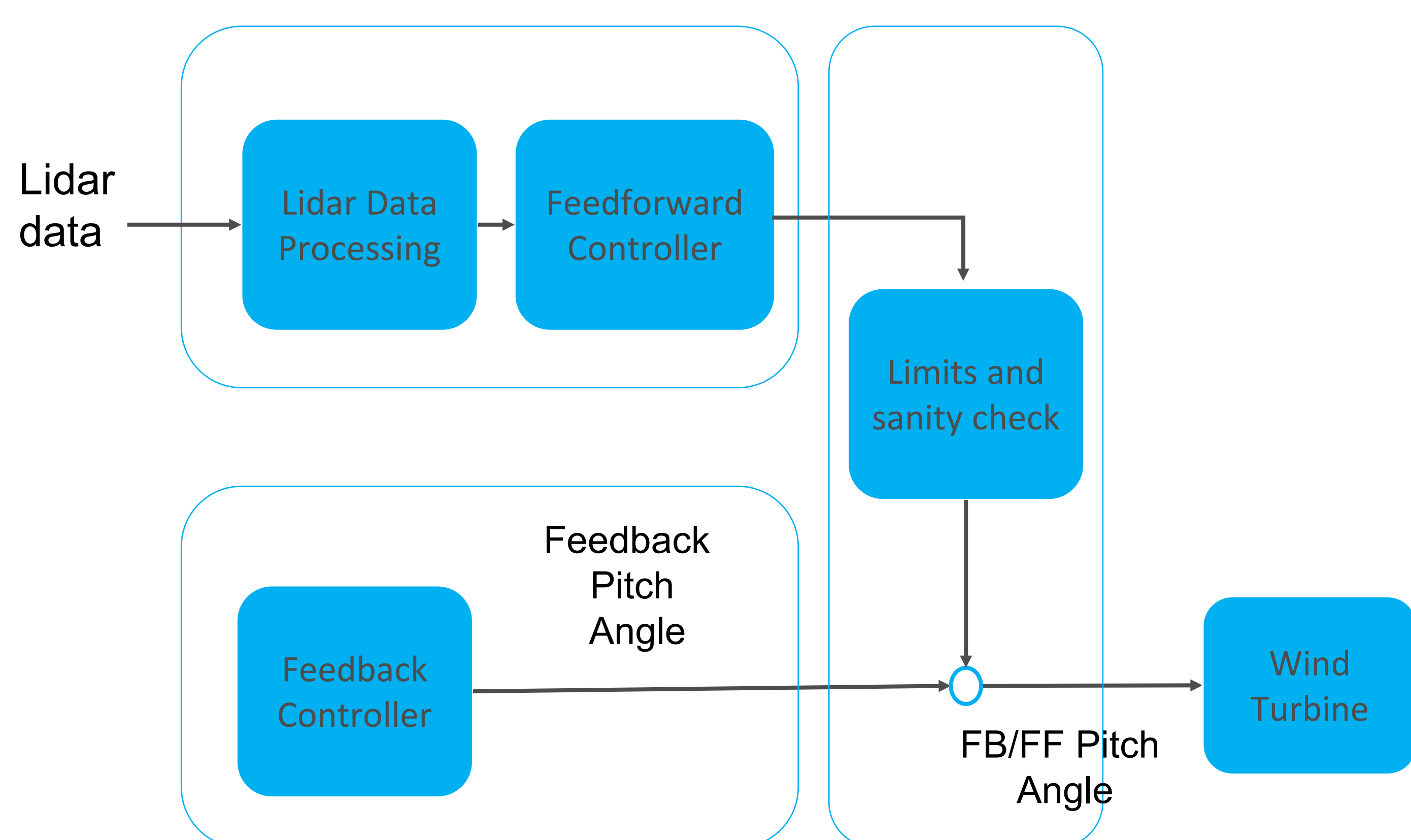


Data-driven approach to the design and implementation of retrofit lidar assisted control

