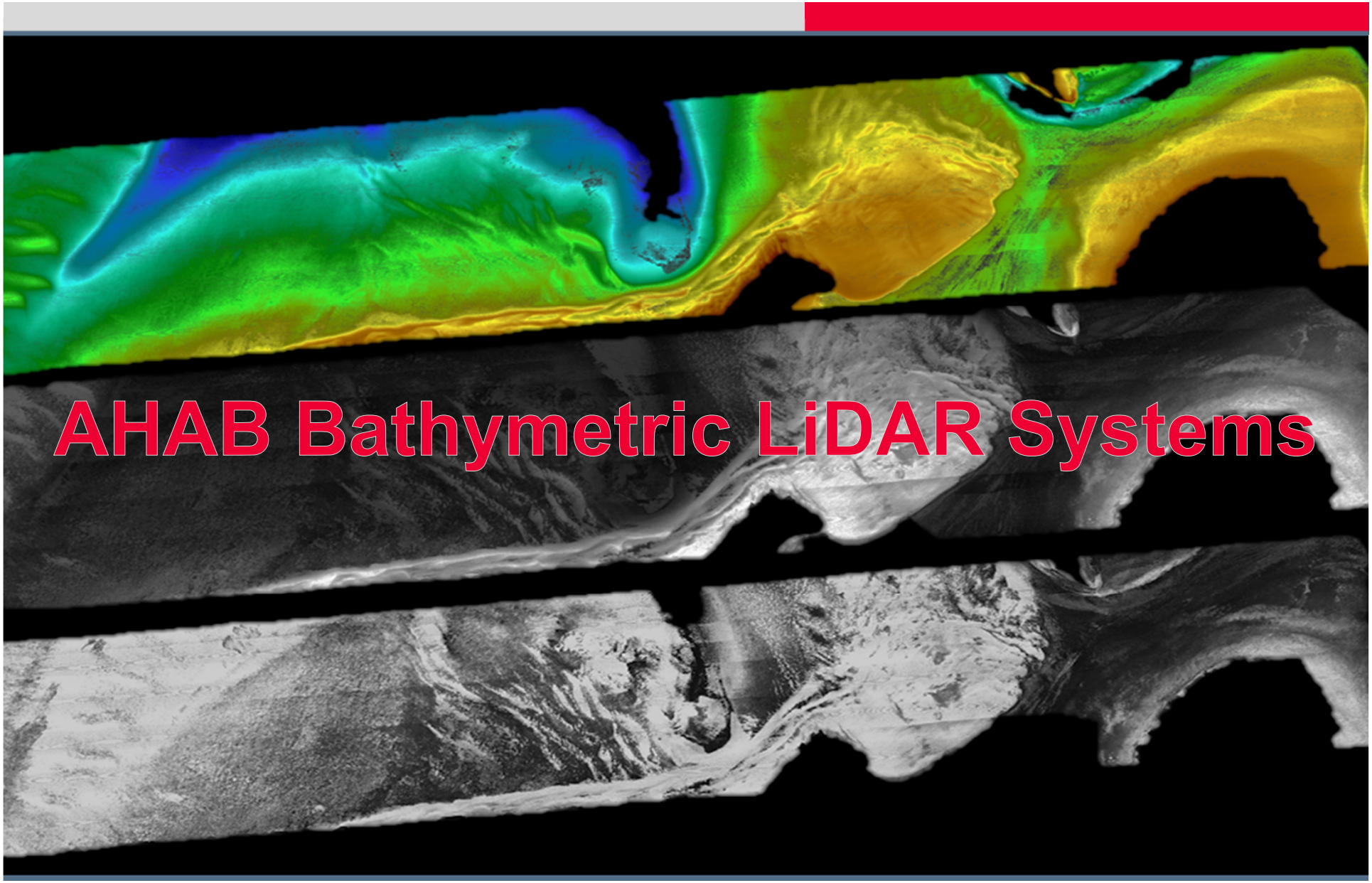

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Airborne Hydrography AB

World recognised manufacturer of Airborne LIDAR systems

Founded 2002

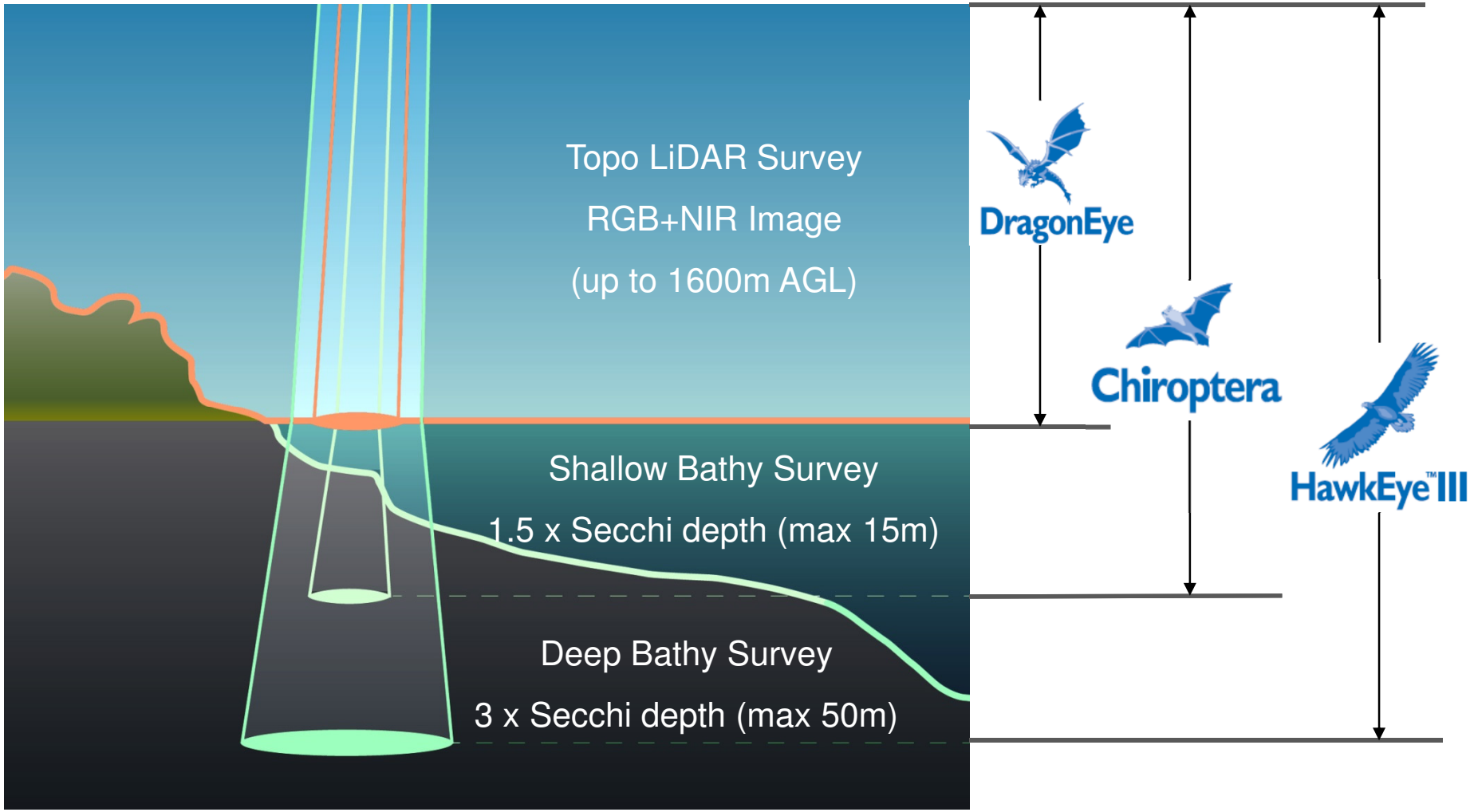
Technology based on Swedish defense developments in bathymetric LIDAR during 1980s and 1990s

Since October 2013 part of Leica Geosystems

Leica Geosystems - when it has to be right + AHAB Airborne Hydrography AB

AHAB Airborne Hydrography AB | - when it has to be right Leica Geosystems

AHAB LiDAR Systems



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AHAB products

Chiroptera$_{II}$ – Shallow bahtymetric LIDAR

Leica FMS	AHAB Operators Console
Leica: Mission pro Leica: Flight pro	Operator LIDAR interface Touchscreen

Leica Camera	AHAB LiDAR Control Unit
Leica RCD 30 80 MPIX RGB+IR	Full waveform 1,8 GSa/s, 170 Gflops 12 bit digitization

Topo-scanner	Shallow Bathy
500 kHz 1,6 km	35 kHz 1,5 Secchi

LIDAR Survey Studio™ 2.0
- LiDAR processing software

Output data

Chiroptera

Chiroptera Sensor head

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AHAB products

HawkEye$_{III}$ – Deep penetrating bathy LIDAR

Leica FMS	AHAB Operators Console
Leica: Mission pro Leica: Flight pro	Operator LIDAR interface Touchscreen

Leica Camera	AHAB LiDAR Control Unit
Leica RCD 30 80 MPIX RGB+IR	Full waveform 1,8 GSa/s, 170 Gflops 12 bit digitization

Topo-scanner	Deep Bathy	Shallow Bathy
500 kHz 1,5 km	10 kHz 3 Secchi	35 kHz 1,5 Secchi

LIDAR Survey Studio™ 2.0
- LiDAR processing software

Output data

HawkEye III Sensor head

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Three Channel LIDAR – Why ?

- **Each sensor optimised for its tasks**
  - Laser divergence
  - Laser energy
  - Receiver sensitivity
  - Receiver field of view
  - Apperture size
  - Receiver type
  - Laser pulsewidth
  - PRF
  - Scanner speed
  - Optics

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Three Channel LIDAR – Why ?

Topo

No water surface interference

No broaderning of the beam due to water volume scattering

No losses due to water volume attunuation

Shallow Bathymetry

Full water surface interference

Some broaderning of the beam due to water volume scattering

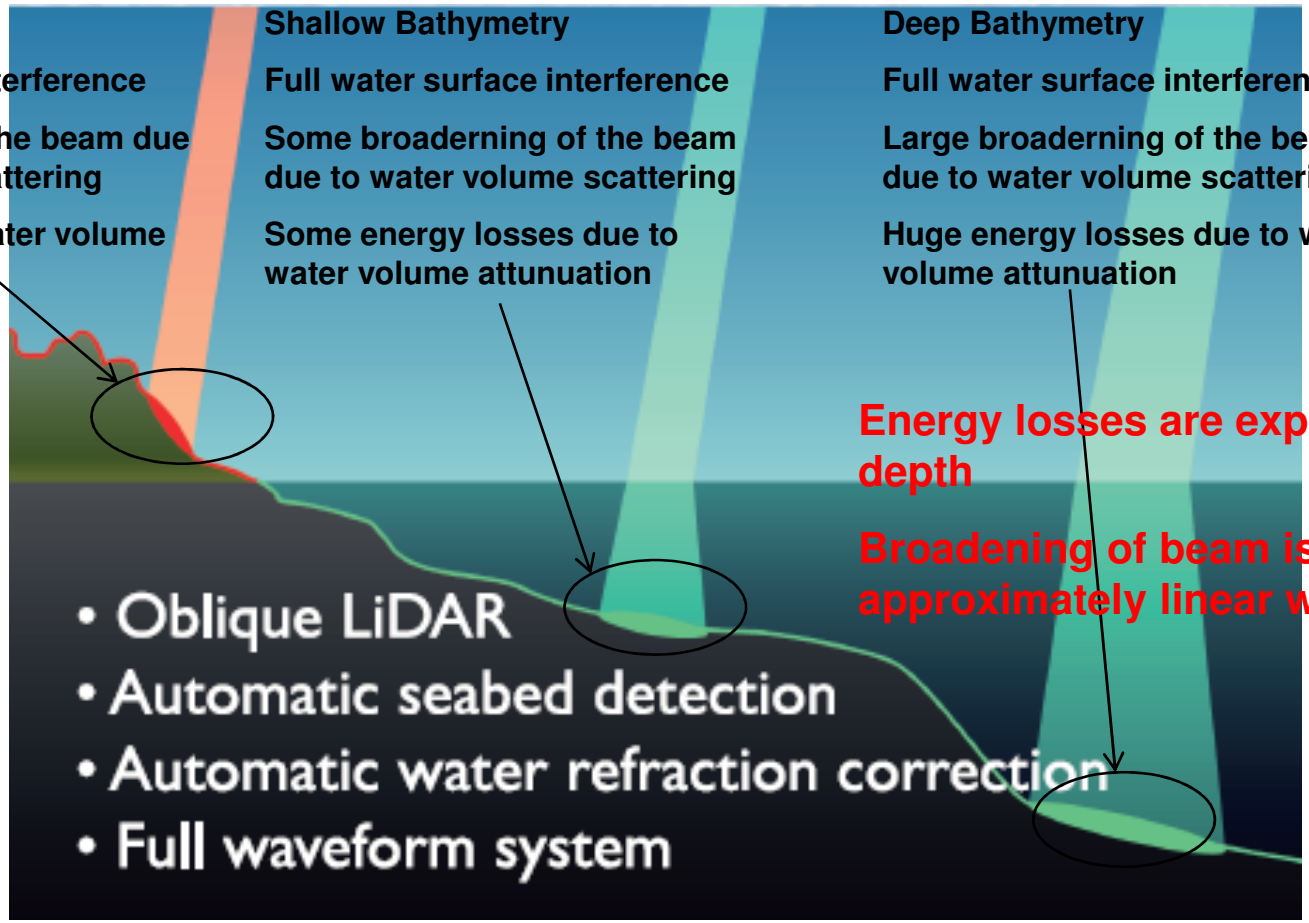
Some energy losses due to water volume attunuation

