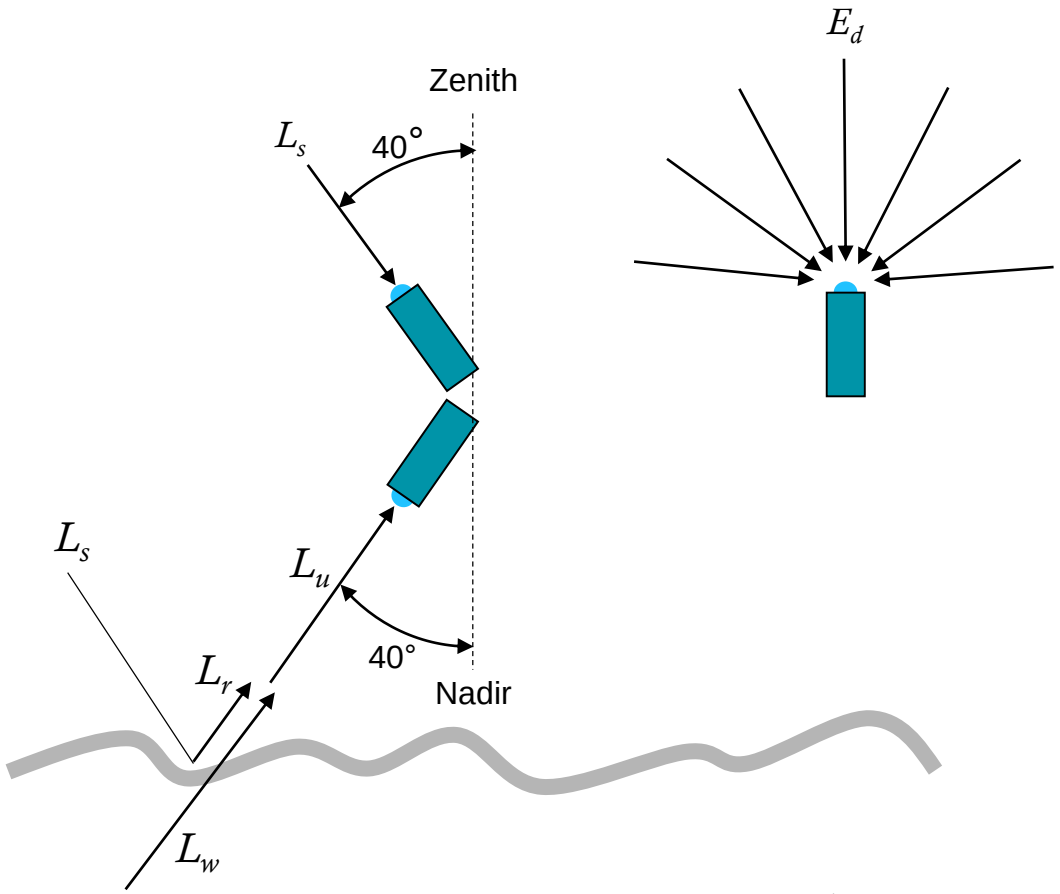
LIMNOVIS

A new platform for optimized in-situ validation measurements at inland water bodies

Stefan Plattner, Peter Gege, Thomas Schwarzmaier

Measuring R_{rs}



$$R_{rs}(\lambda) = L_w(\lambda) / E_d(\lambda)$$

$$L_{w(\lambda)} = L_{u(\lambda)} - L_r(\lambda)$$

$$L_r(\lambda) \sim L_s(\lambda) \cdot 0.028$$

Influence from Boat and Crew

Problem

The ship's hull and superstructres, including the persons on the boat …

- … may reflect a significant amount of light towards the measurement target or spectrometer
- … may cast a shadow to the area measured
- … may cover a significant part of the hemisphere seen by the E_d sensor when it is not mounted at the highest point

Solution

unmanned boat (USV) with a lower cross-section

Drift and Rotation

Problem

Due to wind and current, boats tend to turn or move. During a series of measurements, this can cause inconsistent results due to

- **unwanted rotation:** changing measurement geometry, casting shadows, sunglint
- **unwanted movement:** changing water body, changing bottom type, changing water depth

