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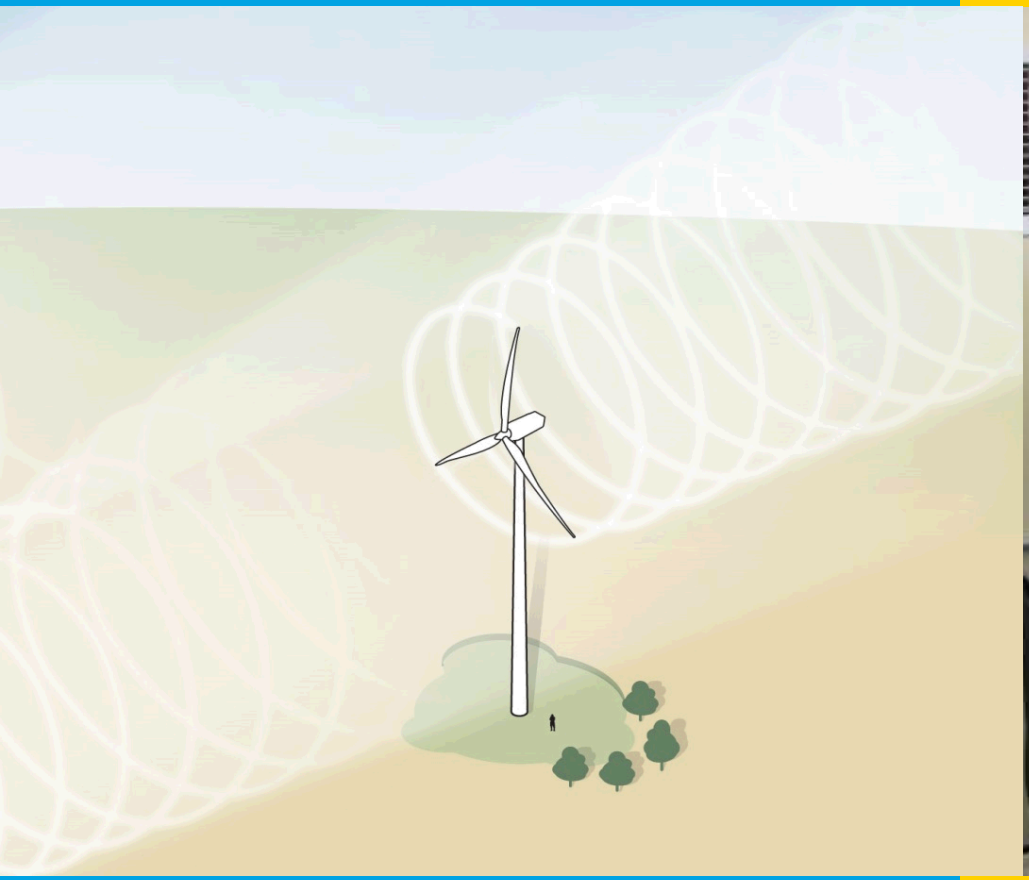
SAND2014-1711P