Deep Bathymetry

Full water surface interference

Large broaderning of the beam due to water volume scattering

Huge energy losses due to water volume attunuation



Energy losses are exponential with depth

Broadening of beam is approximately linear with depth

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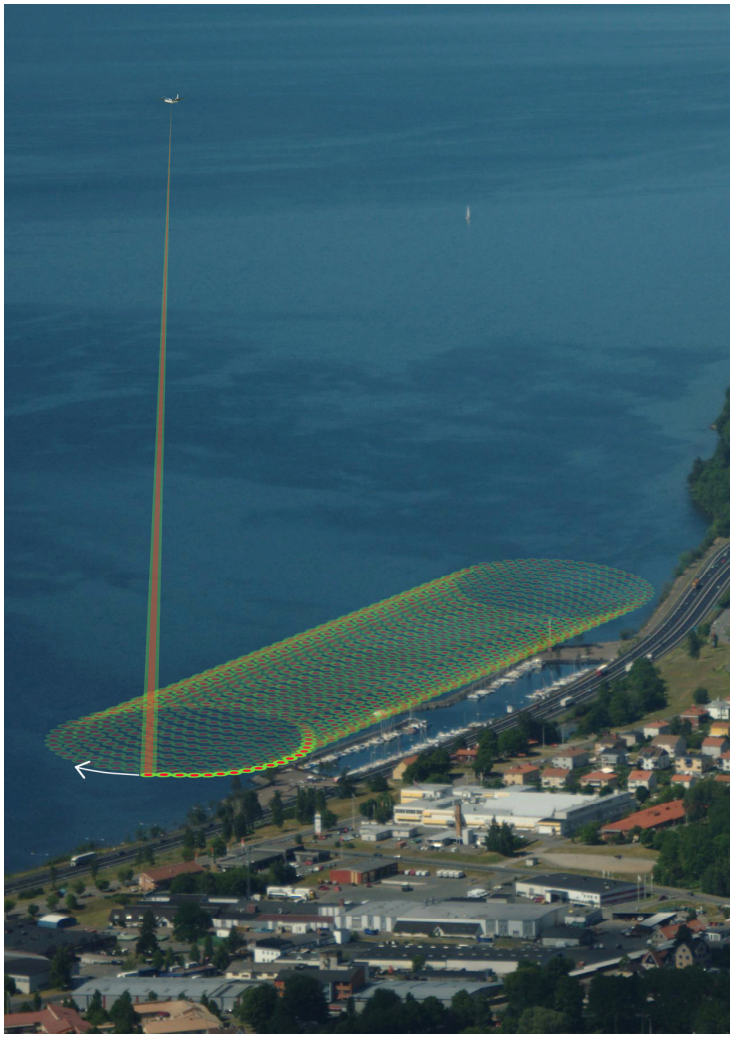
HawkEye$_{III}$ Key features

- **Bathymetric data capture Deep Channel**
  - Deep: 10 KHz, single receiver
  - Full waveform capture, oblique scanner
  - Real time waveform analysis
  - Depth penetration about 3 Secchi or 50m
- **Bathymetric data capture Shallow Channel**
  - Shallow: 35 KHz, single receiver
  - Full waveform capture, oblique scanner,
  - Real time waveform analysis
  - Depth penetration about 1,5 secchi or 15m
- **Topographic data capture**
  - Up to 500 KHz Single receiver
  - Full waveform capture, oblique scanner
  - Real time waveform analysis
  - Max altitude: 1600 m



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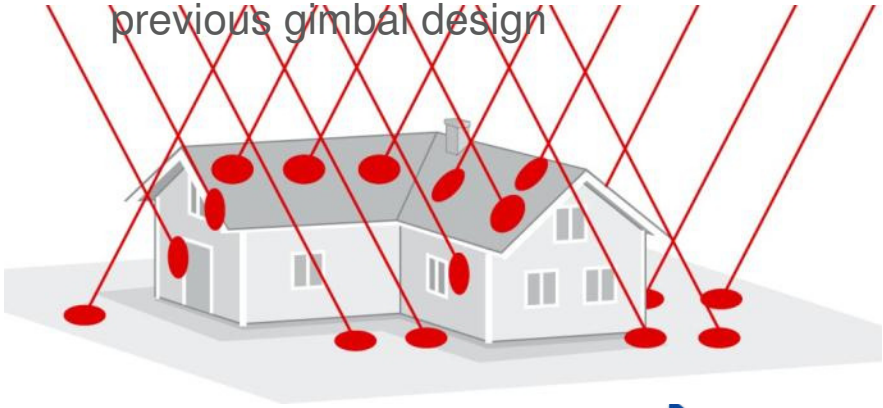
Oblique LIDAR

Oblique LIDAR - elliptical LiDAR scanning

- Superior coverage of vertical and tall objects such as buildings, walls, piers, poles
- Less shaddow effects in the data
- Less sensitive for surface wave interaction
- LiDAR waveform capture from two different angles
- Increased accuracy compared to the previous gimbal design



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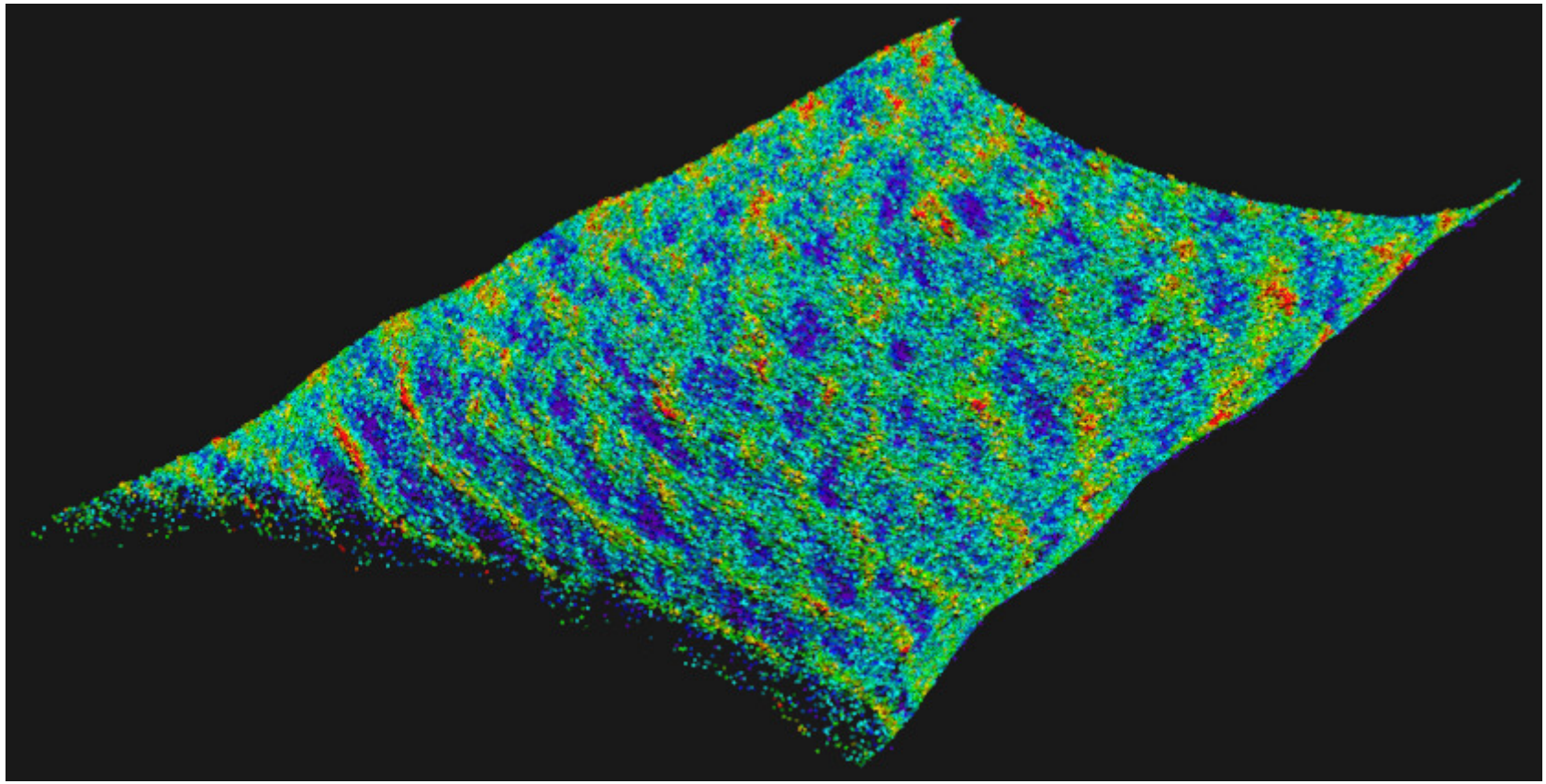
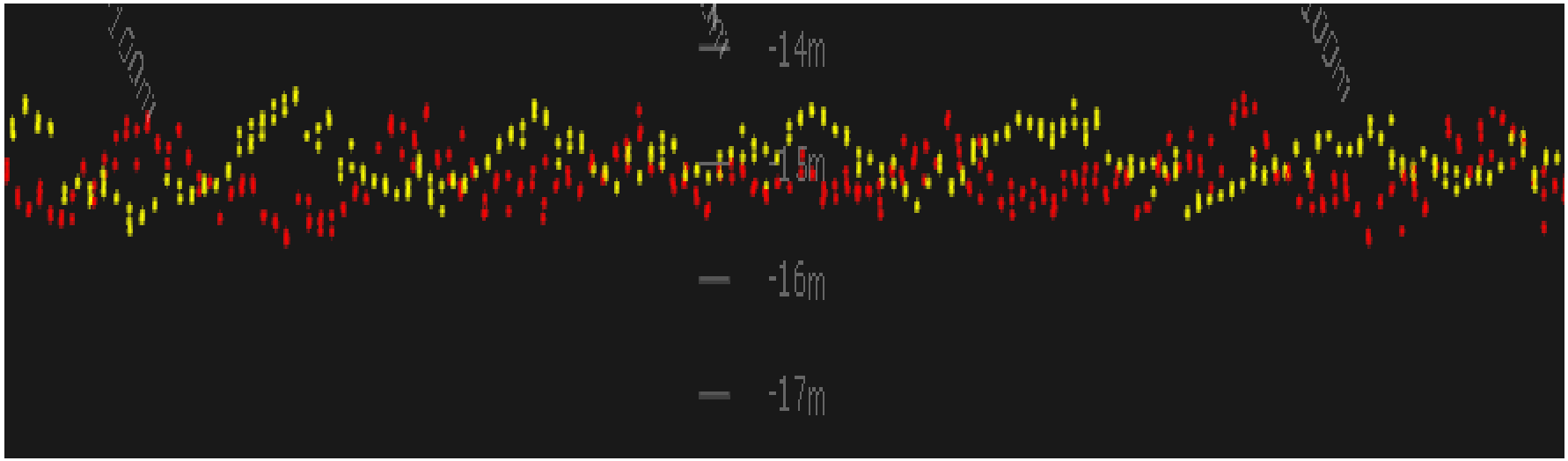
Water surface measurement



Water surface measurement



1 meter waves => correpsonds to about 25 cm variation on sea bed if a mean water surface is used for the refraction correction

By local water surface elevation measurement this variation can to a large extent be eliminated

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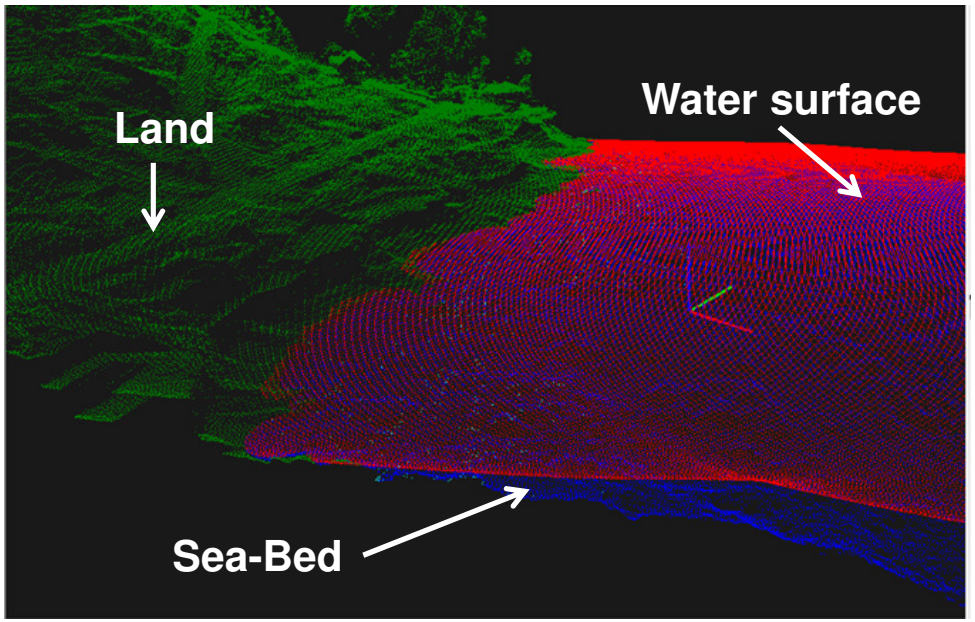
Key performance of a bathymetric LIDAR system

Distinguish between green returns on land, from water surface and within the water volume (sea-bed)

