# Test Procedures

Testing will begin once three conditions are fulfilled:

1. This test plan is complete and signed by both the client and NREL
2. NREL has complete installation and checkout of meteorological and turbine instrumentation required for the test
3. The client has signed a test readiness document that indicates that the turbine is ready for testing.
   1. Yaw offsets

Yaw offsets are achieved on the DOE 1.5 using National Instruments-based hardware to subtract the desired offset from the wind vane signal before it is input to the turbine’s yaw control system. This strategy induces a yaw offset in the turbine without requiring modification of the yaw control algorithm.

Based on the interest in implementing wake steering using positive yaw offsets (a counter-clockwise rotation of the nacelle relative to the wind direction), the experiment will focus on postivie yaw offsets. However, for model validation, a single negative yaw offset will be evaluated. As explained in (Fleming, et al., 2019), based on a loads analysis of the DOE 1.5 under different amounts of yaw misalignment (Rick Damiani, 2018), a limit of +20˚ was chosen for implementation of wake steering at a commercial wind farm. However, previous yaw misalignment experiments on the DOE 1.5 have used yaw offsets up to +/-25˚ (Rick Damiani, 2018), (Annoni, et al., 2018). To capture the expected range of yaw offsets that will be implemented by wake steering controllers, as well as a negative yaw offset and a larger positive yaw offset for model validation, the yaw offset schedule in Table 4. Yaw Offset Schedule will be used.

The yaw offset controller will cycle between each yaw offset, holding each value for 30 minutes and repeating the schedule every 2.5 hours. The specific order of yaw offsets is intended to reduce the magnitude of the most extreme change in yaw orientation. The first 5 minutes after a new yaw offset is selected will be discarded to account for yawing transients.

Table 4. Yaw Offset Schedule

| Yaw Offset | 0˚ | 25˚ | 18˚ | 10˚ | -18˚ |
| --- | --- | --- | --- | --- | --- |
| Duration | 30 min | 30 min | 30 min | 30 min | 30 min |

* 1. Data Collection Requirements

The test will continue until, at a minimum, all requirements listed in Table 5 are fulfilled for each target yaw misalignment. To fulfill the test requirements, each data period must correspond to a mean wind direction within +/-15˚ of the prevailing wind direction of 285˚. Testing will continue until it NREL agrees that sufficient data has been collected.

Table . Minimum Data Requirements for Acoustics test

| Measurement Type | Requirements |
| --- | --- |
| Overall measurements | At least 30 one-minute averages. |
| For A-weighted sound pressure level:  (for turbine and background measurements) | At least 3 minutes of data with wind speeds ±0.5 m/s of the integer values of 6, 7, 8, 9, and 10 m/s |
| For octave or third octave band measurements:  (for turbine and background measurements) | At least 3 minutes of data with wind speeds ±0.5 m/s of the integer values of 6, 7, 8, 9, and 10 m/s |
| Narrow band measurements:  (for turbine and background measurements) | At least 2 minutes of data with wind speeds ±0.5 m/s of the integer values of 6, 7, 8, 9, and 10 m/s |

# Bibliography

Annoni, J., Fleming, P., Scholbrock, A., Roadman, J., Dana, S., Adcock, C., . . . Schlipf, D. (2018). Analysis of Control-Oriented Wake Modeling Tools using Lidar Field Results. *Wind Energy Science*, 819-831.

Fleming, P., King, J., Dykes, K., Simley, E., Roadman, J., Scholbrock, A., . . . Lopez, H. (2019). Initial Results from a Field Campaign of Wake Steering Applied at a Commercial Wind Farm - Part 1. *Wind Energy Science*, 273-285.

Rick Damiani, S. D. (2018). Assessment of Wind Turbine Component Loads under Yaw-Offset Conditions. *Wind Energy Science*, 173-189.