SAND2014-18600C

DOE / SNL Scaled Wind Farm Technology (*SWiFT*) Facility Overview

swift.sandia.gov

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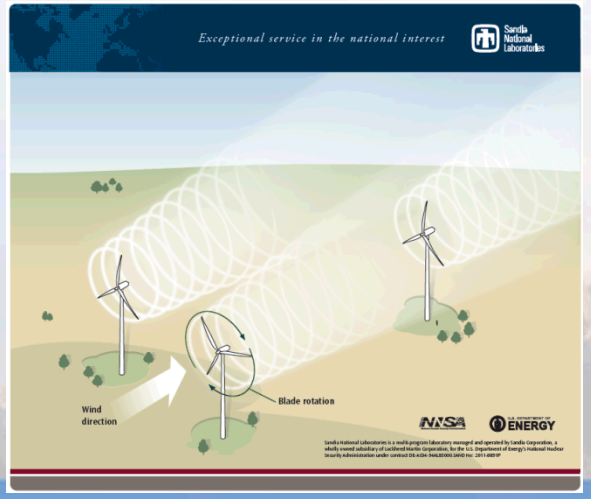
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

SWiFT Facility

SWiFT exists to:

- Reduce turbine-turbine interaction and wind plant underperformance
- Develop advanced wind turbine rotors
- Public open-source to advance simulation capabilities



Facilities:

- Three variable-speed variable-pitch modified wind turbines with full power conversion and extensive sensor suite
- Two heavily instrumented inflow anemometer towers
- Site-wide time-synchronized data collection

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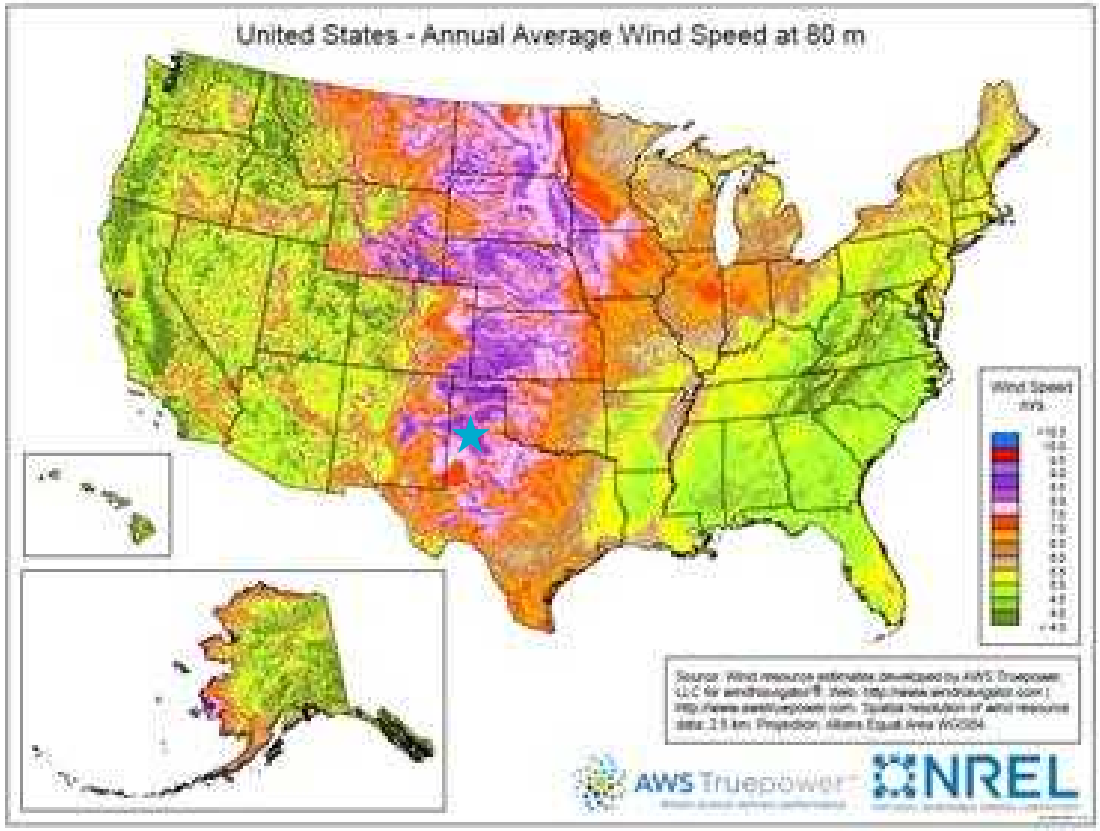
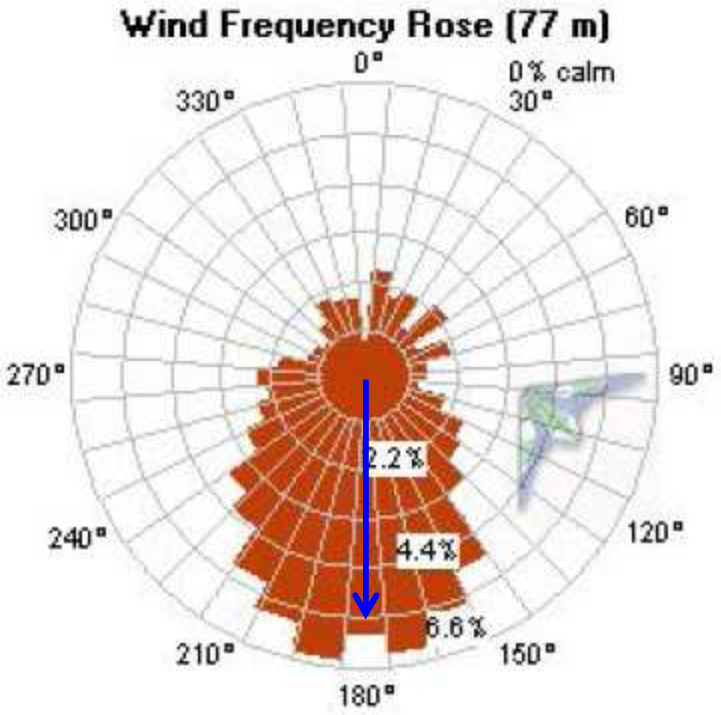
Outline

- **What is the SWiFT Facility?**
- **What research projects use SWiFT?**
- **What is the future of SWiFT?**

