Port Hedland Industries Council

2024

The use of atmospheric LiDAR in Port Hedland

Like many organisations monitoring air quality, PHIC has debated and trialled the benefits of Light Detection and Ranging (LiDAR) technology in Port Hedland. While PHIC acknowledges that LiDAR is a useful tool or technique, trials have identified limitations, which appear to be exacerbated where there are multiple dust sources and other particulate matter in the air, which is the case in Port Hedland.

WHAT IS LiDAR?

LiDAR - Light Detection and Ranging - was developed in the early 1960s and has proven to be an extremely versatile technology used for a wide variety of purposes including remote sensing, vehicle automation and atmospheric studies.

HOW DOES LiDAR WORK?

The basic principle behind atmospheric LiDAR is relatively simple – the instrument (transmitter) releases rapid pulses of laser light along a path (to a receiver) and measures the time it takes for each light pulse to return. This is a similar principle to radar, except it uses a laser beam. The laser pulse signal strength is reduced as it reflects on larger particles in the atmosphere, such as pollen, water droplets, dust etc. The light that is not reflected by particles continues.

WHAT DOES LiDAR MEASURE?

In the case of Port Hedland, the atmospheric LiDAR trials were seeking to understand the potential source, directional movement of dust plumes, and concentrations of dust particles in the Port Hedland Airshed.

LiDAR measures the relative concentration of all particulate matter (not just dust) including PM_{10},$PM_{2.5}$, water vapour, and other suspended particulates and solid objects, which can then be represented visually.

LiDAR is therefore a useful tool in this regard, however care should be exercised when interpreting such imagery on the basis that it is simply a two-dimensional representation of the three-dimensional movement of particles in the atmosphere.

