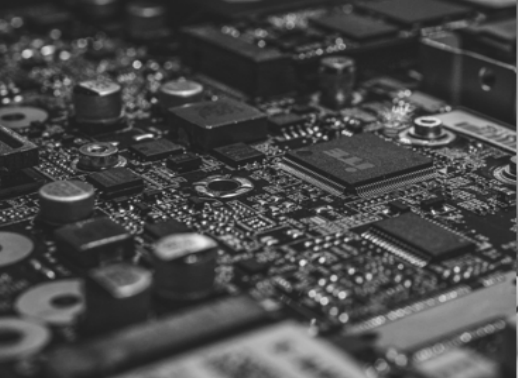

The OpenLidar initiative for wind lidar hardware and software collaboration

Wind lidars are complex devices that take huge expertise to develop and operate. How could future lidar be designed to enable and support experimentation and collaboration?

The OpenLidar initiative was started in 2015 by members of IEA Wind Task 32. Its goal is to encourage collaboration around wind lidar hardware and software by developing a modular wind lidar architecture and providing a framework for cooperation.

Integrated solutions are not the only answer

Wind lidar are designed and optimised for specific applications, for example to measure vertically-resolved profiles or to scan arbitrary patterns from a fixed point. They also integrate much of their function into a single unit. This focus reduces manufacturing costs and helped enabled early adoption by simplifying industry learning, but it also has some drawbacks. Such integrated systems are hard to adapt for other tasks, are usually "black boxes", can be over-engineered, and are hard to upgrade. As a result new applications often require entirely new devices. This need to start from scratch reduces the potential for technological innovations and makes it harder to try new applications.

The benefits of modular wind lidar

Most wind lidar manufacturers tend to have a base design that they adapt for different uses. This reduces development costs and can speed market acceptance. For example, a scanning optics head (for following an arbitrary measurement path) could be replaced with a rotating prism to create a vertically-profiling lidar. As a result, many lidar designs are already inherently modular. However, the module boundaries are not consistent across suppliers and so cannot be exchanged. Also, there is often little information about the data processing taking place inside the modules.

Coordinated modular lidar would allow systems to be changed and optimised depending on the lidar's use case. Modules could be developed by experts and combined by users for specific use cases. This would require well-defined interfaces between the modules for power, signals, and mounting. Ideally, vendors would also provide detailed documentation of each module.

OpenLidar

The OpenLidar concepts

The heart of the OpenLidar initiative is the idea of modular lidar systems with clear interfaces and good documentation. Based on a survey of existing devices, the OpenLidar group developed a generic modular wind lidar architecture where the modules are connected by power and data buses (Figure 1 and Table 1). The function of each module can be customised for a specific application.

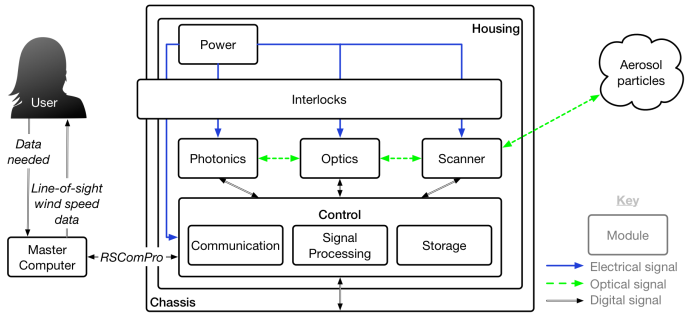

Figure 1: The OpenLidar modular wind lidar concept uses digitalisation to enable innovation in wind lidar.

Each module requires interfaces, a module-specific controller to convert commands into action, and hardware and software to implement those commands. The modules would also be documented. These interfaces, controller, hard- and software, and documentation would allow them to be combined with other modules to create a lidar system with predictable characteristics. Importantly, such a lidar could also be modelled in detail using the design information, and those models could be validated through module unit tests.

It is important to note that a functioning lidar does not have to be a single unit. It could also be several hardware units connected by cables for data, power, and signals. These separate units would be for e.g. the photonics, optics, and scanner (e.g. Figure 2) and there would therefore be several chassis and housing modules, each with their own interlocks.