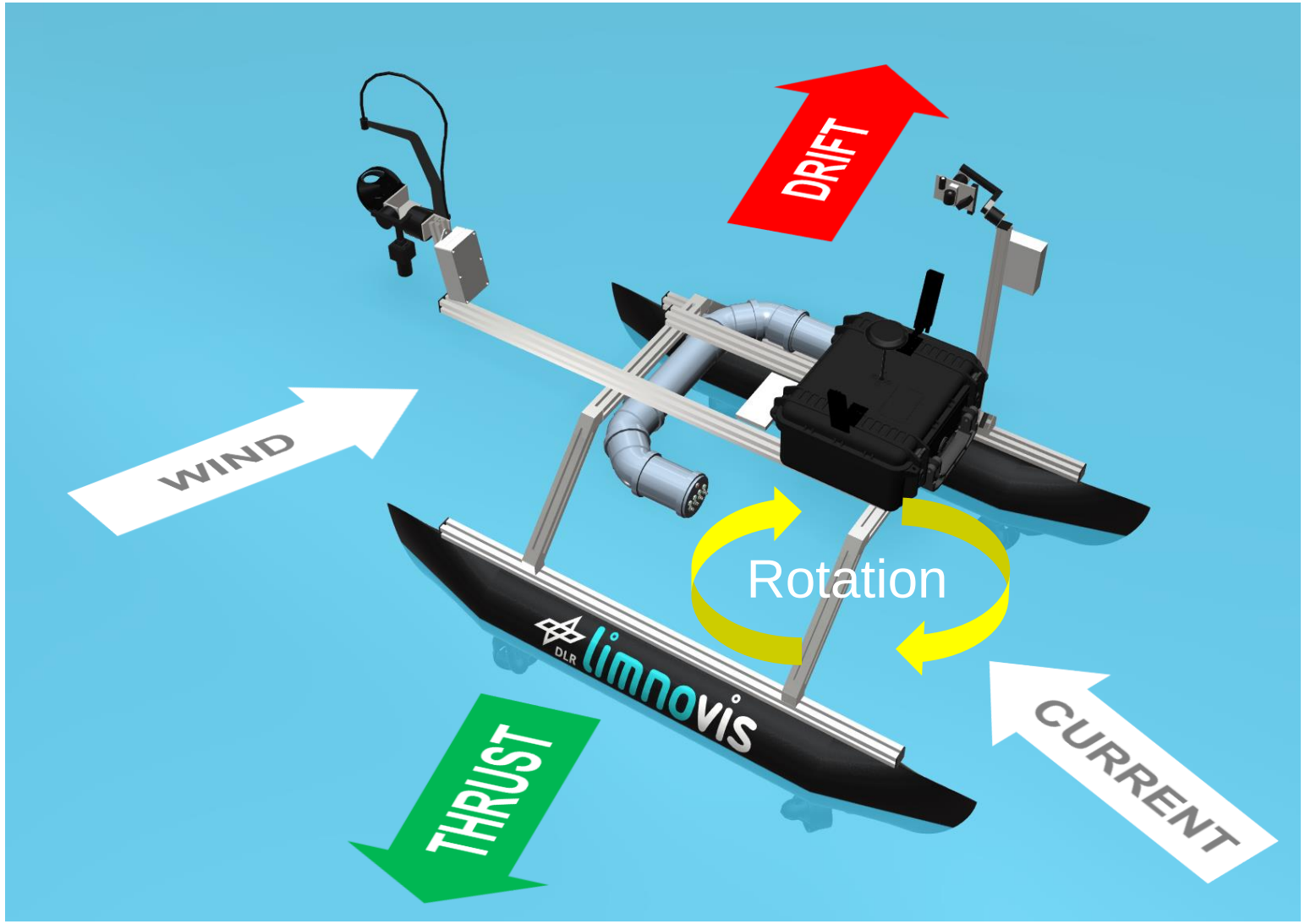
Solution

ship/boat capable of holding position and orientation simultaneously and **indepedently**

LimnoVIS: USV with Omnidirectional Maneuverability

Vehicle

- operates remotely controlled or autonomouos
- compact size: approx. 1.5 m x 1 m
- precise RTK GPS (acc. up to 1 cm)
- positioning accuracy ~10 cm
- can keep/change position and orientation **independently**



