SAND2015-7292PE

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

swift.sandia.gov

Jonathan White

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.

Sandia's History

THE WHITE HOUSE
WASHINGTON

May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract the direction of the Sandia Laboratory at Albuquerque, New Mexico.

This operation, which is a vital segment of the atomic weapons program, is of extreme importance and urgency in the national defense, and should have the best possible technical direction.

I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.

I am writing a similar note direct to Dr. O. E. Buckley.

Very sincerely yours,

Harry Truman

Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

Sandia National Laboratories

Sandia's Sites

Albuquerque, New Mexico

Livermore, California

Kauai, Hawaii

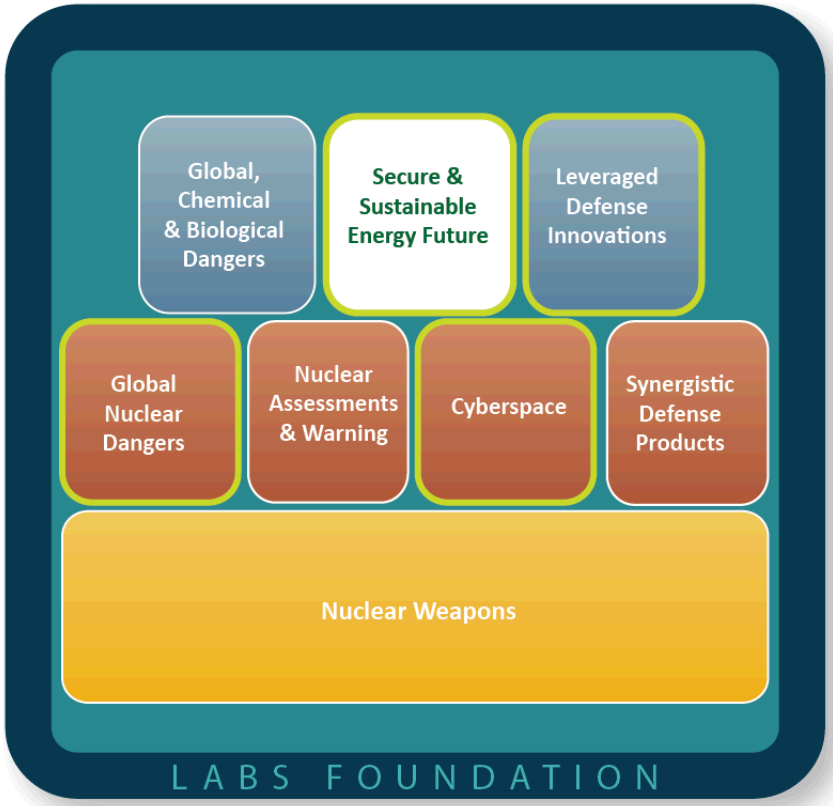
Waste Isolation Pilot Plant, Carlsbad, New Mexico

Pantex Plant, Amarillo, Texas

Tonopah, Nevada

Mission Area Framework

- 10,800 employees and 5,000 with advanced degree
- FY2014 operating costs were $2.6 billion



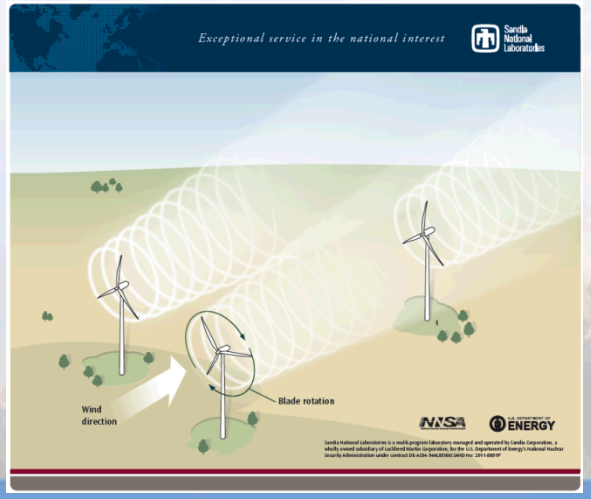
Sandia National Laboratories
Wind Energy Department

- **Established in Mid 1970's**
  - Primary focus VAWT's
- **Continuously expanded SNL Role in U.S. Wind Power Program**
- **Over 25 years developing SNL/MSU Material Database**
- **SNL Blade Emphasis Started 2 decades ago with numerous successes**
  - Carbon Spars, Swept blades, Flat-Backs, Active Aero
- **Blade Manufacturing has been a Temporary Focus in 1998-99 & 2012-13**
- **Various Reliability Efforts for past 8 years**
- **SWIFT Scaled Test Facility Commissioned 2013**
- **Focus on Wind Farm versus Wind Turbine 2012**
- **Future:**
  - Prove & Expand Scaled Testing
  - Validate Wind Plant Models
  - Understand Inflow & Wakes
  - Optimize the Wind Plant
  - Develop Mechanisms to Enhance Reliability (materials, lightning protection, etc.)
  - Plan Wind Farms more Effectively

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:

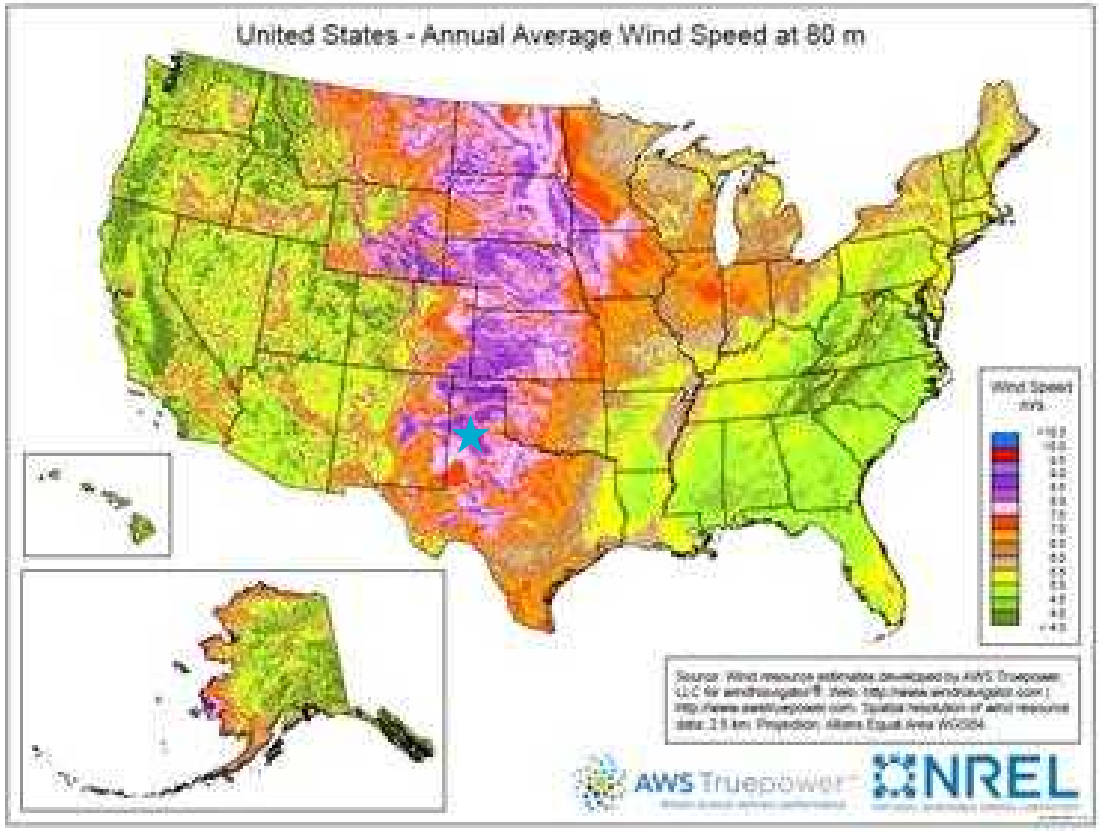
- Three variable-speed variable-pitch modified wind turbines with full power conversion and extensive sensor suite
- Two heavily instrumented inflow anemometer towers
- Site-wide time-synchronized data collection

Sandia National Laboratories

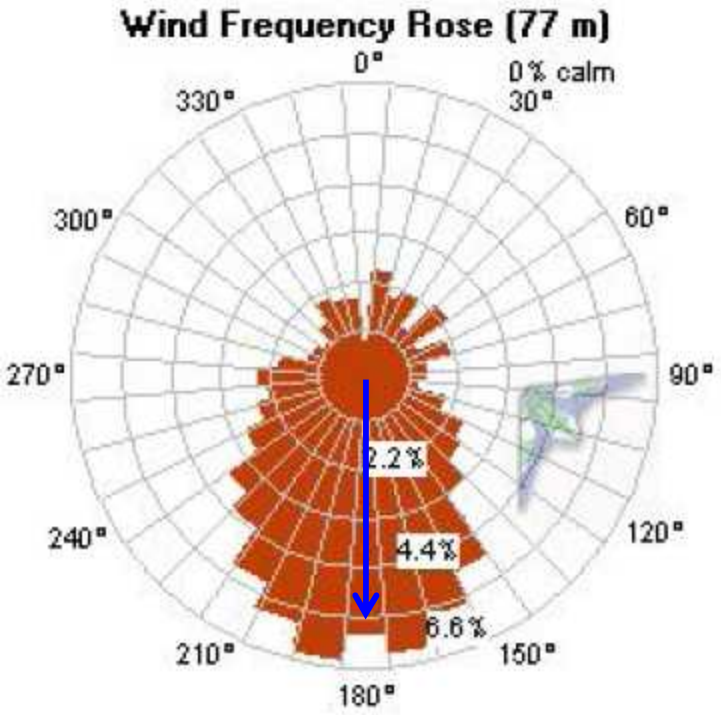
Outline

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

Location, Location, … Location

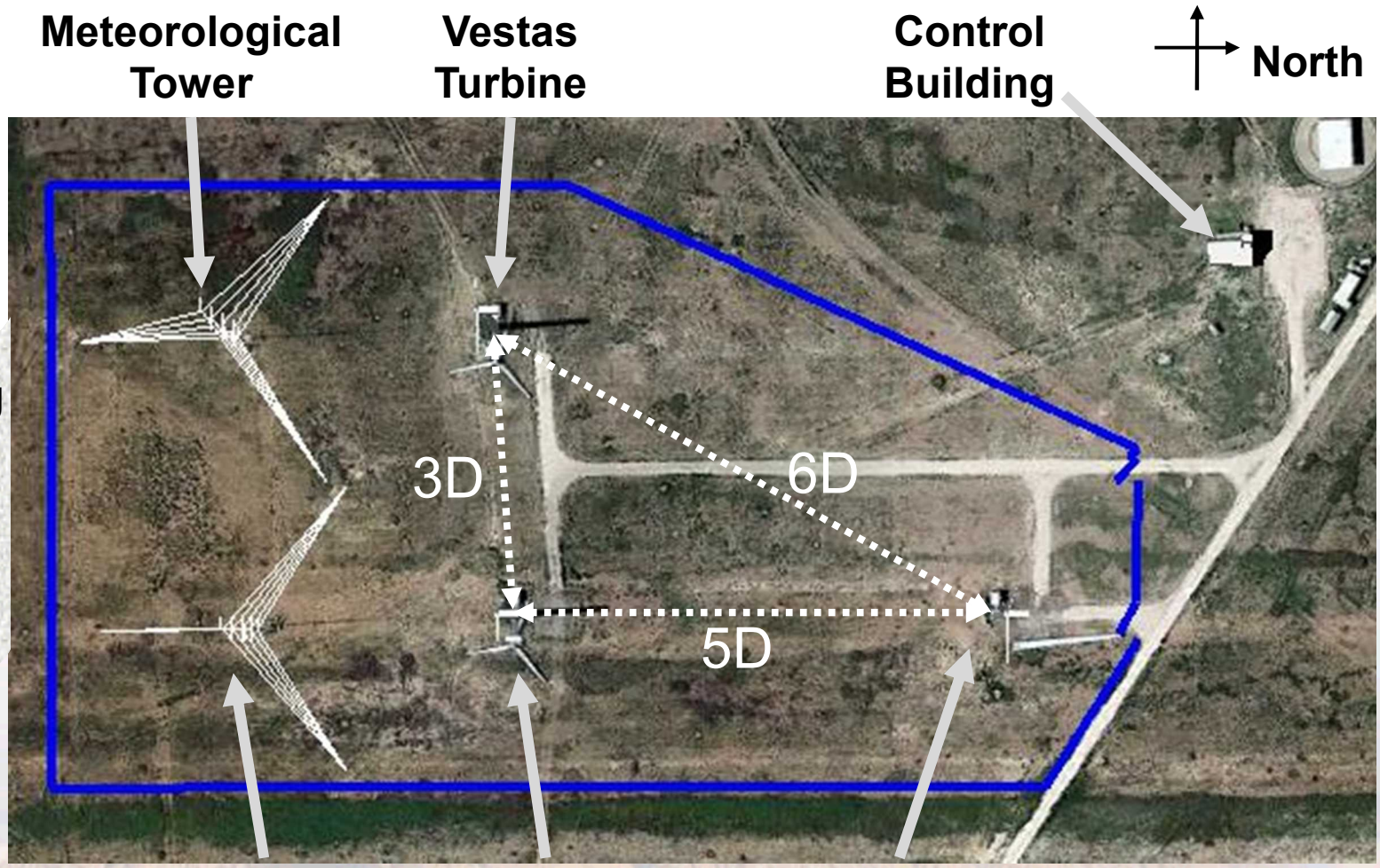


- **7.5 m/s at 50 m, Class 5 Wind Site!**
- **Consistent South Wind, 180.5° Average**



