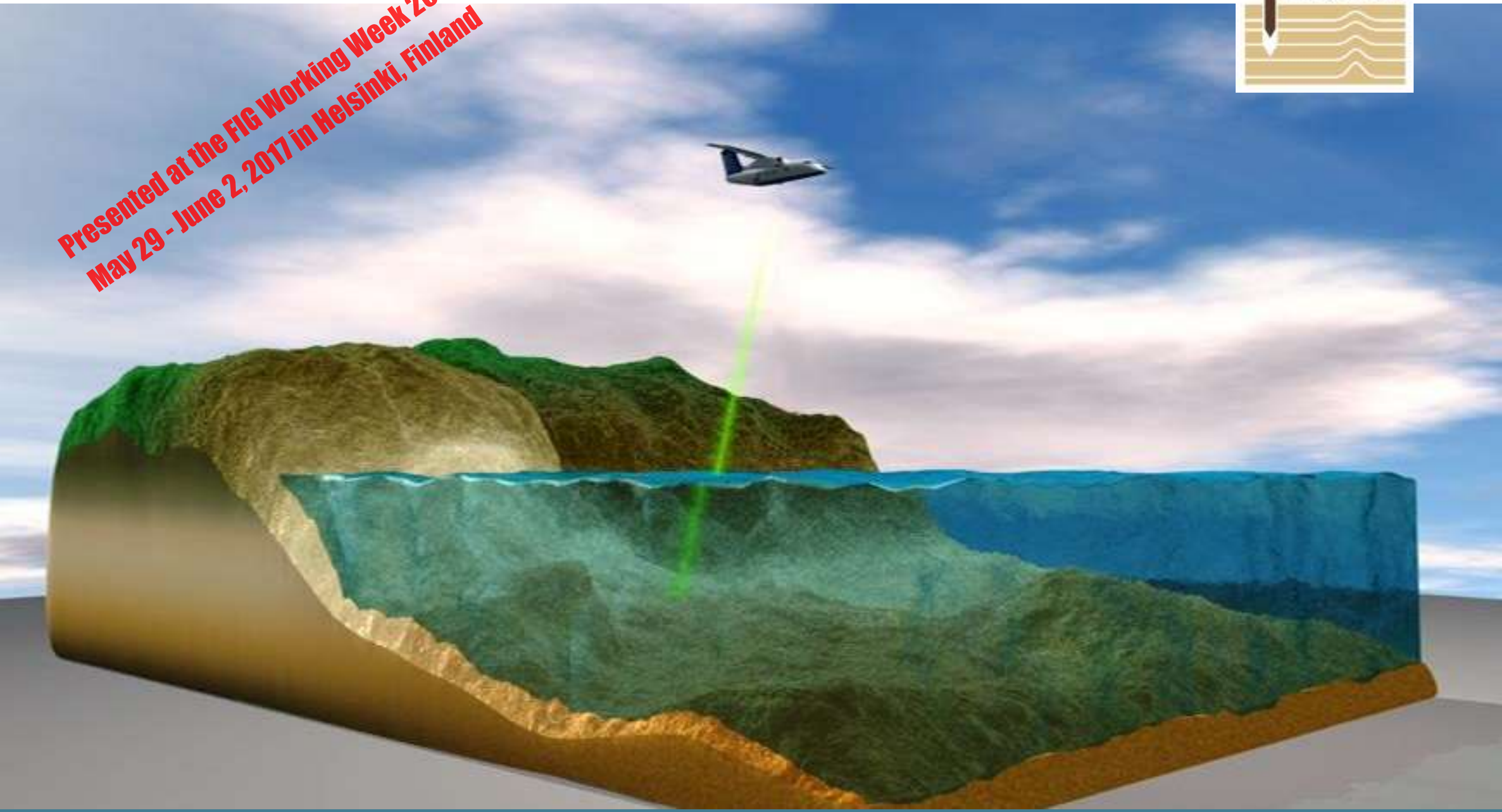
Presented at the FIG Working Week 2017,
May 29 - June 2, 2017 in Helsinki, Finland

