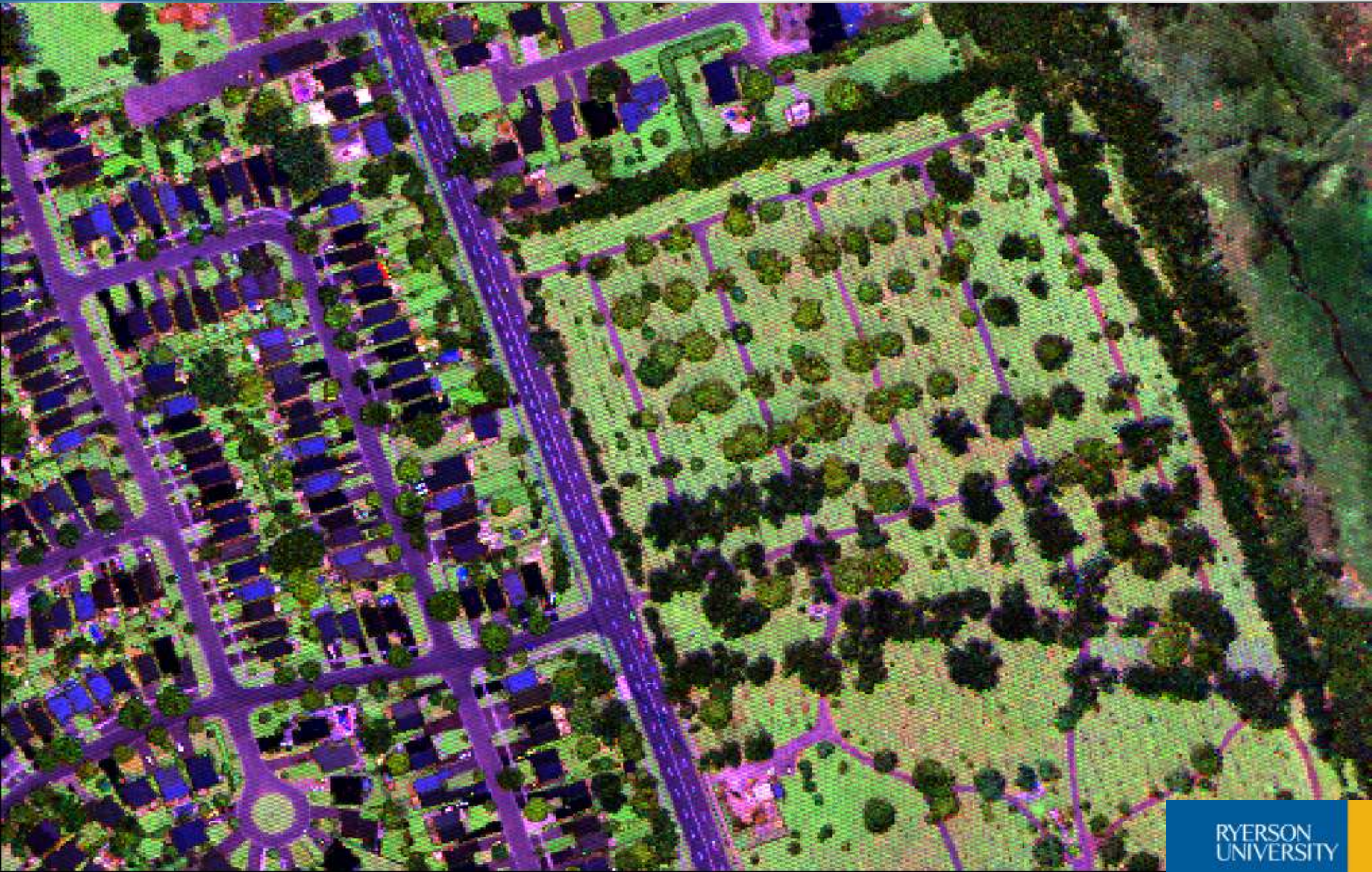
Dense topography:
Achieve extreme point density and consistent point distribution with Titan's 900 kHz pulse repetition frequency, 210 Hz scanner rate, and gyro-stabilized sensor configuration

Radiometric Correction - 1550 nm

Radiometric Correction - 1064 nm

Radiometric Correction - 532 nm

Natural Color Composite - Lidar intensity only



RYERSON UNIVERSITY

False Color Composite – 3D Land Classification