TEXAS TECH UNIVERSITY

SWiFT Layout



Sandia National Laboratories

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

Sandia National Laboratories

Why this size?

Research-Scale

Minimum research cost and time

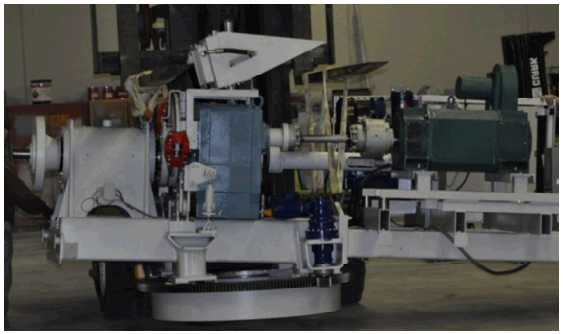
Exact Scaling

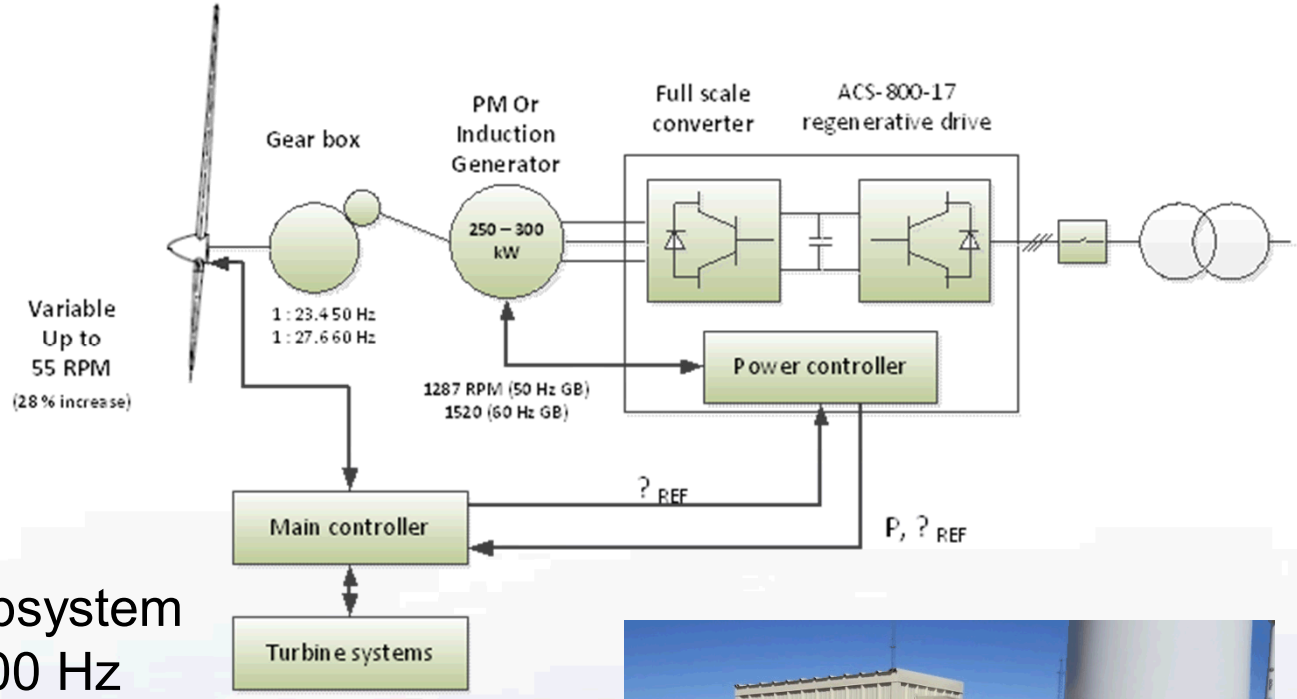
Megawatt-Scale

- **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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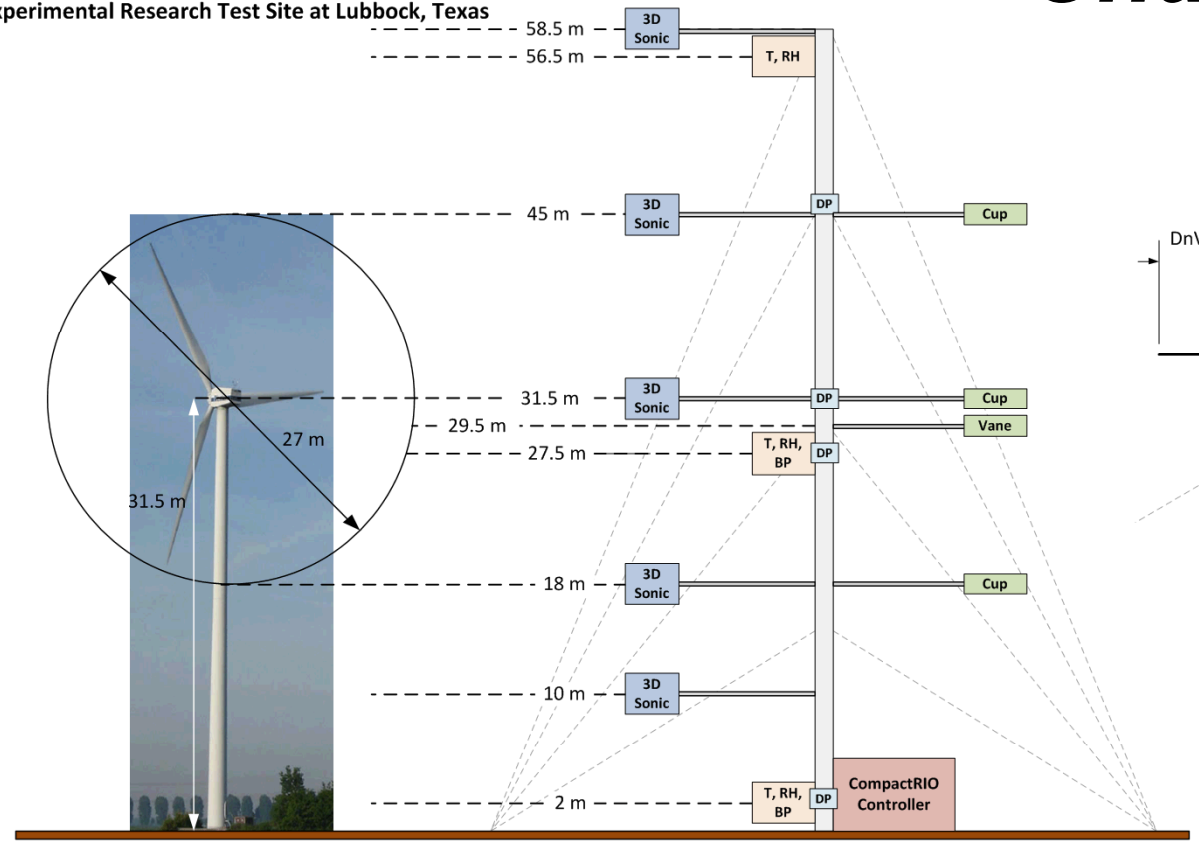
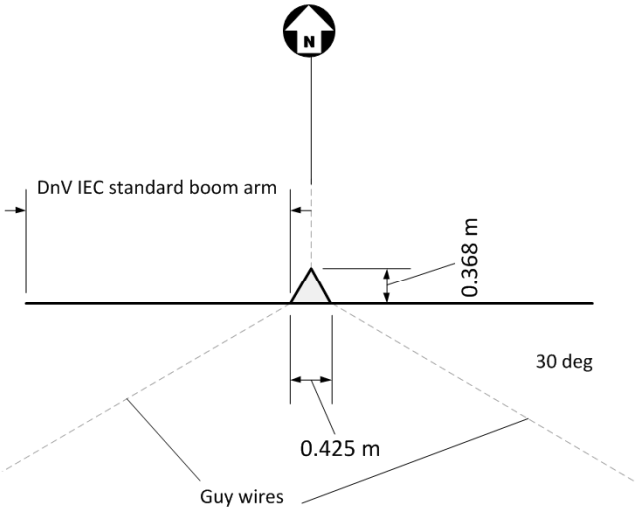
Inflow Characterization