LIDAR MONITOR TOP VIEW

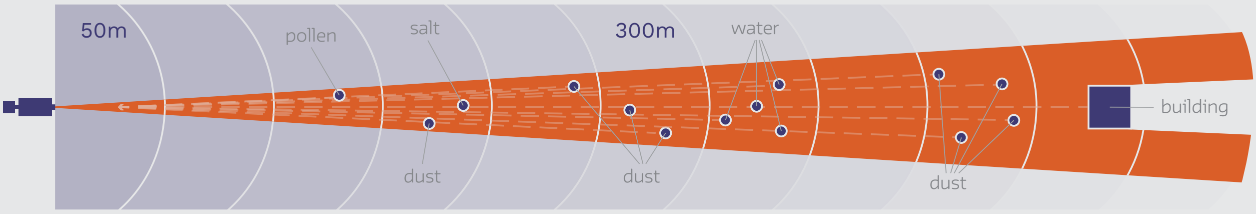
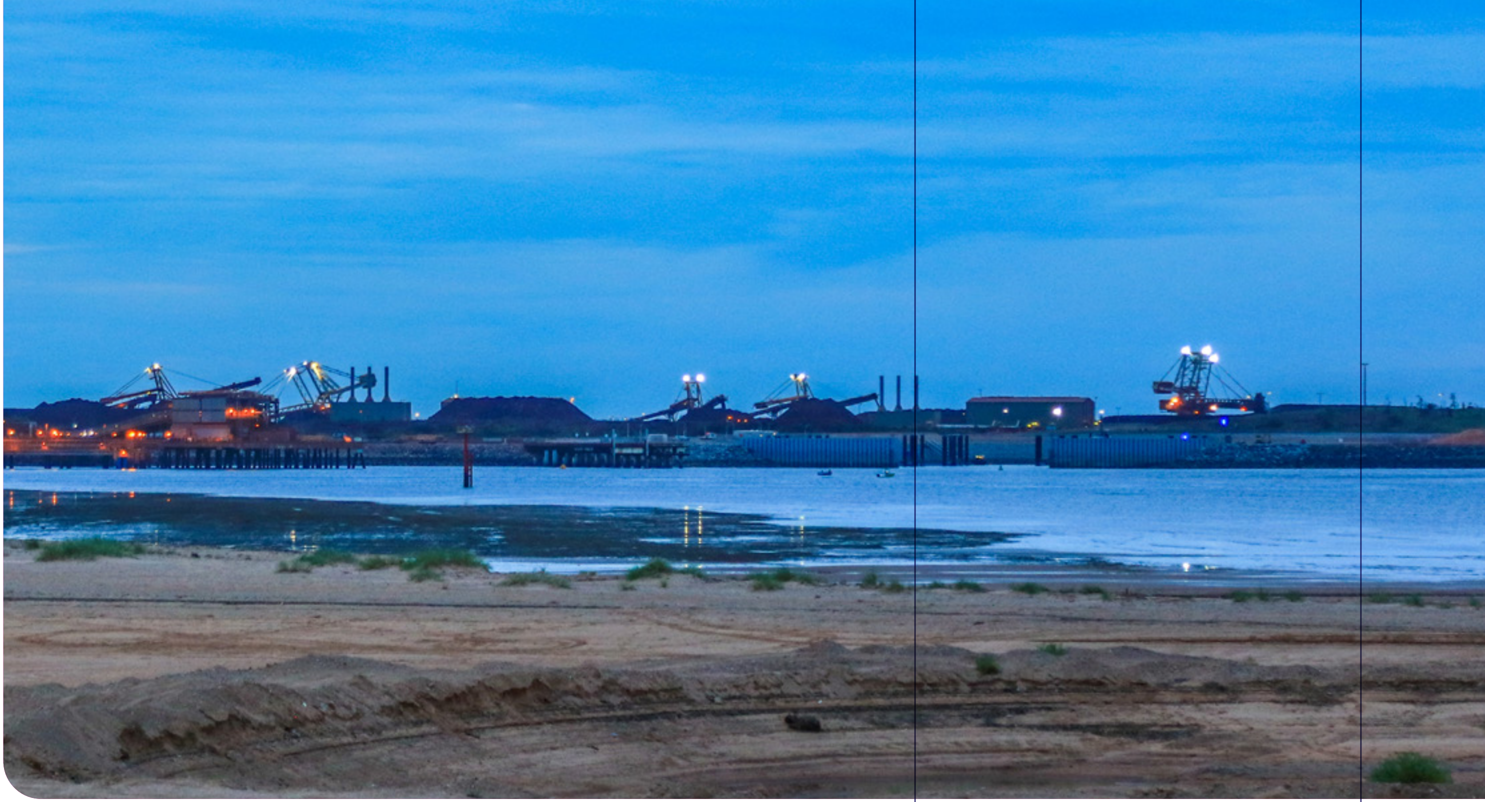


FIGURE 1 LiDAR measures all particulate matter in the atmosphere including, dust, pollen, salt, water vapour and other suspended particles. The measurement doesn't differentiate between types of particulate matter, it provides relative concentration bands of matter. This can lead to a misinterpretation of the data.



LiDAR TRIALS IN PORT HEDLAND

Three trials have applied LiDAR to assess dust in Port Hedland. These trials have been carried out by researchers, government and industry for varying purposes between 2011 and 2017. The trials include:

- CRC CARE (2011)
- PHIC LiDAR trial (2014-2016)
- Department of Water and Environmental Regulation (DWER) (2017).

PHIC has operated a series of Beta Attenuation Monitors (BAM) as prescribed by an Australian Standard (AS/NZS 3580.9.11:2008) in Port Hedland since 2009. These monitors form the Port Hedland Ambient Air Quality Monitoring Network (AAQMN).

All trials undertook some form of calibration to the Port Hedland AAQMN data with the aim of ensuring a correlation factor.

REVIEW OF TRIALS

PHIC commissioned Environmental Technologies and Analytics (ETA) to conduct a review of the three Port Hedland LiDAR trials.

The Use of LiDAR in Measuring Airborne Particulates – A Technical Review of LiDAR Trials in Port Hedland shows the objective for all three trials were similar – to evaluate LiDAR as a tool for determining the sources of dust and tracking their pathways within the Port Hedland Airshed.

A copy of the report is available on the PHIC website.