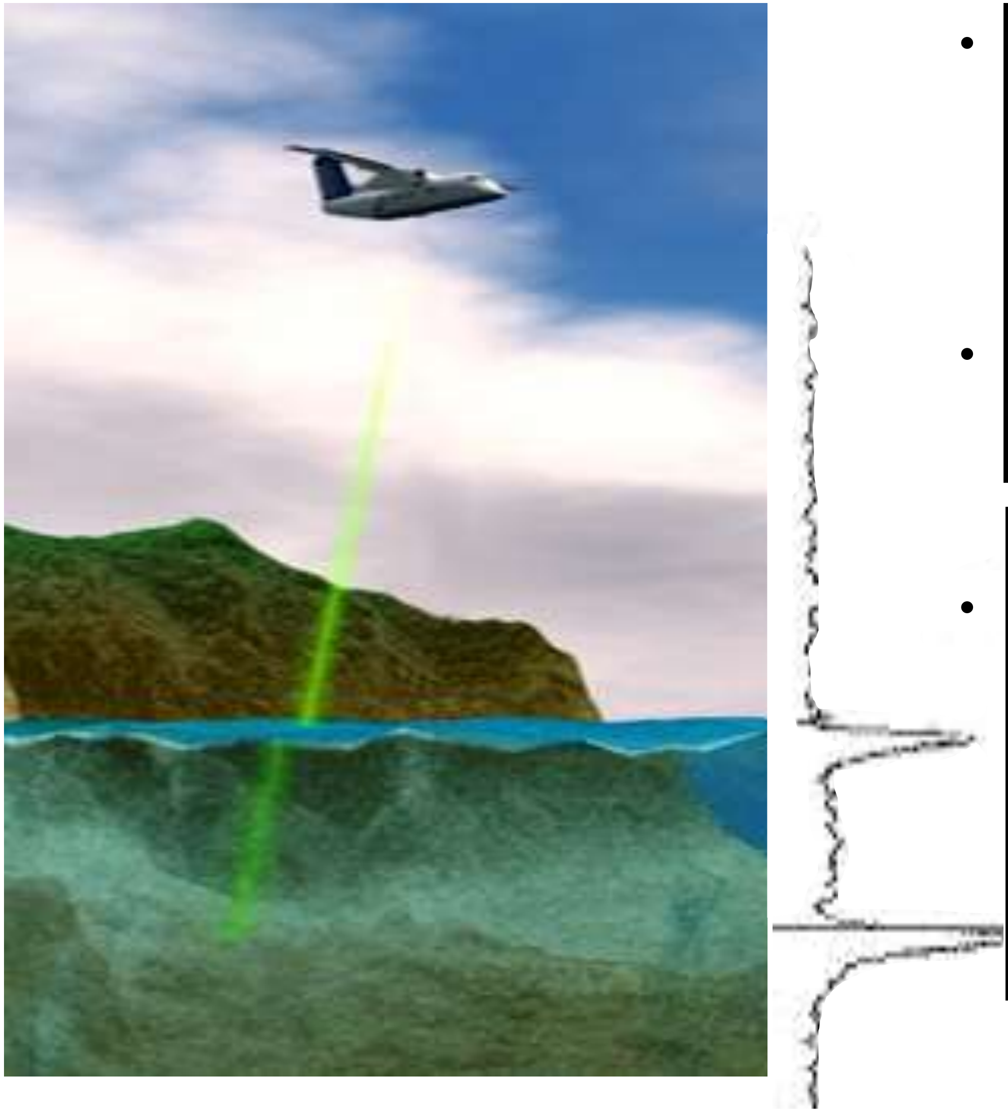


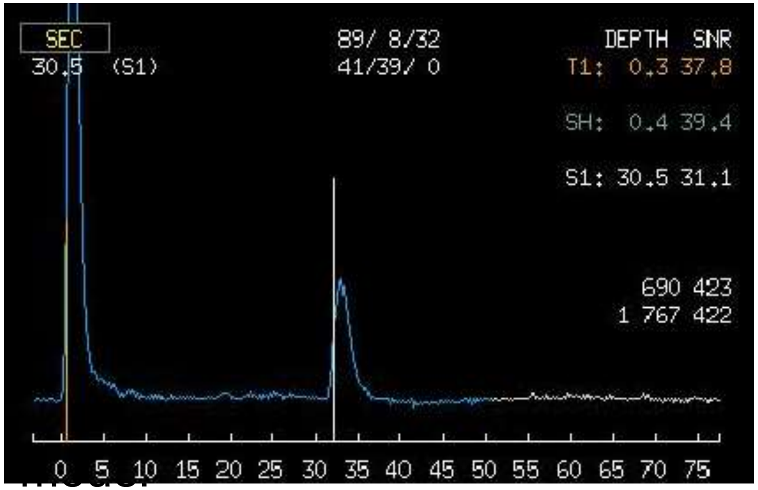
Airborne LiDAR Bathymetry Operations in Challenging Environments, as Experienced in Finland

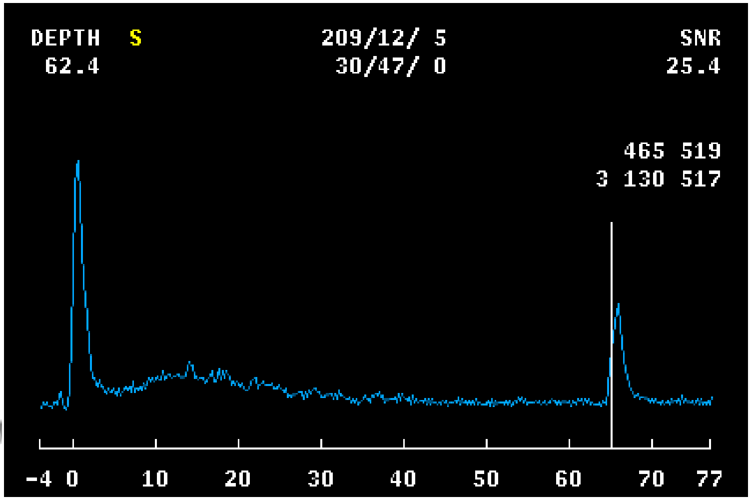
Hugh Parker, Fugro, FIG Working Week, 1 June 2017