Wake Measurement System

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Purpose & Objectives

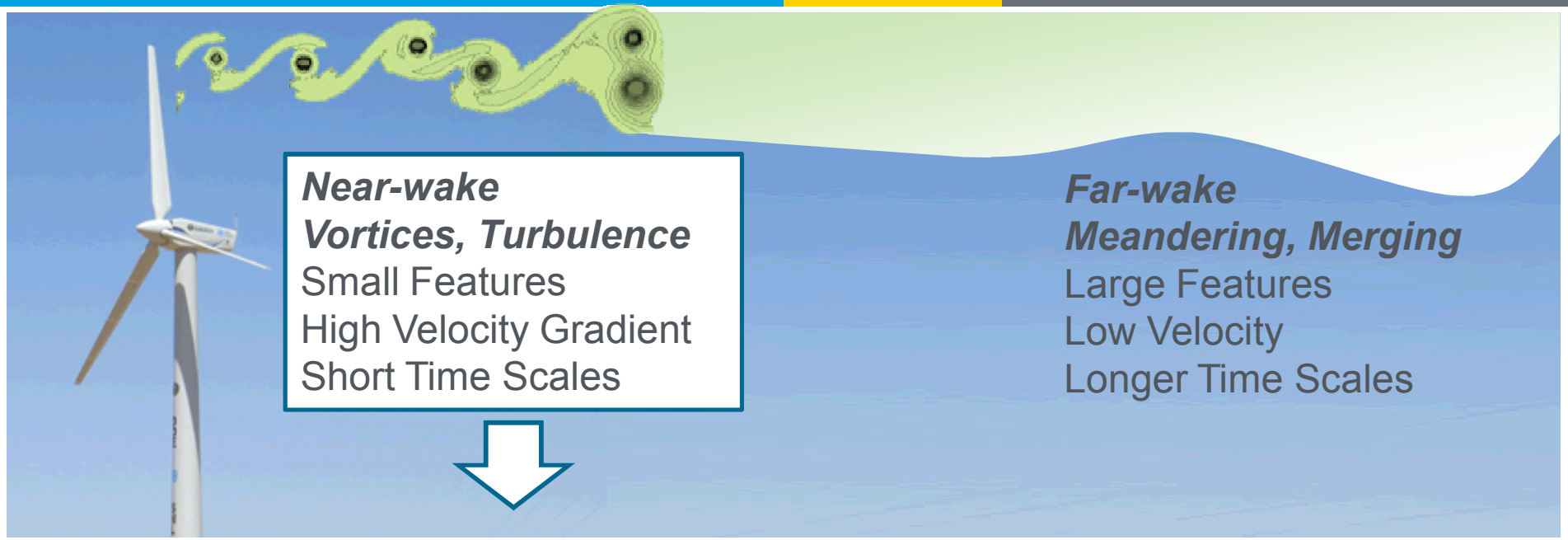
Problem Statement: Turbine wake formation and evolution is not sufficiently well understood, leading to uncertainty in wind plant performance.

Impact of Project: Innovative instrumentation providing field data will enable validation of research codes and design tools used to optimize wind plant performance.

This project aligns with the following DOE Program objectives and priorities:

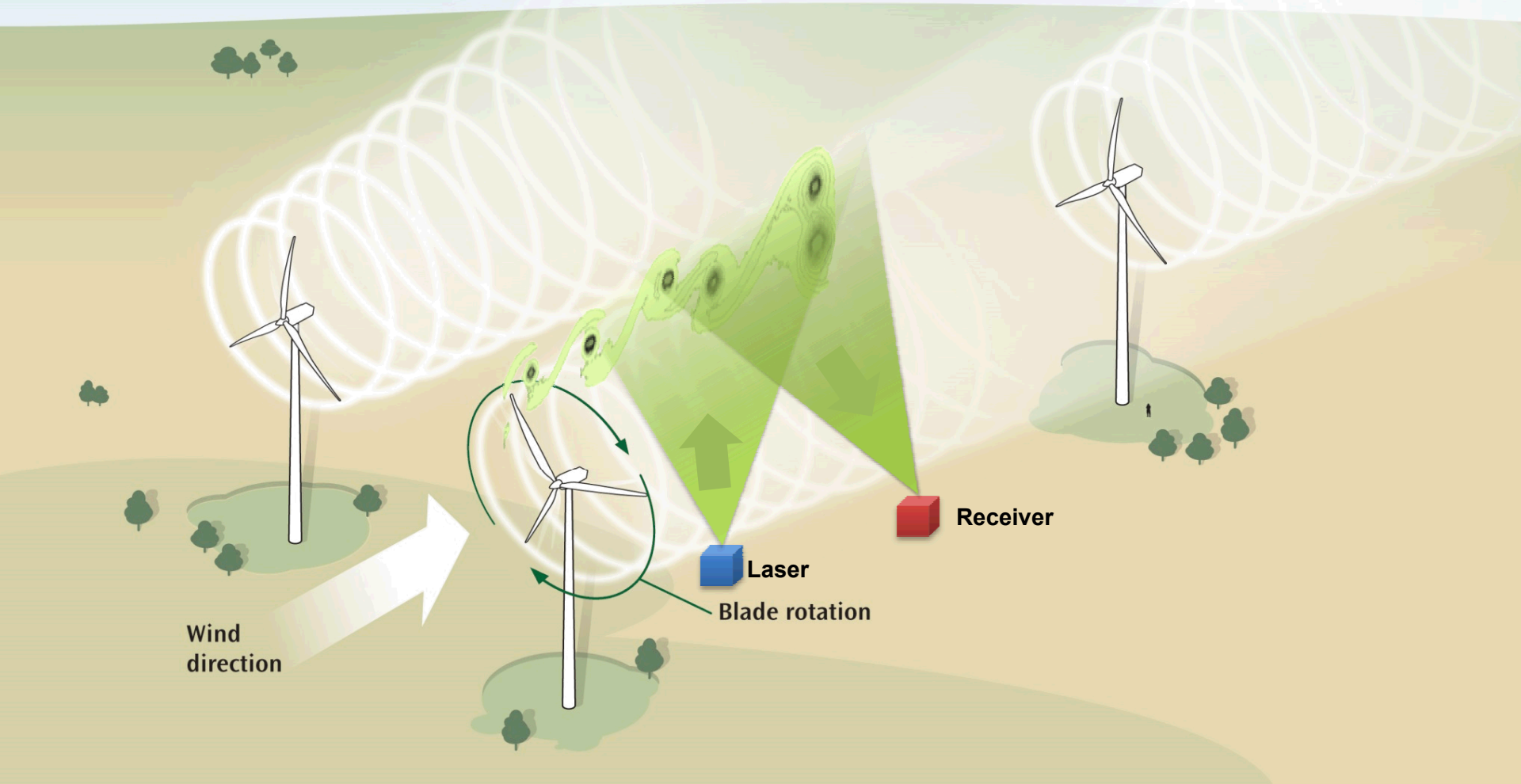
- **Optimize Wind Plant Performance:** Reduce Wind Plant Levelized Cost of Energy (LCOE)
- **Testing Infrastructure:** Enhance and sustain the world-class wind testing facilities at Universities and national laboratories to support mission-critical activities