- **=> Automatic classification of land, surface and sub-surface returns**



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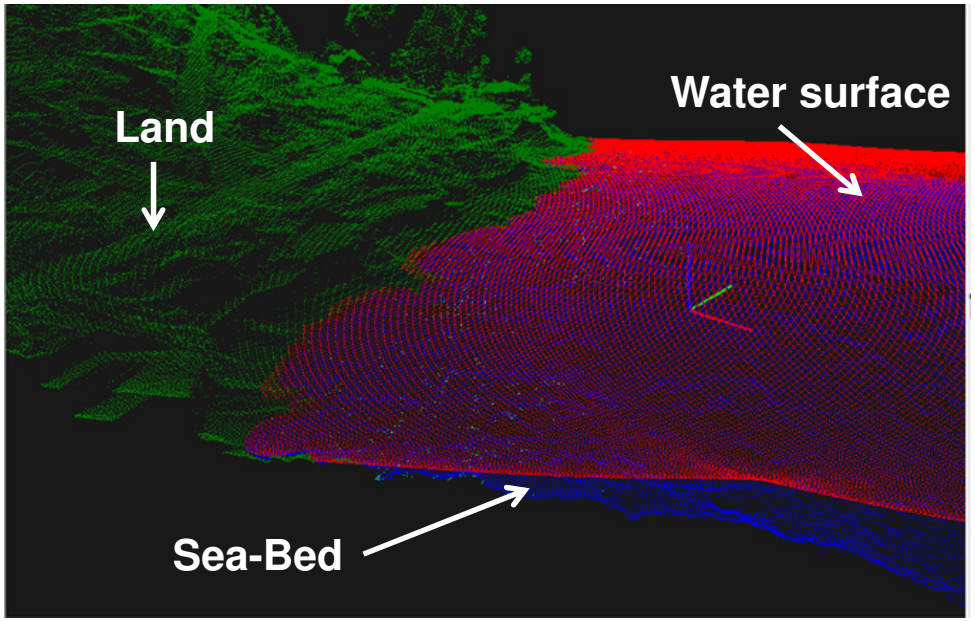
LIDAR Survey Studio™ - LiDAR processing software

- **LiDAR processing software for all AHAB products**
  - DragonEye, Chiroptera, HawkEye
  - Convertion of all LiDAR waveforms to LiDAR returns
  - Flight trajectory import
  - Automatic water refraction correction
  - Automatic LIDAR data classification
- **3D viewer / editor**
  - 3D visualisation (zooming, panning, rotating ....)
  - Viewing LiDAR data by classes
  - Cleaning / Editing Lidar data



Automatic data classification

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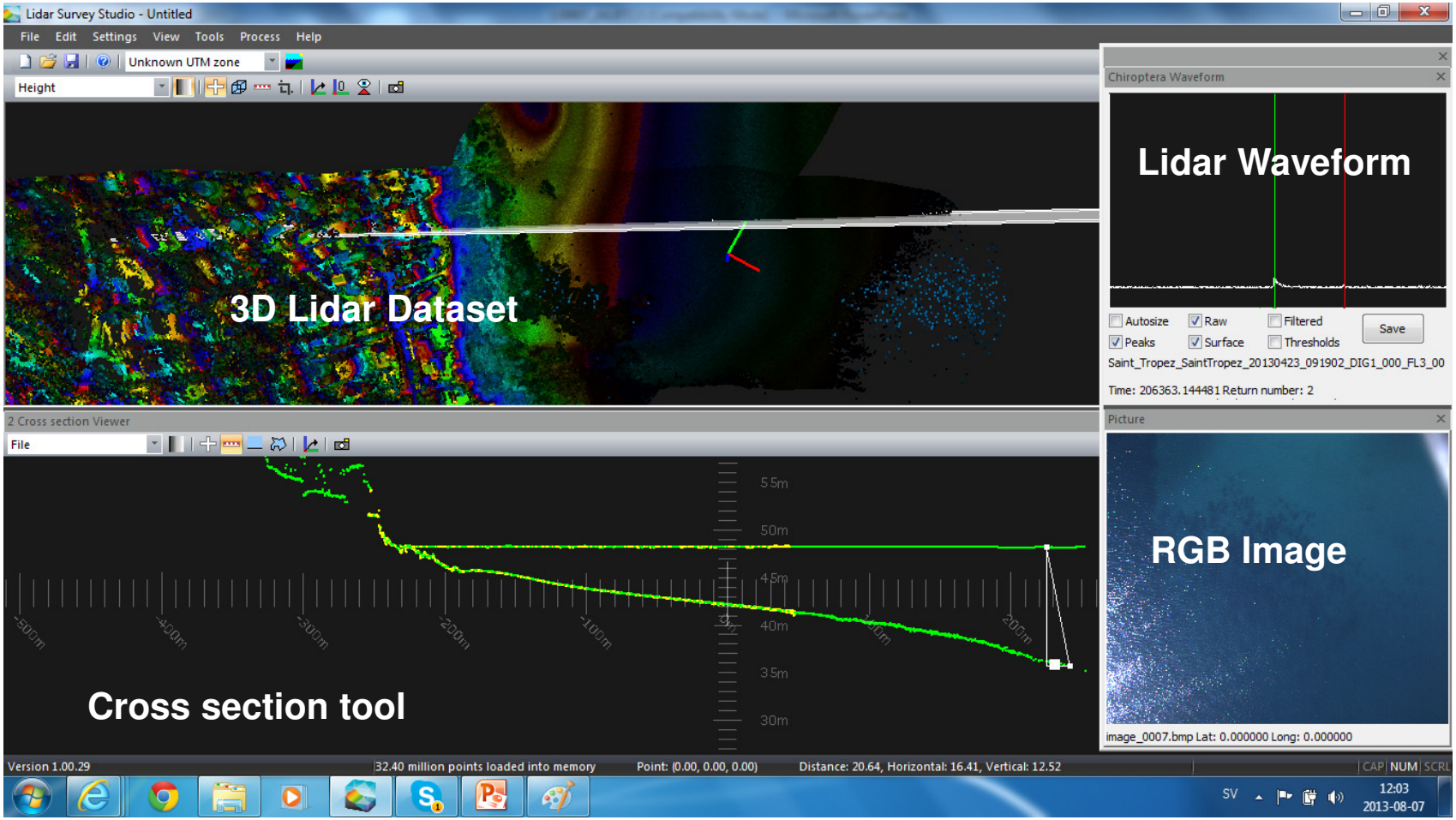
LIDAR Survey Studio™
- LiDAR processing software



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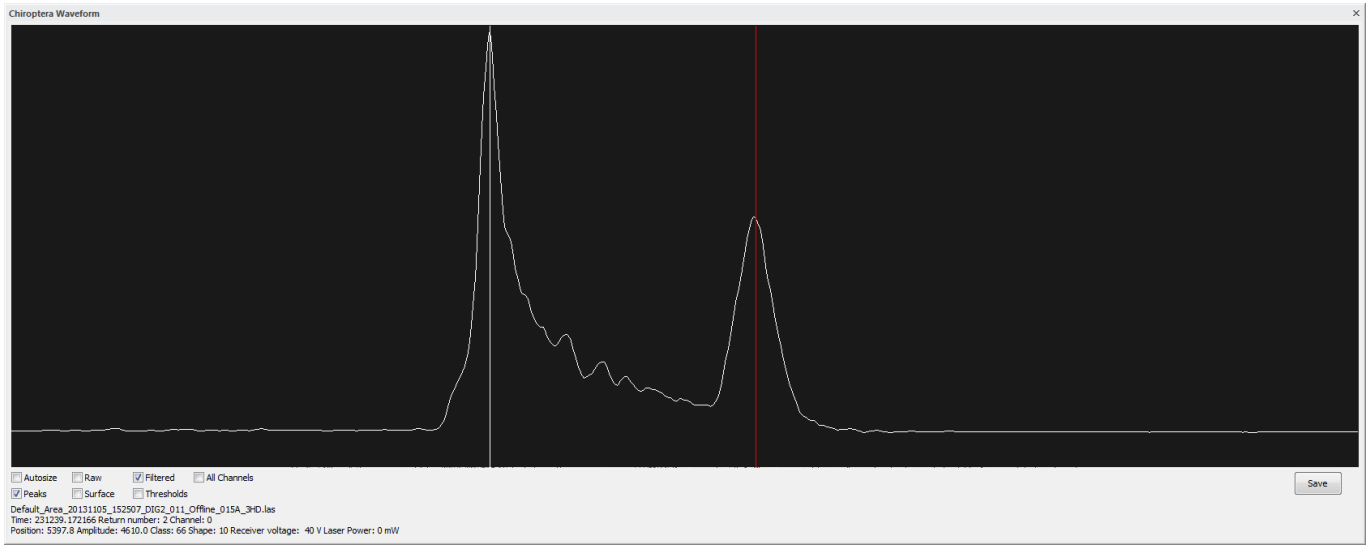
LIDAR Survey Studio™
- LiDAR processing software

- **LiDAR waveform viewer**
  - HawkEye III and Chiroptera stores all bathymetric waveforms
  - Viewing all bathymetric LIDAR waveforms
  - Local water surface altitude for each waveform



HawkEye III – Deep channel waveform

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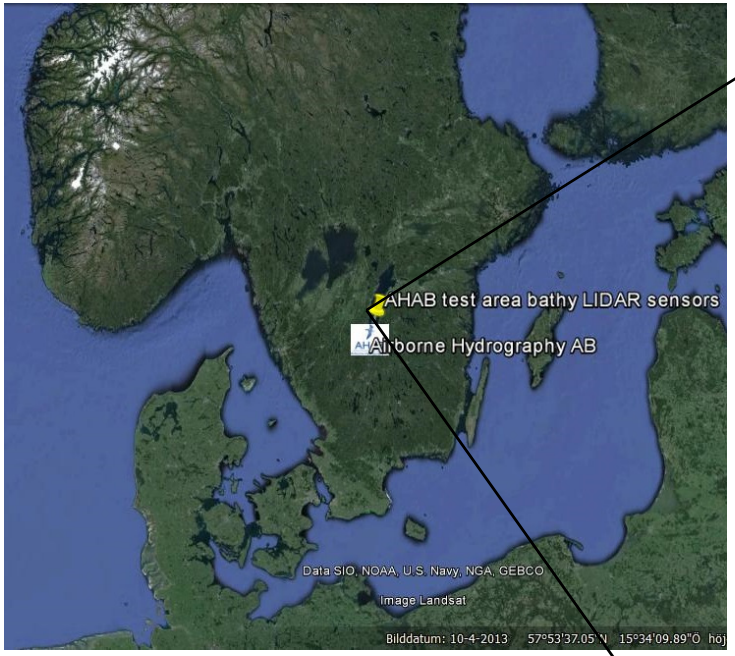
AHAB test area for bathy LIDAR



Lake Vättern (Sweden)

K_d = 0.2

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AHAB test area for bathy LIDAR