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

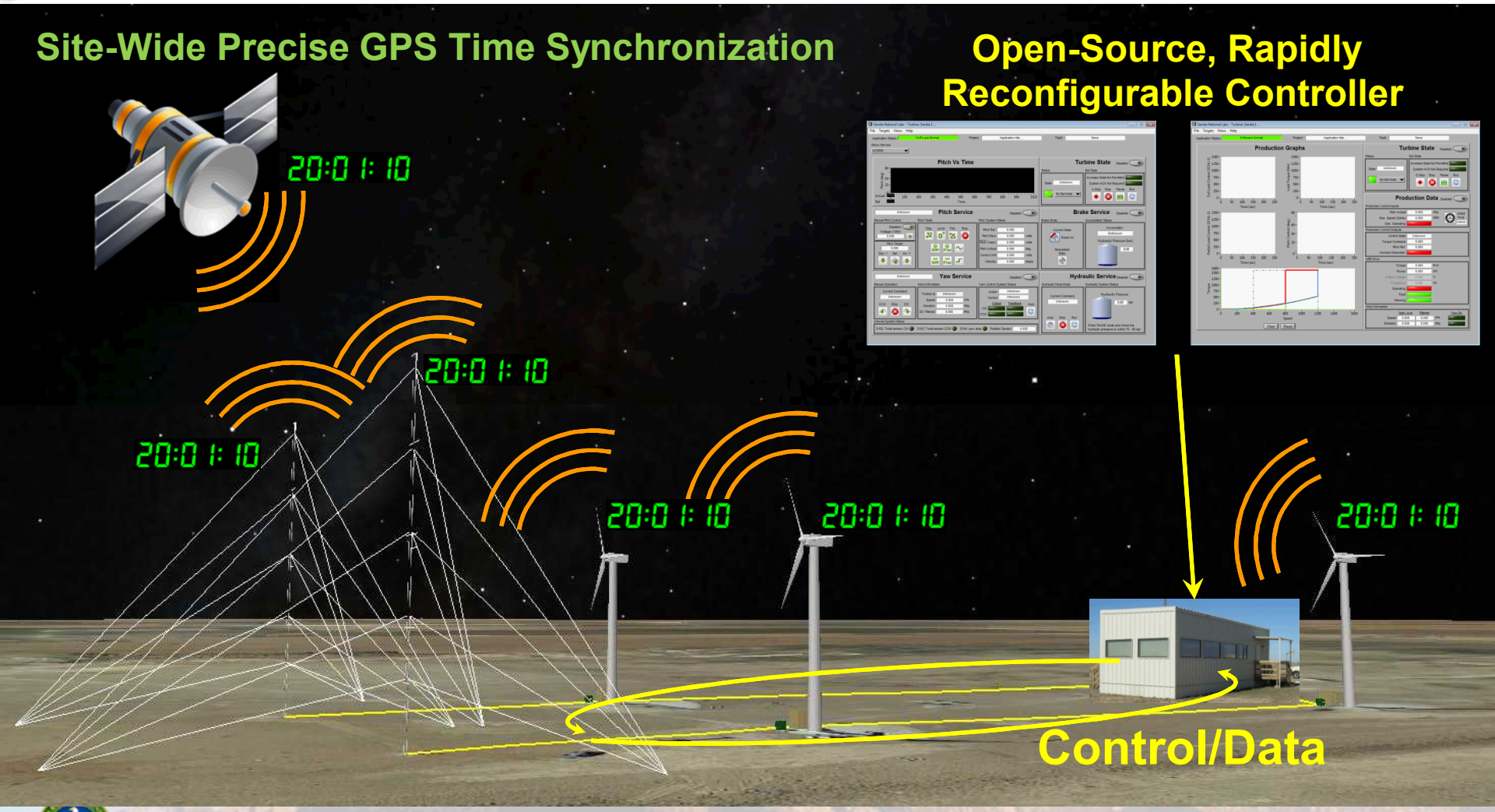
Met mast heights*

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

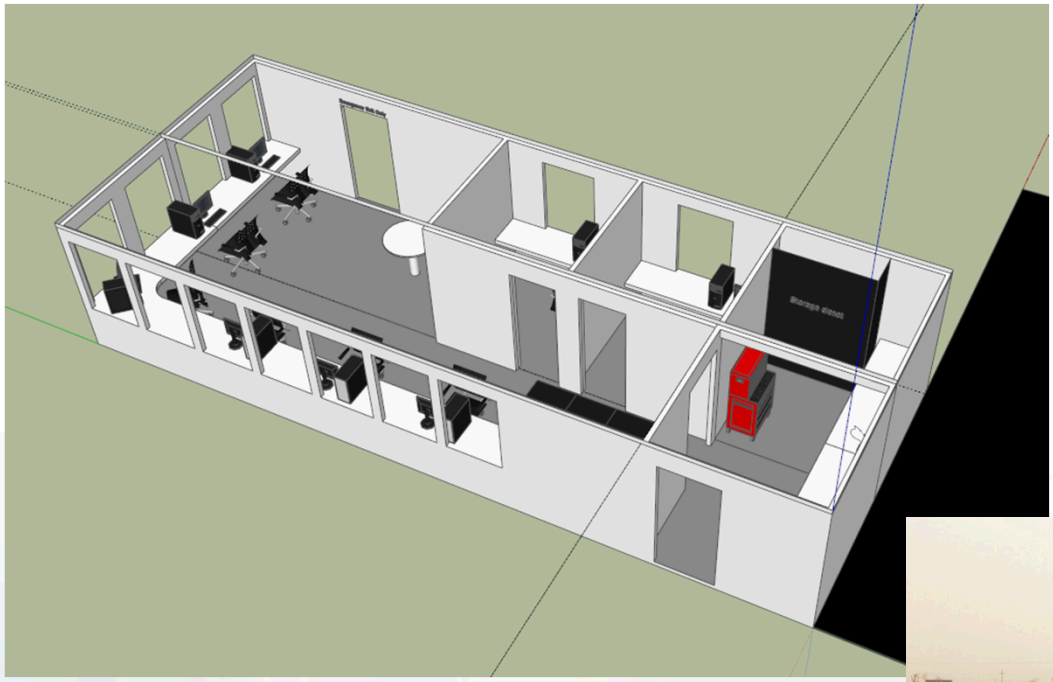
Guy wires
Radius 47.5m

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

Outline

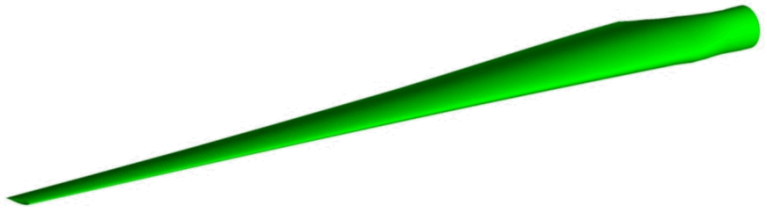
- What is the SWiFT Facility?
- **What research projects use SWiFT?**
