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DOE / SNL Scaled Wind Farm Technology (SWiFT) Facility at TTU

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NNSA Sandia National Laboratories

Outline

- *DOE/SNL Objectives of Scaled Wlnd Farm Technology Facility*
- *SWIFT Overview*
- *Collaborative Partnerships*
- *Progress Updates*

DOE/SNL Objectives of Scaled WInd Farm Technology Facility

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Exceptional service in the national interest

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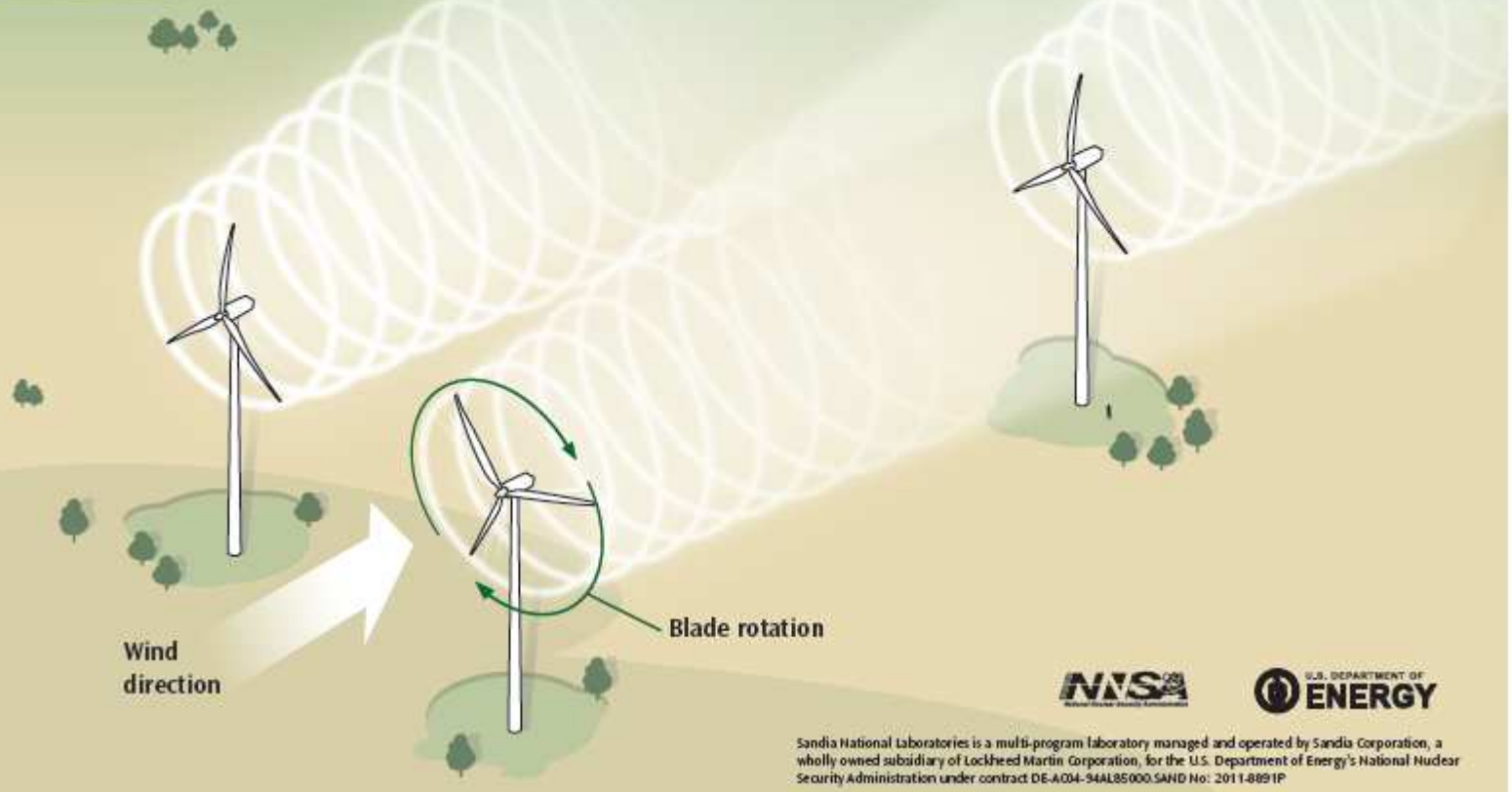

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DOE/SNL Objectives

- ***Study of turbine to turbine interaction***
  - *Tip vortices, wake growth, wake mixing, meandering wakes*
  - *Inflow turbulence, low-level jets, advanced features*

- ***Advanced wind turbine rotor development***
  - *Passive load control: bend-twist coupling, sweep-twist coupling, passive camber control, flat-back airfoils*
  - *Active load control: smart rotor, nonlinear wind turbine control, smart turbine design*
  - *Advanced sensing technologies: operational monitoring, structural health monitoring, prognostics*

- ***Aerodynamics, aero-elasticity, and aero-acoustics testbed***
  - *Inboard aerodynamics, 3D blade flow, NUMAD / BPE design tool advancement, near-blade acoustic generation, acoustic propagation, acoustic beam-forming*

SWIFT Overview

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Objectives and Approach

- **What:** SNL is recapitalizing the DOE / SNL wind turbine testing facilities.
- **Why:** Variable-speed variable-pitch turbine operation with relevant Reynolds numbers and acceptable testing cost/time is required to transfer new innovative technologies to industry, i.e. buy down high-risk. USDA is less committed to supporting wind energy (Change in mission).
- **Who:** A research institution committed to wind energy research and education, capable of supporting testing facilities, personnel, schedule, and process.
- **When:** 2 months. Foundations are being designed, turbines are being refurbished, and controller is being engineered.
- **Where:** Texas Tech University most committed and viable to hosting the site.