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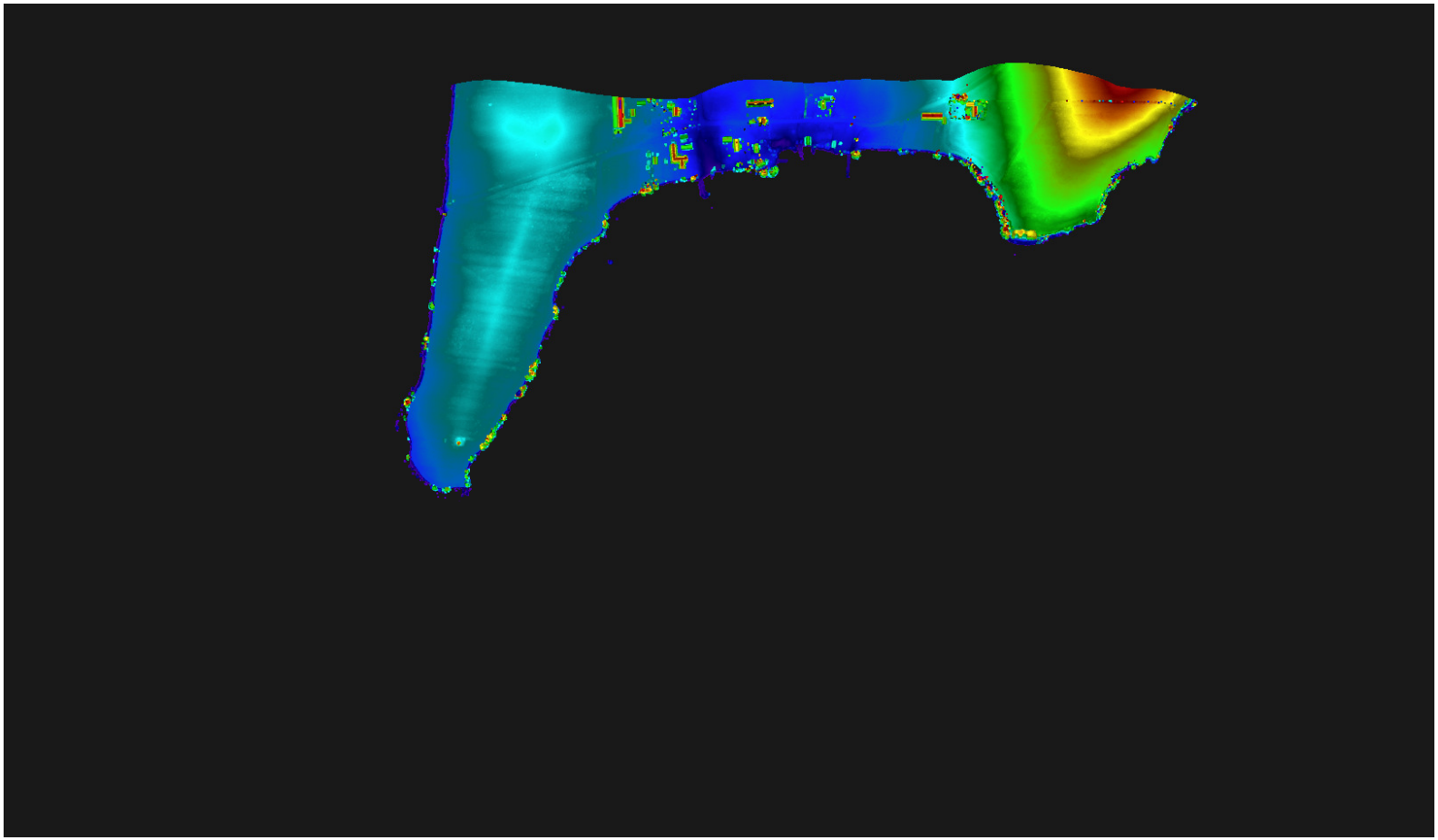
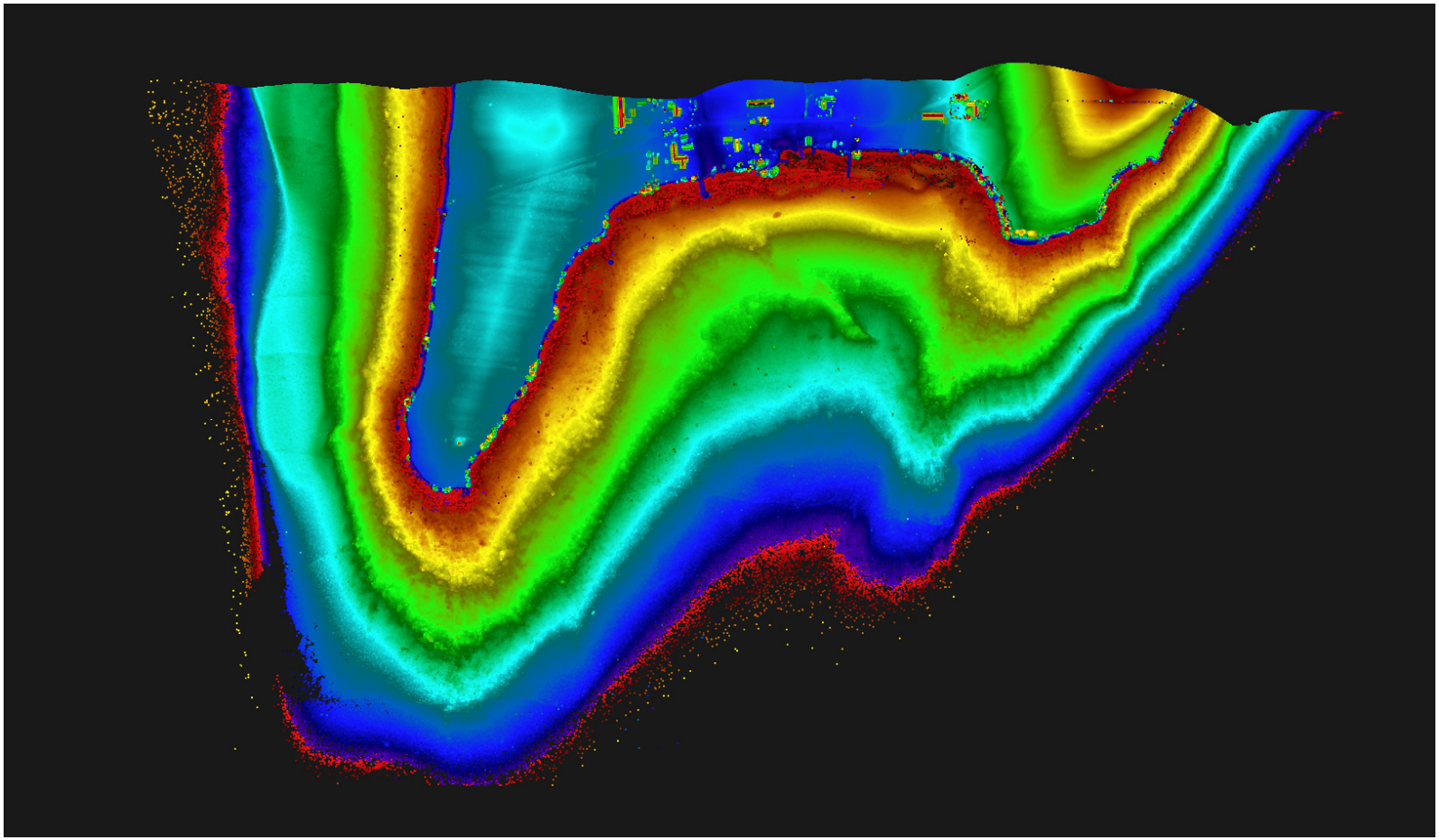
HawkEye$_{III}$ – Pure Topo



HawkEye$_{III}$ – Topo and Shallow



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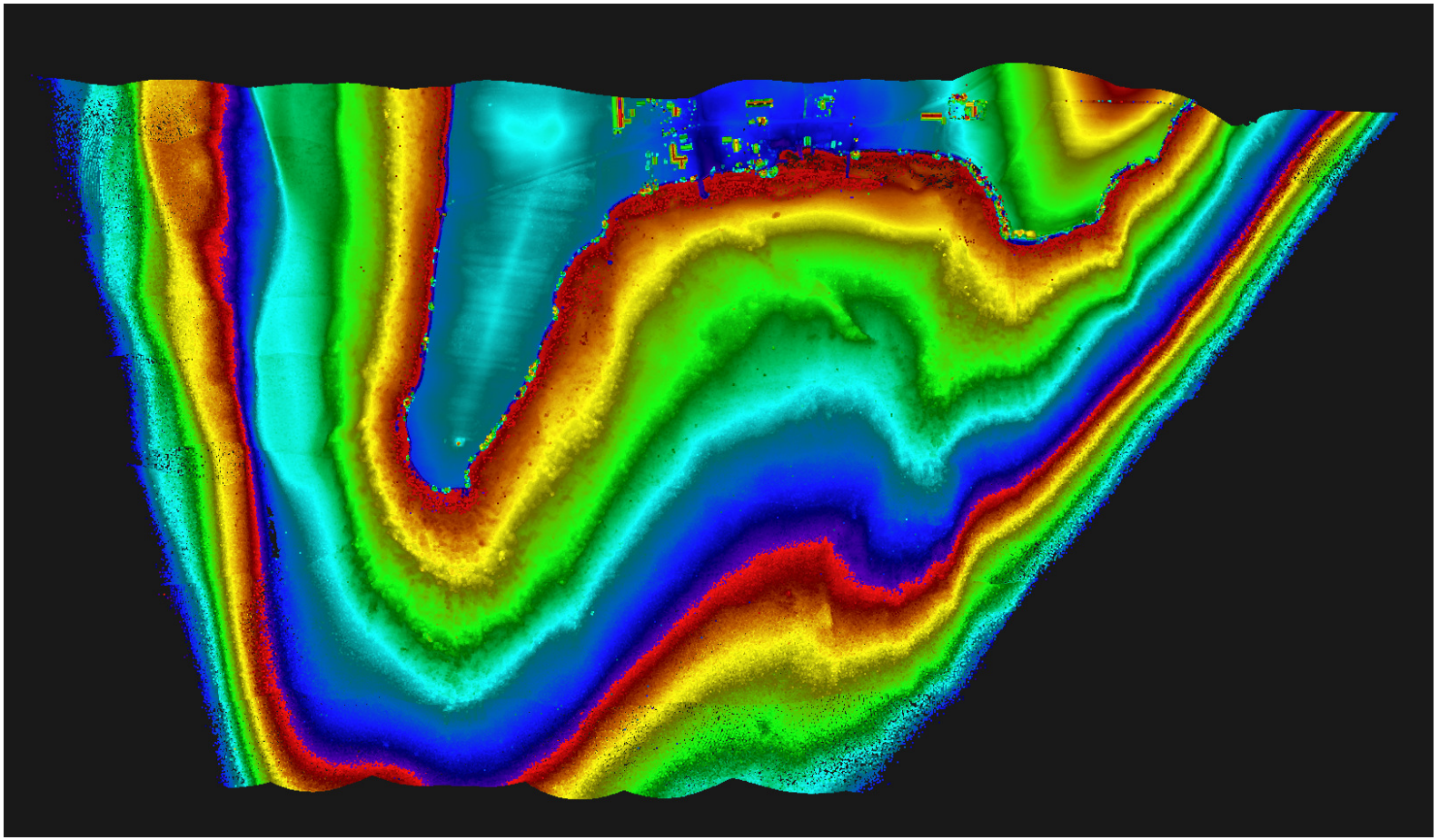
HawkEye$_{III}$ – All Channels



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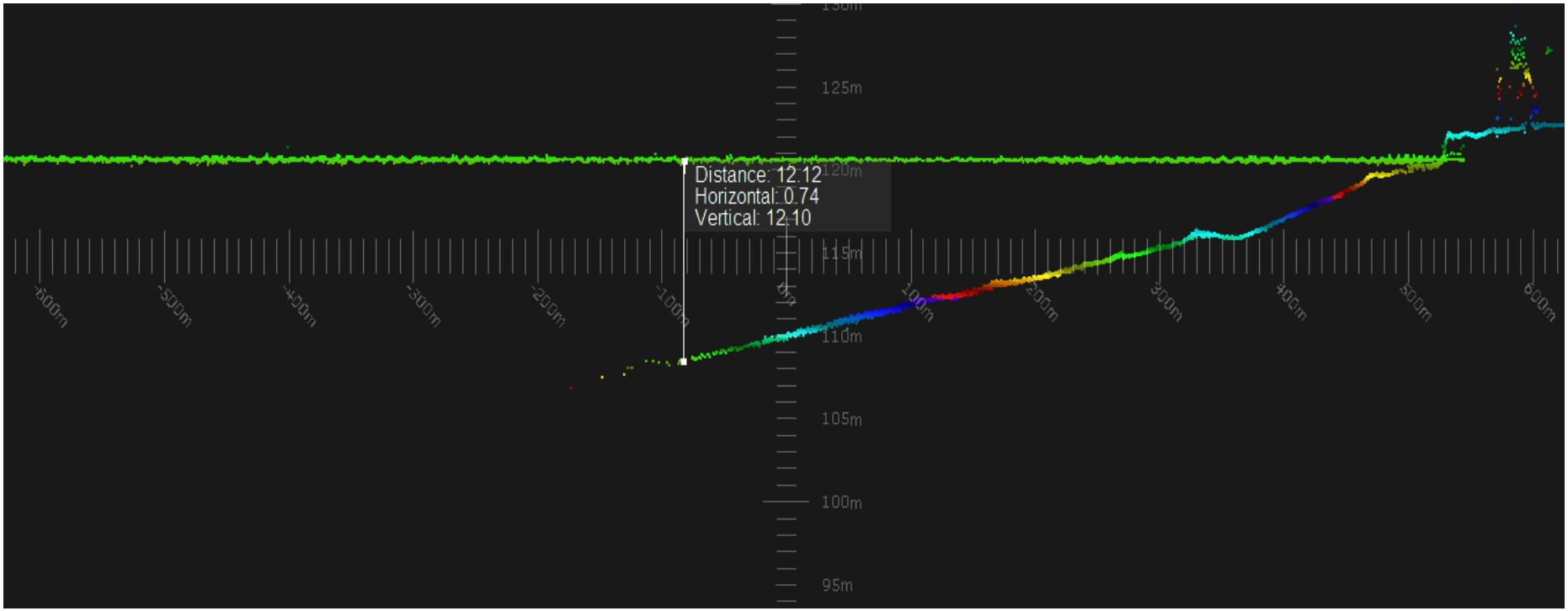
HawkEye$_{III}$ - Topo and Shallow