- What is the future of SWiFT?

SWiFT Baselining

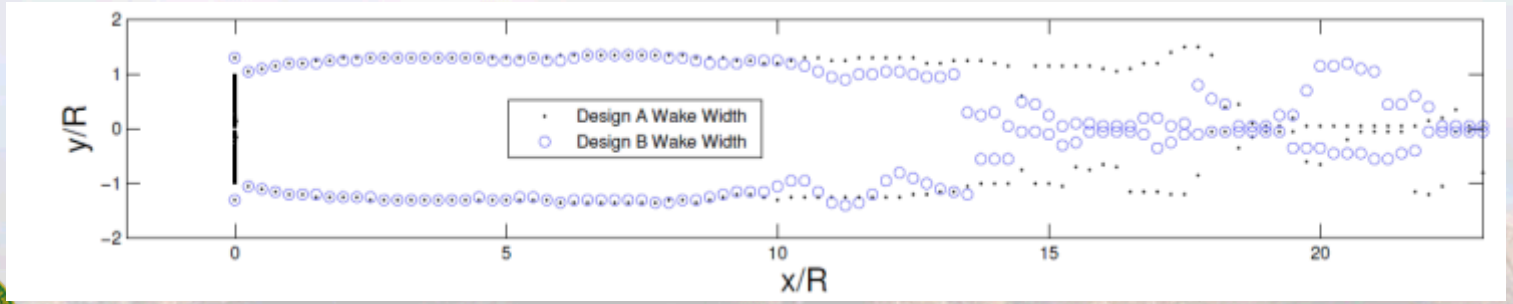
- Detailed analysis of fundamental turbine-turbine interaction
- Calibration and verification of public open-source wind turbine / plant model
- Data quality analysis and troubleshooting

National Rotor Testbed

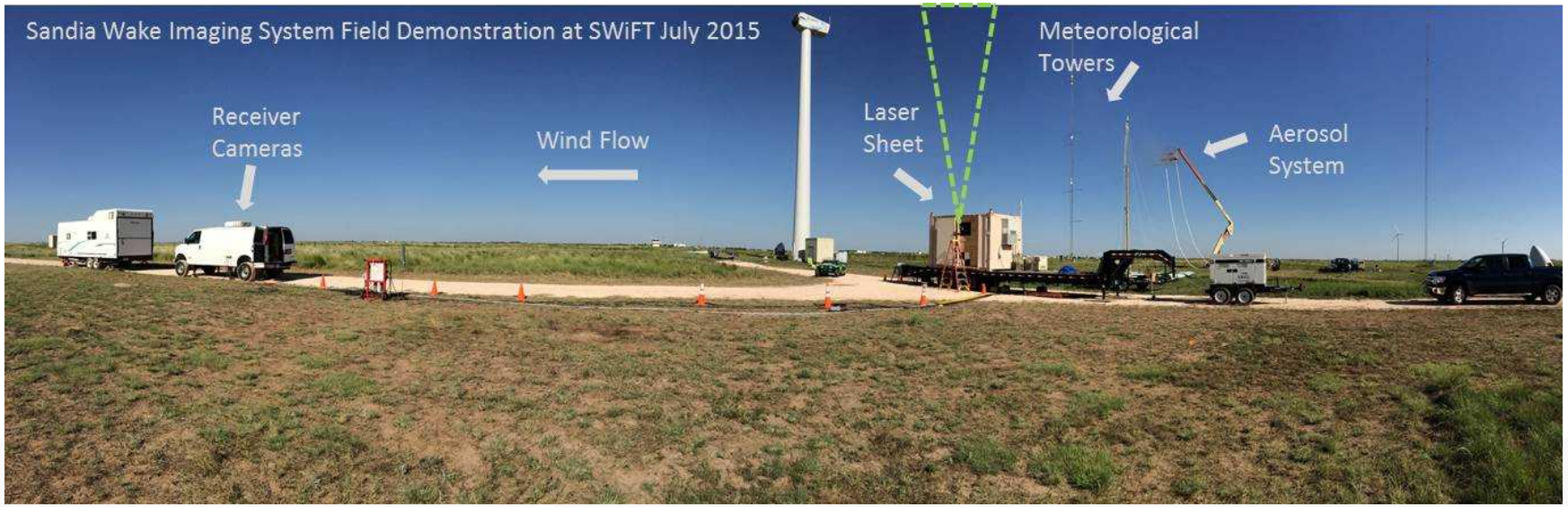
- The National Rotor Testbed is a rotor innovation to enable technology acceleration