Introduction

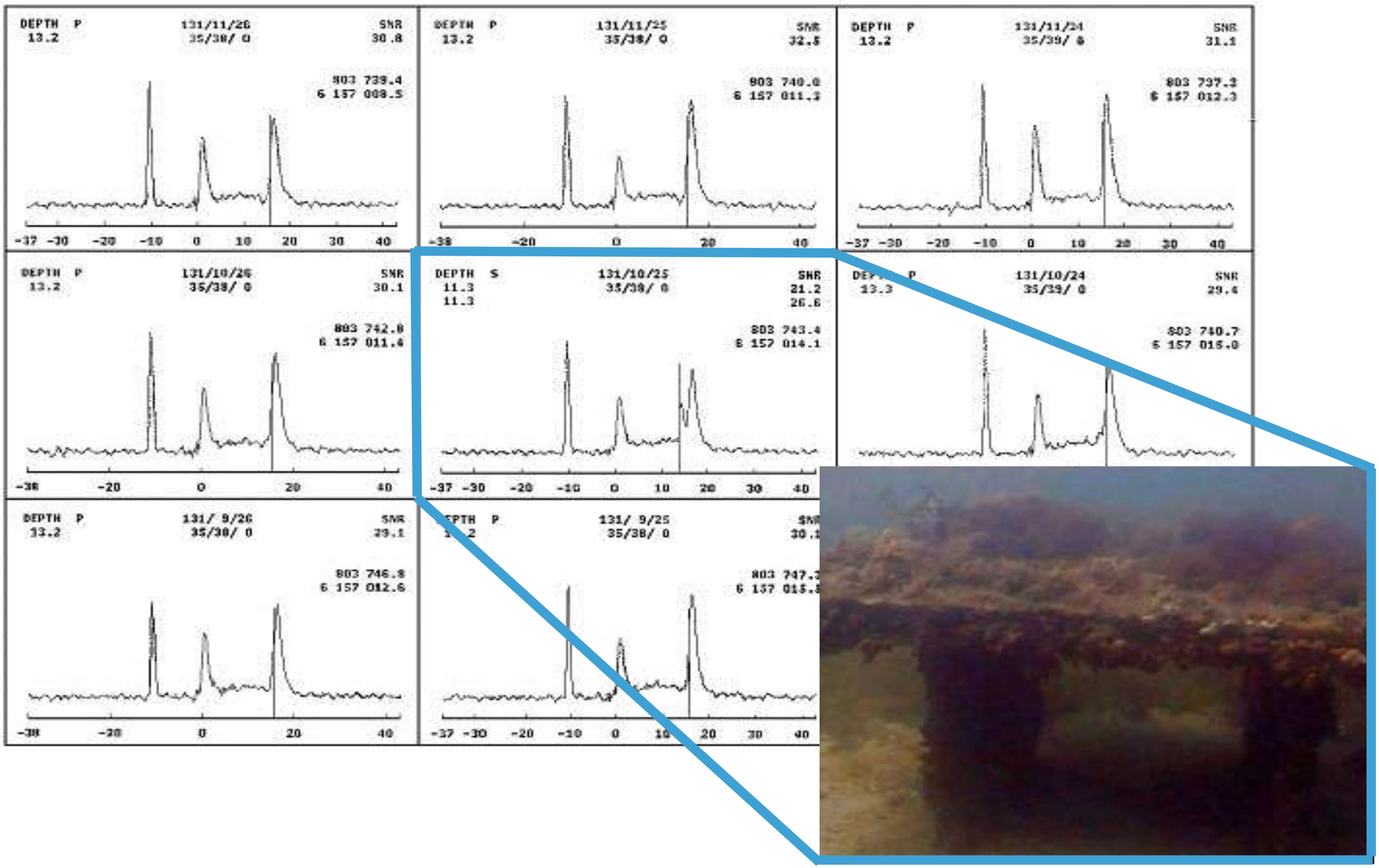
Overview of Technology







Overview of Technology



There are now 2 types of ALB systems in production/operation:

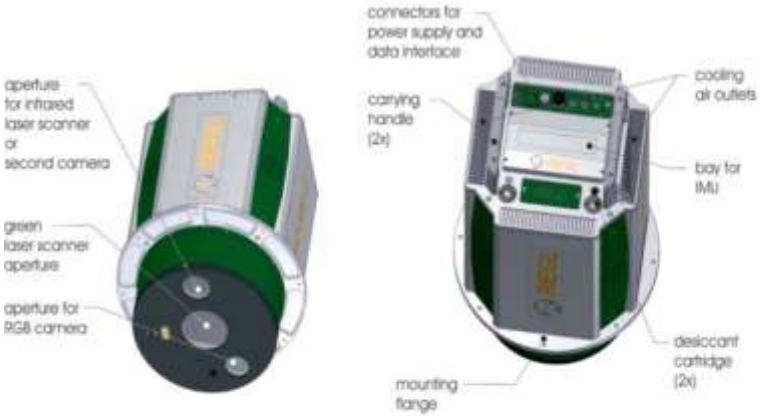
1. **<u>Traditional Bathymetric LiDAR Sensors with High Power / Lower PRF</u>**

<u>Examples</u>: Fugro LADS HD (Mk 3 / Mk 2 / Mk 1)
Teledyne Optech CZMIL Nova (deep channel), SHOALS
Leica Hawkeye III (HE II / HE I)

2. **<u>Topo / Bathy Sensors (for shallow Water) with Low Power / Higher PRF</u>**

<u>Examples</u>: Leica Chiroptera II
Riegl VQ-820-G
Riegl VQ-880-G
Teledyne CZMIL Nova (shallow channel)
USGS EAARL-B

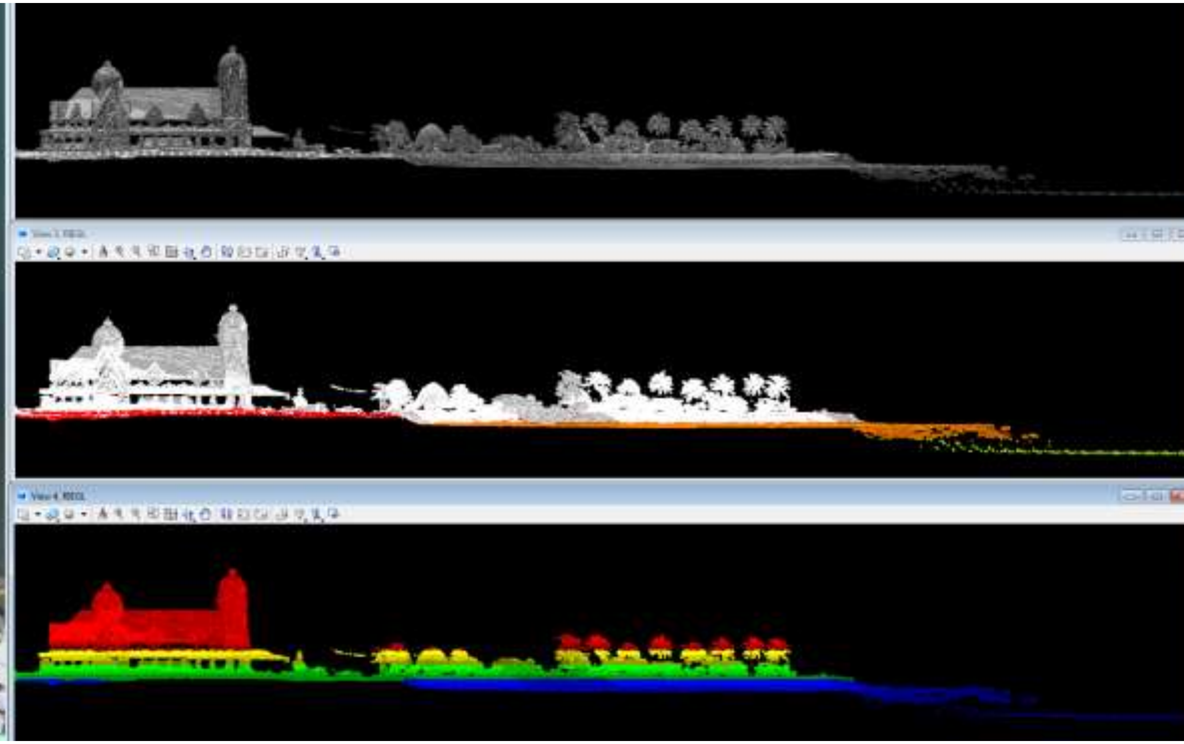
Fugro's "LADS HD" High Powered ALB system



