INNOVATION AT PORT: A SMART APPROACH TO SUSTAINABLE AND RESILIENT OPERATIONS

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Weather and air quality measurements are part of a modern system supporting the safe and sustainable operation of complex port environments. Reliable and accurate measurement of weather conditions are critical for approaching the port and berthing safely, while tracking the amount, sources and movement of air pollution gives port authorities the power to make informed decisions and comply with local regulations.

Improving air quality and weather resilience are high priorities for ports surrounding industries and communities. Even as organisations work to mitigate air pollution, climate change is bringing more severe weather events more often. Addressing these challenges can potentially save millions of lives and billions in costs, not to mention preserving the environment for generations to come.

Many cities are taking a "smart city" approach to solving these challenges by enhancing situational awareness and optimising resources to maximise wellbeing. Think innovation, participation, collaboration and coordination between all stakeholders.

Fortunately, the same technology that enables cleaner and safer communities is also an advantage for port environments.

NOWCASTING FOR SAFER AND MORE EFFICIENT PORT OPERATIONS

The modern alternative to generic forecasting, the point nowcasting, delivers hyperlocal weather conditions to port authorities up to six hours ahead. Nowcasting tools dramatically improve situational awareness, improve safety and operational continuity, and enable much more confident, data-driven decisions: safe timing of vessel approaches and crane lifting operations, more accurate determination of the real need for tugs supporting vessels and mooring needs at berth, plus safe loading and unloading operations during the right wind conditions to name a few.

ABOVE
Port of Genoa, Italy, where the WindCube Scan 400S was located for Project Thunderr

For example, operators can make just-in-time decisions to move dusty bulk when there is no wind or determine whether spraying water will be effective in current conditions. Port leaders can protect personnel before the storm hits and reduce downtime after passing storm, instead of making an educated guess on closures. Aside from averting major accidents, these have serious implications for day-to-day operational continuity.

USE CASE: NOWCASTING WITH WIND LIDAR

Wind is the world's most destructive natural phenomenon, and port environments are continually exposed to the elements where their structures are put to the test. Europe has a 50-year-old model for forecasting the effects of cyclones on ports, but none for thunderstorms — partly because storms along the coasts are rare and brief. This exposes ports to safety risks and has led to over-engineered or inadequately built port structures.

The wind engineering group at the Department of Civil, Chemical and Environmental Engineering (DICCA) at the University of Genoa, Italy, began a project to understand wind fields and optimise wind forecasting. Project Thunderr became an ongoing collaboration

LEFT
WindCube Scan 400S in Italy, port of Genoa. Courtesy of University of Genoa and the Project Thunderr.

"EVEN AS ORGANISATIONS WORK TO MITIGATE AIR POLLUTION, CLIMATE CHANGE IS BRINGING MORE SEVERE WEATHER EVENTS MORE OFTEN."

including organisations in Germany, the Netherlands and Canada which leverages wind LiDAR to expand storm research and improve port construction and structure design.

DICCA selected the Vaisala WindCube® Scan 400S Doppler LiDAR, which provides 3D scanning at ranges up to 10 kilometres from the shore, to complement the extensive wind monitoring network. Spanning several ports across Italy and France, the wind monitoring network includes more than 30 ultrasonic anemometers, 3 LiDAR vertical wind profilers, and PTH sensors. The network detects the position, diameter, structure, direction and translational speed of downbursts, while software separates wind events and collects a wide range of information types to classify the weather scenarios in which thunderstorms occur. WindCube Scan plays an important role in proving how LiDAR can be used for updating decades-old forecast models — and creating new ones — for use in port construction and operations.

Project Thunderr was completed in 2021, with project leaders on track to study 25 thunderstorms during this time. The project has already provided extensive, promising data that could enable everything from wind tunnel testing of new building designs to new classifications for the types and severity of storm-related structural damage. After Project Thunderr, new European research project called ERIES was established, which is focused on the transnational access of research infrastructures in the fields of structural, seismic, wind and geotechnical engineering, for carrying out research on the reduction of losses and disruptions due to multi-hazards, the management of the associated risks and the development of solutions for a greener and more sustainable society. Scanning LiDAR will be used as part of this project to help develop future standards for experimental techniques in wind engineering.

Massimiliano Burlando, Associate Professor at the University of Genoa, said: "In Project Thunderr LiDAR equipment helped us to capture fine detail from the inside of a storm, so we could gauge its geometric structure, distribution and evolution as the storm progresses... Data from the research will help us to design and build safer and more cost-efficient dock structures."