LimnoVIS: Measuring R_{rs}

Hold Position and Orientaion

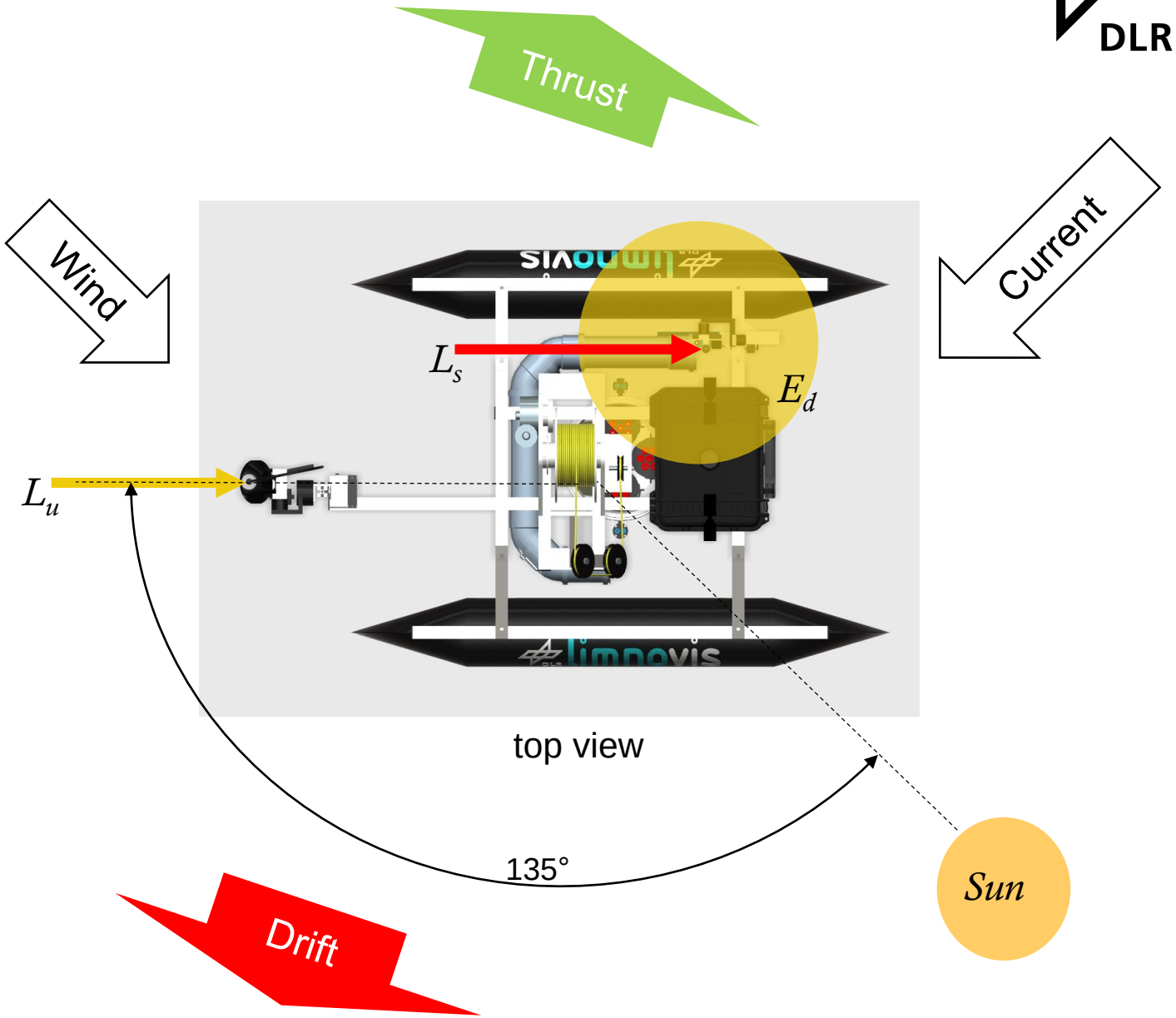
- stationary measurement with fixed position and orientation