DOI 10.5281/zenodo.3414197
Version 0.9: September 24, 2019

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Table 1: The main functions of the OpenLidar modules.

Module	Function
Power	power conversion and conditioning, current and voltage control
Interlocks	safe operation of the system
Photonics	Laser source, beam splitter, detector
Optics	beam forming and focusing
Scanner	beam steering, position sensing
Controller	manages other modules; converts input commands to system actions
Communications	transfer data to/from the device
Signal processor	process raw data to e-WindLidar level 0 data [1]
Storage	data memory
Housing	weather protection, environmental conditioning
Chassis	physical carrier(s) for modules

Modular lidar in use

The OpenLidar group set out a potential architecture for modular wind lidar in 2016. A similar architecture was used in a scanning device in 2017 [2], and in 2018 a UK lidar company partnered with a University to connect a ground-based lidar to optics mounted on a drone via a glass fibre [3]. Now, several companies supply lidar systems where the optics, photonics, and data processing units are in separate units.

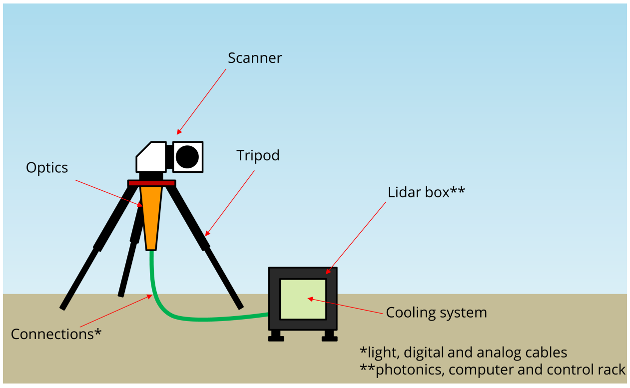

Figure 2: Openlidar modules can be combined in many ways.

Breaking lidar up into smaller and lighter units will lead to experiments for other applications, for example in urban meteorology, for vehicles and aviation, and elsewhere.

The OpenLidar development roadmap

The IEA Wind Task 32 OpenLidar Working Group aims to support the development of modular wind lidar. This group will document the modular architecture and their interfaces, allowing vendors and other manufacturers to develop hardware and software for the modules. These hardware and software can then be used by others for new applications.

During 2020 more than 20 PhD students will start working on projects in two EU Horizon 2020 Innovative Training Networks, Lidar Knowledge Europe (ITN LIKE) and FLOAting Wind Energy NetwoRk (ITN FLOAWER). Several will apply the OpenLidar concept, adding to the body of knowledge around the development and use of modular lidar.

Documentation will be an essential part of the OpenLidar platform. The architecture and modules are documented at Github/e-WindLidar. Github provides structured environment for creating the definitions and gathering feedback, and is familiar to most of the software development community. Anyone designing, building, or selling OpenLidar modules is encouraged to review these, and provide information about their modules.

Conclusions

The OpenLidar concept aims to enable innovation and collaboration on wind lidar device hardware and software by creating a well-defined modular architecture. This is documented at Github and can be used by anyone working on wind lidar technology.

References

The following documents are all open access.

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This white paper was self published by IEA Wind Task 32.

The International Energy Agency is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 30 member countries and beyond. The IEA Wind Technology Collaboration Programme supports the work of 38 independent, international groups of experts that enable governments and industries from around the world to lead programmes and projects on a wide range of energy technologies and related issues.

IEA Wind Task 32 exists to identify and mitigate the barriers to the deployment of wind lidar for wind energy applications.

For more information: See the OpenLidar module definitions on GitHub. We welcome feedback as issues. **Authors and OpenLidar initiative team:** Andrew Clifton (U. Stuttgart, Germany), Nikola Vasiljevic (DTU Wind Energy, Denmark), Ines Würth (U. Stuttgart), Steffen Raach (U. Stuttgart & sowento), Florian Haizmann (ZSW), Holger Fürst (U. Stuttgart). **Images:** Banner, left to right: Alexandre Debiève on Unsplash, SWE U. Stuttgart, Markus Spiske on Unsplash. Figure 1 by A. Clifton. Figure 2 by N. Vasiljevic.