Riegl "VQ-880-G" Low Powered ALB System

Reference: Quadros, N., 2013, LiDAR Magazine • Vol. 3 No. 6, "Unlocking the Characteristics of Bathymetric LiDAR Sensors"

Background and overview of sensors



Topo/Bathy (Shallow Water) ALB Sensors

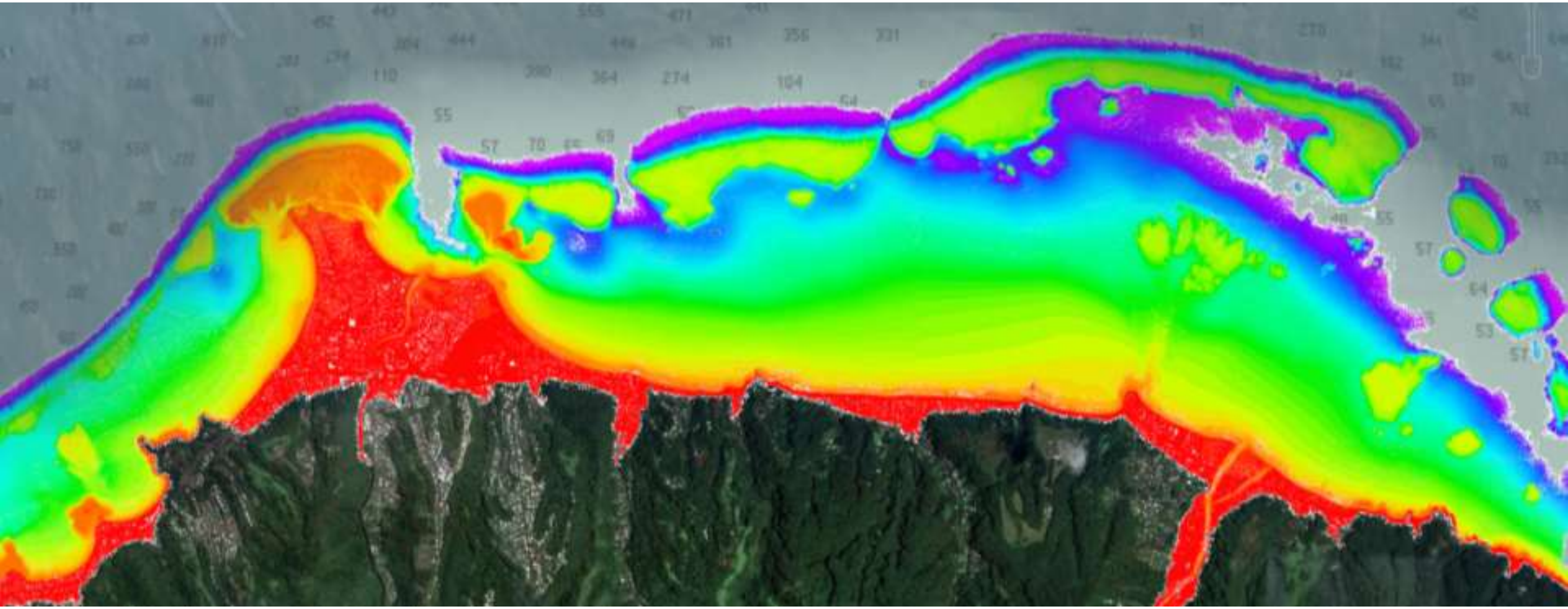
1. <u>Pros</u>:

   High Frequency/High resolution/small footprint, smaller units for installation

2. <u>Cons</u>:

   Lower power, Limited depth performance, 1 – 1.5 x Secchi Depth

Background and overview of sensors



Traditional Bathymetric LiDAR Sensors

1. <u>Pros</u>:

   High power, Greater depth performance, 2 – 3 x Secchi Depth

2. <u>Cons</u>:

   Low Frequency/lower resolution/larger footprint, Larger units for installation

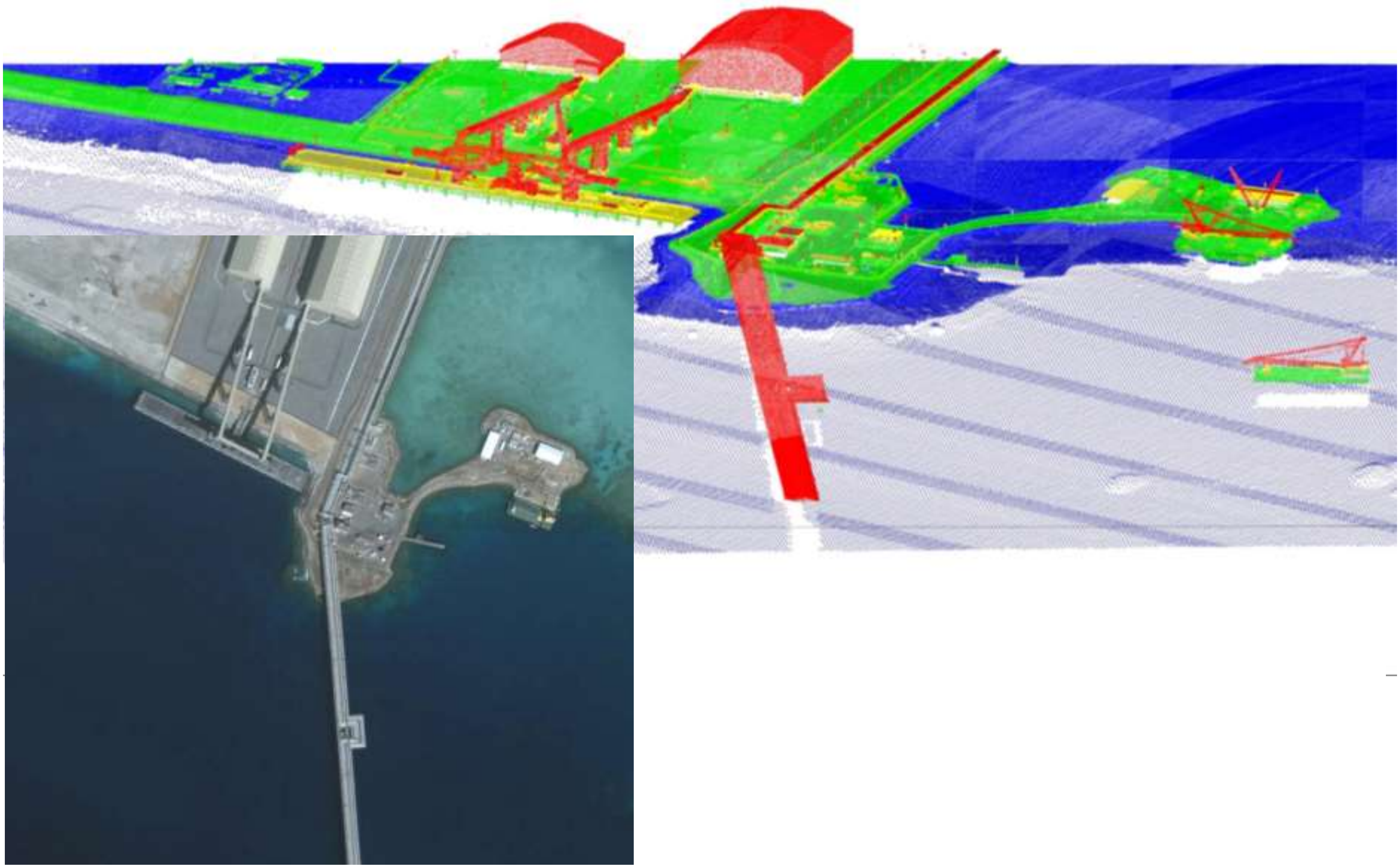
Multi-sensor operations

Common practice is to nowadays undertake ALB surveys using both type of sensors, for example:

1. **LADS HD**
    - 7mj Laser Power
        - Depth performance to 80m in best conditions (3 x Secchi disk)
    - High Data Quality
        - Wide Aperture Receiver
        - Automatic Gain Control - for optimised signal return
    - Efficient data collection
        - Operating heights from 1200 – 3000 feet
        - 2x2 to 3.5x3.5 m spot spacing;
        - Roll and off-track compensation

2. **RIEGL VQ-820-G**
    - High spatial resolution
        - Up to ~8 points / m^2
    - Depth performance to 10-15m in best conditions (1 x Secchi disk)

Example of LADS + Riegl data



Finland Survey Areas

Priority Areas: ★

Vullgrund 1 (Coastal)

Kukkosalmi (Lake)

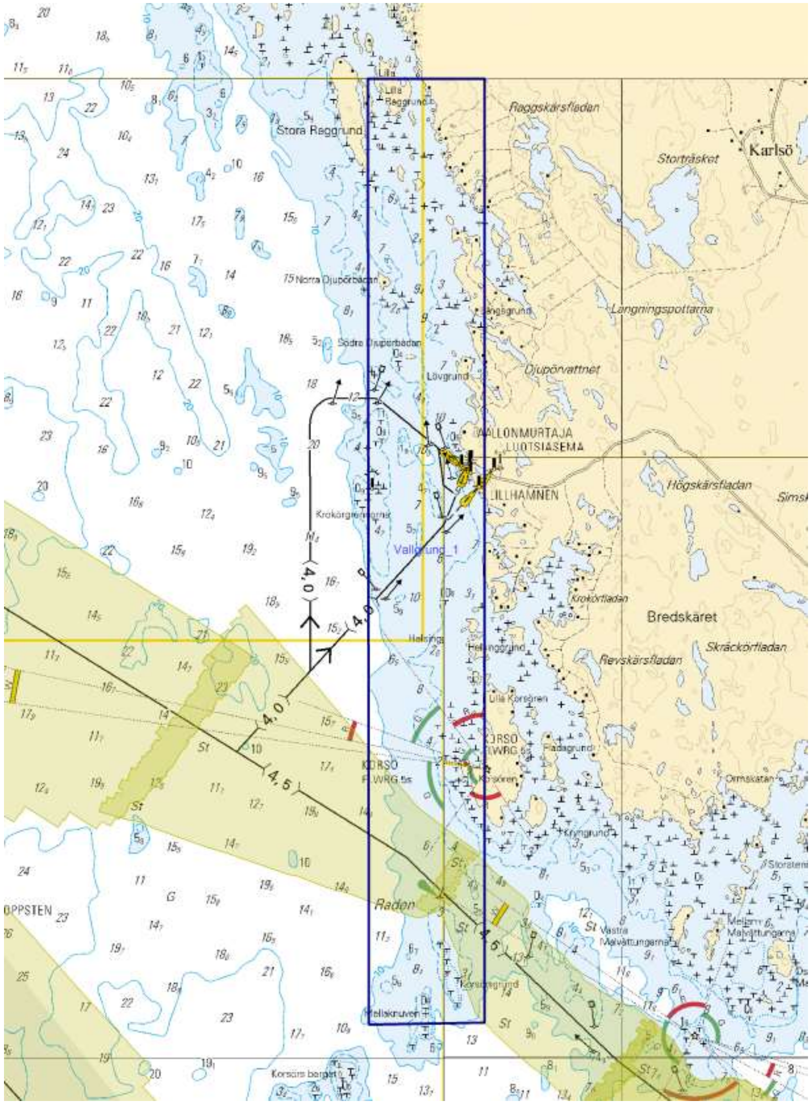
Ahoselka (Lake)

