Potential of a novel airborne hydrographic laser scanner for capturing shallow water bodies

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Airborne Laser Hydrographic Mapping
River Loisach, Germany, July 2011

Data: Airborne HydroMapping (AHM)
Outline

- **What is** Airborne Laser Hydrography (**ALH**)?
- **How** does it work?
- **Sensors**
  - Costal mapping: Optech: SHOALS 3000
  - Fluvial mapping: Riegl: VQ-820-G Laser Scanner
- Potential **fields of application**
- **First results**
  - Pond alongside River Danube, February 2011
  - River Loisach, June/July 2011
- **Summary and Outlook**
What is Airborne Laser Hydrography / Bathymetry?

- Airborne Laser (or LiDAR) Bathymetry (ALB) is a technique for measuring the depths of relatively shallow, coastal waters from the air using a scanning, pulsed laser beam. It is also known as Airborne Laser Hydrography (ALH) […].

Typical applications include bathymetric surveys of federal navigation channels, large offshore areas, ports and harbours, shore, coral reefs, […]

Gary C. Guenther et. al: MEETING THE ACCURACY CHALLENGE IN AIRBORNE LIDAR BATHYMETRY, EARSeL-SIG-Workshop LIDAR, Dresden, 2000
Airborne Laser Hydrography

Multiple wavelengths

- **Near infrared (1064 nm)** for topography and water surface
- **Green (532 nm)** penetrates water column and reflects from sea/river bottom
- Green laser source via frequency doubling of original near infrared (Nd:Yag) signal
Laser signal propagation

Source: Guenther et. al, 2000
ALH: Benefits

ALH benefits

• **quick and cost effective surveys**
• where **difficult, dangerous or impossible** by waterborne sensors
• constant swath **width independent** from water depth
• provides **hydrography and topography**
• **seasonal changes** (after storms, floods, ...)

**Turbidity is the limiting factor!**
**Measurement only during favourable environmental conditions**

Source: Guenther et. al, 2000
## Sensors: Shoals 3000 (Optech, Canada)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth accuracy</td>
<td>IHO-I: &lt;25 cm</td>
</tr>
<tr>
<td>Min/Max depth</td>
<td>~1.5 m / 50 m</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>~7 ns</td>
</tr>
<tr>
<td>Pulse energy</td>
<td>5 mJ</td>
</tr>
<tr>
<td>Net. meas. rate</td>
<td>3 kHz</td>
</tr>
<tr>
<td>Sounding density</td>
<td>2x2 m² - 5x5 m²</td>
</tr>
<tr>
<td>Flying altitude</td>
<td>200 - 500 m</td>
</tr>
<tr>
<td>Swath width</td>
<td>-0.75 x altitude</td>
</tr>
<tr>
<td>Eye-safe altitude</td>
<td>&gt;200 m AGL</td>
</tr>
<tr>
<td>Sensor dimensions</td>
<td>800 H x 500 W x 580 D (mm)</td>
</tr>
<tr>
<td>Control rack dim</td>
<td>400 H x 530 W x 600 D (mm)</td>
</tr>
<tr>
<td>Laser rack dim</td>
<td>490 H x 530 W x 590 D (mm)</td>
</tr>
<tr>
<td>Chiller rack dim</td>
<td>440 H x 530 W x 590 D (mm)</td>
</tr>
</tbody>
</table>

Source: www.optech.com
LIDAR bathymetry of Galway Bay (source INFOMAR 2006),
### Riegl VQ-820-G

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wavelength</strong> λ</td>
<td>532 nm</td>
</tr>
<tr>
<td><strong>Ranging accuracy</strong></td>
<td>25 mm</td>
</tr>
<tr>
<td><strong>Min/max depth</strong></td>
<td>0-15 m (1 Sechhi)</td>
</tr>
<tr>
<td><strong>Pulse duration</strong></td>
<td>~1 ns ≡ 30 cm</td>
</tr>
<tr>
<td><strong>Pulse repetition rate</strong></td>
<td>500 kHz (net: 200)</td>
</tr>
<tr>
<td><strong>Footprint @ 500 m</strong></td>
<td>50 cm</td>
</tr>
<tr>
<td><strong>Pt dens. @ 500 m</strong></td>
<td>10-50 pts/m²</td>
</tr>
<tr>
<td><strong>Full waveform</strong></td>
<td>Online/post proc.</td>
</tr>
<tr>
<td><strong>Scan mechanism</strong></td>
<td>Rotating prism</td>
</tr>
<tr>
<td><strong>Scan pattern</strong></td>
<td>Elliptic arcs</td>
</tr>
<tr>
<td><strong>NOHD/ENOHD</strong></td>
<td>100 m / 500 m</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>28 kg</td>
</tr>
</tbody>
</table>

**Diagram:**
- [Image of a plane with a laser beam directed into water, showing transmitted and received laser pulses.]

**Mandlburger et al., Airborne Hydrographic Mapping**
Riegl VQ-820-G

Riegl VQ-820-G

Source: www.riegl.com
Potential fields of application

- **Hydrodynamic-Numerical (HN) modelling**
  - Capturing geometry for Watercourse DTMs in a single flight mission
  - Detailed representation of river bed topography
  - Calibration/validation of sediment transport models
  - Turbid water conditions: Capturing of littoral zone

- **Hydro-morphology**

- **Hydro-biology**

- **River restoration**

- **Mapping of bankside**

- **Ecology**

- **Monitoring**
Surveying groyne fields

Results: First real-world flight mission
Pond @ River Danube, February 2011

Digital (Summer) Orthophoto

Source: Mandlburger et al., 2011;
Data: Riegl LMS
Results: First real-world flight mission
Pond @ River Danube, February 2011

LiDAR point cloud

Data: Riegl LMS
Results: First real-world flight mission
Pond @ River Danube, February 2011

Source: Mandlburger et al., 2011;
Data: Riegl LMS
LiDAR Bathymetry - Results

Results: First real-world flight mission
Pond @ River Danube, February 2011

Source: Mandlburger et al., 2011;
Data: Riegl LMS
River Loisach, Germany, July 2011
River Loisach, Germany, July 2011
Cross sectional comparison, River Loisach, Germany, July 2011
Cross sectional comparison, River Loisach, Germany, July 2011
Airborne LiDAR hydrography

- Costal Mapping
  - Well established method
  - Operational systems:
    - SHOALS (Optech), HawkEye (AHAB), LADS (Fugro), ...
  - Sophisticated data processing
  - Heavy and bulky systems
  - Moderate measurement rate / point density

- Fluvial Mapping:
  - Riegl VQ-820-G
Summary and Outlook

- Riegl VQ-820-G
  - Compact instrument → helicopter, light aircraft
  - NIR + Green laser → simultaneous mapping of topography + river bed
  - High net measurement rate → high point density
  - Short laser pulses → mapping of very shallow water bodies
  - Full waveform → detailed data analysis
  - High potential for different fields of (fresh) water sciences

- Outlook
  - Technical improvements (max depth, eye safety, ...)
  - Geometric/radiometric calibration (strip adjustment in two-media-case)
  - Point classification (water surface, water bottom, bare ground, vegetation, ...)
  - Full waveform analysis (turbidity, water quality, ...)
  - Feedback loop with water scientists

Scientific project proposal (COMET/FFG)
Thank you for your attention!!

Questions??