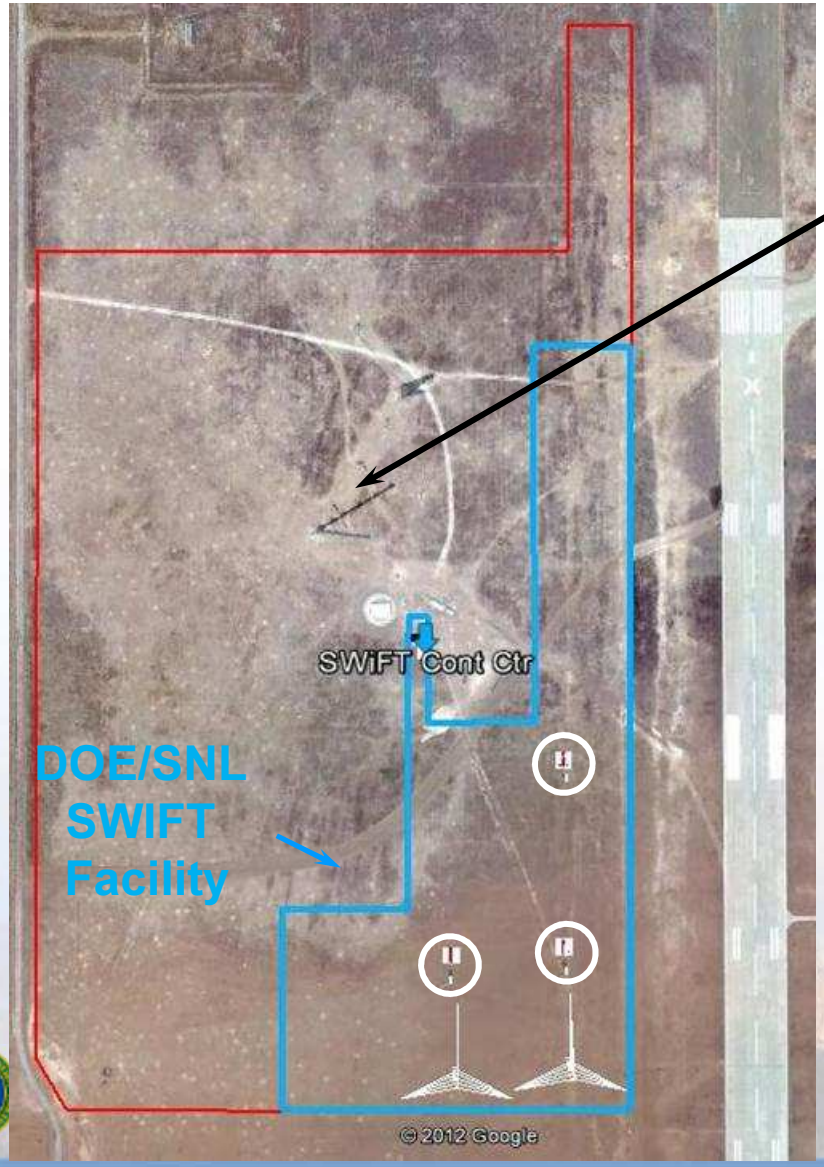
Site Plan

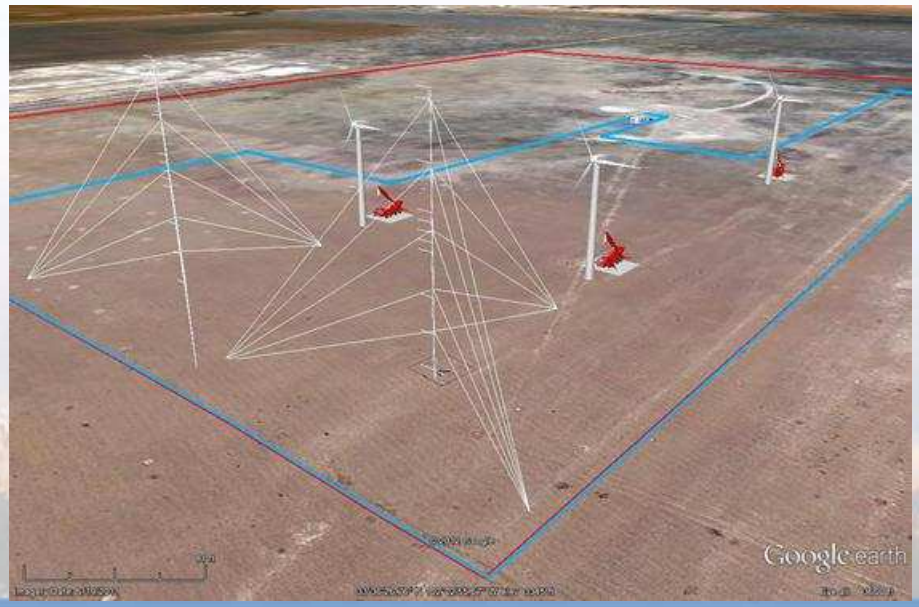

United States
Reese Technology Center TTU, Lubbock, TX


Reese Technology Center TTU, Lubbock, TX
Reese Center
Lubbock
Wolfforth

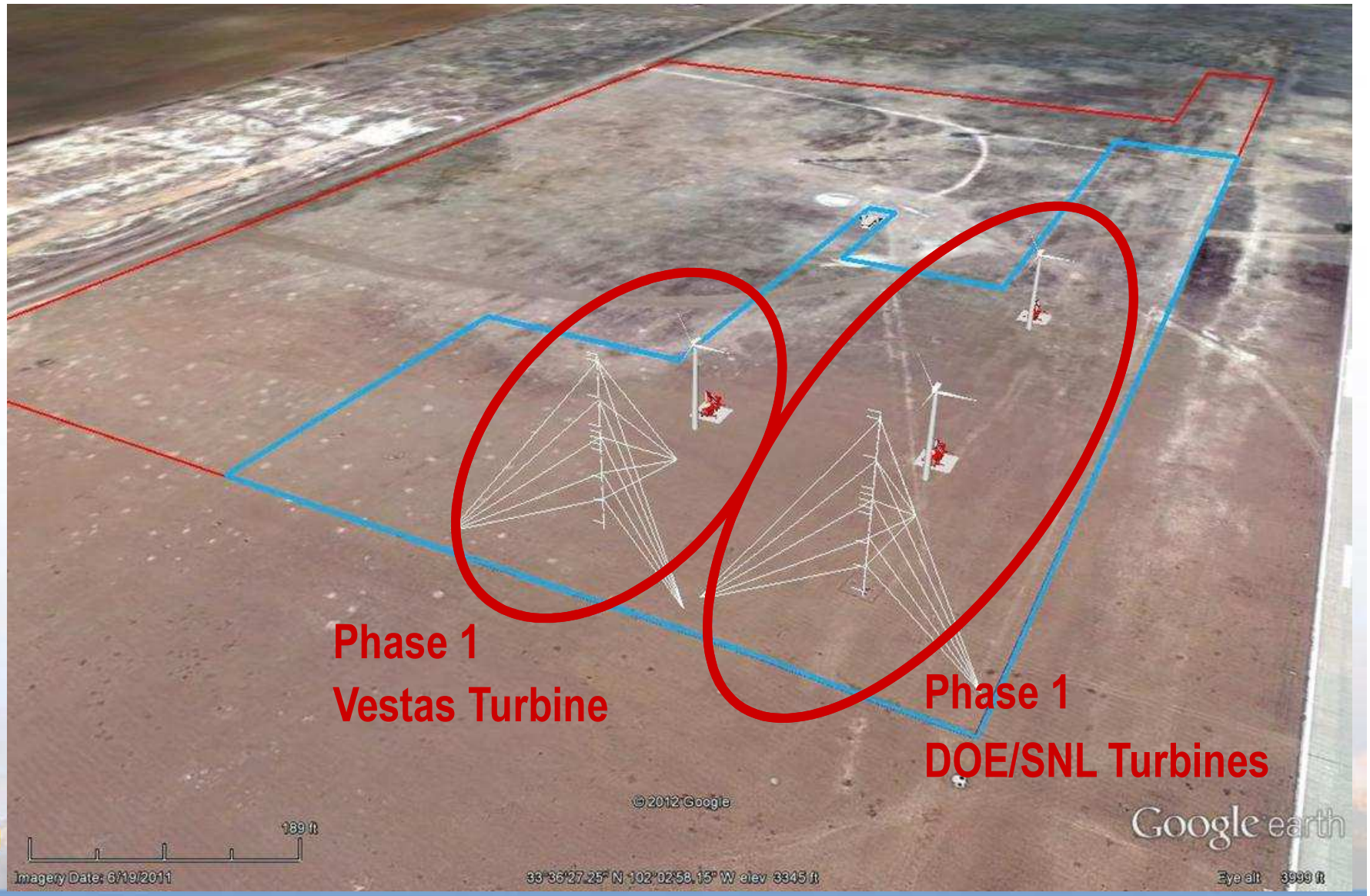

Future Control Building
ALSTOM Turbine