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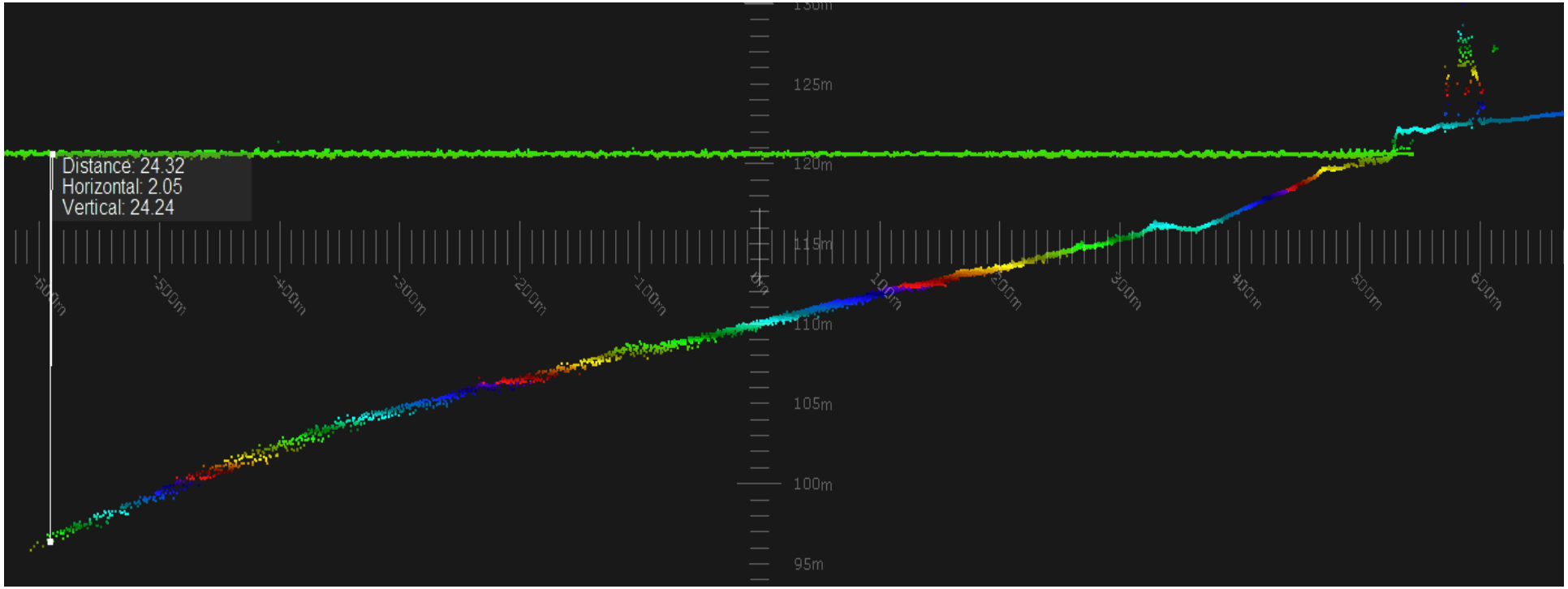
HawkEye$_{III}$– Topo, Shallow and Deep



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Reference data - Topography

- Leica Viva GS14, GNSS
- Calibration tool

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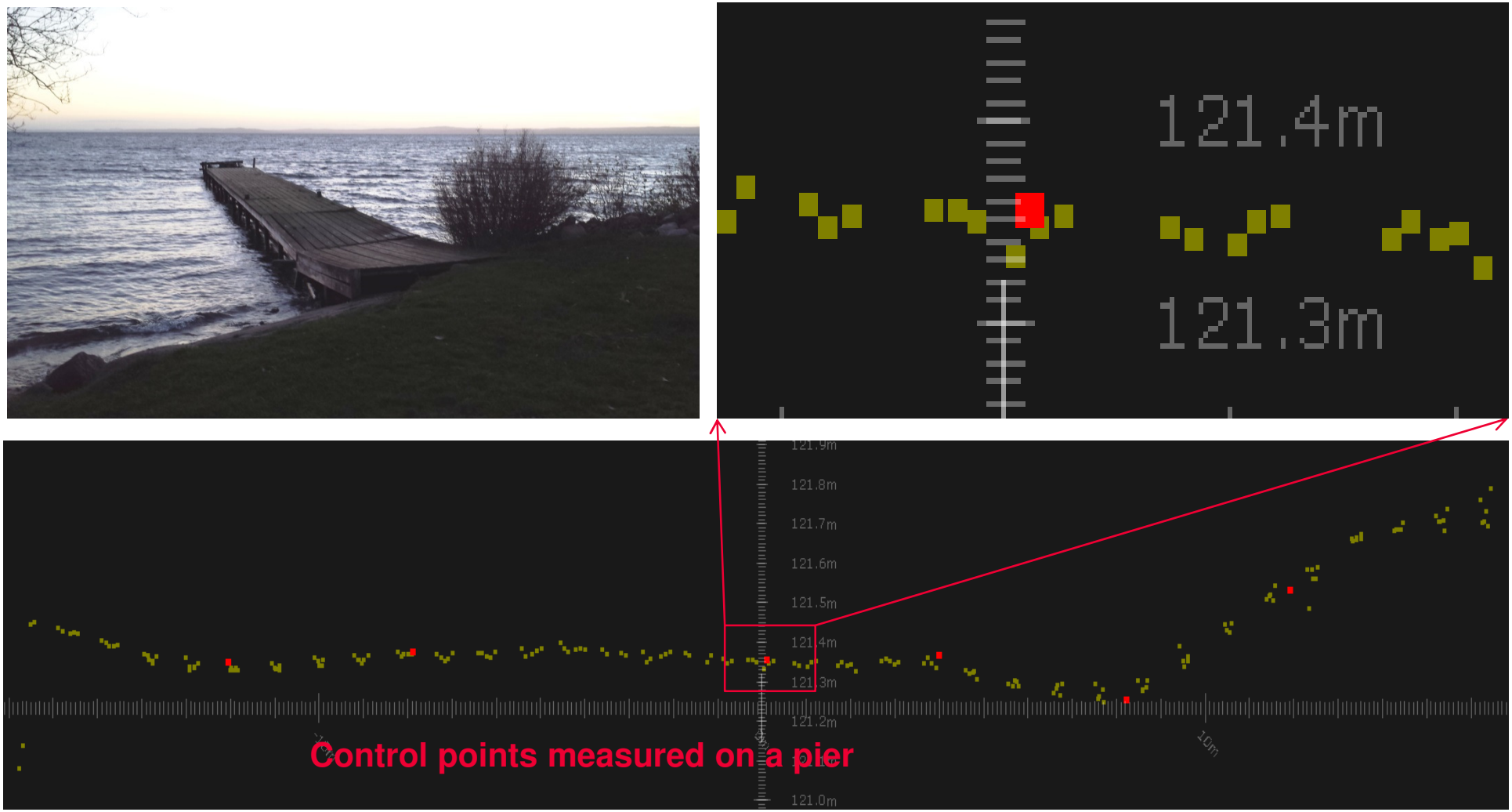
Control points on a pier



Control points measured on a pier

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Control points on a light house

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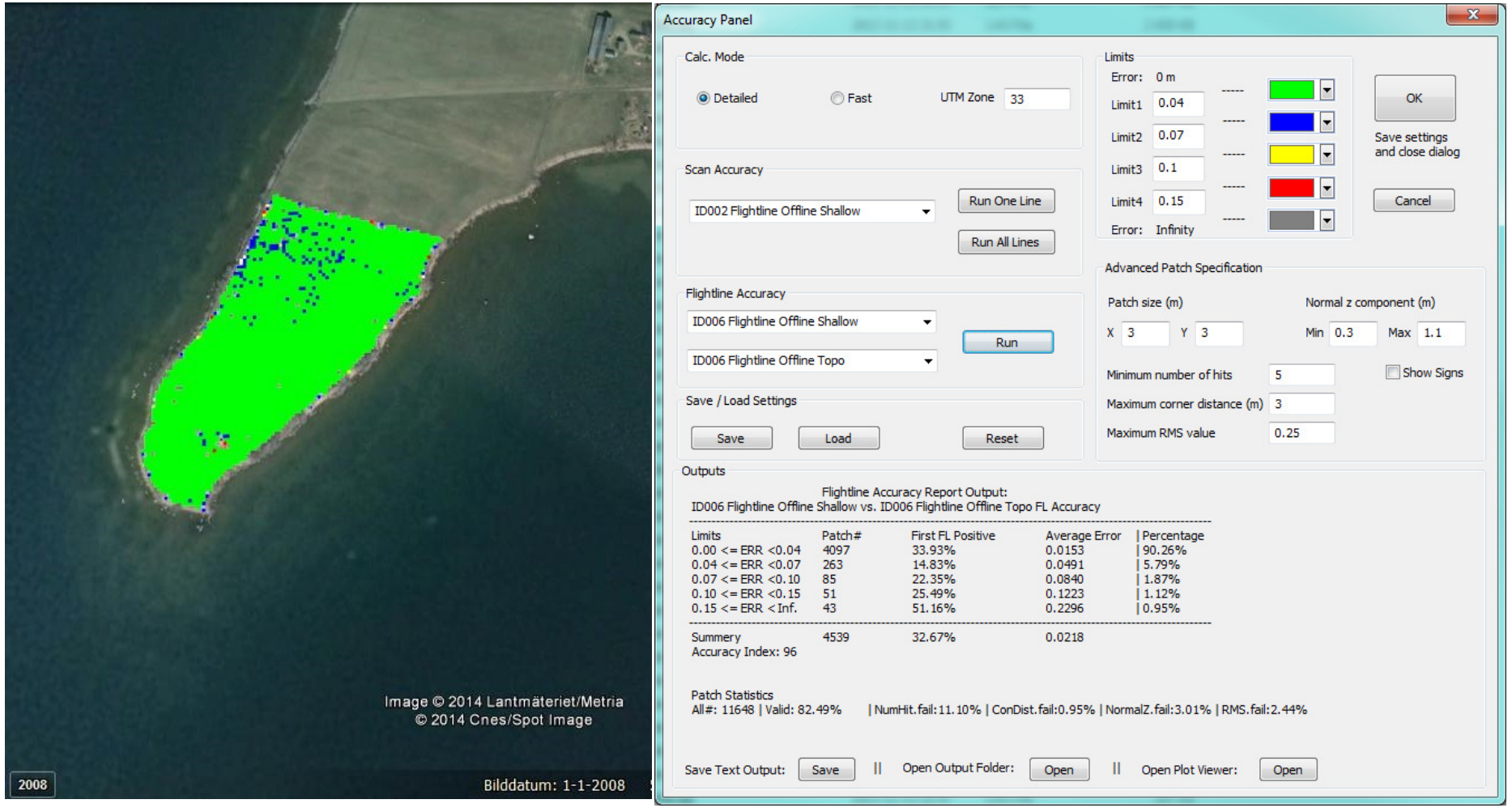
Accuracy - Topo vs Shallow channel



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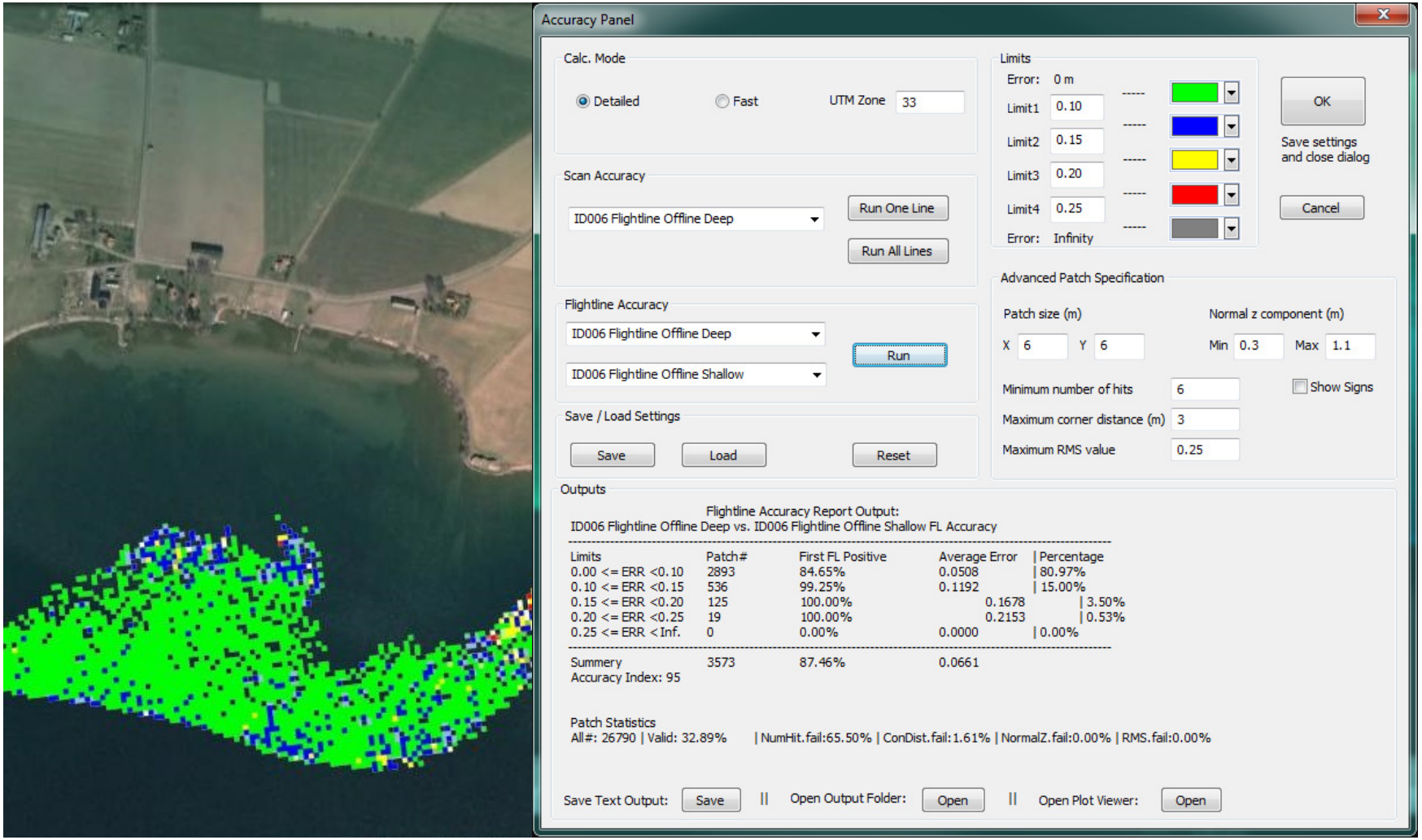
Accuracy – Deep vs Shallow