Secondary Areas: ★

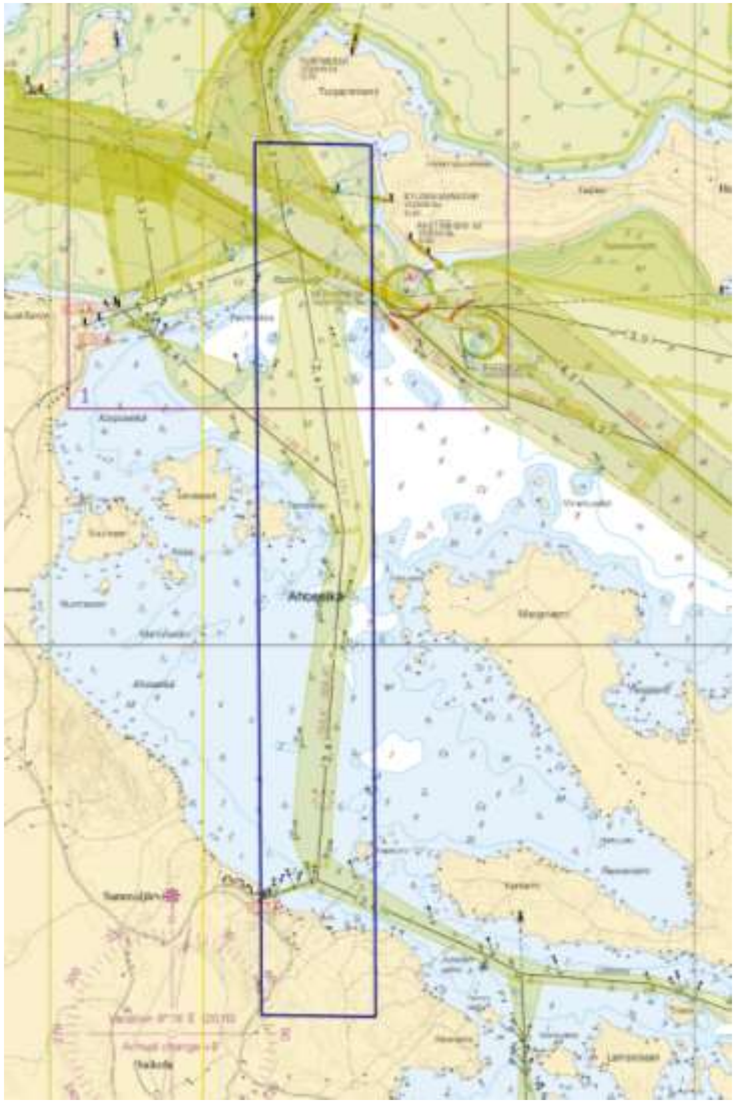
Vullgrund 2 (Coastal)

Partakoski (Lake)

Finland Survey Areas



Vullgrund 1 (Coastal)



Ahoselka (Lake)

Finland Survey Areas - Coastal

Finland Survey Areas – Lakes

Finland Survey Areas – Lakes

Operations

Flight #	Date Flown	Take-off Airport	Landing Airport	Objectives Flown / General Comments
1	18 Nov 2015	Vaasa	Vaasa	No objectives completed due to low cloud. Flight aborted due to weather.
2	23 Nov 2015	Vaasa	Vaasa	Survey: Vallgrund 1 area completed at 200% coverage.
3	23 Nov 2015	Vaasa	Vaasa	Calibration / Verification: RIEGL VQ-820-G boresight lines, TIP and GCP points (covered in snow).
4	24 Nov 2015	Vaasa	Joensuu	Survey: Kukkosalmi area flown at <100% coverage. Low clouds. Flight aborted due to weather.
5	6 Dec 2015	Joensuu	Vaasa	No objectives completed due to low cloud. Flight aborted due to weather.
6	7 Dec 2015	Vaasa	Vaasa	Survey: Vallgrund 2 area completed at 200% coverage. Verification: TIP and GCP points, TIP areas.
7	8 Dec 2015	Vaasa	Joensuu	Survey: Ahoselka area flown at <100% coverage. Kukkosalmi area completed at >100% coverage. Calibration / Verification: LADS HD rooftops (Jyvaskyla), CGP points (Kerimaki).

Lead-up to survey:

1. Antenna / lever-arm survey
2. Static position check
3. Setup GNSS base stations
4. Establish ground control
5. Reconnaissance of areas

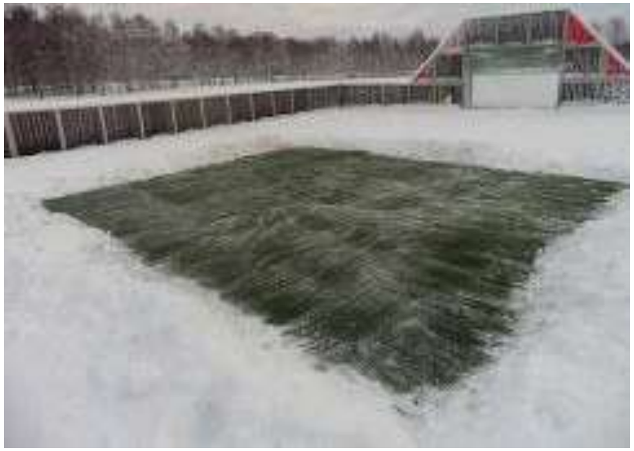
During Survey:

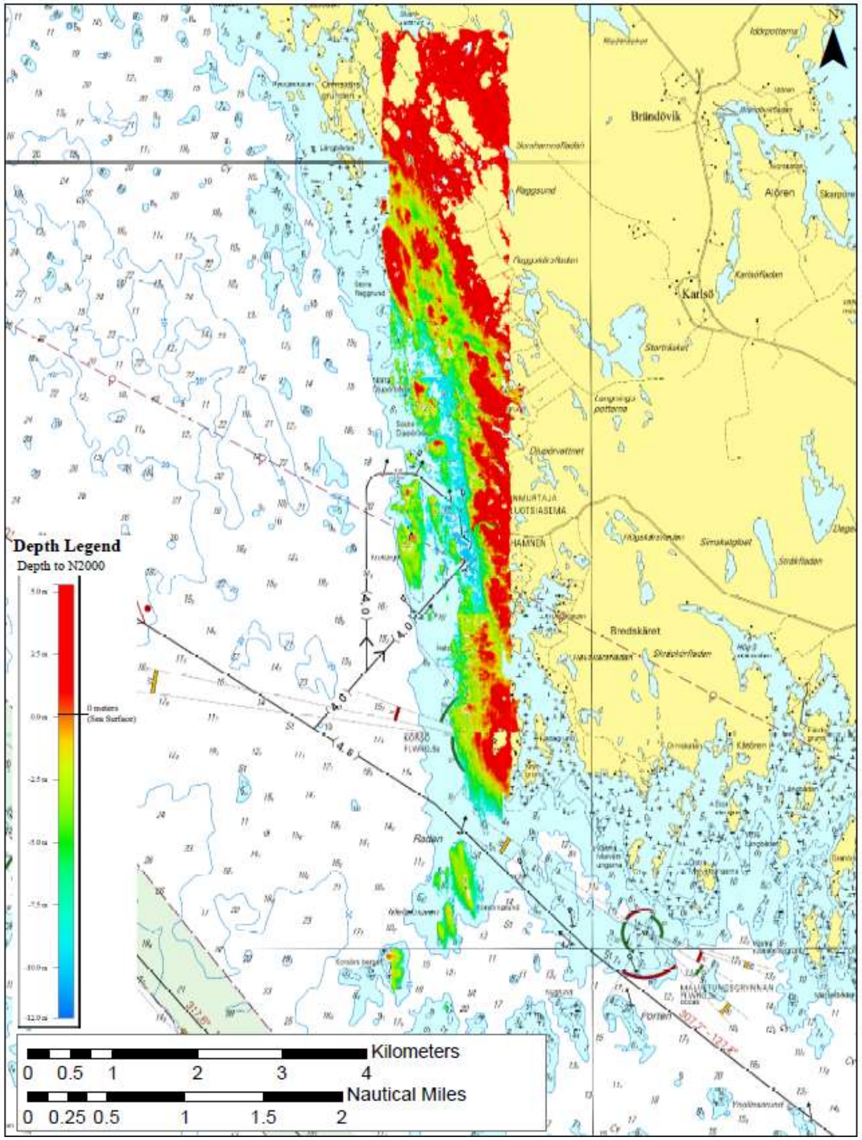
1. Check sensor calibrations
2. Cross lines
3. Quality assessment
4. Forward deployments