Reese Center
Repurposed Building 350

Turbine Site Plan

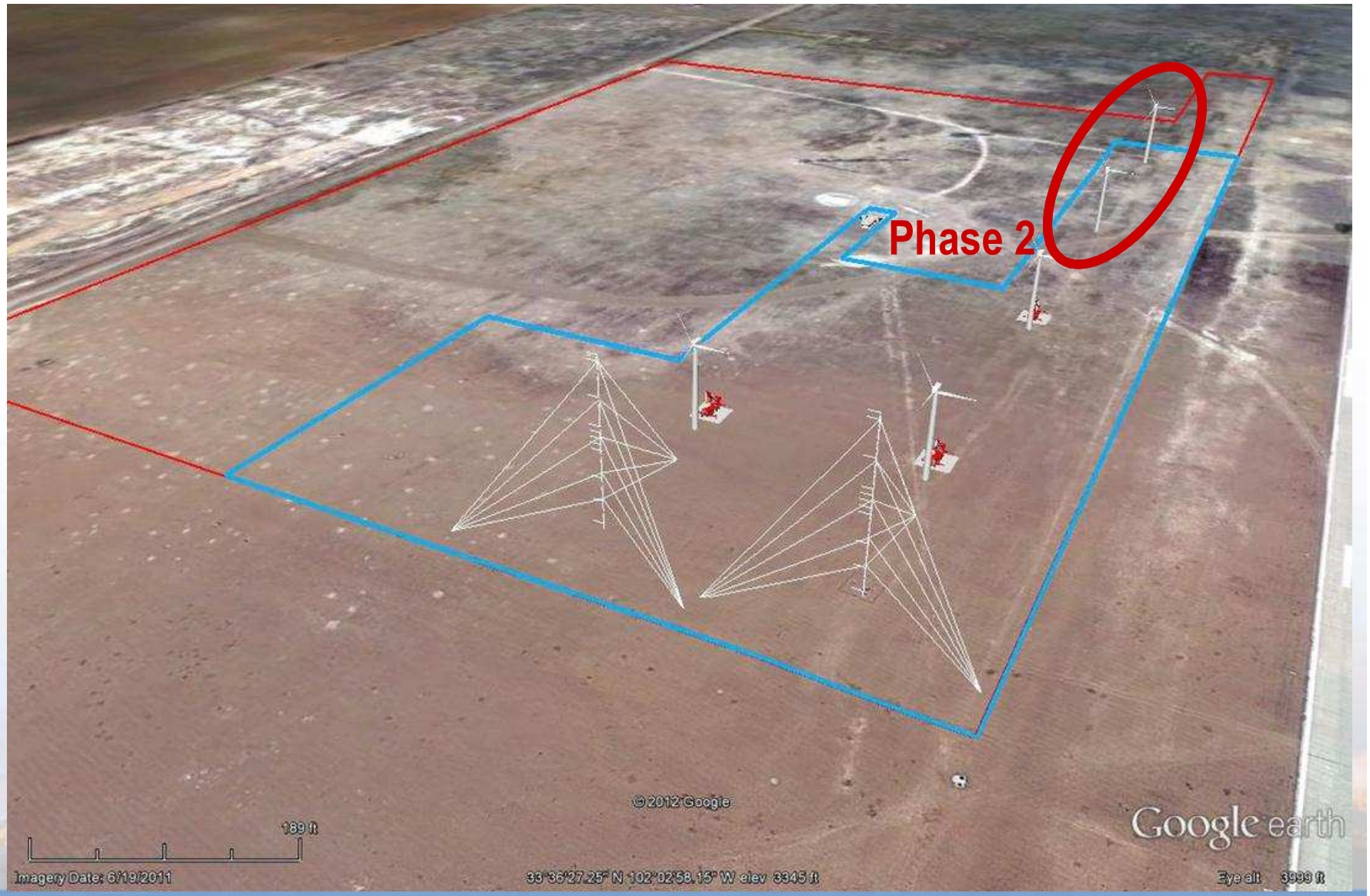




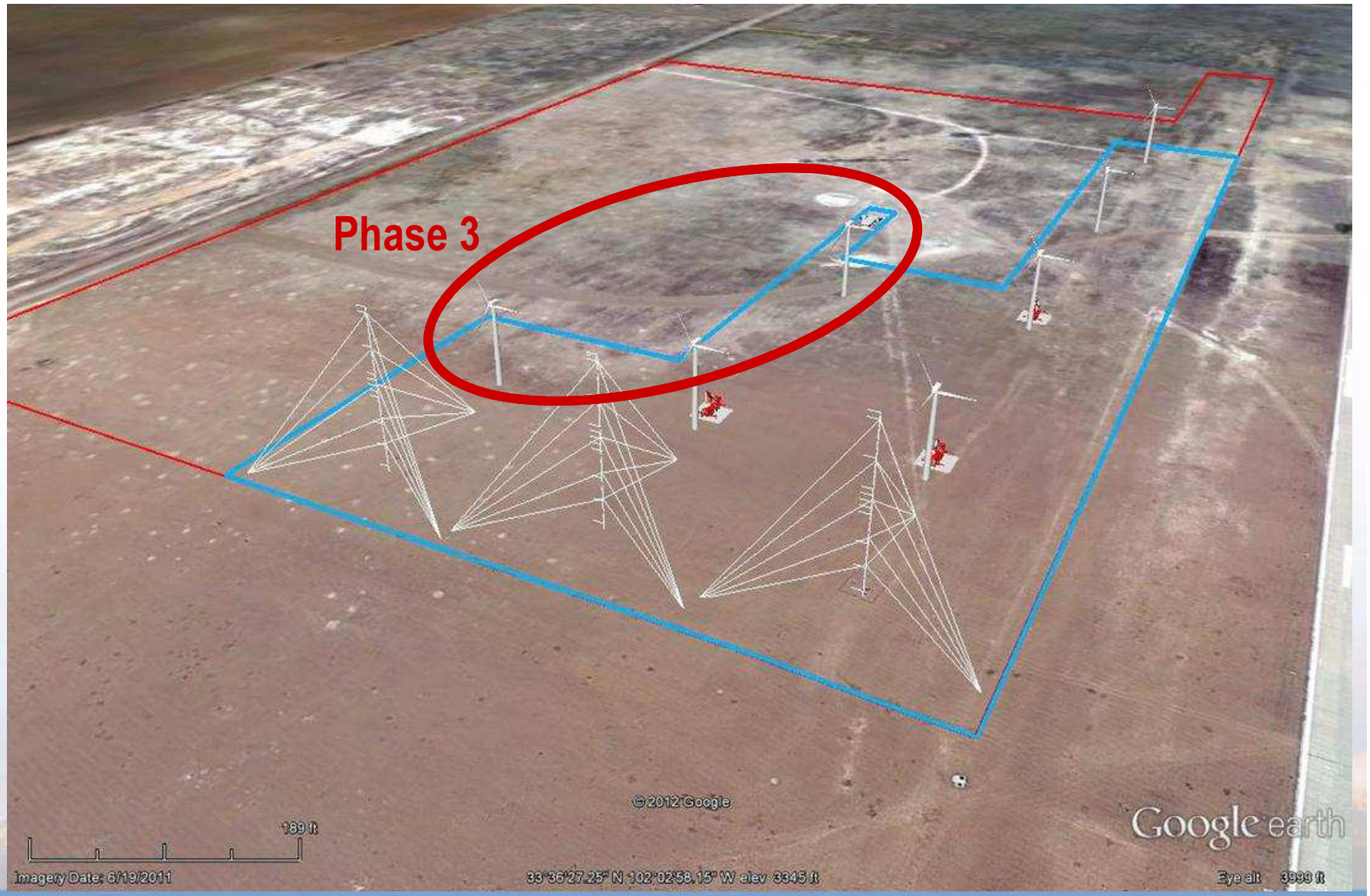
SWIFT Array Long-Term Plan



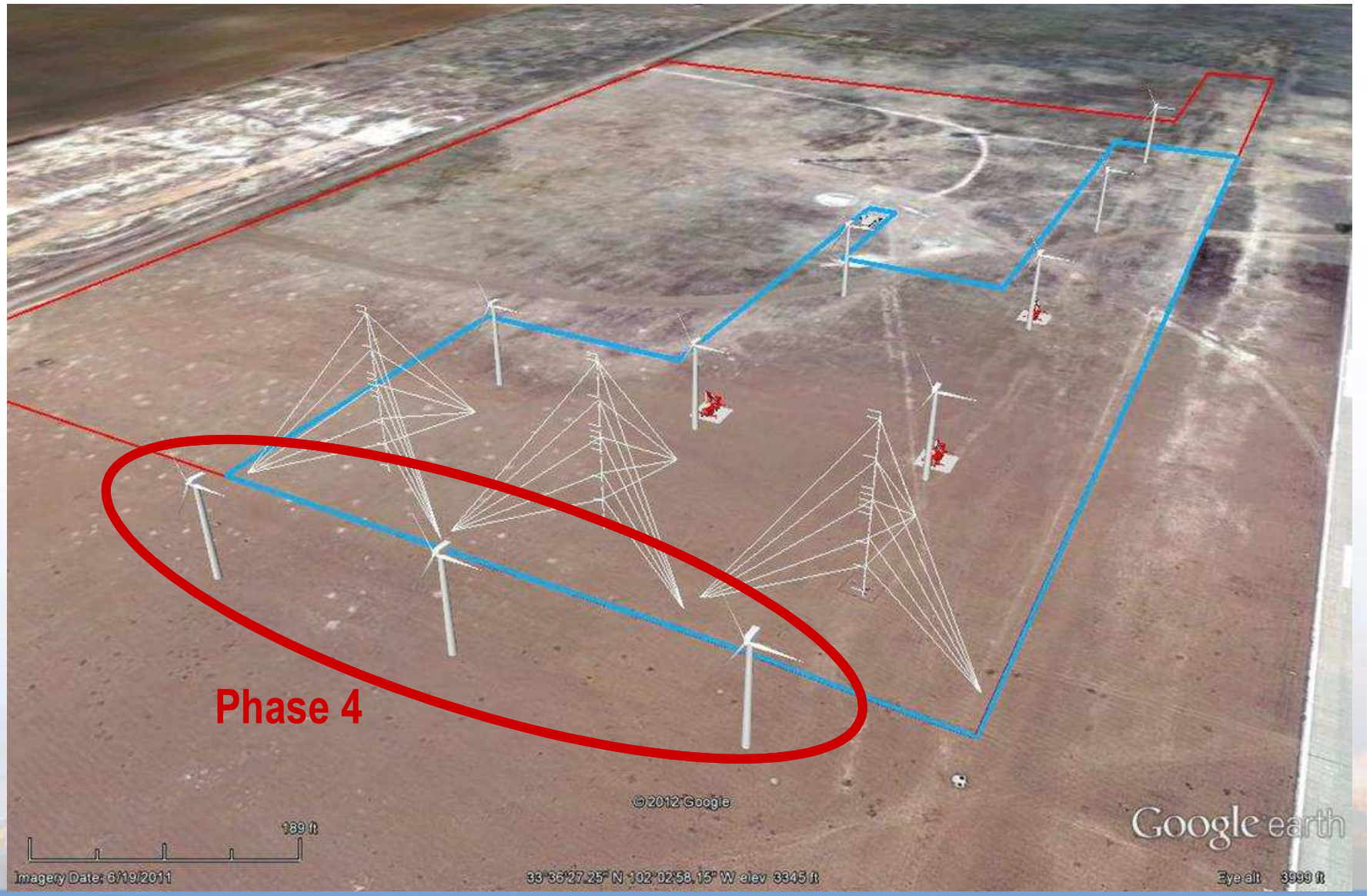
SWIFT Array Long-Term Plan



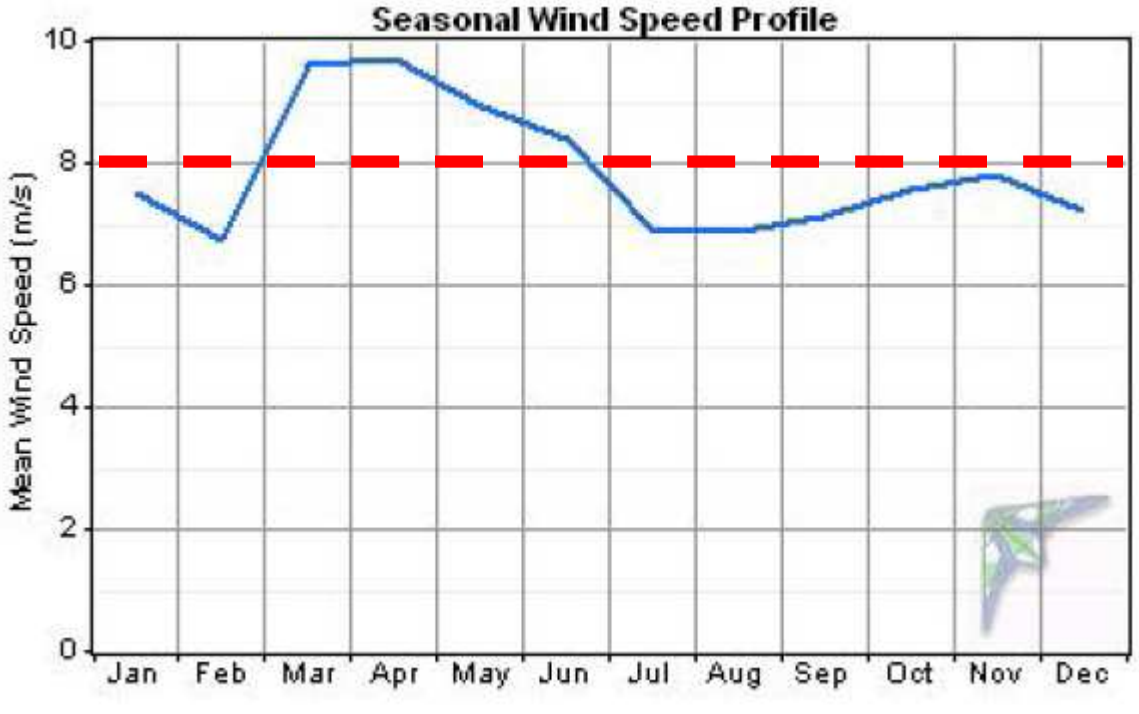