REVIEW CONCLUSIONS

The review of these reports determined that the general objectives had been met, with the finding that: 'The LiDAR unit is very capable in tracking plumes, if so configured and controlled'.

> "LiDAR calibration is critical to the quality of the data which is produced."

This indicates that LiDAR is excellent at showing relative backscatter maps. However, the application of calibration to convert the results to mass concentration can be difficult and to date, the methods used have been technically simplistic. It is also essential that the limitations of LiDAR raised in the ETA review be taken into account when undertaking future studies.

LIDAR MONITOR SIDE VIEW

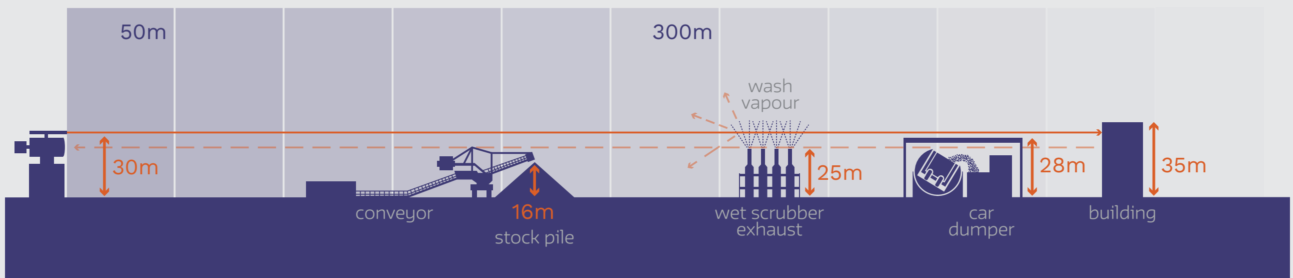


FIGURE 2 LiDAR only operates at the level it has been set. The return signal only monitors either elevated sources or plumes that have reached the scan height.

SUMMARY OF REVIEW FINDINGS

A review of the three trials was conducted by Dr John Holdsworth from the University of Newcastle for Environmental Technologies & Analytics (ETA). The aim was to determine the appropriateness and validity of relying upon LiDAR as a monitoring tool for ambient dust measurement. Important issues included:

- Scanning height of the LiDAR
- Sampling angle
- Wind speed
- Data presentation
- Calibration to Australian Standard monitors

Please see the full report for more details.

Scan height

A 2-D scan may not provide an accurate representation of source locations (Figure 2).

Plumes from elevated sources could be over-represented in the LiDAR scan, giving the skewed impression that these are the only dominant sources within the Airshed.

Plumes from ground level sources could be ignored, or underrepresented.

This could happen if the plume does not reach the height of the LiDAR scan or becomes 'diluted' with height and distance downwind.

There is also the potential for plumes from co-located sources to merge.

Wind speed

The wind speed increases with height, so the wind speed (and potentially the wind direction) is higher at the LiDAR scan heights than at 10m, the height at which wind speed measurements are often taken.

Sampling

Due to the measurement methodology, each full 360 degree scan of the LiDAR takes 10 minutes, allowing for two seconds for every one degree arc.

As the distance from the LiDAR increases the area contained within the scan also increases, which decreases the spatial resolution. (see Figure 1).

Data presentation

There was limited information to determine the process of converting the raw data into a visual scan.

There were incidencies of the code being adjusted to improve the visual representation.

The results were adjusted to highlight the anthropogenic plumes rather than show the natural aerosol load existing in the region.

Calibration

Taking into account factors including height, wind speed, timing and area, the assumption that a LiDAR can be calibrated to, or is measuring, PM_{10} concentrations is an inaccurate representation of the data comparison process that can be achieved.

Any attempt to correlate the LiDAR measurements with BAM measurements needs to be undertaken in such a way as to account for the fundamental differences in the two techniques. The trials referencing the BAM comparison to date have not dealt with this issue in a thorough or technically reliable manner.