Hold Position + Change Orientation

- BRDF Measurements

Change Position + Keep Orientation

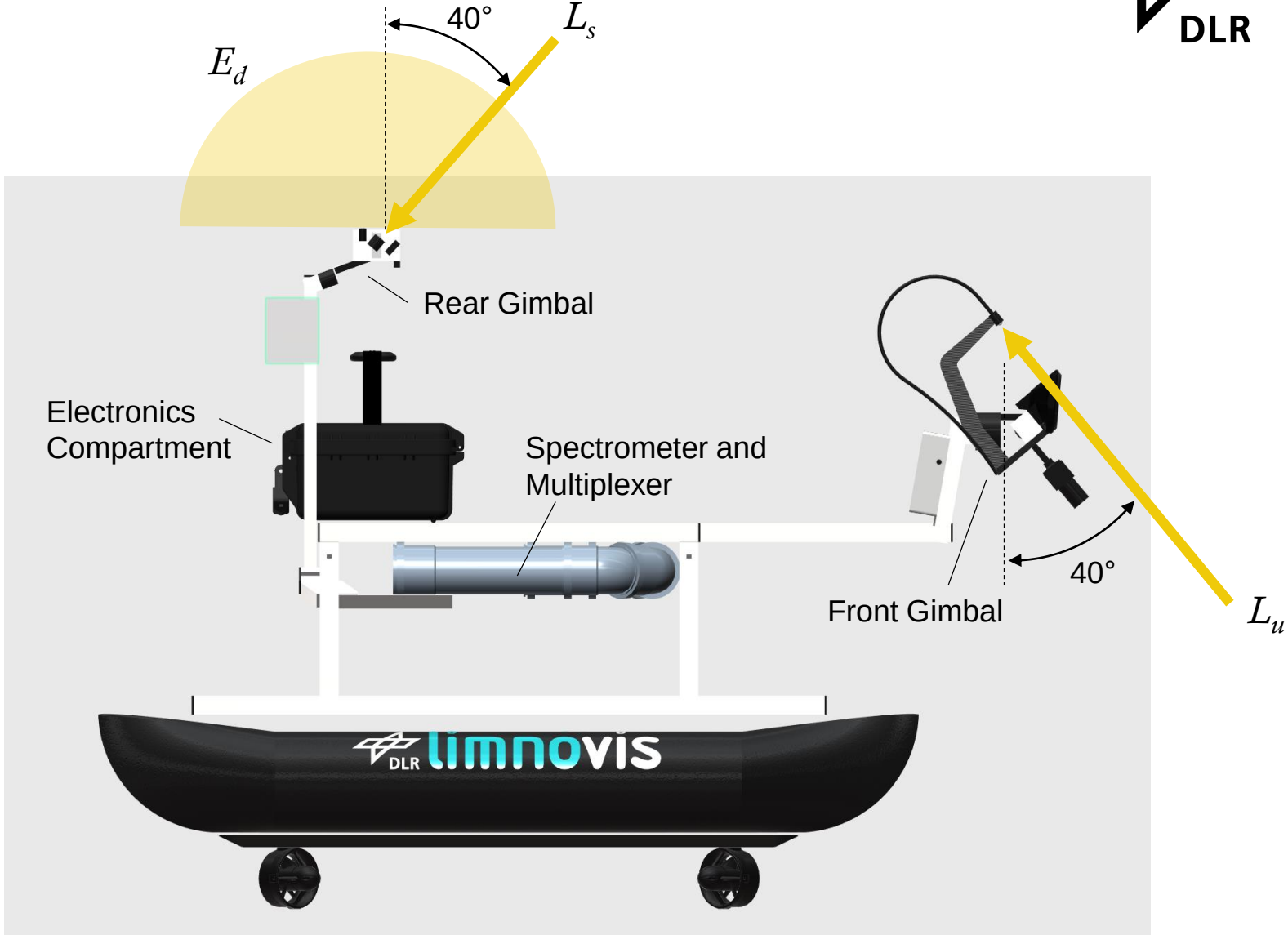
- measuring transsects with constant orientation



LimnoVIS: Measuring R_{rs}

Setup

- optics for measuring L_u and L_s can be set to an arbitrary viewing angle
- optics are gimbal-stabilized to compensate for waves
- E_d can be measured by a dedicated optics with cosine corrector or via L_u optics and diffuse reflectance standard
- 3 different reflectance standards can be turned into the L_u light path