SWIFT Array Long-Term Plan



SWIFT Array Long-Term Plan

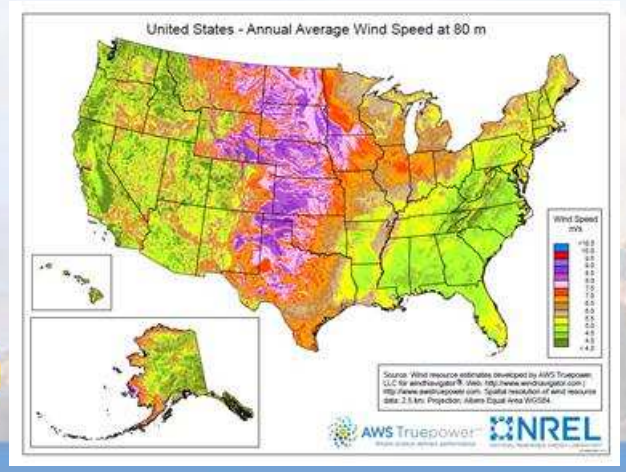


Wind Resource Assessment

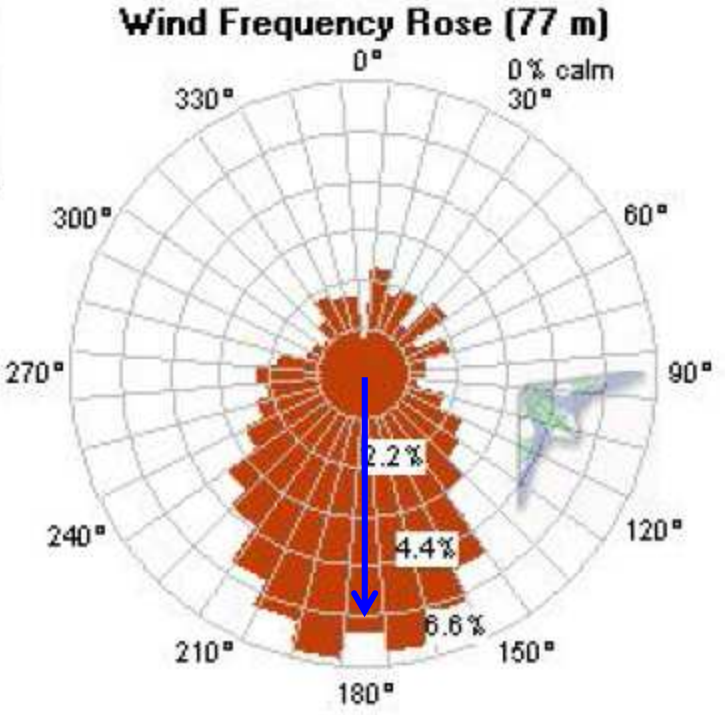


8 m/s at 77 m
(7.5 m/s at 50 m)

Class 5 Wind Site!



Consistent Wind
South
180.5° Average



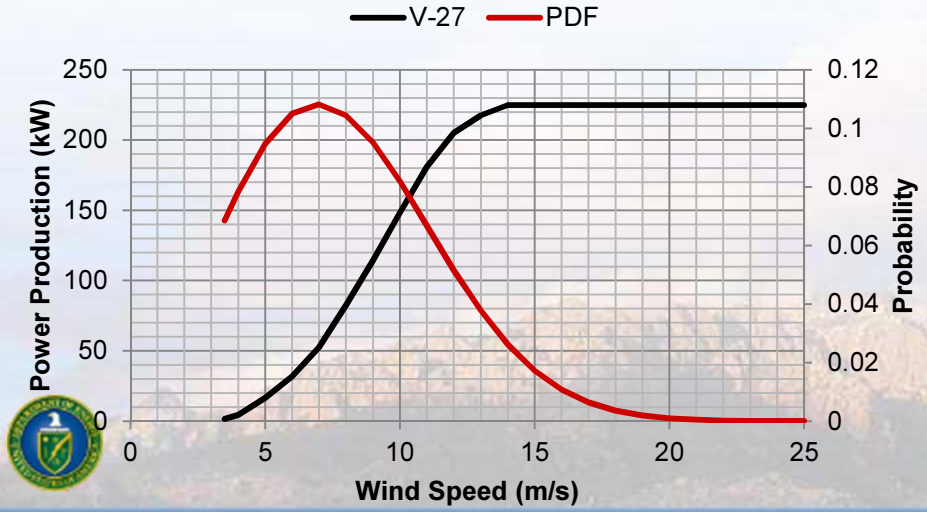
Proposed Test Turbine

Modified Vestas V-27

- 300 kW (0 – 55 rpm)
- 13 m (43 ft) Blade Length
- Pitch Control in Region 3
- 30 m (98 ft) Tower Height
- Reynolds Number ~2×10^6
- Highly reliable

Site Production

- 7 m/s hub-ht. average
- 92 kW Average
- 41% Capacity Factor



What is Research-Scale?