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Poel, Baltic Sea

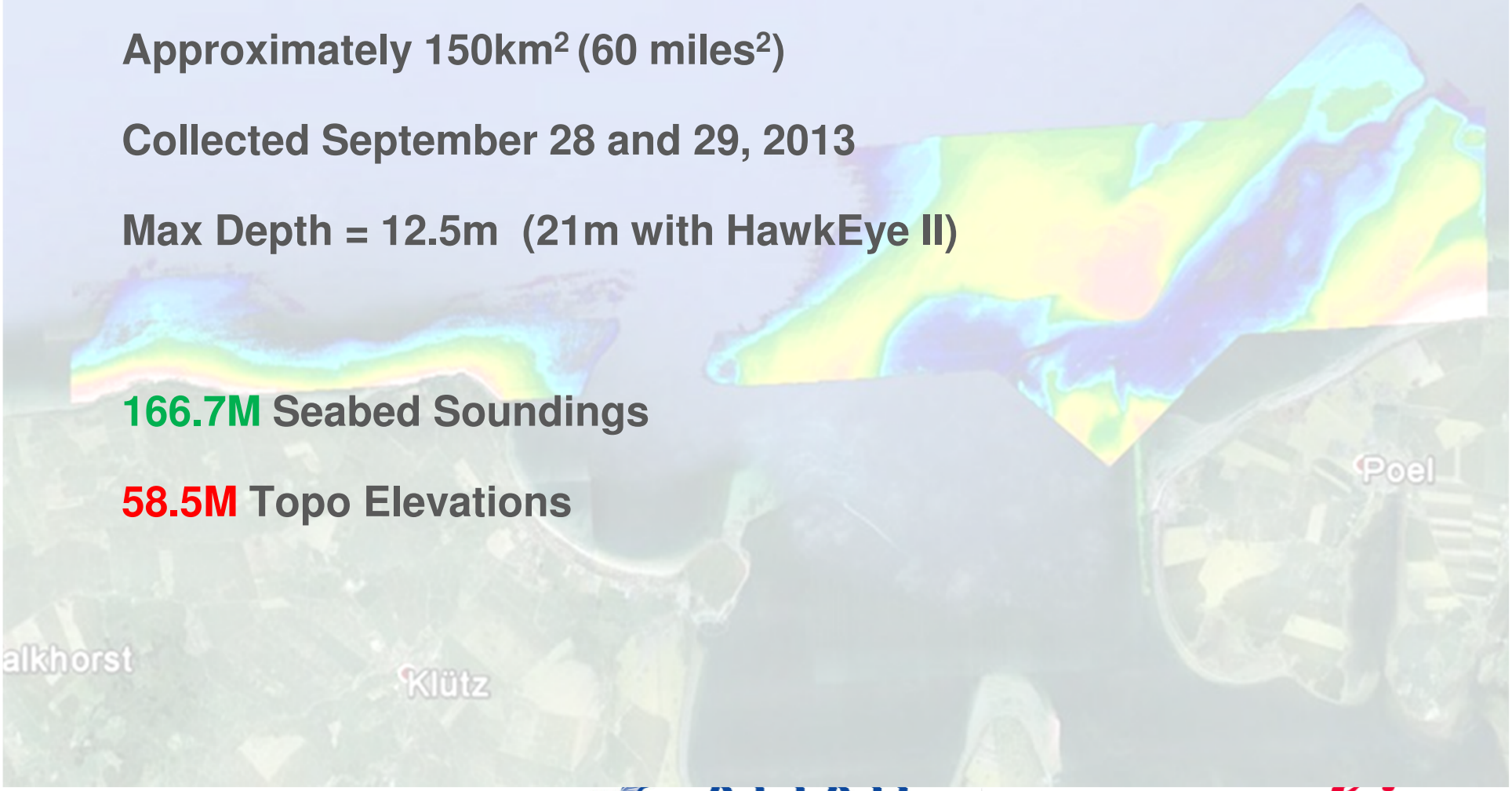
Approximately 150km^2 (60 miles^2)

Collected September 28 and 29, 2013

Max Depth = 12.5m (21m with HawkEye II)

166.7M Seabed Soundings

58.5M Topo Elevations



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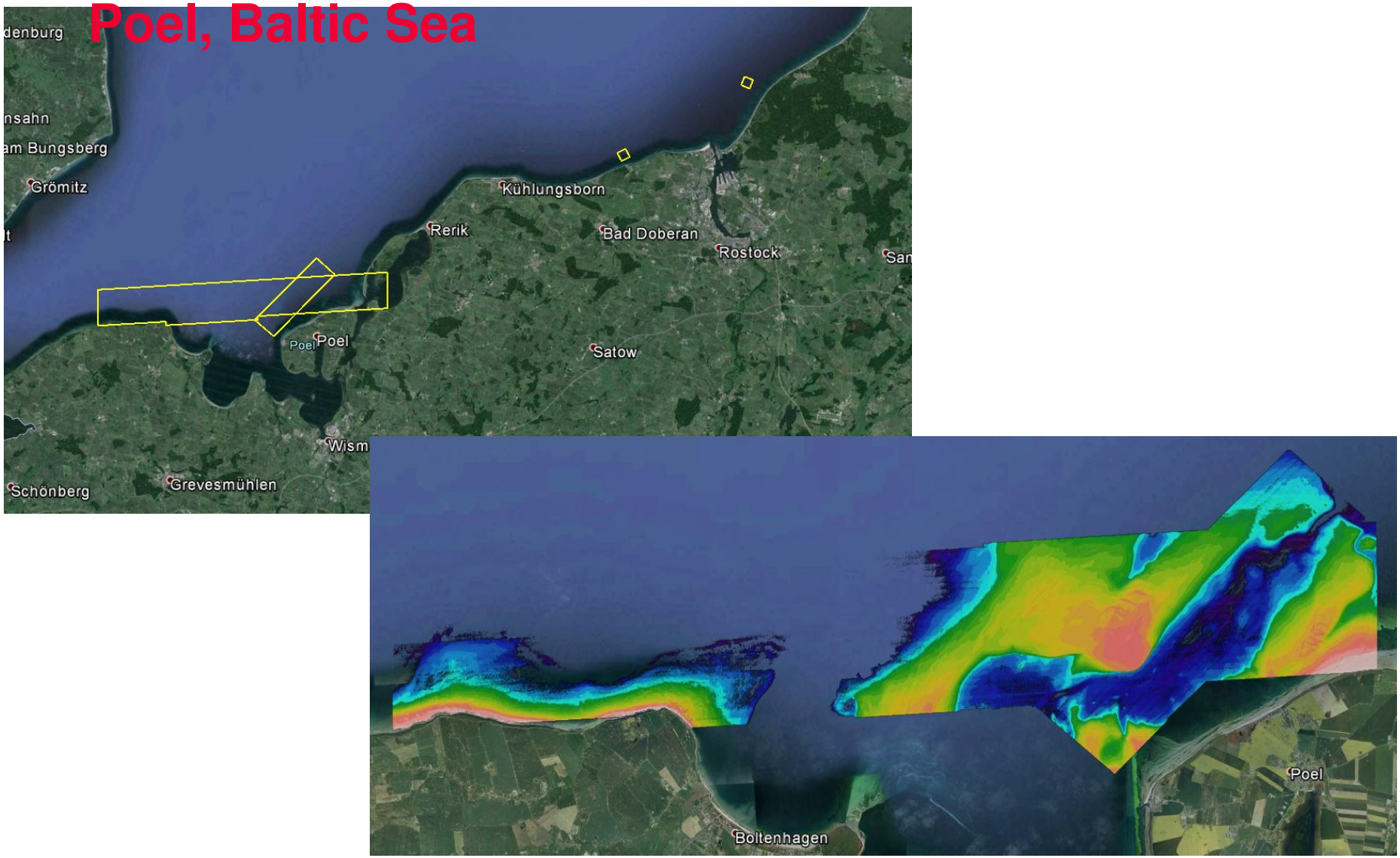
Poel, Baltic Sea



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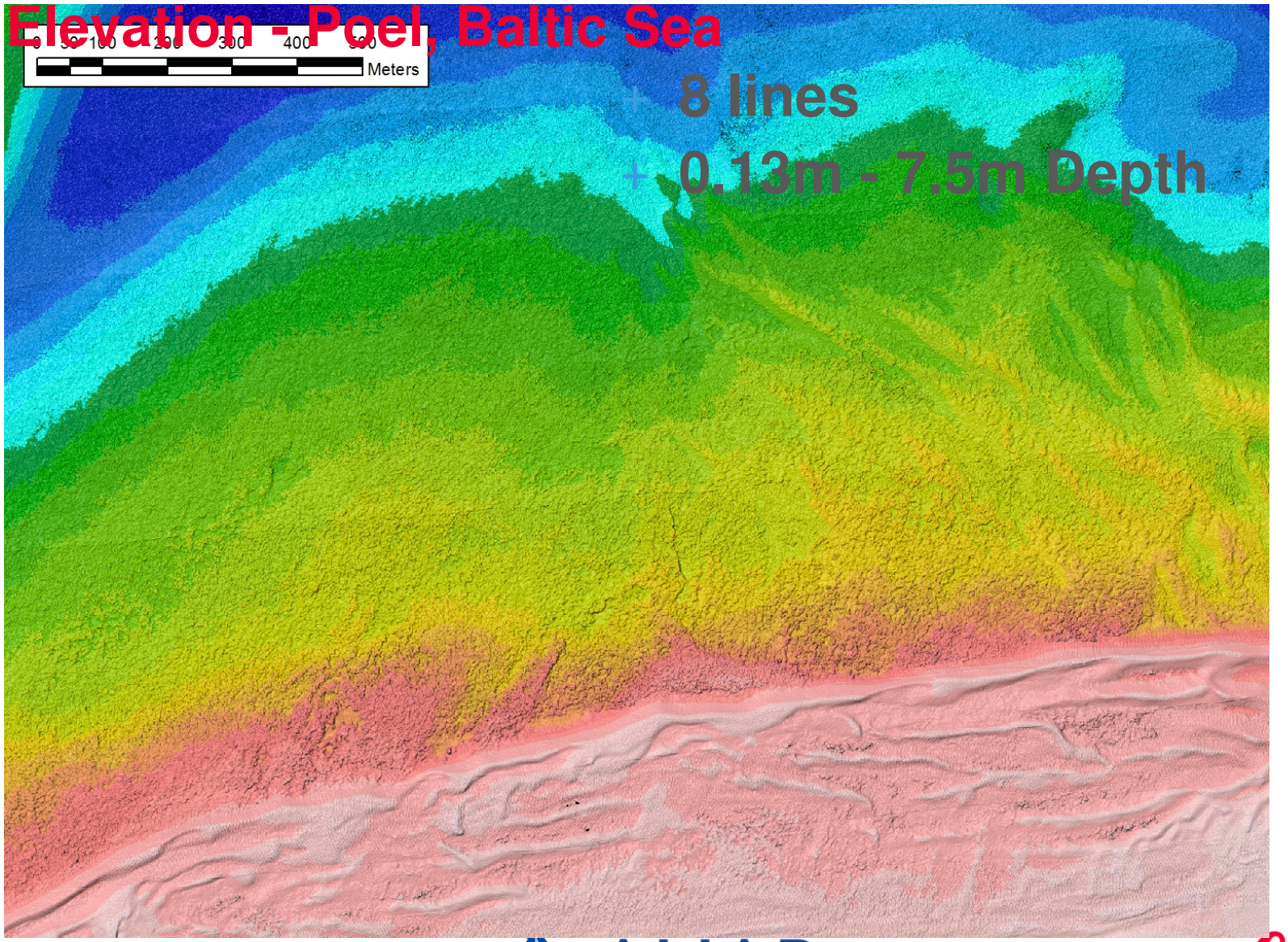
Elevation - Poel, Baltic Sea



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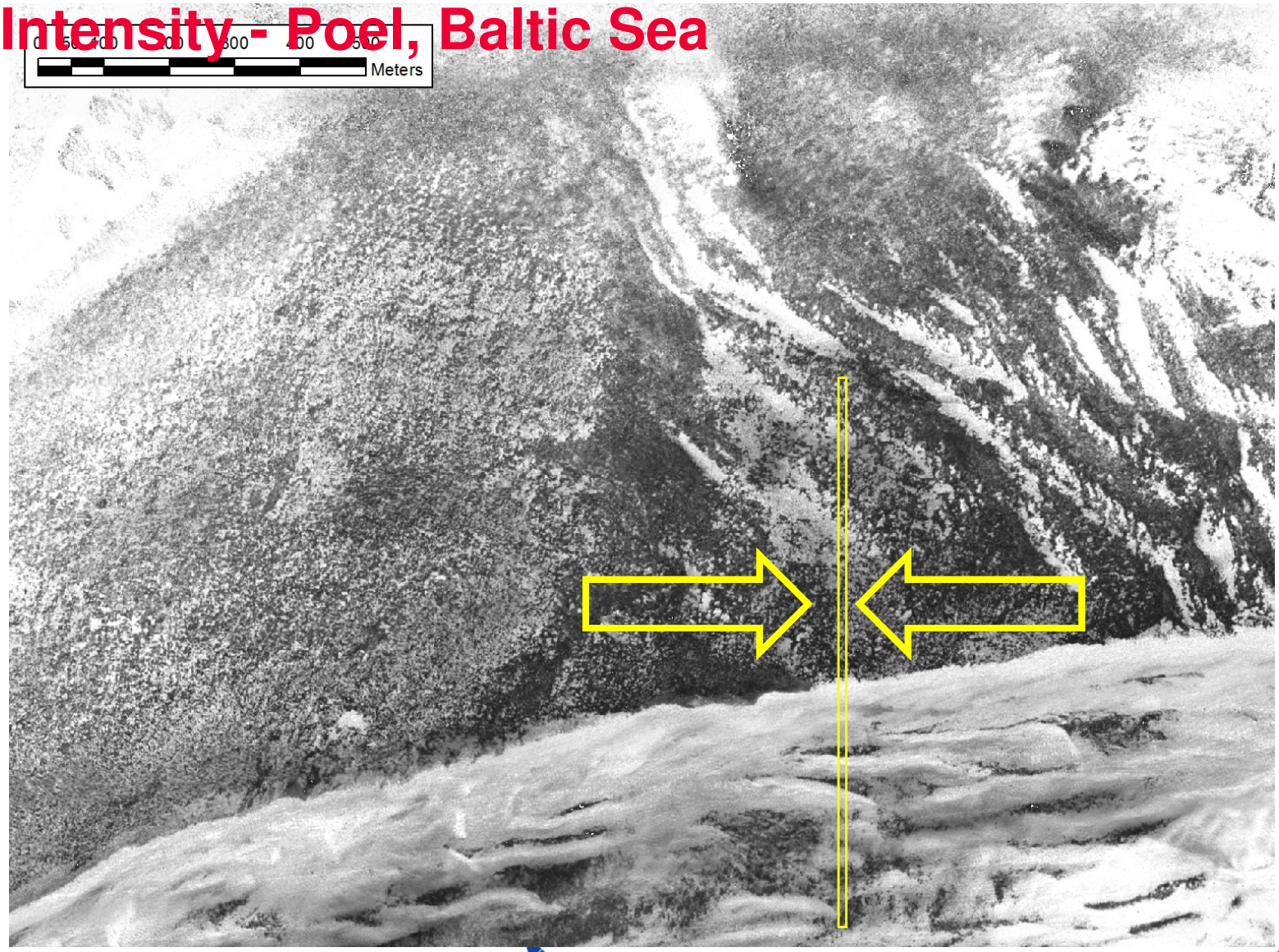
Intensity - Poel, Baltic Sea