Location, Location, … Location

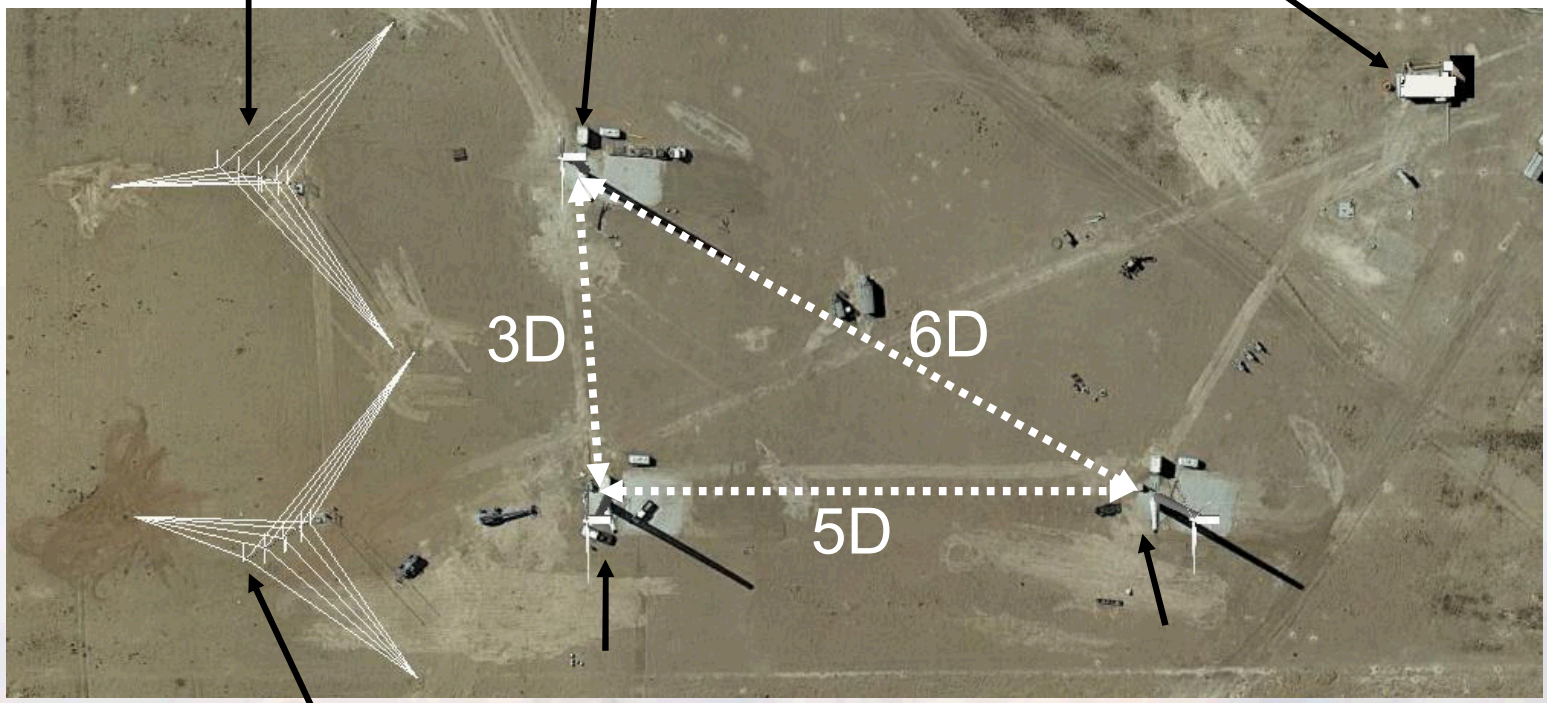


- **7.5 m/s at 50 m, Class 5 Wind Site!**
- **Consistent South Wind, 180.5° Average**



TEXAS TECH UNIVERSITY

SWiFT Layout



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SWiFT Wind Turbines

Hardware

- Collective Pitch System
- 300 kW Variable Speed Generator
- AC-DC-AC Full Scale Convertor
- National Instruments controllers
- Complete turbine / rotor state instrumentation
- Fiber Optic blade sensing system

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Why this size?