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

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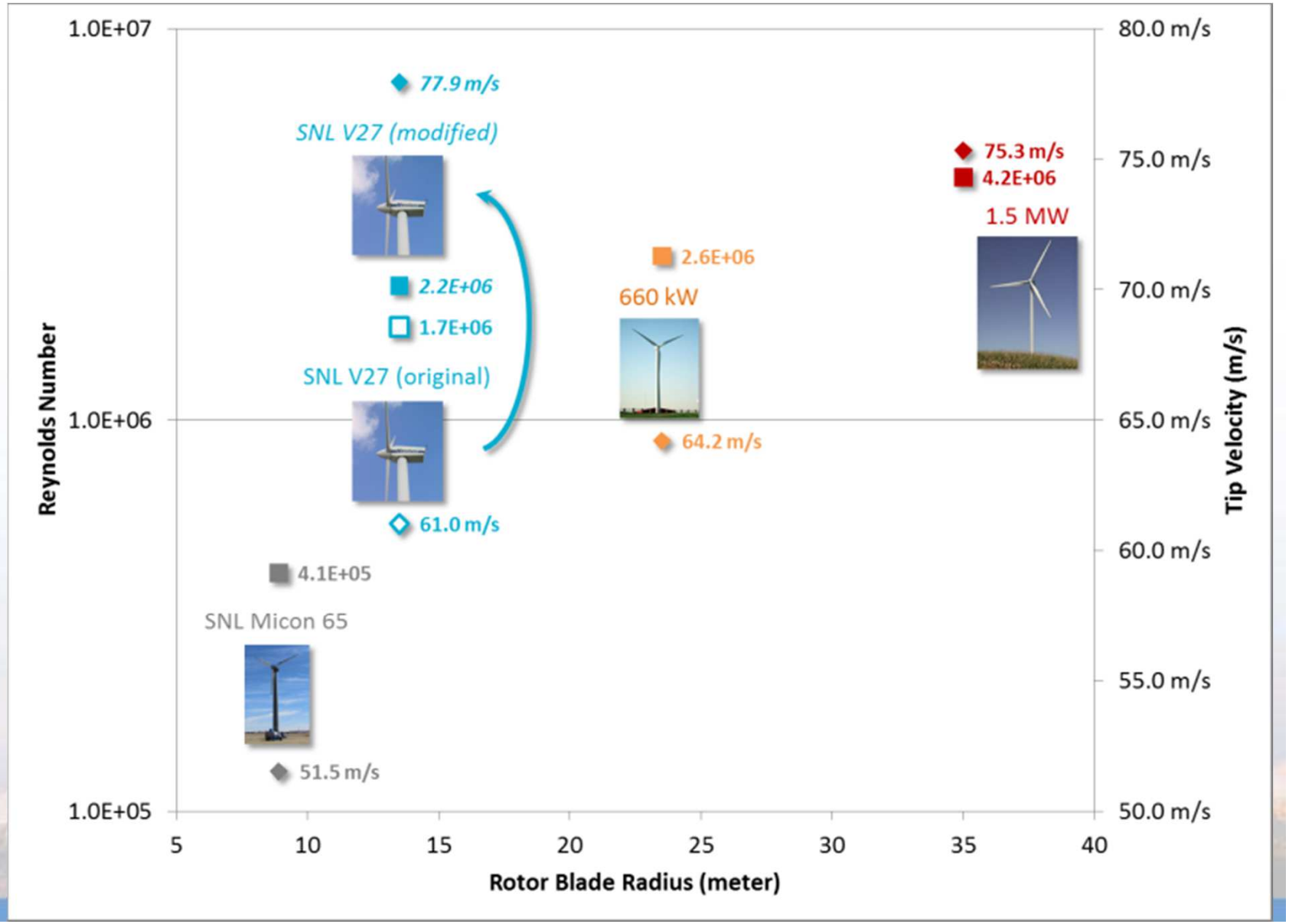
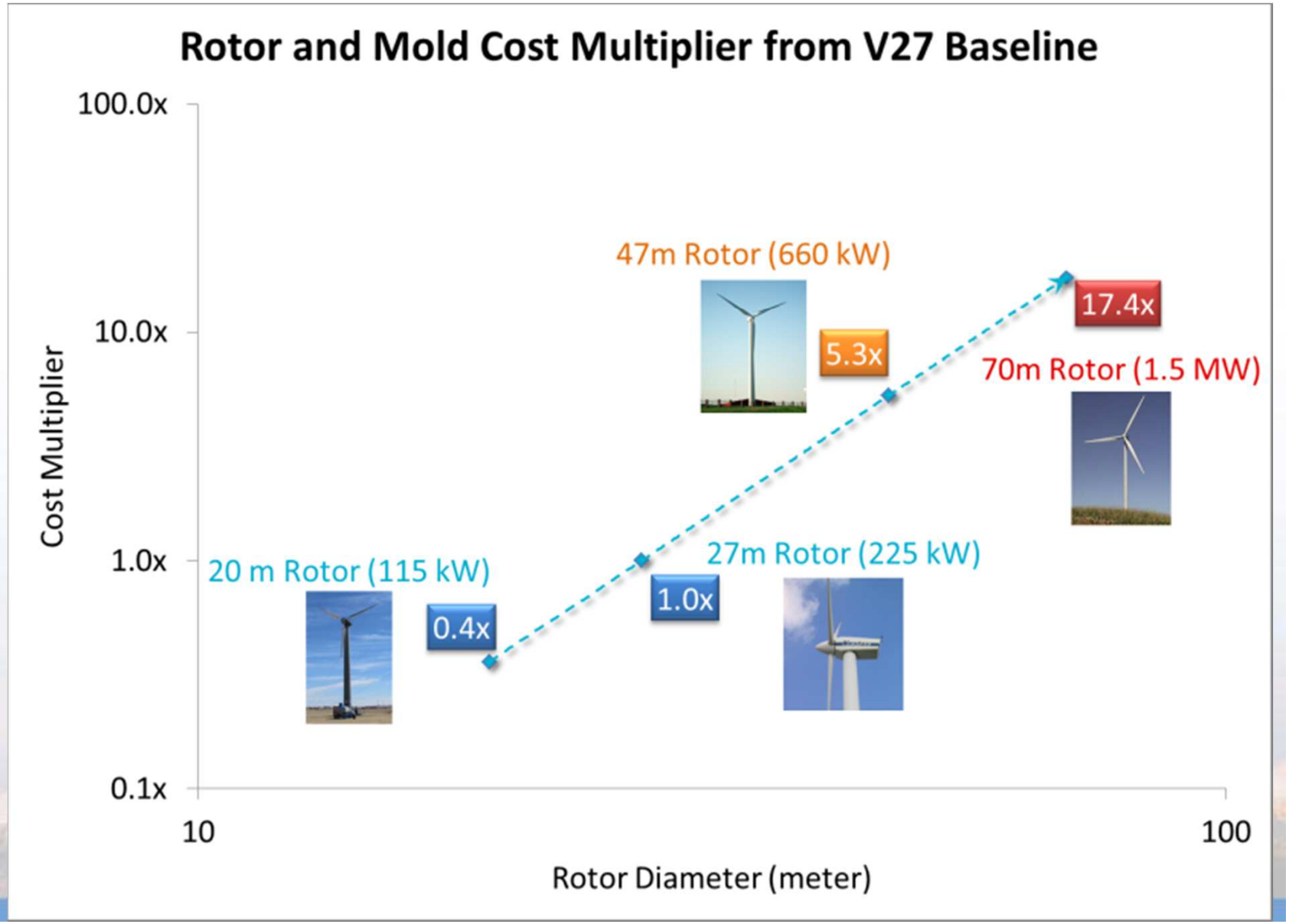
Aerodynamic Scaling



Cost Efficiency



Crane Cost Comparison

Research Scale (225 kW)