THE WEATHER AND AIR QUALITY CONNECTION

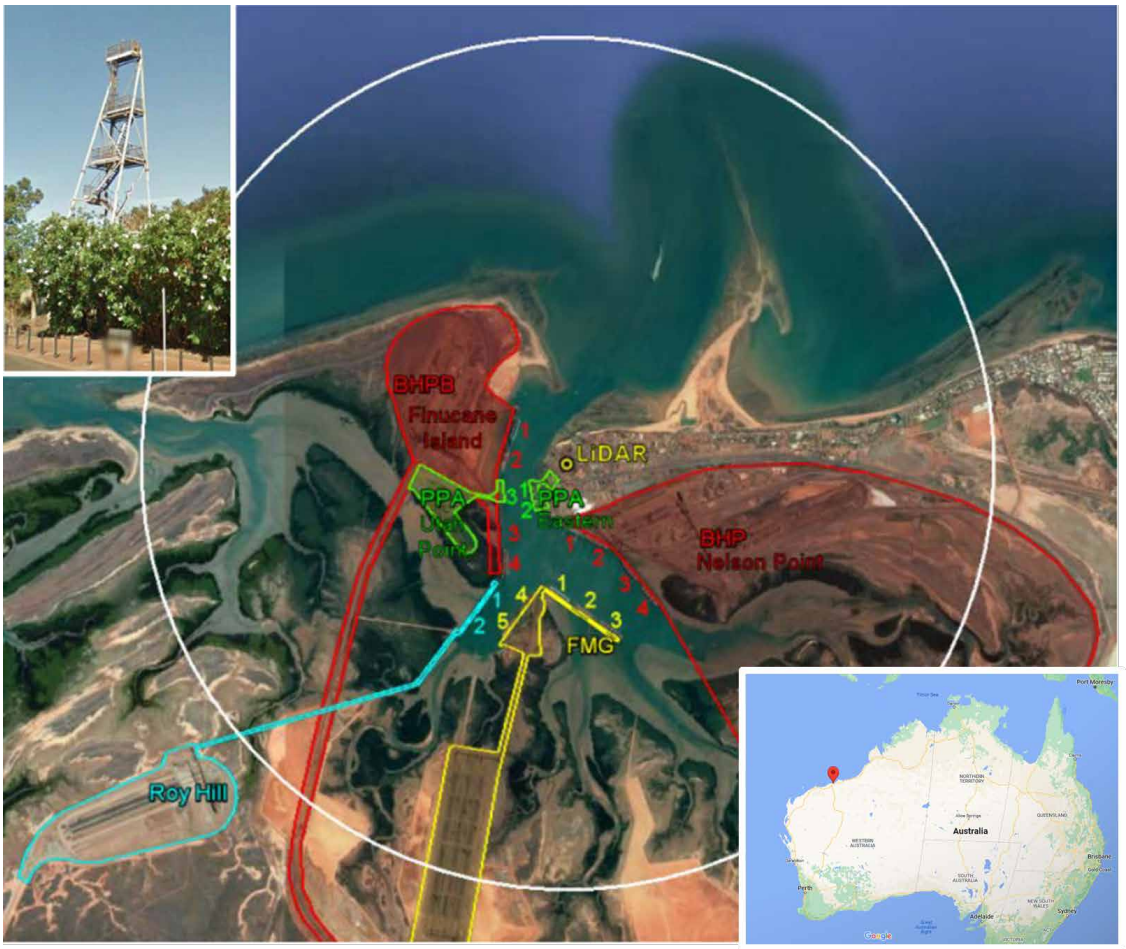
Air quality is always connected to the weather, and their measurements are much more valuable when combined with real-time data about wind speed and direction, temperature, humidity, barometric pressure and other factors that directly affect pollution and its travel.

This information does more than help port authorities track and measure pollutants. Health and safety managers, harbour masters and other decision makers can understand the location and concentration levels of dust plumes, while historical data helps them meet documentation standards and demonstrate actions and their effectiveness.

WIND AND AEROSOL LIDAR: FILLING GAPS IN PORT AIR QUALITY AWARENESS

Despite advances in measurement and analysis technology, there are significant gaps in many ports' understanding of local air quality and weather conditions. General weather and air quality forecasts have never been enough: in addition to constantly changing coastal conditions, large port areas often include different structures and landscapes that create microclimates where emissions, wind and sea spray fluctuate.

Doppler LiDARs such as WindCube Scan retrieve wind information by analysing the doppler shift of laser beams backscattered by particles in the atmosphere. The backscattered signal received by the LiDAR is highly dependent on atmospheric particles (type, size, density), and a lot of additional information can be retrieved by



LEFT
Port Hedland outlining industries and players currently using the port to export commodities such as BHP, Fortescue Metals Group Limited (FMG), Roy Hill, Pilbara Ports Authority (PPA) and Dampier Salt. The five-kilometre radius white circle is centered on the LiDAR location atop the Town Centre Viewing tower (inset) and represents the approximate coverage of the LiDAR beam.