Research-Scale

Minimum research cost and time

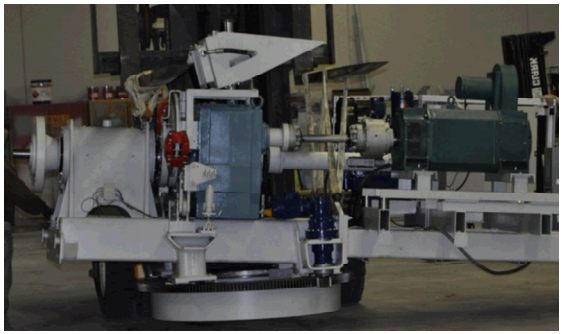
Exact Scaling

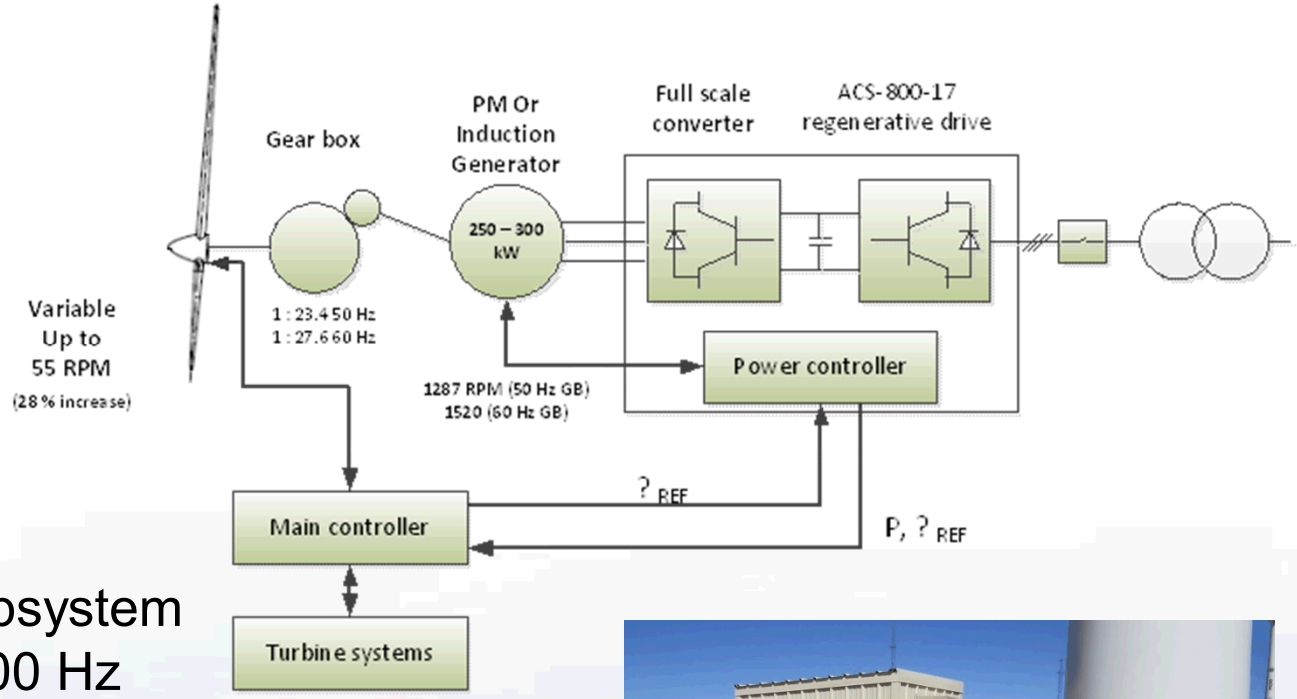
Megawatt-Scale

- **A cost-efficient size for which research can be directly scaled to larger, more costly and time-consuming sizes.**
- **Requirements:**
  - Operation at Reynolds Number (scaling parameter) between 10^6 and 10^7
  - Tip speeds approaching 80 m/s for acoustics and large rotor projects
  - Variable-speed variable-pitch operation
  - Minimal cost and time associated with research operations
  - Highly reliable turbine
  - Minimal restrictions on publication and intellectual property

SWiFT Wind Turbines

Control Software





- Open Source Code
- Modularized by Subsystem
- EtherCAT up to 1000 Hz
- All DAQ signals available for control
- Running on NI Veristand
- Parameterized Variable Speed and Torque Controller
- Maintains all original safety systems and alarms

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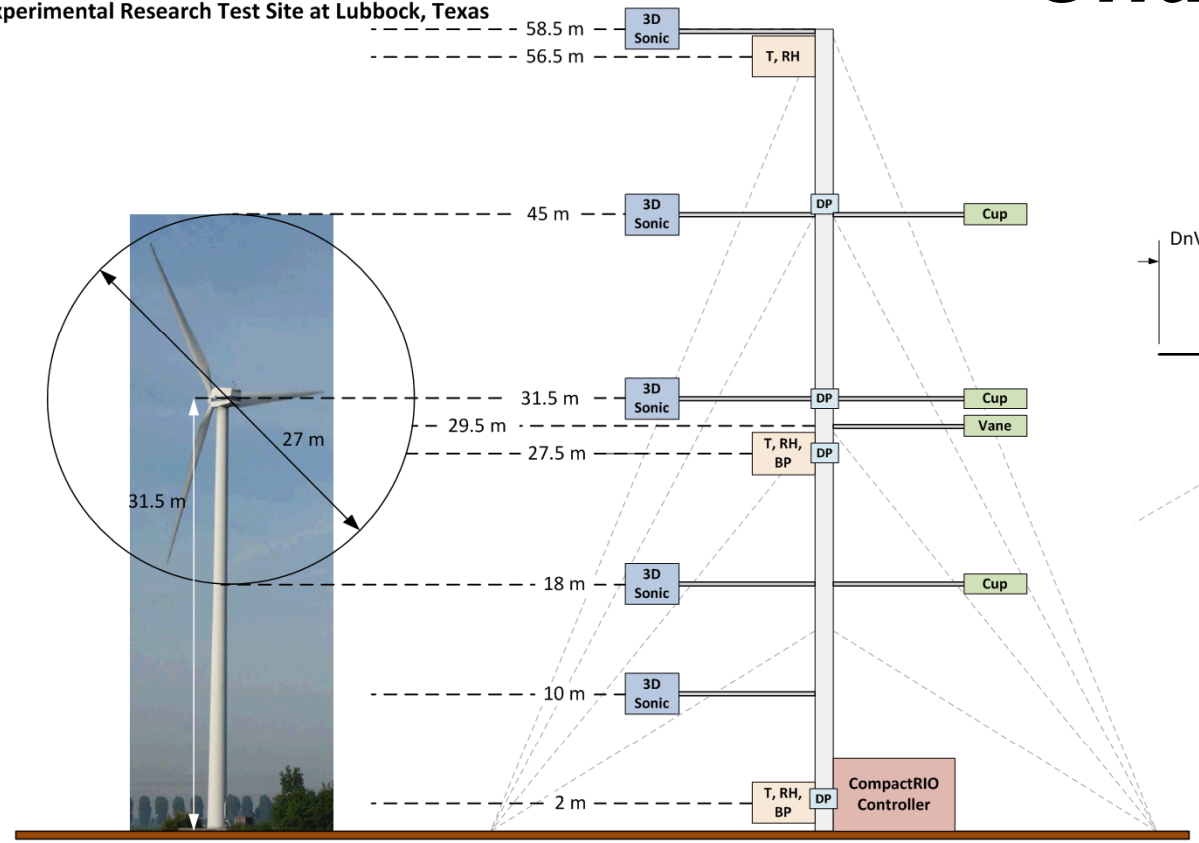
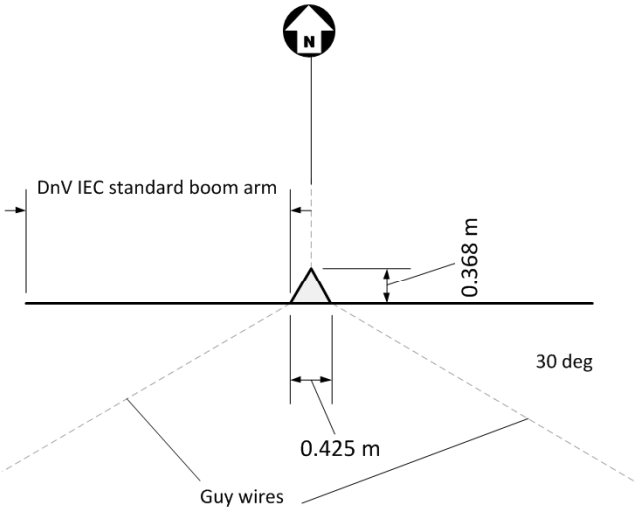
Inflow Characterization