Megawatt Scale

Costs

$5,000 v. $250,000

Scheduling

Days Ahead v. Months Ahead

Testing Risk

Low v. High

National Open-Source Research Asset

DOE / SNL Rotor Blade Designs

DOE / SNL FAST / ADAMS Model of V27

Feasibility Proof **Technology Demonstration** **Commercialization**

TRL-1 **TRL-2** **TRL-3** **TRL-4** **TRL-5** **TRL-6** **TRL-7** **TRL-8** **TRL-9**

Basic Research **Technology Development** **Sub-Scale Testing**

DOE / SNL Advanced Blade Testing at NREL-NWTC

DOE / SNL SWIFT Facility at TTU

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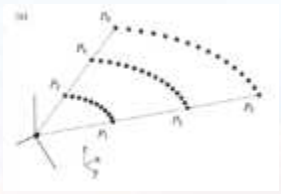
Research-Scale
Examples of Success

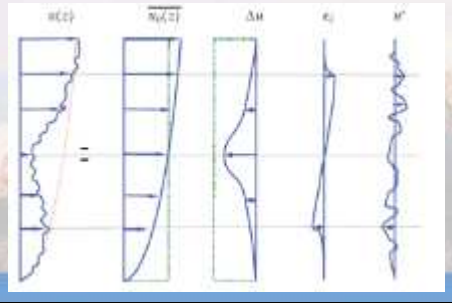
Risø DTU
National Laboratory
for Sustainable Energy
DTU

- *"Light detection and ranging measurements of wake dynamic Part I & II" 2011*


LIDAR Scanning of 95 kW Turbine Wake

Decomposition of Wake Deficit



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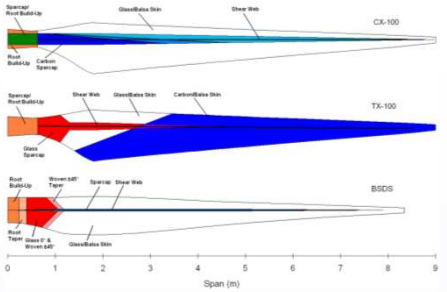
- CX / TX / BSDS Blade Family Study



Fabrication and Testing at the 115 kW Scale

tpi

USDA United States Department of Agriculture
ARS Agricultural Research Service
Conservation & Production Research Laboratory

Result: **24% reduction in damage equivalent load and initiated industrial use of carbon, flatback airfoils and twist-bend coupling.**

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Development Partnerships

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SWIFT Partnerships

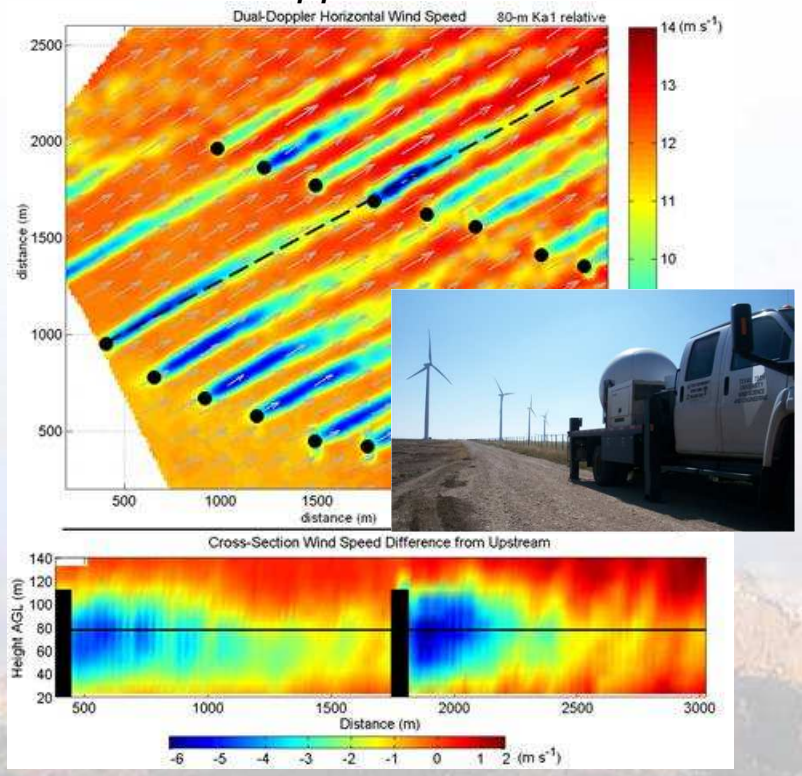
DOE/SNL/TTU Partnership

- ***Wind Science and Engineering Research Center (WISE) has a 40 year history in wind-related research and development***
- ***Unique Capabilities and Facilities***

TEXAS TECH UNIVERSITY

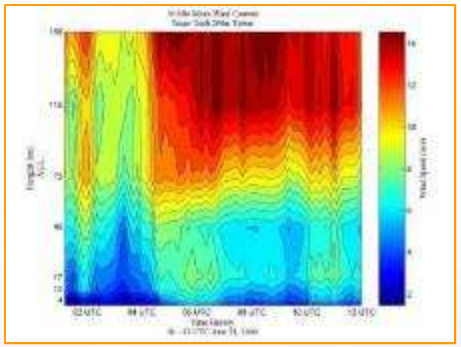
Distributed Wind Resource Assessment

2x mobile Doppler research radars



Large-scale Test Infrastructure

200 meter anemometer tower



MW Wind Turbines

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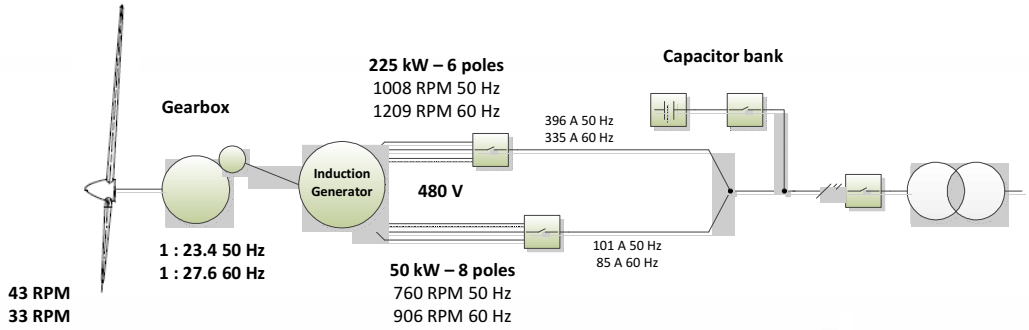
Variable-Speed Upgrade