- 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



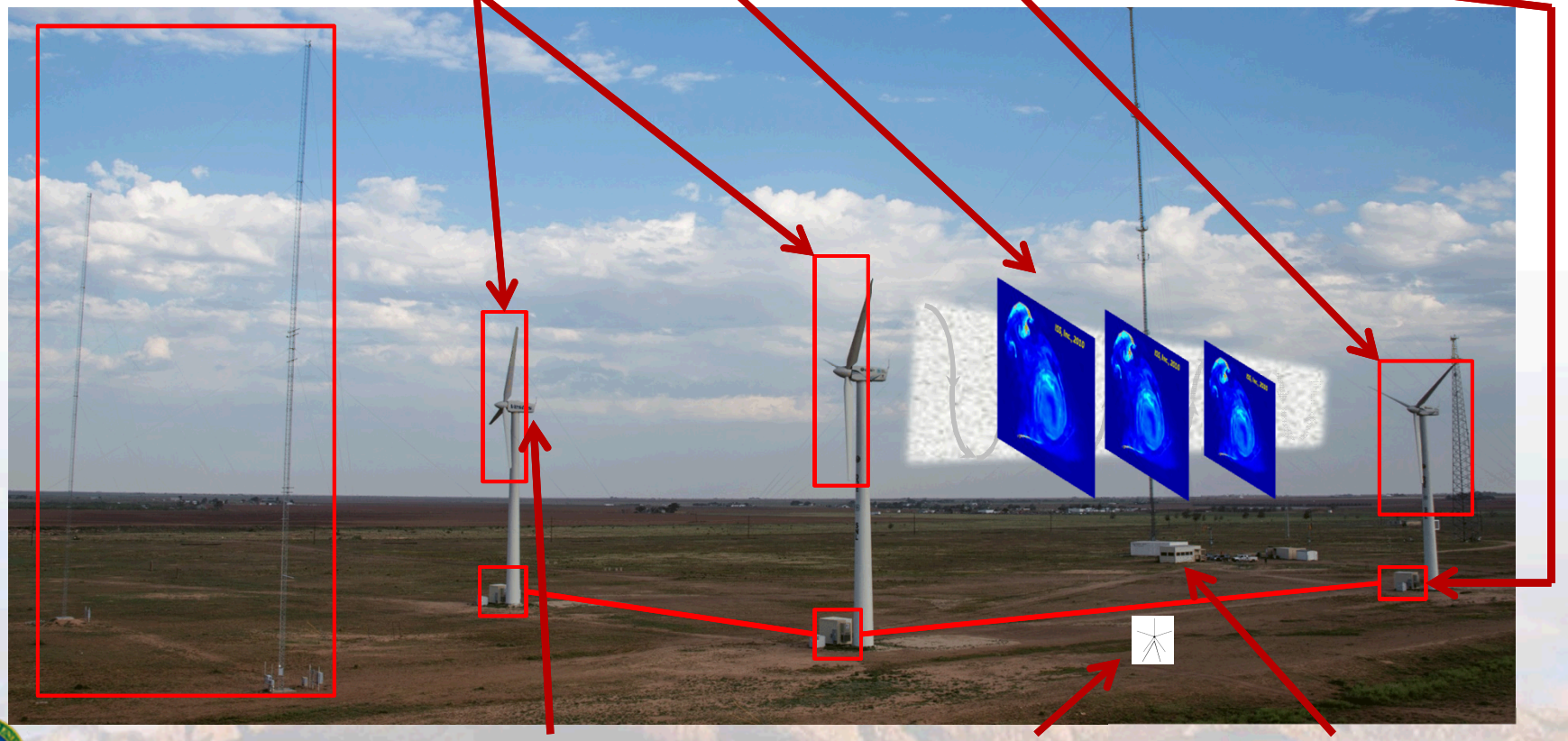
Wake Imaging Measurement System



- 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