Met Mast Configuration

Experimental Research Test Site at Lubbock, Texas





Met mast sensors

3D Sonic: ATI SATI/3A Sonic Anemometer
Cup: Thies Wind Sensor First Class Advanced (IEC accred)
Vane: Thies Wind Direction Sensor First Class
T: 592 Met One Temperature sensor
BP: 092 Met One Barometric Pressure sensor
RH: 593 Met One Relative Humidity sensor
DP: ATI PAD-401 DataPacker

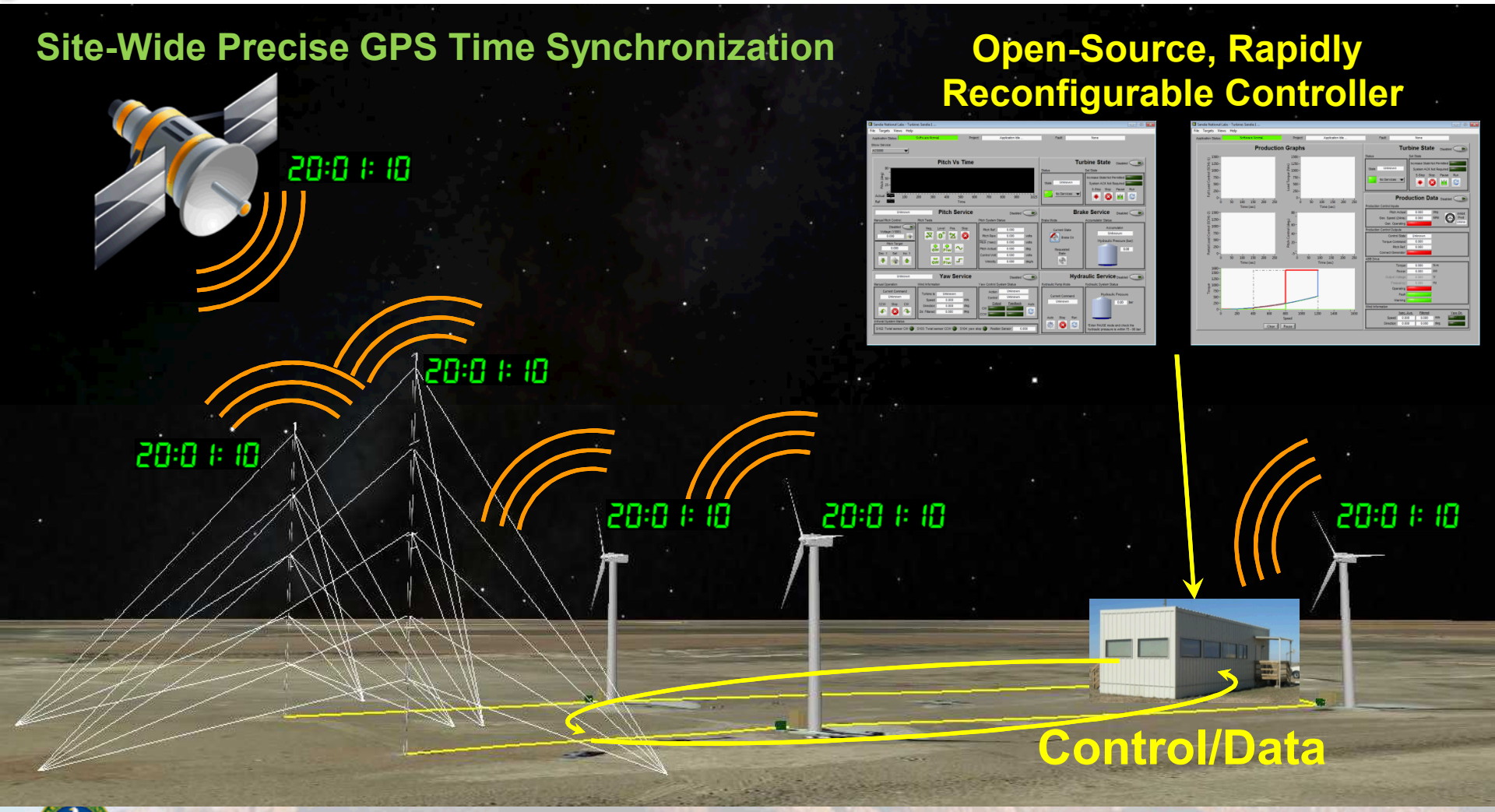
Met mast heights*

58.5 m: 3D Sonic
56.5 m: T, RH
45 m: 3D Sonic, Cup
31.5 m: 3D Sonic, Cup
29.5 m: 3D Sonic, Vane
27.5 m: T, RH, BP
18 m: 3D Sonic, Cup
10 m: 3D Sonic
2 m: T, RH, BP

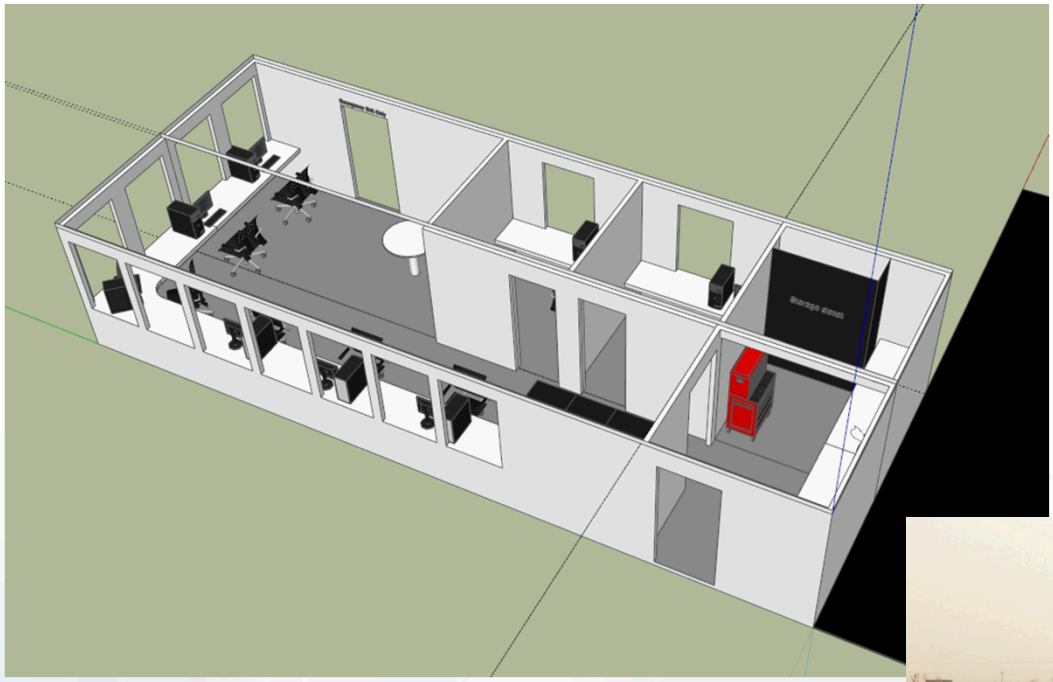
Guy wires
Radius 47.5m

57.91 m
45.11 m
29.87 m
14.63 m

Controls Integrated with Site-Wide Measurement System



Control Building



- Central control and operations
- 700 sq. ft. with 2 temporary offices for proprietary work
- Electrical troubleshooting lab