Fixed Speed



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Vestas

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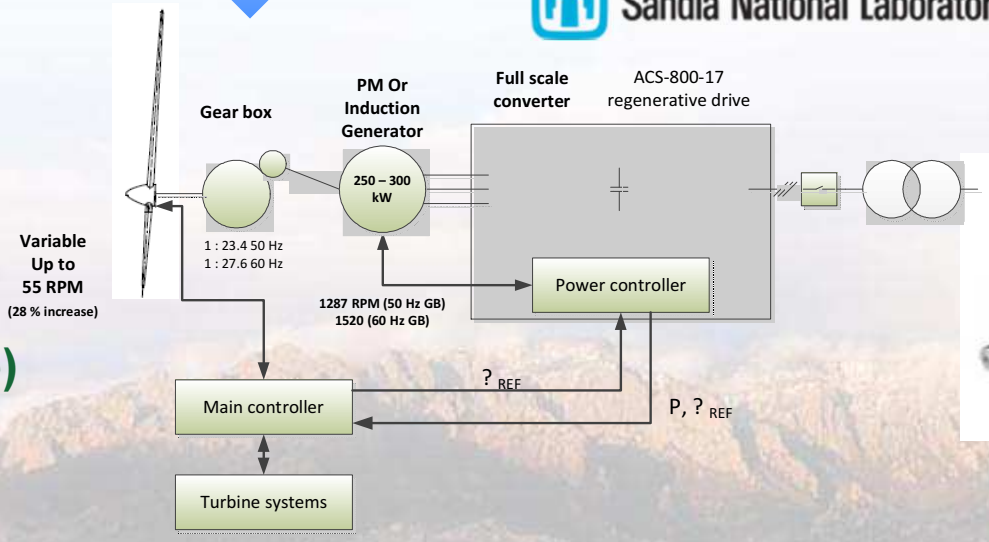
DOE/SNL Variable Speed (Open-source)



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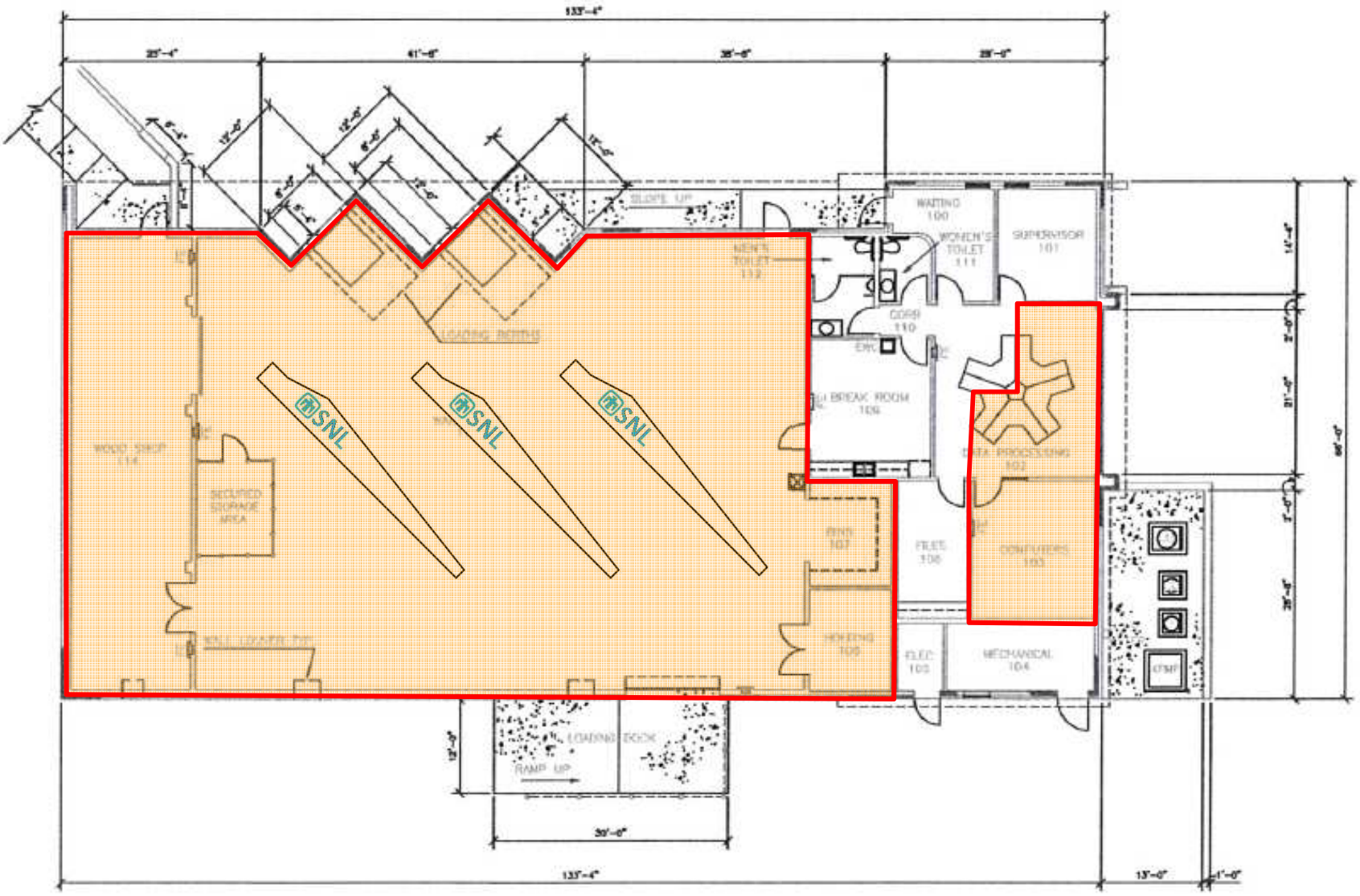
Re-purposed Assembly Building



Progress Updates

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Site Construction

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Anemometer Tower

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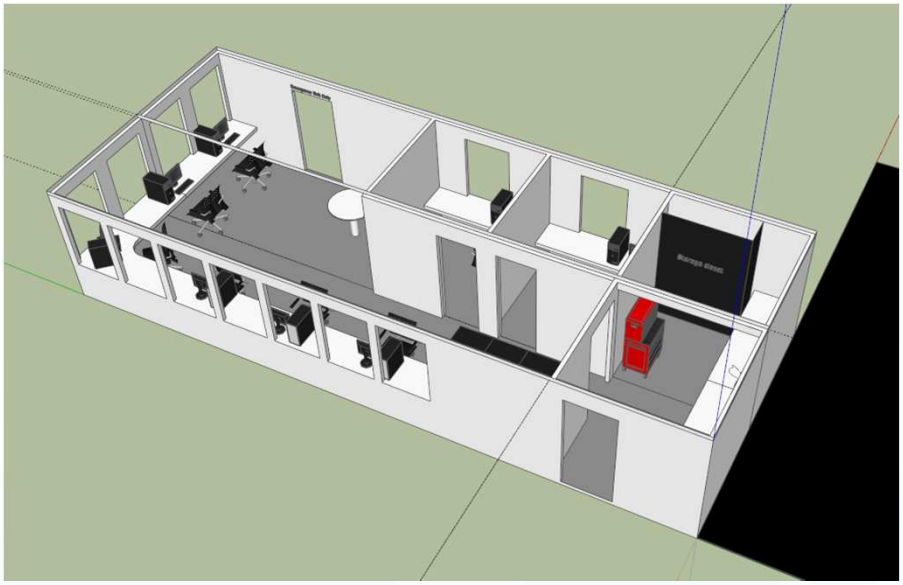
Control Building



Refurbished Assembly Building

Experimental rotor preparation

Machine Shop