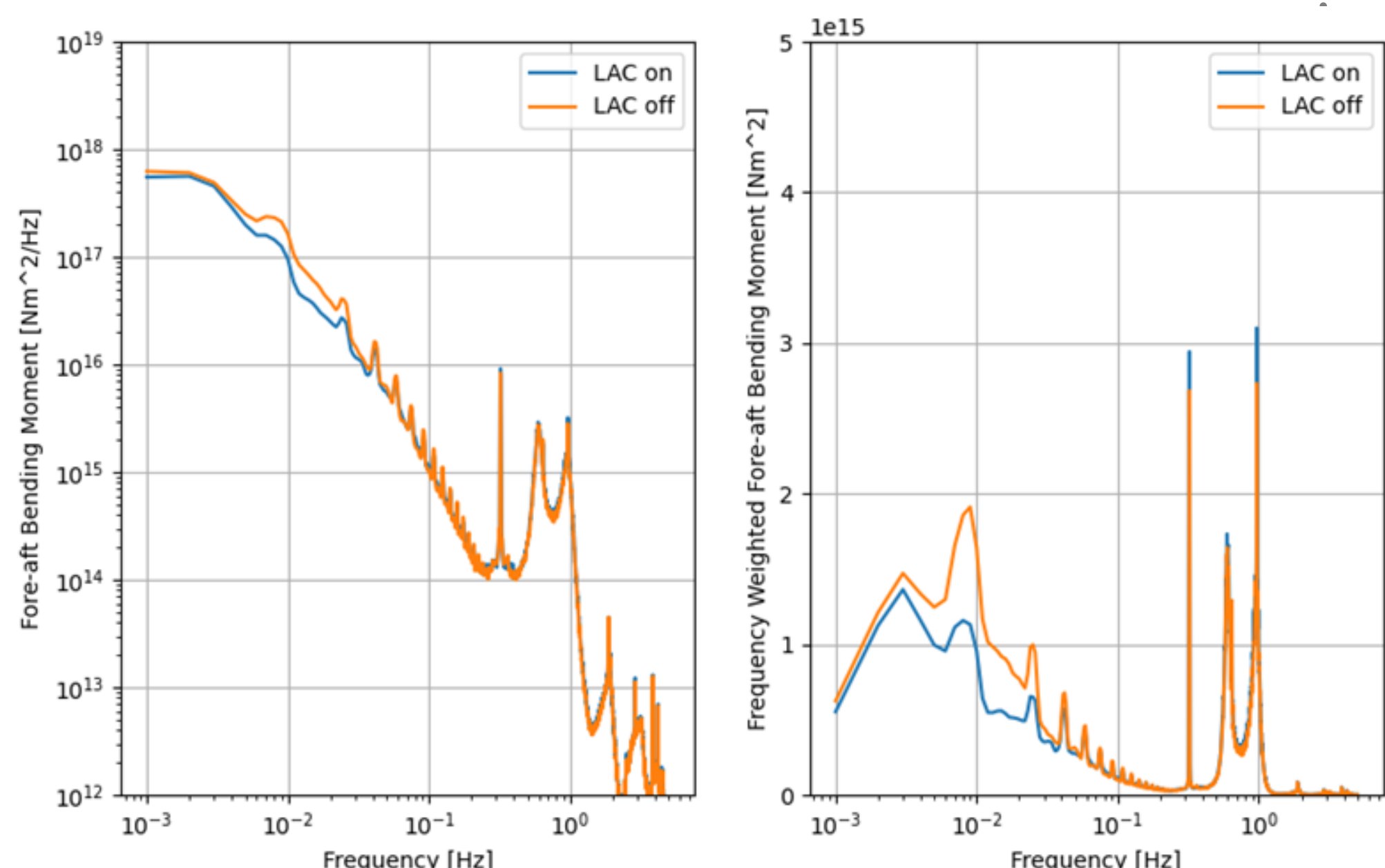
Mark Pitter, Chris Slinger, Feng Guo, David Schlipf, Steffen Raach and Steven White
ZX Lidars

We demonstrate load reduction using lidar assisted control using a feedforward/feedback controller and a simplified lidar system. This solution was retro-fitted to a commercially operating wind turbine. Complex aeroelastic wind turbine models were unavailable and the through life cost of the lidar control system was targeted. Tower fore-aft bending and blade flap edgewise moments were significantly and safely reduced without negative effects on AEP. The methods and technology applied provide an opportunity to reduce the LCOE of current and future turbines

¹ Mark Pitter, Chris Slinger, Feng Guo, David Schlipf, Steffen Raach and Steven White, 'A data-driven approach to the design and implementation of retrofit lidar assisted control systems', May 2023. doi: 10.5281/zenodo.8037351.



- LAC uses a rotor effective wind speed (REWS) preview from a continuous wave (CW) lidar to drive a feed-forward (FF) control element.
- The REWS is calculated from a combination of wind field reconstruction from the raw lidar spectral data, and turbine specific lidar data processing to adaptively isolate beneficial frequencies
- The FF signal is integrated with the legacy feedback (FB) system via an activation block which also acts to ensure turbine safety in the event of missing or poor quality lidar data
- The output of the activation block is used to control blade pitch action.
- To ensure absolute safety of the turbine and personnel:
 - A thorough and conservative Failure Mode and Effects Analysis (FMEA) was undertaken prior to LAC deployment.
 - This was followed by periods of passive deployment then periods of gradually increasing FF gain
- Despite very conservative application for reasons of safety, significant load reductions were observed.



- Provisionally estimated DEL reduction of 8.6% for wind speeds between 7 and 10 m/s
- This translates to a lifetime extension of 40 – 60%
- No detectable negative effect on AEP was observed
- Safe operation was achieved at all times
- For this trial, the turbines were commercially operational and active stall, demonstrating LAC can be robust and retrofitted.
- The methods and technology applied provide the opportunity to expand and scale favorably to current production turbines.