Experimental Preparation Lab

- 4,500 sq. ft. environmentally controlled high-bay experimental rotor preparation
- 1,000 sq. ft. machine shop

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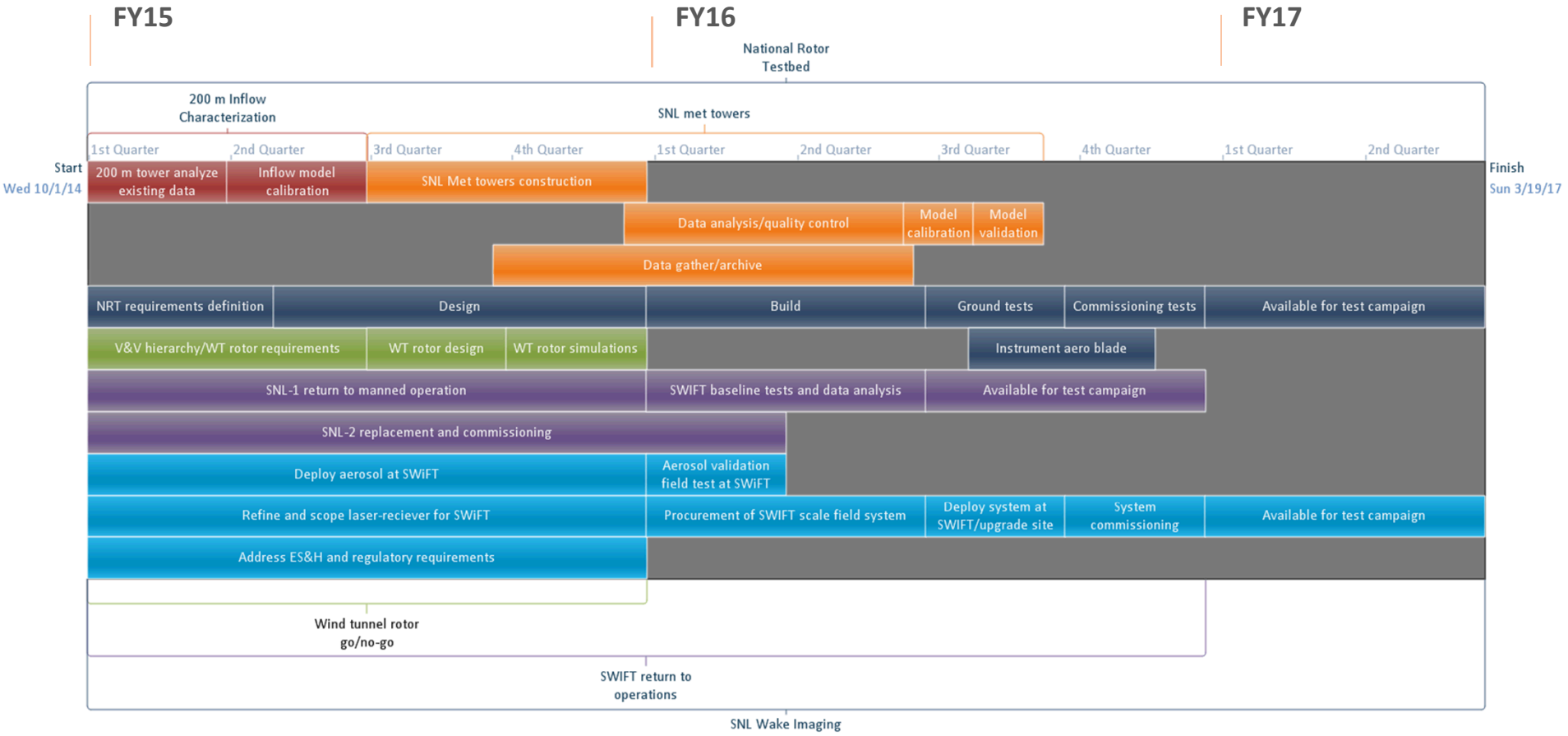
Integrated timeline



SWiFT Baselining

- Detailed analysis of fundamental turbine-turbine interaction
- Calibration and verification of public open-source wind turbine / plant model
- Data quality analysis and troubleshooting

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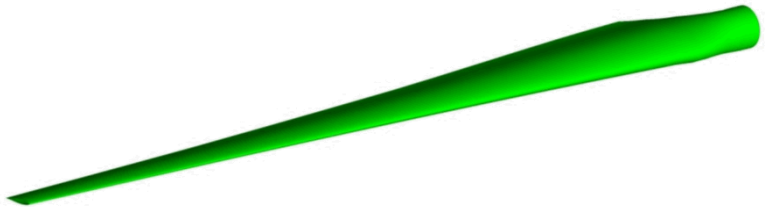
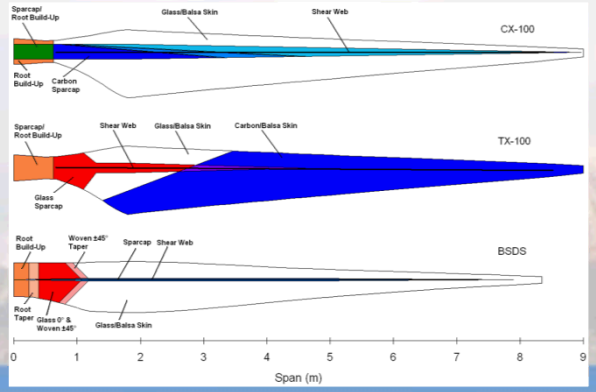
National Rotor Testbed

- The National Rotor Testbed is a rotor innovation to enable technology acceleration