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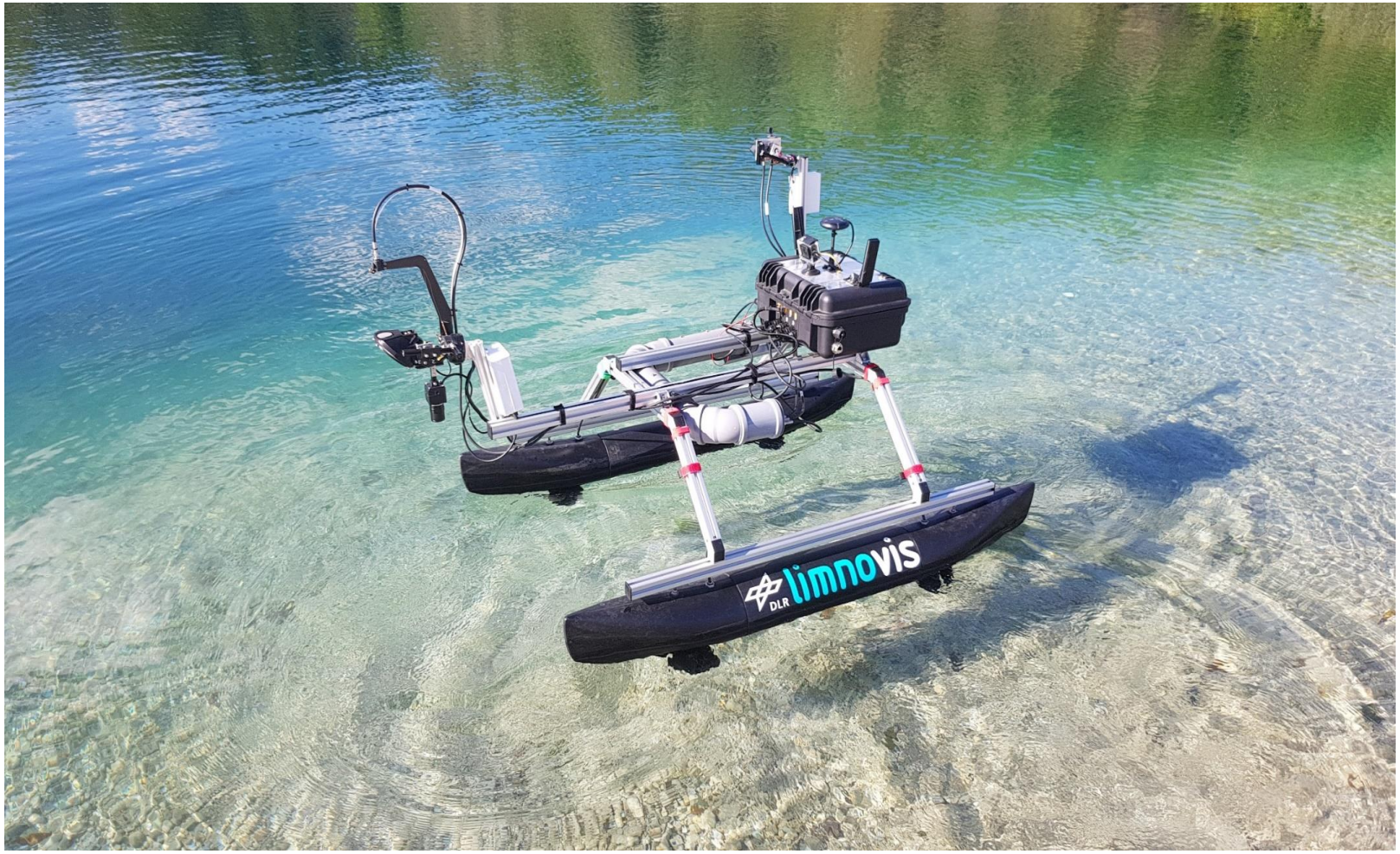
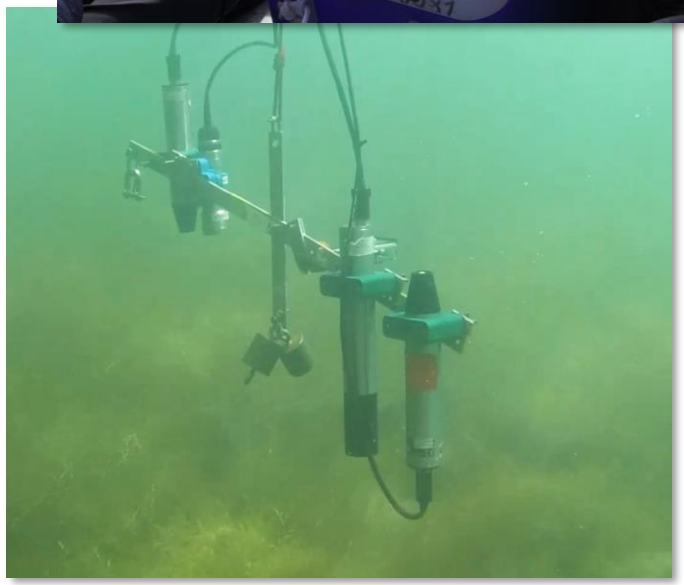


