

The USTUTT-FSL: Development and Validation of an Offshore-Ready Scanning LiDAR for Marine Atmospheric Wind Field Measurements

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- **Floating scanning LiDAR measurements are feasible.**
- **The USTUTT-FSL is the first scanning LiDAR specifically designed for deployment on floating LiDAR buoys.**
- **The ongoing SSwiFT project aims to validate the system under real offshore conditions.**

SYSTEM ARCHITECTURE

- The USTUTT Floating Scanning LiDAR (USTUTT-FSL) developed at the **University of Stuttgart** is a compact, lightweight and energy-efficient scanning LiDAR specifically optimized for operation on floating buoys.

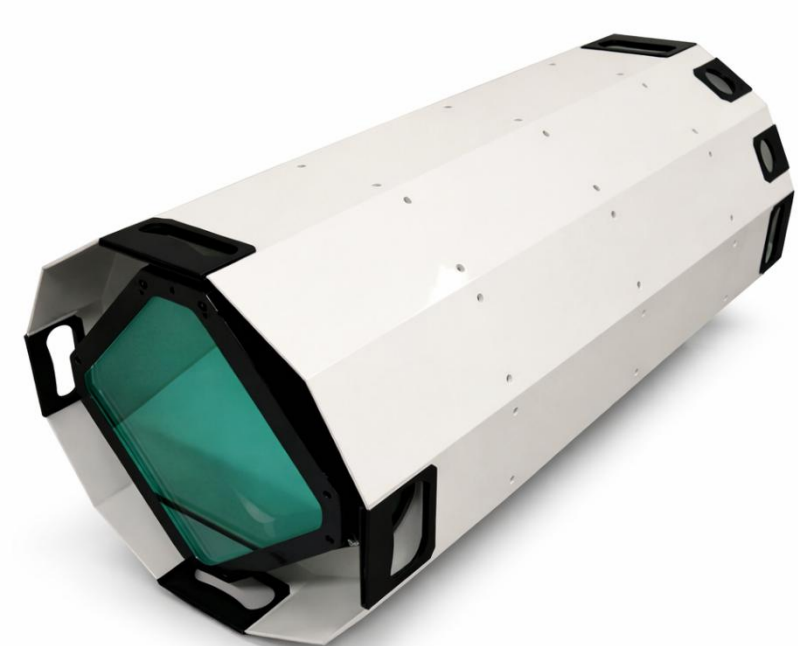


Fig. 1: USTUTT-FSL (Floating Scanning LiDAR)

- Technical specifications:
 - Dimensions (D x L): $\varnothing 370 \times 720$ mm
 - Weight: **35 kg**
 - Power consumption: **max. 85 W**
 - Protection class: **IP67**
 - Measurement range: **45–885 m**
 - Range resolution: **15 m (59 range gates)**
 - Scanning angles: **Azimuth/Elevation: $\pm 26,6^\circ$**
- Technical innovations:
 - Configurable scan geometries
 - Optimized scan speed and measurement range
 - Integrated IMU / GNSS motion tracking
 - Precise scan trajectory control and targeting
 - Real-time system communication

MOTIVATION

- **Floating LiDAR systems** are widely used in offshore wind energy for **wind resource assessment and site characterization**.
- Current systems rely on **vertical profiling LiDARs** (e.g. ZX300M, WindCube 2.1 XP), which measure vertical wind profiles but are limited to predefined measurement patterns (e.g. VAD or DBS).
- **Scanning LiDAR systems** enable spatial wind field measurements and new applications (e.g. wake characterization, power curve verification, wake steering assessment)
- However, commercially available scanning LiDAR systems (e.g. WindCube 200S/400S, StreamLine) have **not yet been deployed on floating buoys**.
- To address this gap, the **University of Stuttgart** developed the **USTUTT-FSL**, a scanning LiDAR specifically designed for deployment on floating platforms.

PROOF OF CONCEPT – NEOWIND

- A measurement campaign on an EOLOS FLS200 floating buoy demonstrated the feasibility of offshore scanning LiDAR measurements using the USTUTT-FSL.

OVERALL CONCEPT: LiDAR MODULAR SYSTEM

- The **LiDAR Modular System (LMS)** combines **vertical profiling LiDARs** and **scanning LiDARs** on a single floating platform.
- The combined operation enables new offshore measurement capabilities and improved characterization of the marine atmospheric wind field.



Fig. 2: USTUTT-FSL integrated into the EOLOS FLS200 buoy as part of the LiDAR Modular System (LMS).

NEW RESEARCH PROJECT: SSwiFT Wind

- **SSwiFT: Scanning & Simulating Flow with Floating LiDAR Technologies**.
- Duration: **01/11/2025 – 31/10/2027**
- Follow-up project to further develop and validate the USTUTT-FSL within the LMS
- Includes a **6-9 month offshore measurement campaign** to validate USTUTT-FSL and compare its performance with established LiDAR systems, targeting advancement towards **TRL 7**.
- Assimilation of USTUTT-FSL measurement data into high-resolution LES models



Fig. 3: SSwiFT concept: floating scanning LiDAR measurements, offshore validation and LES.

CONCLUSION AND OUTLOOK

- **USTUTT-FSL demonstrates the feasibility of floating scanning LiDAR measurements.**
- **The SSwiFT project aims to validate the system under real offshore conditions and advance the technology towards industrial deployment.**

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