- Baseline blades represent functionally scaled-down aerodynamics and structural dynamics of a modern megawatt-scale rotor
- Baseline blade design is public and open
- Enables research in: wake interactions, aero-acoustics, inboard aerodynamics, controls, aeroelastic dynamics



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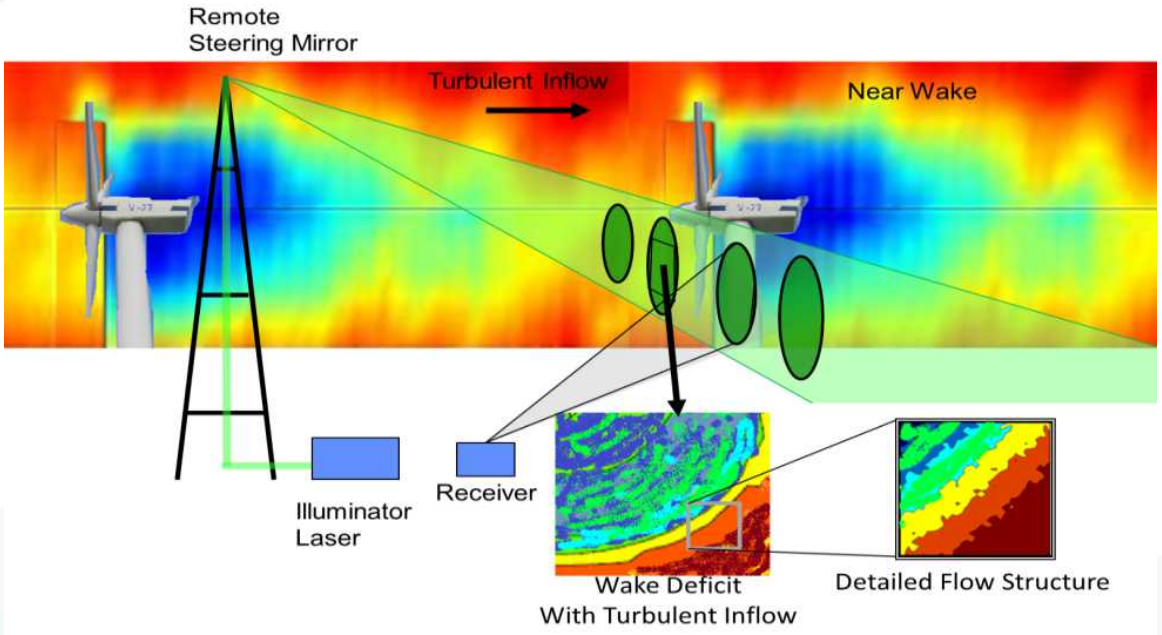
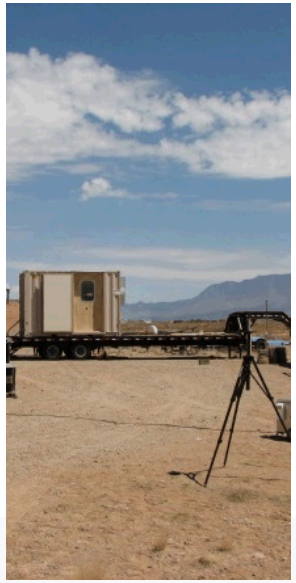
Wake Imaging Measurement System

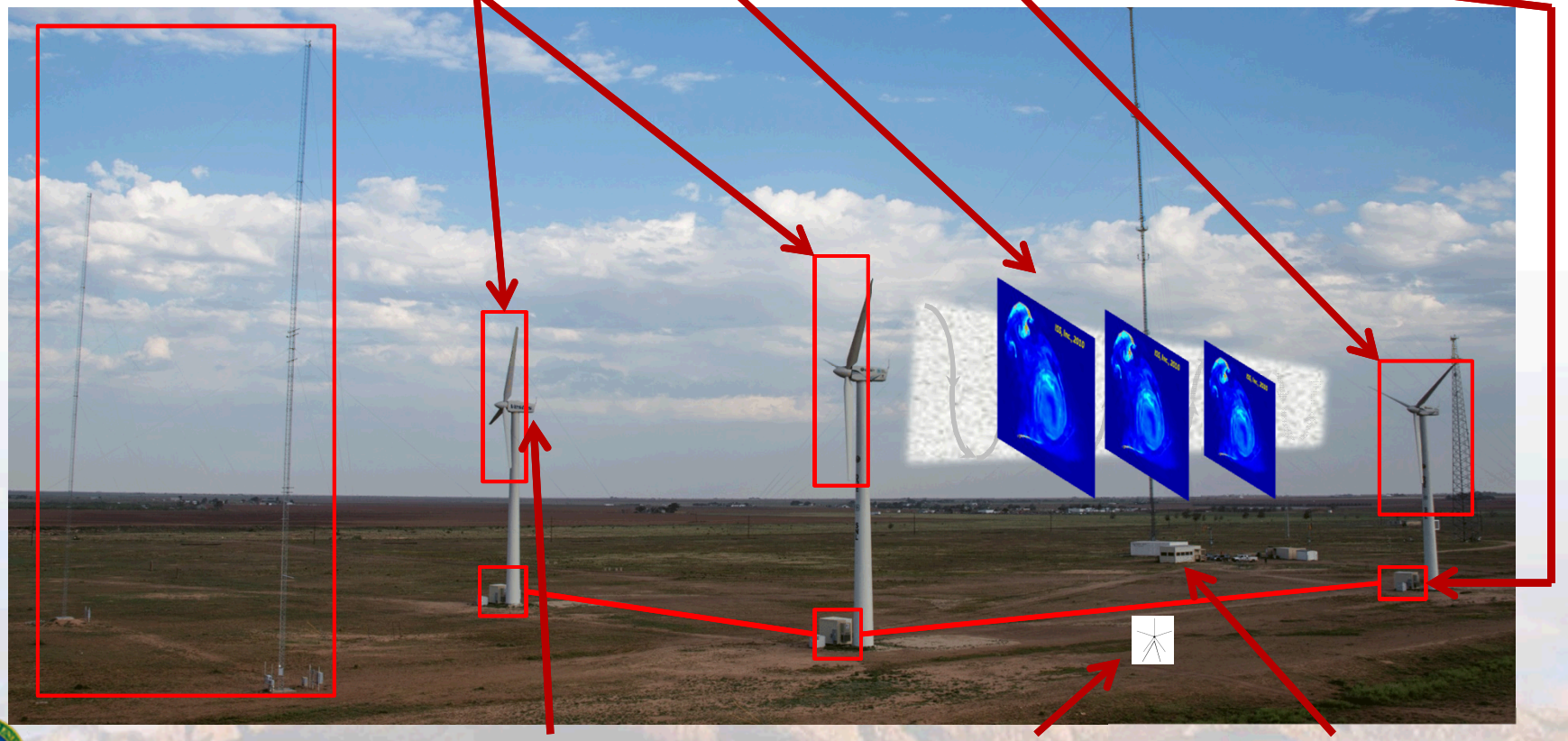




- Capture detailed 3-D flow structures that convect downwind
- High spatial resolution: 16,000 data points per sample
- Imaging allows for fast scanning sufficient to capture sub-rotor scale turbulent flow structures
- Enables direct comparison with high-fidelity and engineering level models