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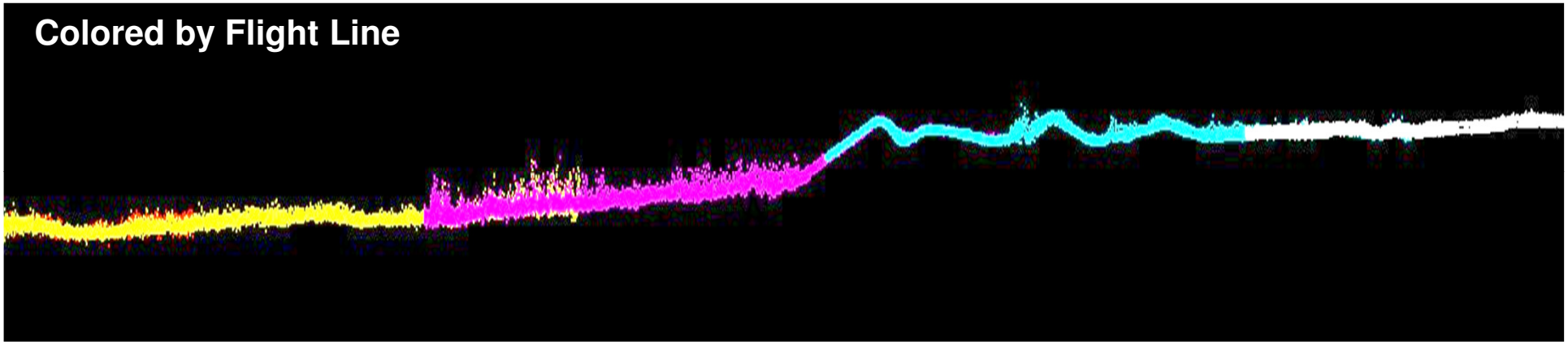
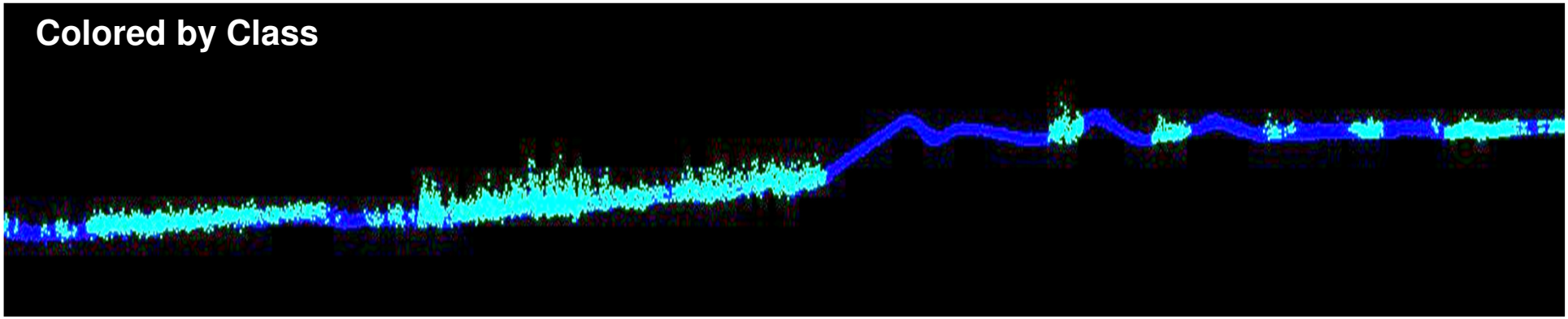
Cross Section - Poel, Baltic Sea

+ 20x Vertical Exaggeration
+ Sea grass is approximately 25cm high





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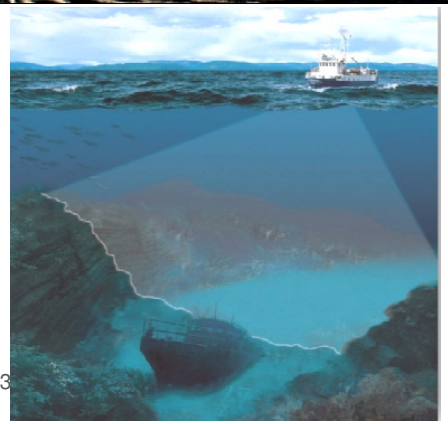
Multibeam reference data - Bathymetry

- **Multibeam reference dataset**
  - Simrad EM 3002 D, 300 KHz, 508 beams
  - Applanix POS MV positioning



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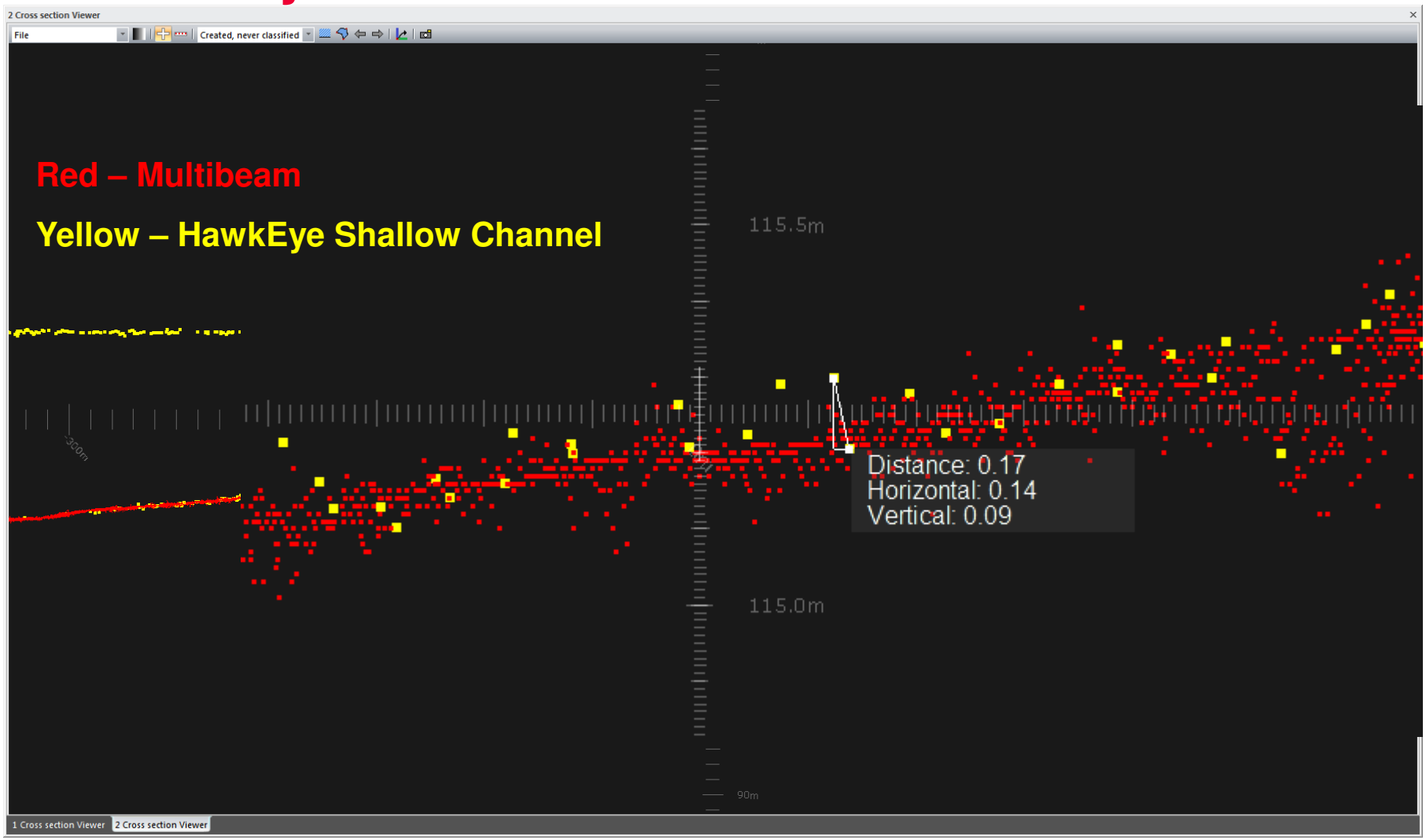
Accuracy – Shallow vs Multibeam reference



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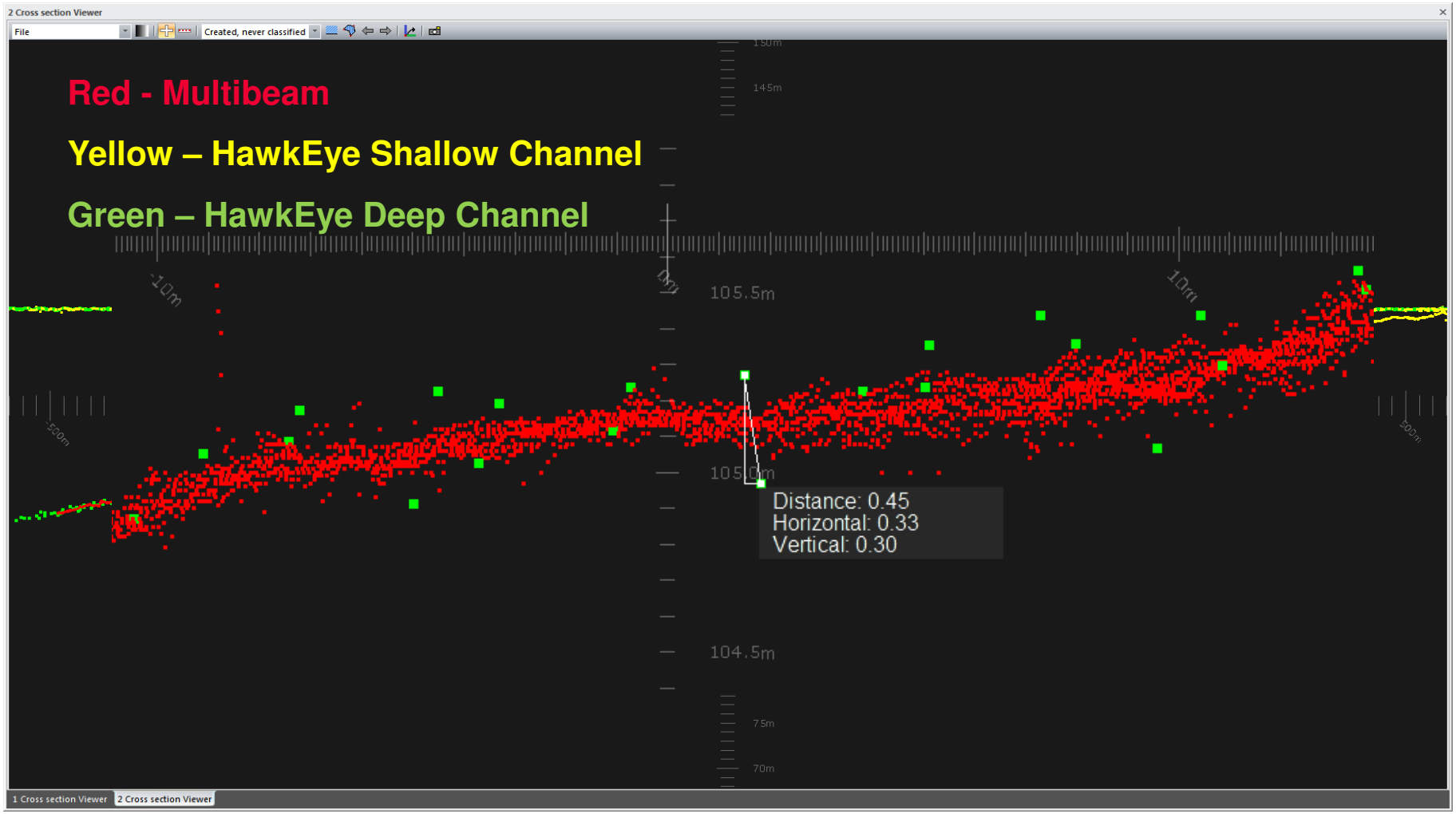
Accuracy – Deep vs Multibeam reference (Zoom)