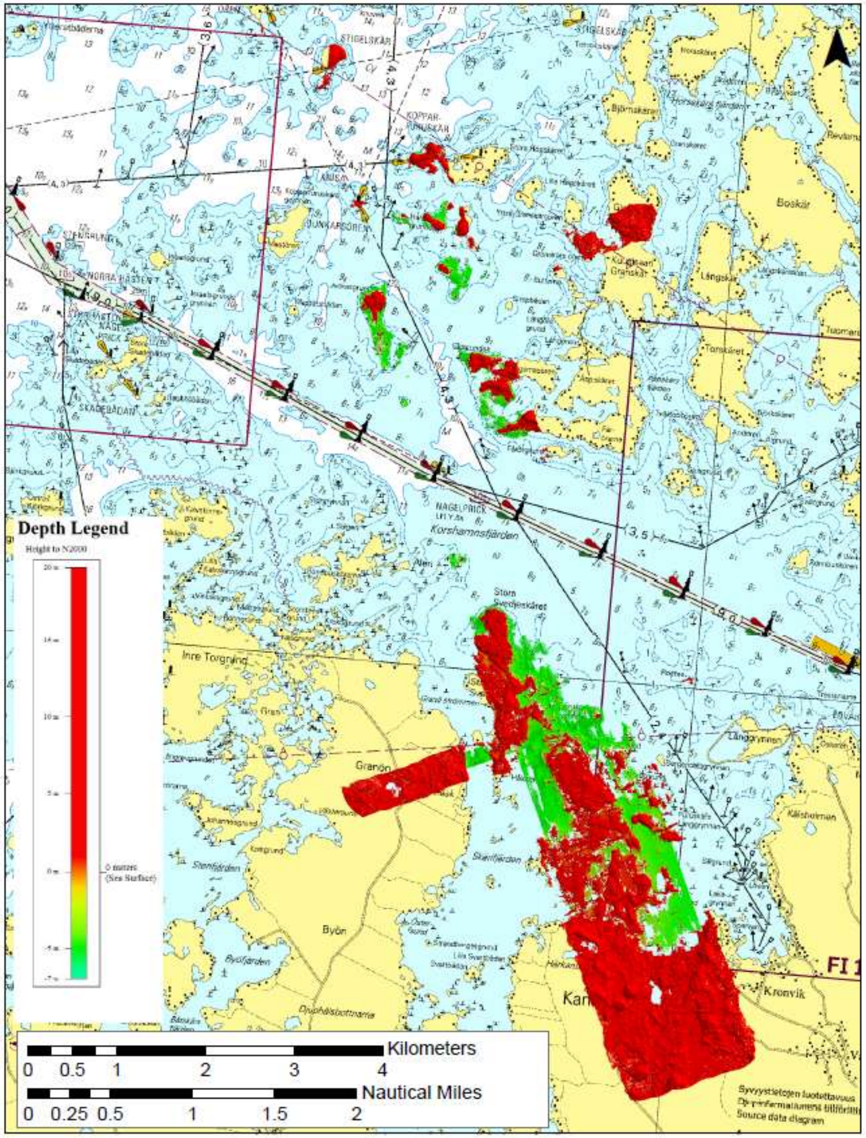
Challenges

<u>Environmental Challenges Encountered</u>

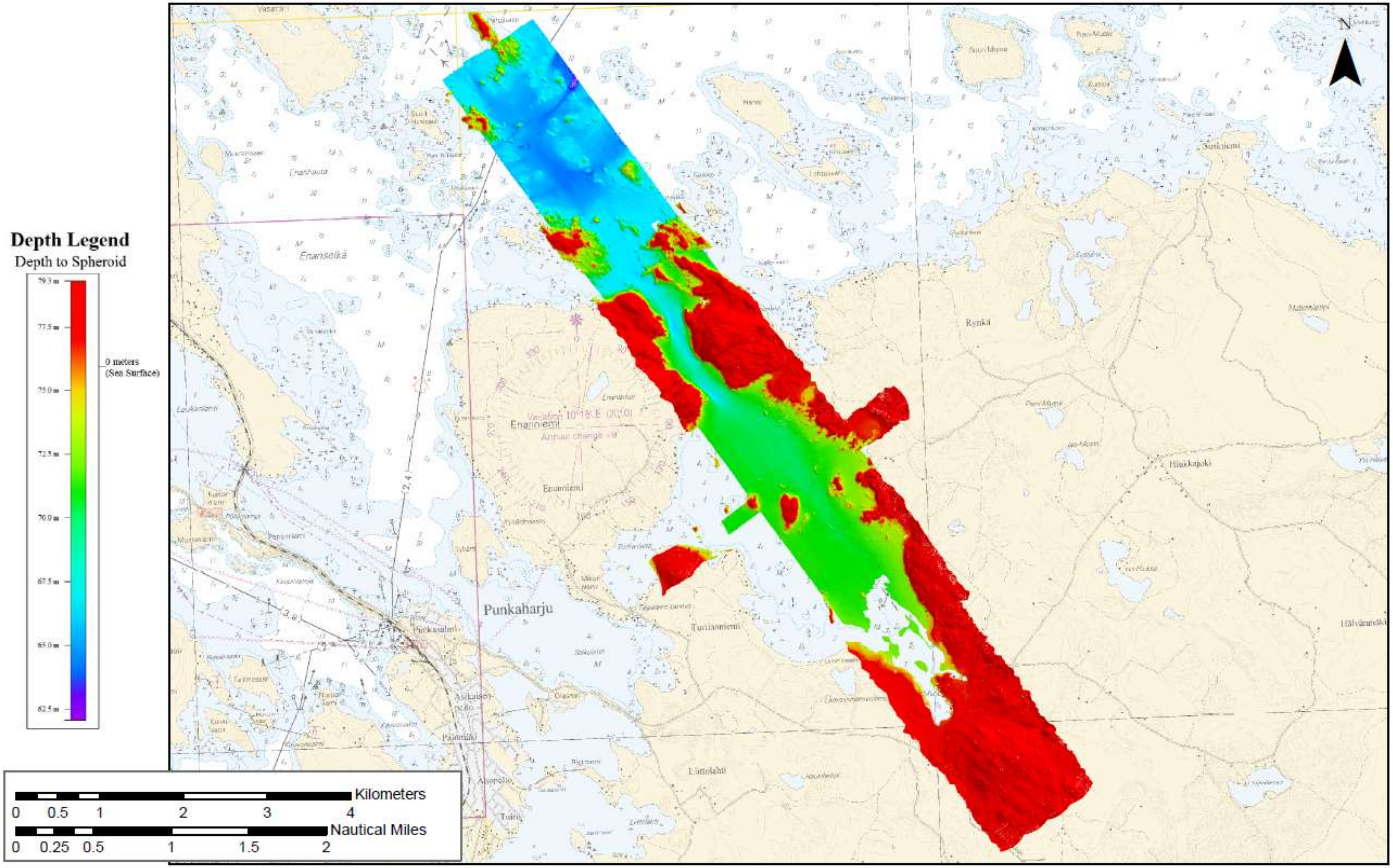
- Weather
  - Low Cloud
  - Rain
  - Snow
  - Sea Ice
- Water Clarity
- Seabed Reflectivity
- Swell




Depth Legend
Depth to N2000
0 meters (Sea Surface)
Kilometers
0 0.5 1 2 3 4
Nautical Miles
0 0.25 0.5 1 1.5 2


Depth Legend
Height to N2000
0 meters (Sea Surface)
Kilometers
0 0.5 1 2 3 4
Nautical Miles
0 0.25 0.5 1 1.5 2

Results – Lake Areas



Recommendations

Utilise a high-power system in order to achieve sufficient depth penetration and resultant coverage

Complement the high-power system with a very high density low-power system in order to fully survey the very shallow, awash and barely drying features.

Provide for alternate coastal and lake areas to be surveyed concurrently to effectively manage poor weather and water clarity.

Conduct ALB surveys during the optimal weather and water clarity periods; June to October may have the best weather,

If MBES infill surveys are planned to extend coverage, fill gaps, or to conduct investigations, schedule the boat work for the following year, so that the ALB data may be fully processed and reported prior to MBES operational planning and execution to ensure vessel safe navigation in these complex areas.

Thankyou

Questions?

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