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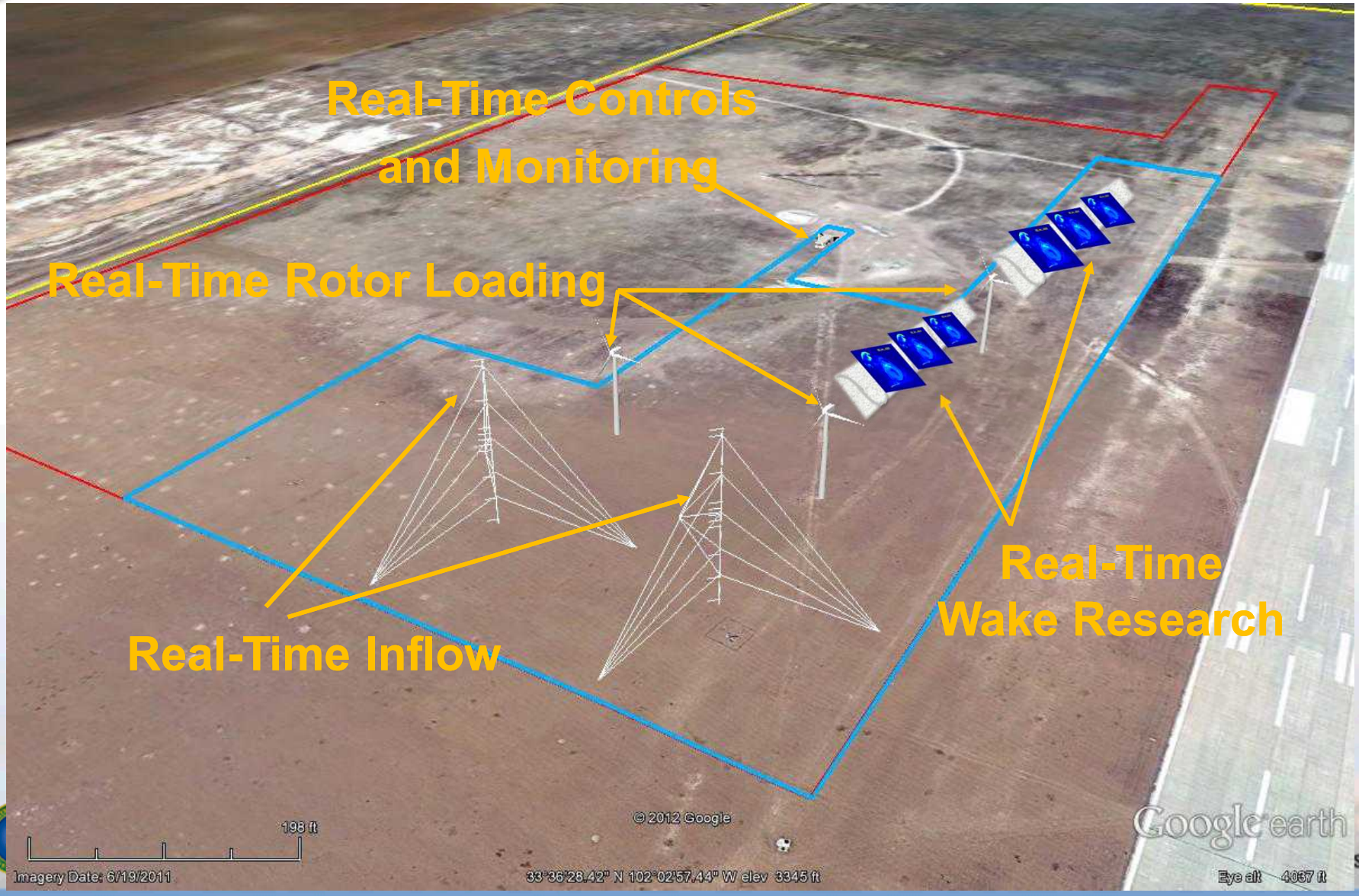
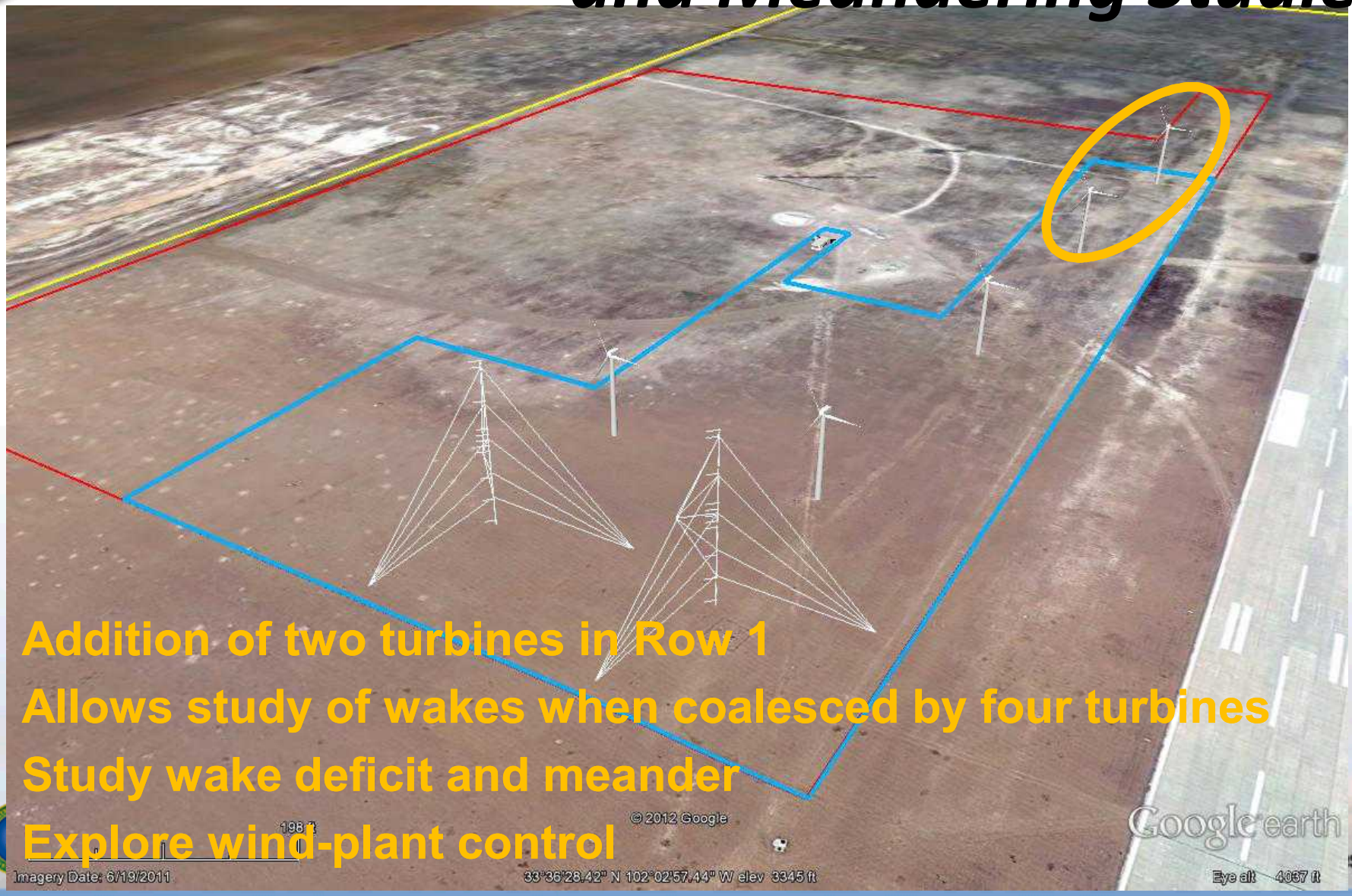
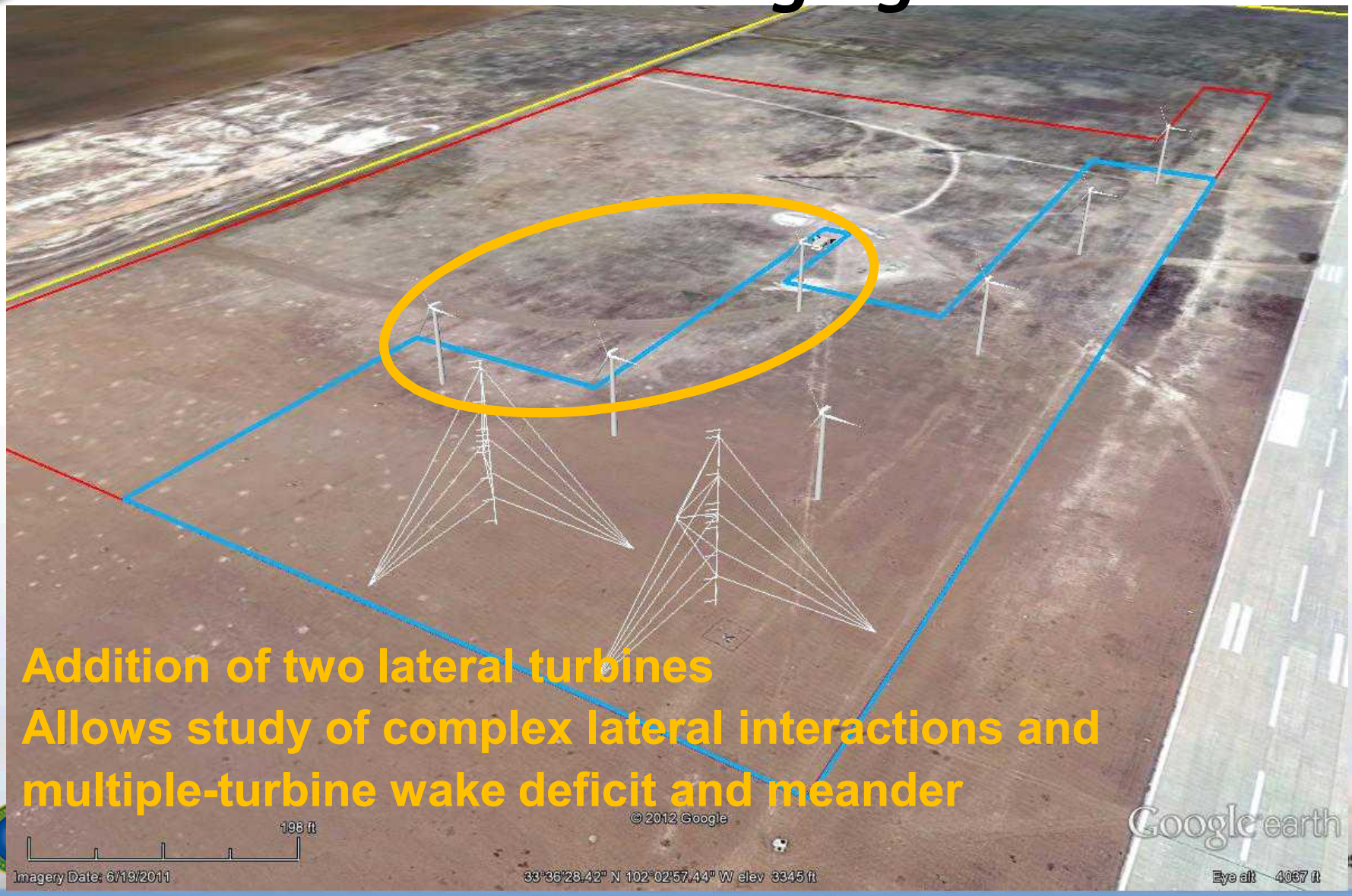
Basic Turbine to Turbine Interaction