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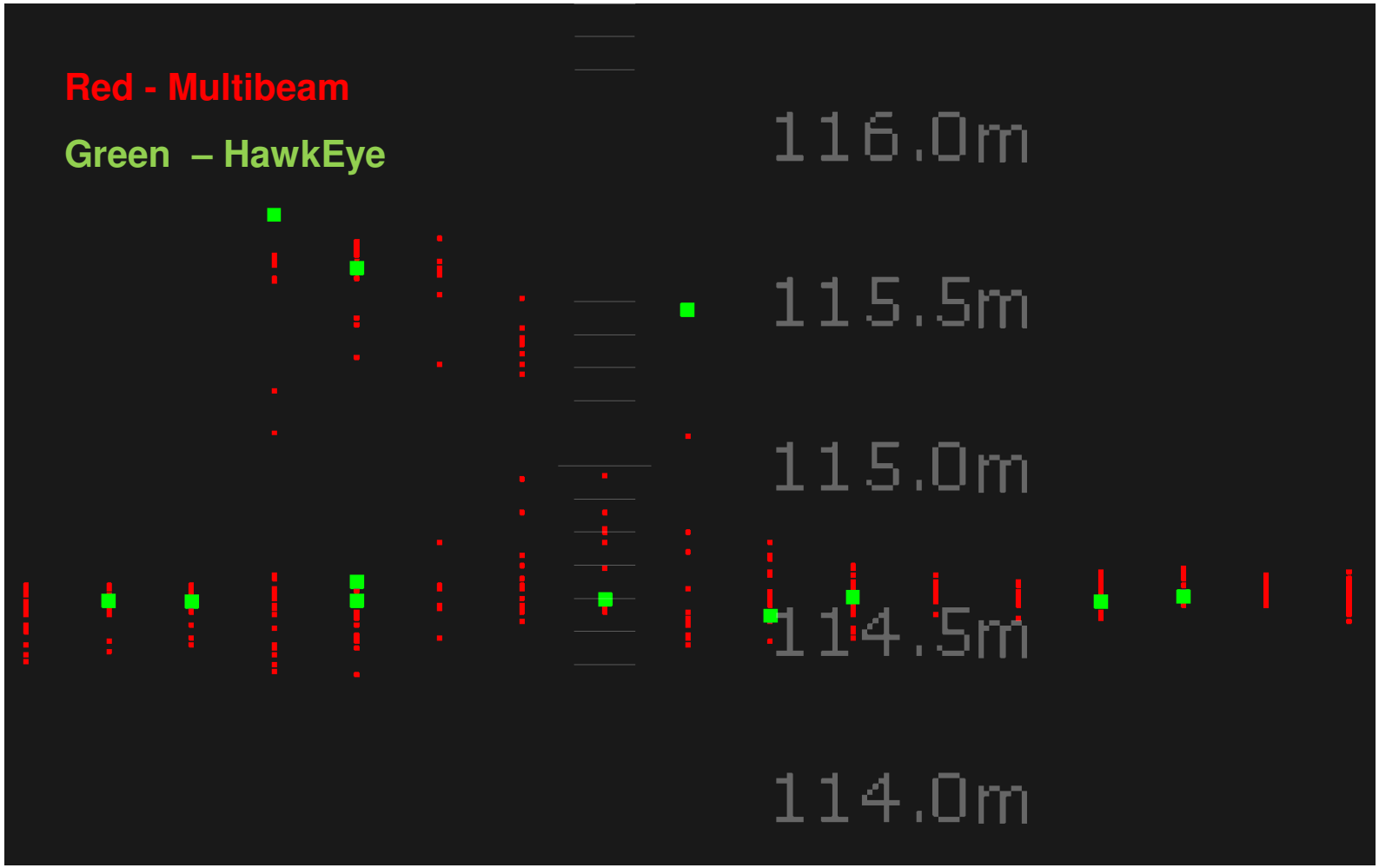
Natural Boulder – 1 meter high 6 meters depth



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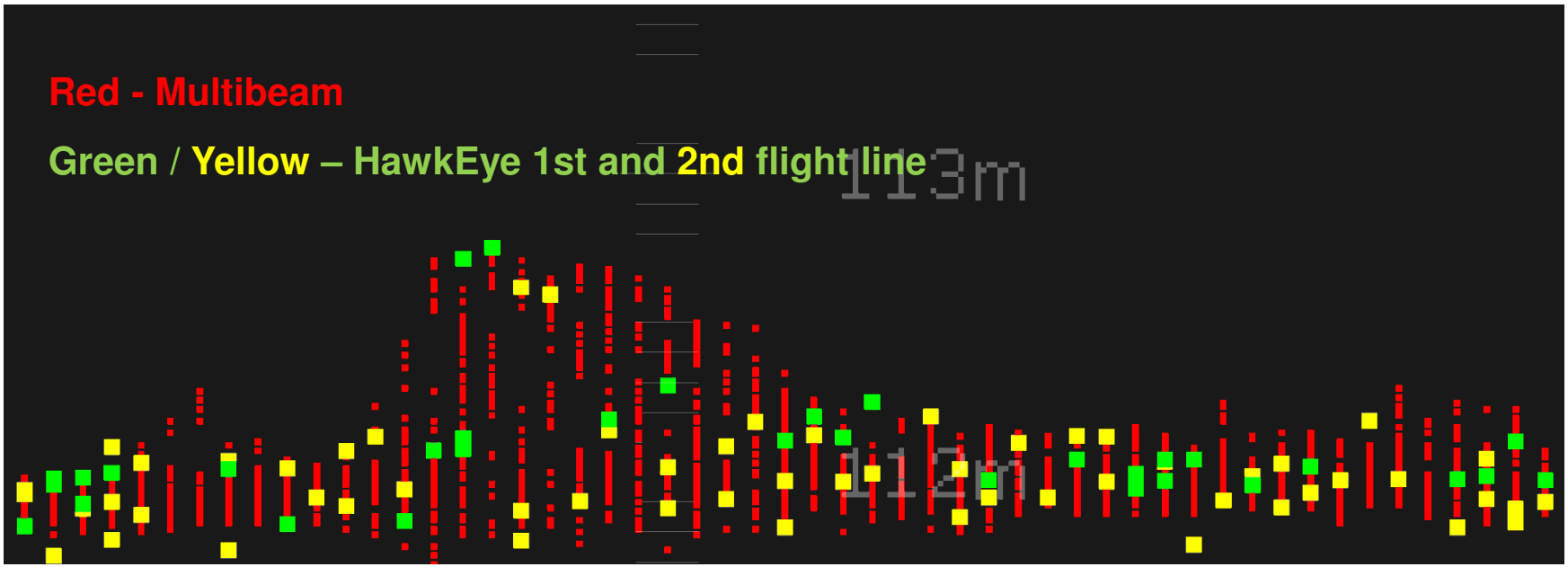
Natural Boulder – 1 meter high 7 meters depth



HawkEye capable of finding IHO Special order sized targets on shallow depths

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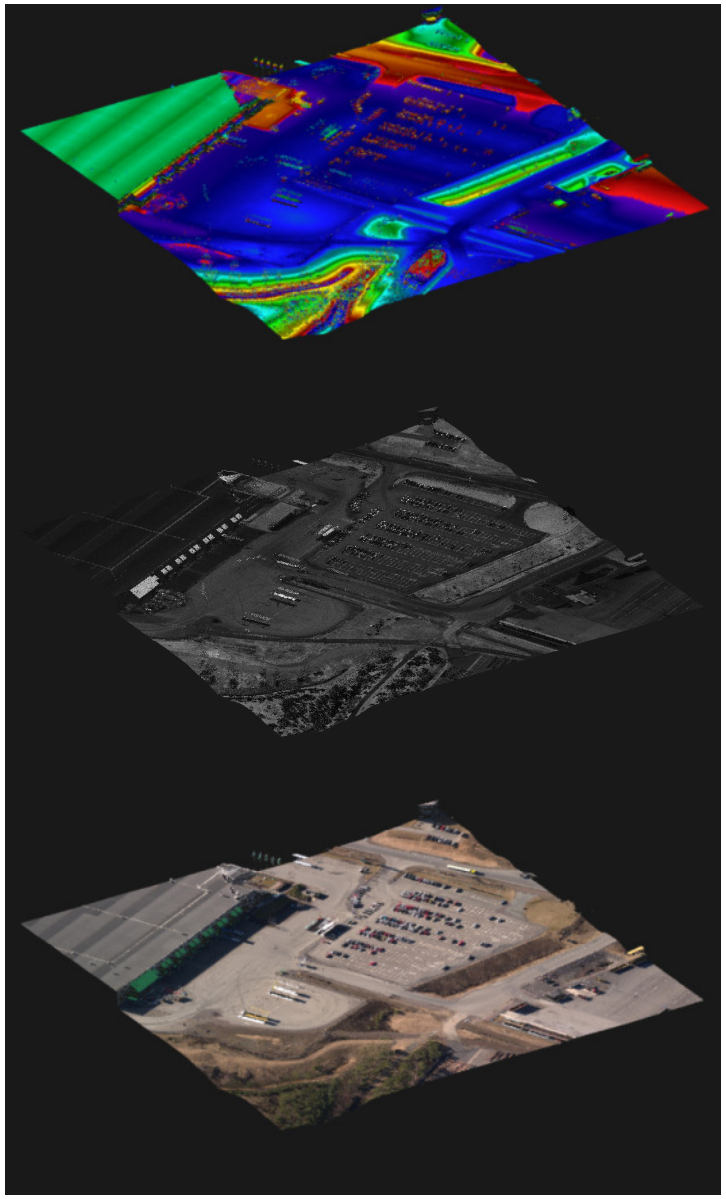
HawkEye$_{III}$
- Summary

- **HawkEye III is a new deep penetrating bathy LIDAR**
  - Shallow channel: 1,5 x secchi
  - Deep channel: 3 x secchi
- **HawkEye III has similar topo and shallow channels as AHAB Chiroptera and DragonEye products.**
  - A deep channel has been added
- **HawkEye III utilizes AHAB LIDAR survey studio processing software**
  - Automatic classification bathy/topo
  - Automatic refraction
- **HawkEye III provides the highest accuracy**
  - IHO special order on shallow depths
  - IHO order 1 at deeper depths



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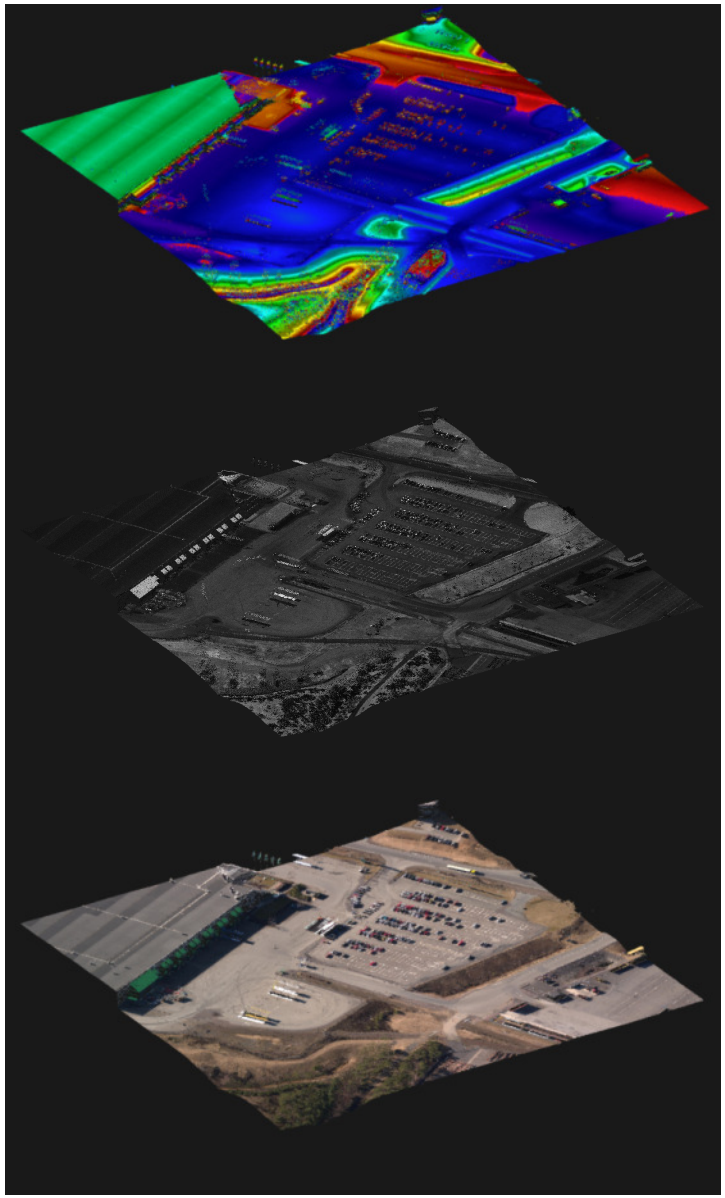
Thanks!

Carl-Johan Stigermark
Andreas Axelsson
Swante Welander
Airborne Hydrography AB, Sweden
E-mail: c-j.stigermark@airbornehydro.com
andreas.axelsson@airbornehydro.com
swante.welander@airbornehydro.com



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