DOE Atmosphere to Electrons Support

- Change focus to Wind Plant Optimization



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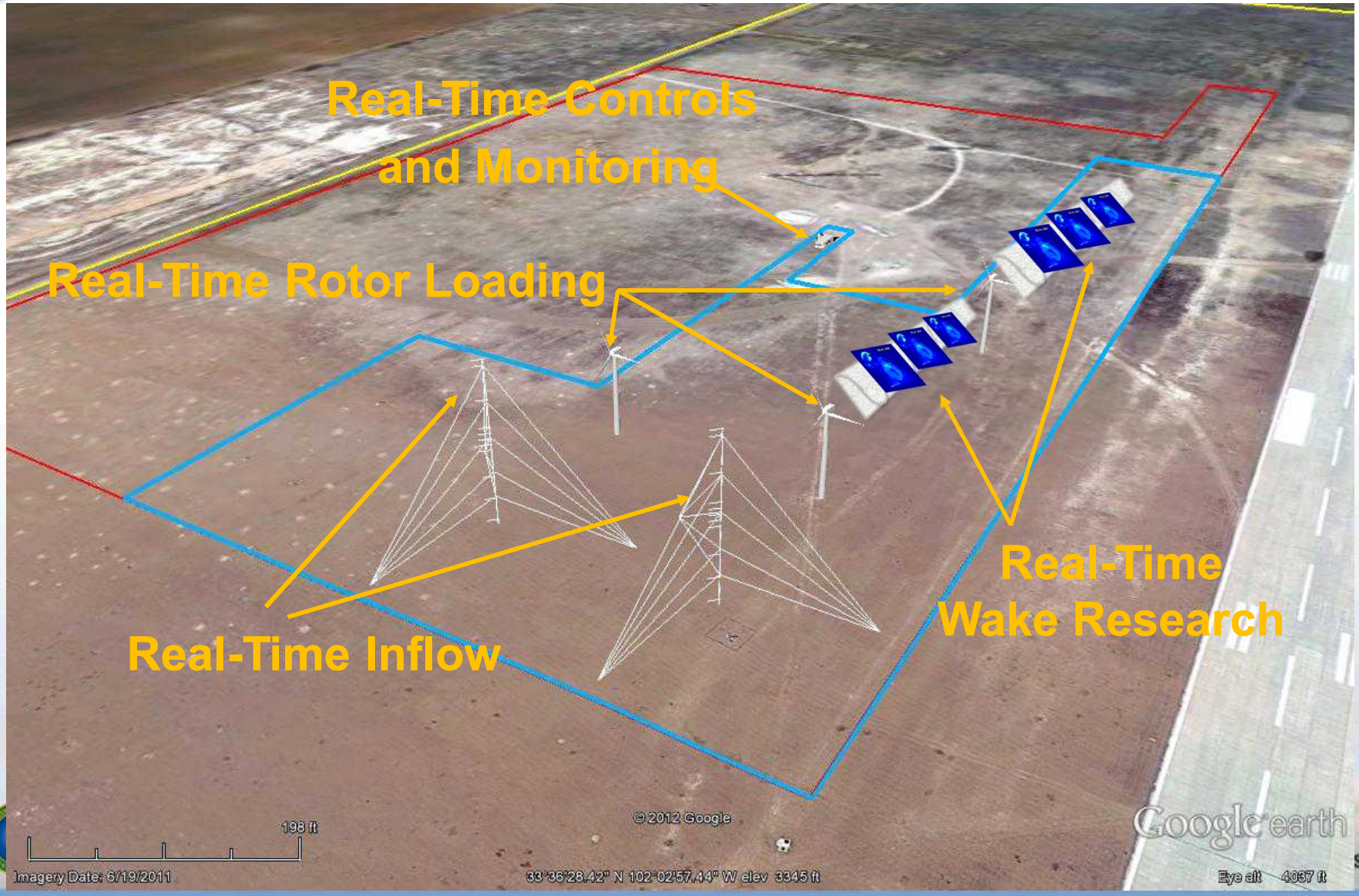
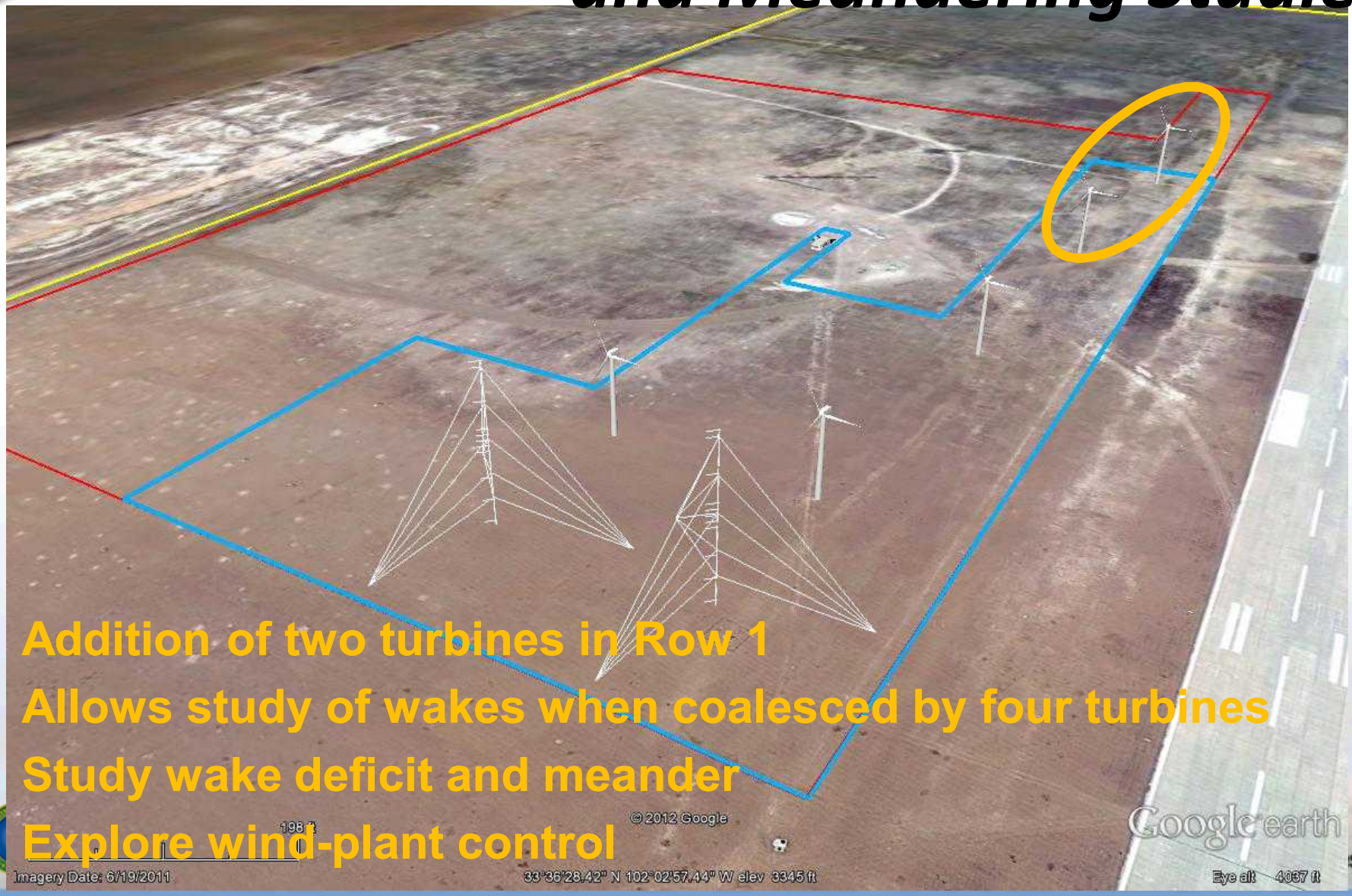