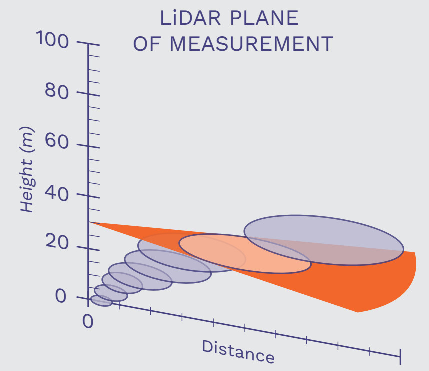


FIGURE 3 Example of scanned plume.

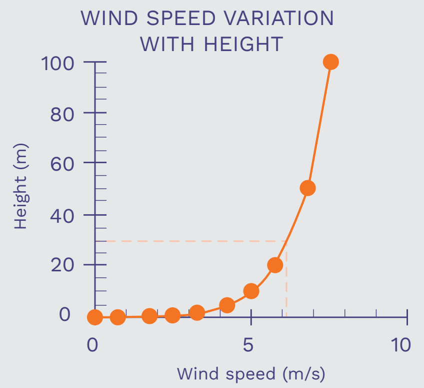


FIGURE 4 Example of wind speed gradient.

LIMITATIONS OF LiDAR

PHIC understands that LiDAR is important to government, industry and the community. However, the limitations identified would indicate that LiDAR it is not necessarily suitable for regulatory purposes.

The Port Hedland LiDAR trials to date highlight specific limitations, which appear to be exacerbated where there are multiple dust sources, as is the case in Port Hedland.

The Department of Water and Environmental Regulation undertook a five-month dust monitoring campaign in Port Hedland using Light Detection and Ranging (LiDAR) technology and a network of standard dust monitors from February – June 2017.

The monitoring campaign generated large quantities of data. The department's LiDAR report on its initial analysis of the data is now available. Insert link: https://www.wa.gov.au/government/publications/mapping-dust-plumes-port-hedland-using-lidar

Further data analysis is ongoing and the findings continue to inform the department's regulatory decision-making under Part V of the EP Act.

It is important to note that LiDAR technology has not been used as a regulatory tool in Australia for several reasons:

- There is no Australian standard for the operation of LiDAR equipment.
- LiDAR is not an acceptable technology or methodology in Australia for point source monitoring.
- Pre-processing of LiDAR monitoring data is required before usable imagery can be developed so it is not applicable to a real-time monitoring scenario.
- LiDAR cannot be used to measure PM_{10} concentrations in isolation. There is no established criteria that can be used as limits for ambient PM_{10} concentrations within the air monitoring network in Port Hedland.
- The visual representation provided by LiDAR is only a two-dimensional representation of the three-dimensional movement of particles in the atmosphere.
- As noted above, LiDAR measures all particulate matter. LiDAR cannot determine the composition of particles and can therefore not distinguish between concentrations such as water spray, bushfire smoke, dust and soot. Accordingly, the bright red areas on LiDAR images do not necessarily indicate high levels of dust. This can easily be misread.
- LiDAR data only provides information on relative particle concentrations.
- LiDAR calibration is critical to the quality of the data which is produced.
- The data is affected by atmospheric changes.

> "Limitations identified would indicate that LiDAR is not necessarily suitable for regulatory purposes."

- The resolution of LiDAR and therefore the reliability of the data is best close to the instrument and reduces over distance.
- LiDAR does not have the ability to see beyond an "obstruction point", whether that obstruction is a physical structure, water vapour or other particles in the air. This means that saturation in high dust close to the LiDAR affects longer range measurements. It also means that solid structures such as buildings may take on a similar appearance to a particulate plume in a LiDAR image.

A SHARED UNDERSTANDING

Given these limitations, it is extremely important that the information provided to the community and the general public is clearly articulated and there is a shared understanding of the purpose of the LiDAR and the use of the findings from the study.

PHIC Members

BHP | Fortescue | Roy Hill | Pilbara Ports | ConsMin | Mineral Resources | Pilbara Minerals | Sandfire

ASSOCIATE MEMBER

QUBE

Port Hedland Industries Council
Kirsty Danby, CEO | **E** ceo@phic-hedland.com.au

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