Measuring Benthic Reflectance

Common Methods

- diver with UW spectrometer:
  - costly
  - additional logistics needed
- UW spectrometer on cable:
  - low spectral resolution
  - no illumination
  - bulky setup
- sediment grabber + measurement in air:
  - disturbed sample
  - unknown effects of measuring in air instead of water



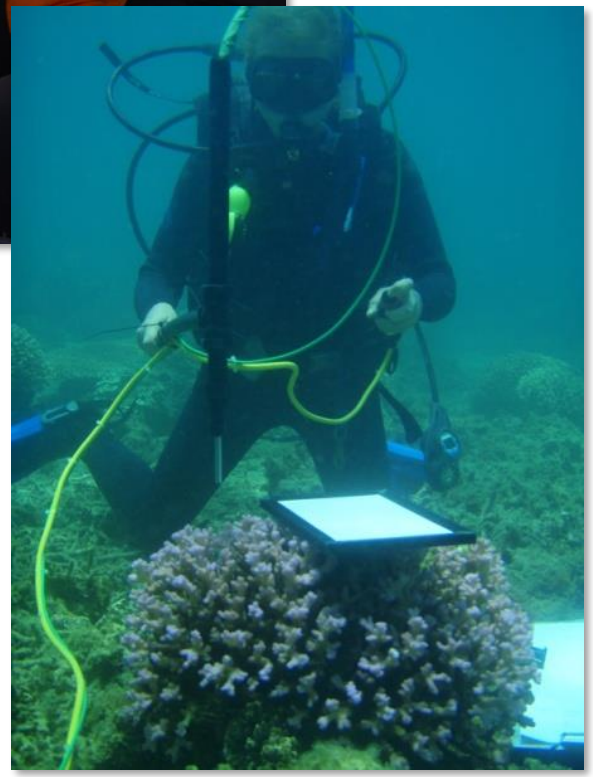
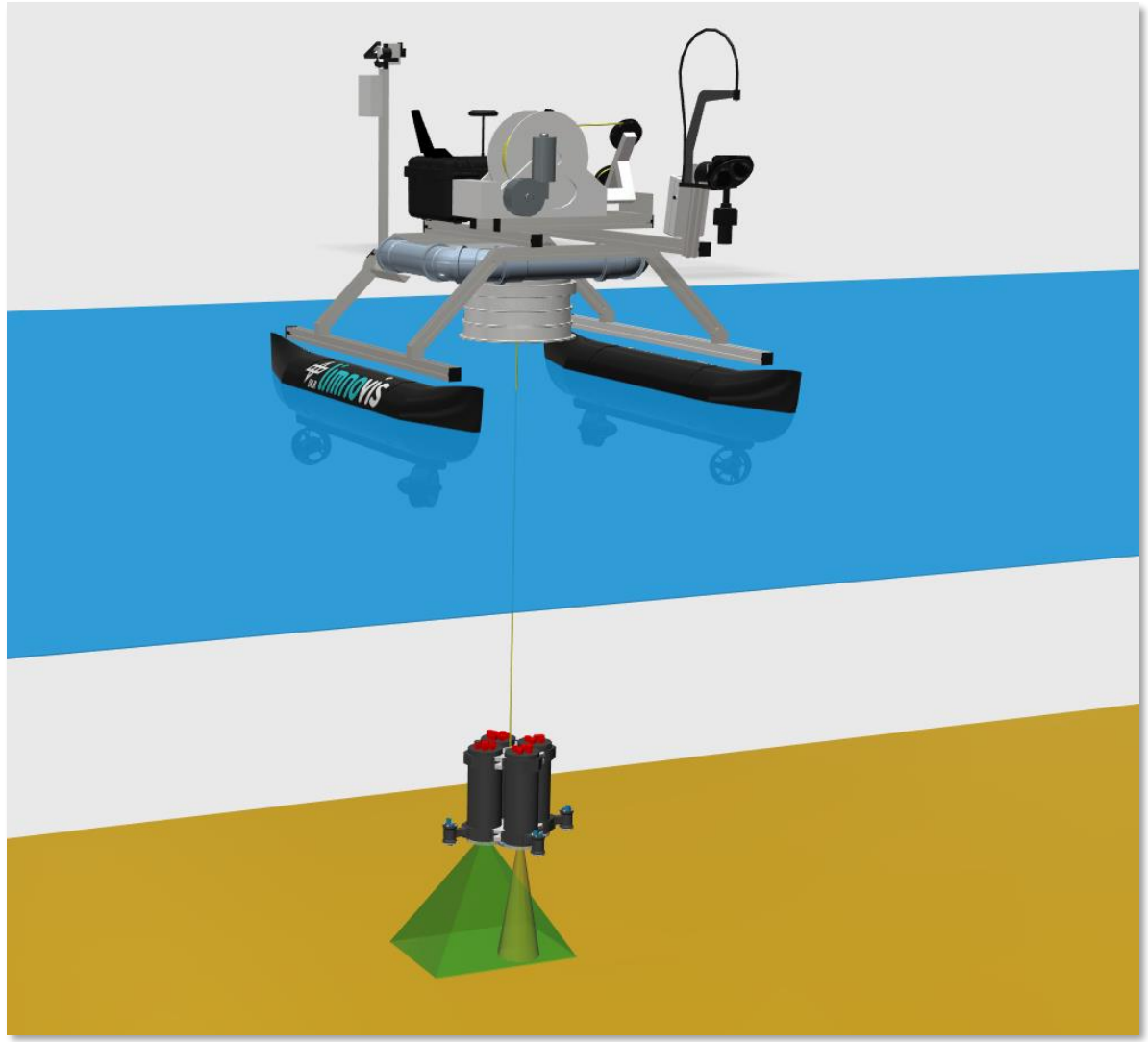


