**Aeroacoustic Assessment of Wind Plant Control Strategies**

**Timeline and Measurement Locations**

Nicholas Hamilton

Research Engineer

National Wind Technology Center

National Renewable Energy Laboratory

14 January 2020

# Project timeline

Table 1. Tentative project timeline.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Event | Date | Description |
| 1. | NEPA Review | Jan. 14, 2020 | Submit for review a NEPA questionnaire, test plan, measurement locations, timeline, and the Special Use Permit between NREL and the U.S. Fish and Wildlife Service (USFW) for research on Rocky Flats National Wildlife Refuge (RFNWR). |
| 2. | Acquire instrumentation | Feb. 1, 2020 | Begin acquisition of acoustic recording equipment (microphones, preamplifiers, signal conditioners) and data acquisition systems (GPS modules, data input interfaces, power and controllers) |
| 3. | Fabricate measurement platforms | Feb. 1, 2020 | Measurements require non-permanent, acoustically reflective sound boards which will be fabricated from plywood sealed against weather and fouling |
| 4. | Test instrumentation | Feb. 15, 2020 | Prototype data acquisition software, calibrate microphones, test acquisition strategy |
| 5. | Acquire cabling | Feb. 15, 2020 | Data acquisition systems will be powered by 14 AWG wire carrying on the order of 40 V DC. Communication to data acquisition hardware will occur over shielded fiberoptic cable. |
| 6. | Coordinate measurement times | March 1, 2020 | Coordinate measurements with USFW, RFNWR, wind turbine operation, meteorological tower measurements |
| 7. | Deploy instrumentation | March 15, 2020 | Deploy cabling and microphones, begin recording. |
| 8 | Collect and remove all equipment | May 31, 2020 (tentative) | Remove all acoustic recording equipment, cabling, data acquisition systems, and support material from RFNWR. A detailed sweep will be conducted to ensure that no materials, waste, or garbage is left behine. |

The timeline above is tentative and depends on approval from NEPA, USFW, and RFNWR. Throughout the course of the aeroacoustics project, soundboards will remain in place for consistent location of measurements, but acoustic equipment will be deployed for each measurement day and removed for the night. All measurement platforms are temporary and will be full removed at the end of the project.

# Measurement locations

A picture containing ground

Description automatically generated

Figure 1. Map of measurement (black points) and DAS subsystem (red points) locations at NREL Flatirons. Power, fiber-optic, and BN cabling are shown in black, blue and red lines, respectively. The green dashed line indicates the boundary between NREL Flatirons and RFNWR.

A close up of a map

Description automatically generated

Figure 2. Schematic of measurement (black) and DAS (red) locations and spacing (m).

The test will continue until, at a minimum, all requirements listed in Table 2 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 requirements are met according to the IEC Standard and NREL engineers agree that sufficient data will be deemed valid through all quality control procedures.

Table 2: Summary of observations specified in IEC 61400-11.

|  |  |
| --- | --- |
| 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 |

# Measurement equipment

Table 3. Data acquisition hardware. Hardware will be used for 3 subsystems to be enclosed in protective housings with ports for communication and power cabling.

|  |  |  |
| --- | --- | --- |
| Quantity | Component | Description |
| 3 | 785622-01 | cRIO-9042, 1.6 GHz Quad-Core, 70T FPGA, RT, 4-Slot, XT |
| 7 | 779680-01 | NI-9250 C Series Sound and Vibration Input Module, 2-Ch, 51.2 kS/s, IEPE and AC/DC |
| 4 | 781632-01 | NI 9467, GPS Time Synchronization Module for C Series |

Table 4. Acoustic recording equipment. A total of 11 measurement locations will be deployed, 8 recording in the audible range, 3 recording low-frequency noise (collocated with data acquisition enclosures).

|  |  |  |
| --- | --- | --- |
| Quantity | Component | Description |
| 9 | 4966-H-041 | microphone/preamp combo for measurements down to 6.3 Hz |
| 4 | 4964 | Microphone for measurements down to 1 Hz |
| 4 | 2669-C | Preamp |
| 4 | 1708 | Signal Conditioner |
| 4 | AO-0414-D-100 | Cable, Microphone, circular-1B 7-pin (M) to circular-1B 7-pin (F), 10m (33.3ft), max.+90°C (194°F) |

Microphones will be deployed on soundboards as specified in IEC 61400-11. Each soundboard consists of a circle of acoustically reflective plywood, 1 m in diameter, treated against fouling and weather.