Image source: Adapted from Government of Western Australia, Department of Water and Environmental Regulation (DWER) 2018, "Mapping dust plumes at Port Hedland using a LiDAR, Technical series - Report No. 2", Feb, p.3."

adequate signal processing.

In addition to wind information, WindCube Scan provides unambiguous information on the relative levels of dust and helps localise and identify dust emissions with clear insights on sources and propagation pathways. The technology also tracks the atmospheric boundary layer height for excellent awareness of pollutant levels. These measurements are useful for ports and other industrial centres that generate substantial particulate emissions carried by the wind in hard-to-predict ways.

USE CASE: SCANNING LIDAR FOR MONITORING FUGITIVE DUST

In the small town of Port Hedland, Western Australia, the Department of Water and Environmental Regulation (DWER) launched a measurement campaign to evaluate sources and amounts of dust that typically move through the area. In addition to natural sources of dust, DWER wanted to see whether port activities contribute significantly to these levels.

There are several large export facilities near the town and it is difficult to determine the causes of emissions based on a conventional PM monitoring network. Determining dust sources and their pathways is critical for understanding exposure to urban communities and adapting dust mitigation strategies.

To address this question, DWER chose the Integro™ Lidar Network developed by Vaisala partner Acoem Australasia (Ecotech Pty Ltd.). Integro is composed of a

LEFT
Port Hedland, Australia

Vaisala WindCube Scan LiDAR, PM monitors, meteorological sensors and Acoem Airodis™ software.

Integro is a turnkey solution that correlates data from dust monitors and optical data from WindCube Scan to display 3D, near-real time mass concentrations (in µg/m3) for the complete area scanned with the LiDAR. This calculation occurs within a few minutes with Acoem Airodis software using a correlation algorithm developed by Acoem Australasia. This provides operation managers with data that allows immediate implementation of targeted dust management measures.

The campaign took place over a five-month period in 2017 and included a Vaisala WindCube Scan 200S LiDAR, installed and operated by Acoem Australasia, along with air quality monitoring equipment. The WindCube Scan 200S performs 24/7 real-time wind and aerosol measurements and high-level data processing. It is a versatile tool for recovering accurate wind and aerosol backscatter measurements in any scanning geometry up to 6km.

Two Beta Attenuation Monitors (BAM) were set up to collect additional data. WindCube Scan measurements were focused on assessing sources of dust lift off, while the BAM results measured air quality against interim air management criterion and provided reference points.

DWER published their findings in the report: 'Mapping dust plumes at Port Hedland using a LiDAR, Technical series - Report No. 2.' Among their main conclusions:

- There were three instances near the port area where PM10 levels exceeded guidelines of 50 micrograms per cubic meter, mostly due to dust lift-off from wind or mechanical processes, and originated from a southerly direction.
- The LiDAR and BAM showed a strong correlation, giving DWER confidence in using scanning LiDAR as a valid representation of atmospheric particle loading.

ADAPT TO A GUSTY FUTURE, CONFIDENTLY

Wind LiDAR is already crucial for many applications across the wind energy, aviation, meteorology, and maritime industries. Today, with climate change providing new risks and operational challenges, ports can quickly and efficiently deploy wind LiDAR to make a real difference to their operations. The same scanning LiDAR can provide measurements for both wind nowcasting and dust monitoring applications, empowering all stakeholders to make ports and their surrounding environments safer for people and more sustainable for the planet.

"NOWCASTING DELIVERS HYPERLOCAL CURRENT AND NEAR-FUTURE (UP TO SIX HOURS AHEAD) WEATHER CONDITIONS TO PORT AUTHORITIES."

ABOUT THE AUTHORS

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Elena Garcia manages the strategy and business development for Vaisala Urban and Industrial Solutions. She has been working in Leosphere and Vaisala since 2015. In the beginning, Elena worked with WindCube lidars in wind power and then expanded to meteorology and air quality applications. In her current role, she is working to grow and develop Vaisala products and services for new business areas in the field of weather and environmental resilience in urban and industrial areas.

ABOUT THE ORGANISATION

Vaisala Oyj is a global leader in weather, environmental, and industrial measurements. We provide observations for a better world with space-proof technology, even exploring Mars and beyond. Backed by 85+ years developing the most trusted, versatile weather solutions in meteorology, aviation, wind energy, maritime and many other applications, these proven technologies are finding homes at ports worldwide.

We are a reliable partner for customers around the world, offering a comprehensive range of innovative observation and measurement products and services. Headquartered in Finland, Vaisala employs over 2,000 professionals worldwide and is listed on the Nasdaq Helsinki stock exchange.

Learn more about how Vaisala is helping port authorities increase situational awareness and make decisions that make a difference at vaisala.com/sustainableports.