Image: N. Pinnel

Measuring Benthic Reflectance

LimnoVIS Method

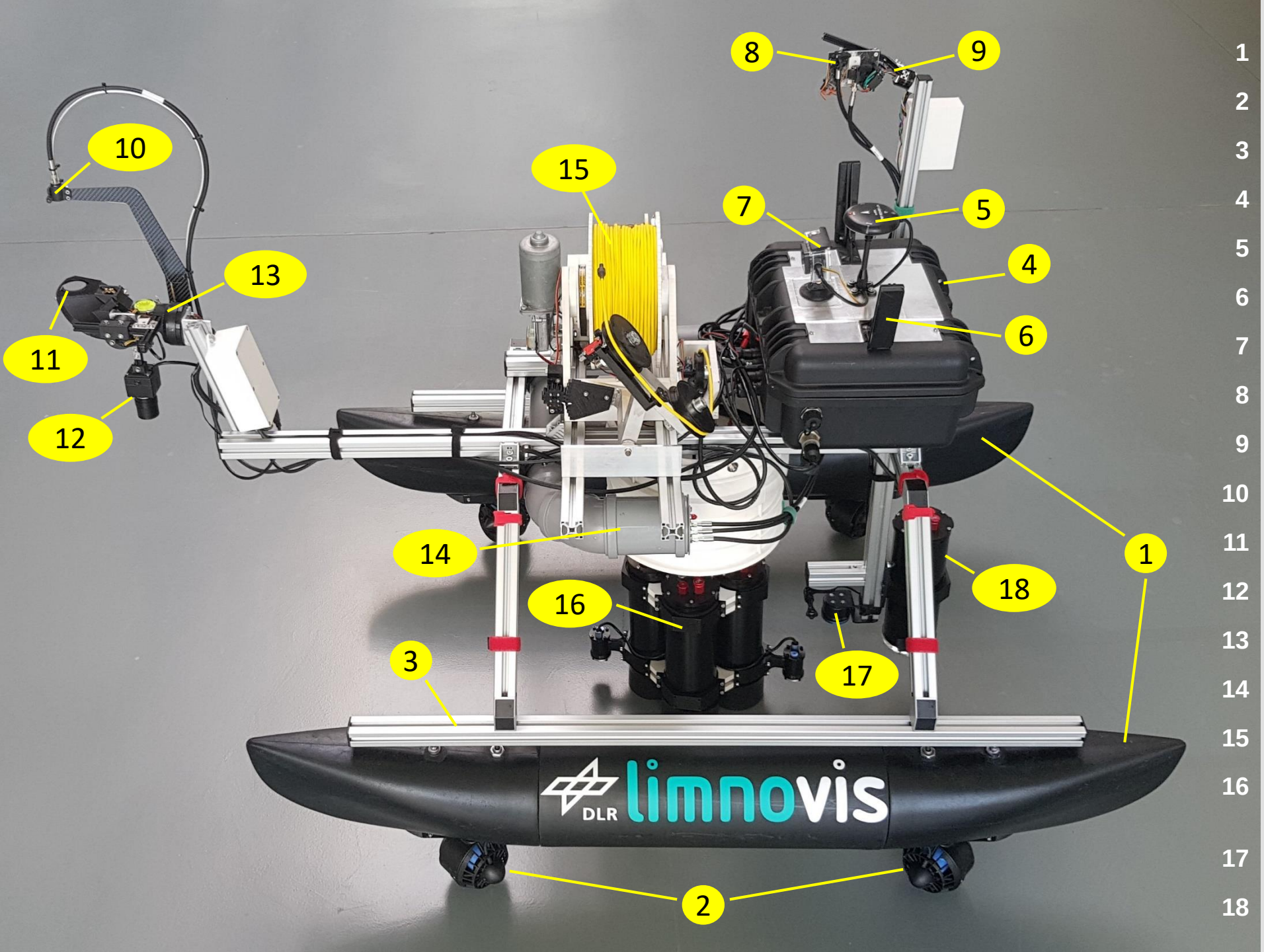
- profiler equipped with Broadcom QWave VIS/NIR Spectrometer (350 – 880 nm, ~1 nm resolution)
- E_d measured via diffuse reflectance standard
- active illumination (halogen lamp) for spectrometer measurements
- live view camera for supervising measurement and for documentation



LimnoVIS Profiler

Additional Features

- mounted on winch with 30 m cable
- green laser rangefinder for measuring distance to bottom
- additional LED illumination for taking photos
- logging of temperature profile for improving echosounder accuracy
- benefits from position holding capabilities of LimnoVIS



1	Hulls
2	Thrusters
3	Frame
4	Electronics
5	GPS Antenna
6	Data Antennas
7	Navigation Camera
8	L_s and E_d Optics (Cosine Corrector)
9	L_s and E_d Gimbal
10	L_u and E_d Optics (via Spectralon)
11	Changeable Reflection Standards
12	Camera for Documentation
13	L_u and E_d Gimbal
14	Spectrometer with Multiplexer
15	Winch for Profiler
16	Profiler with Spectrometer and Camera
17	Echosounder
18	Underwater Camera

Outlook 2023

- finishing software for sensor control (user interface) and data storage
- first application for R_{rs} validation (EnMAP) at Lake Constance
- EU Horizon project *Triquetra*:
  - photogrammetric mapping (2D and 3D) of shallow-water cultural heritage site at Lake Starnberg
  - Bathymetric survey with echosounder
- testing setup for BRDF measurements
- comparative E_d measurements: cosine corrector vs. reflectance standard
- adding a sky-blocking L_u sensor

Imprint

Topic:	**LIMNOVIS** A new platform for optimized in-situ validation measurements at inland water bodies
Date:	2023-03-22
Author:	Stefan Plattner, Peter Gege, Thomas Schwarzmaier
Institute:	Remote Sensing Technology Institute (IMF)
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