Deep-Row Wake Deficit and Meandering Studies



Complex Lateral Wake Merging and Meander



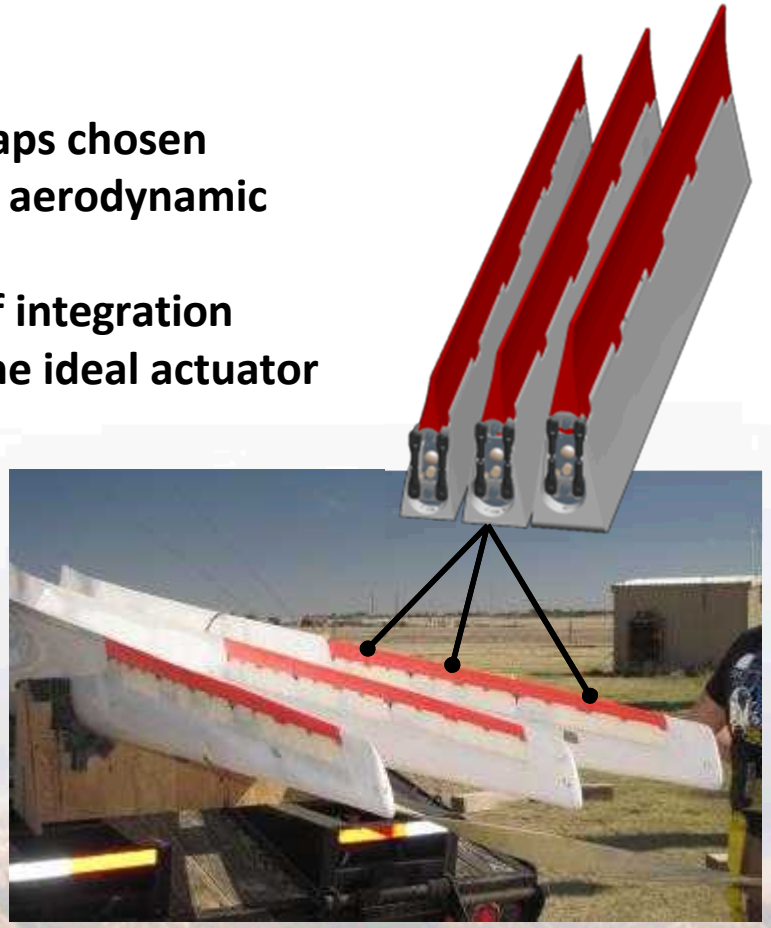
SMART Rotor Project Overview

SMART rotor project goals

- **Evaluate adequacy of simulation tools for active aerodynamic load control**
- **Gain insight into the challenges of integration**

Conventional hinged flaps chosen

- **expectation of good aerodynamic control authority**
- **relative simplicity of integration**
- **but not necessary the ideal actuator for active aero**



Thank you!

This work is supported by the US DOE EERE Wind and Water Power Program.