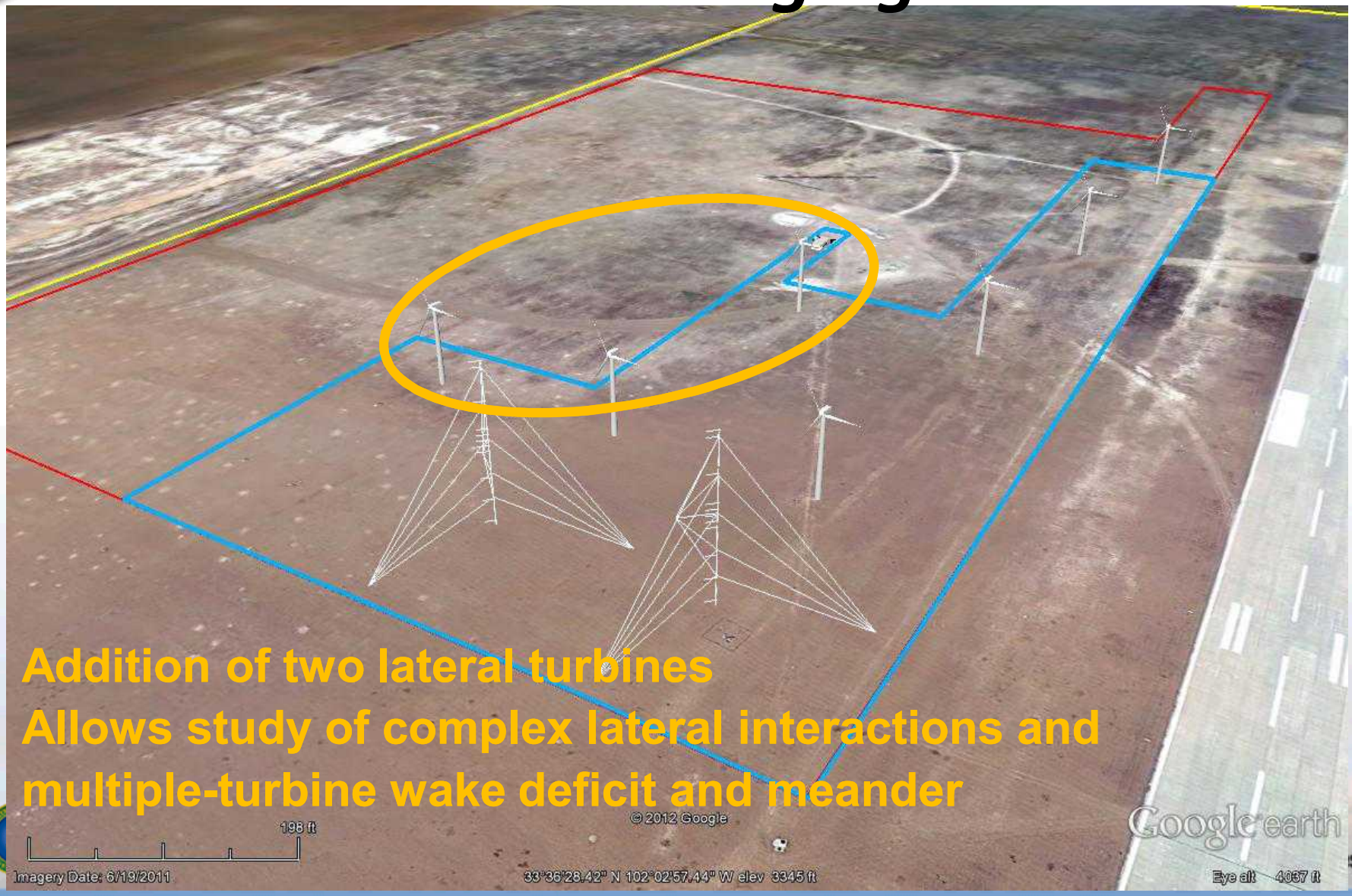
Basic Turbine to Turbine Interaction



Deep-Row Wake Deficit and Meandering Studies



Complex Lateral Wake Merging and Meander



Thank you!

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