Technical Approach



Existing Systems	Challenges in Near-wake field testing
Particle Image Velocimetry (PIV)	**Small field of view** due to particle size and camera resolution relation. Particle release outdoors an **EH&S challenge**.
Scanning LIDAR	**Time resolution** of scanning point measurements is insufficient to capture coherent flow structures

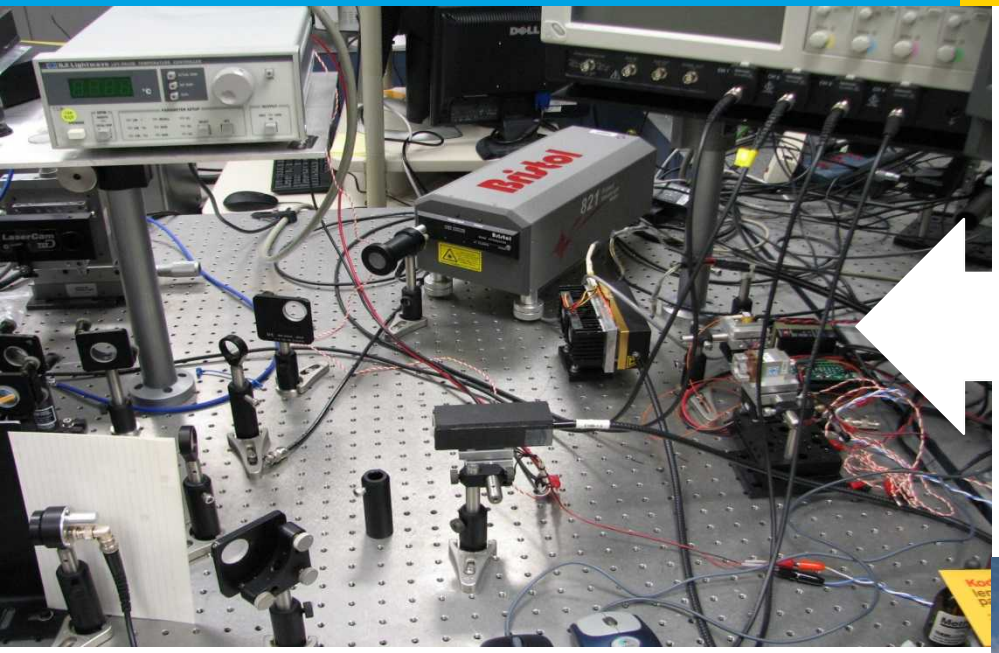
Measurement Technique: Planar Doppler Velocimetry



Risk reduction approach:

- Demonstrate simplest possible system
- Address make-or-break components
- Build up from lab to field experiments
- Identify and resolve ES&H issues early
- Leverage deep expertise, equipment, and facilities at Sandia to save time and money

Technical Approach



Initial lab experiments:

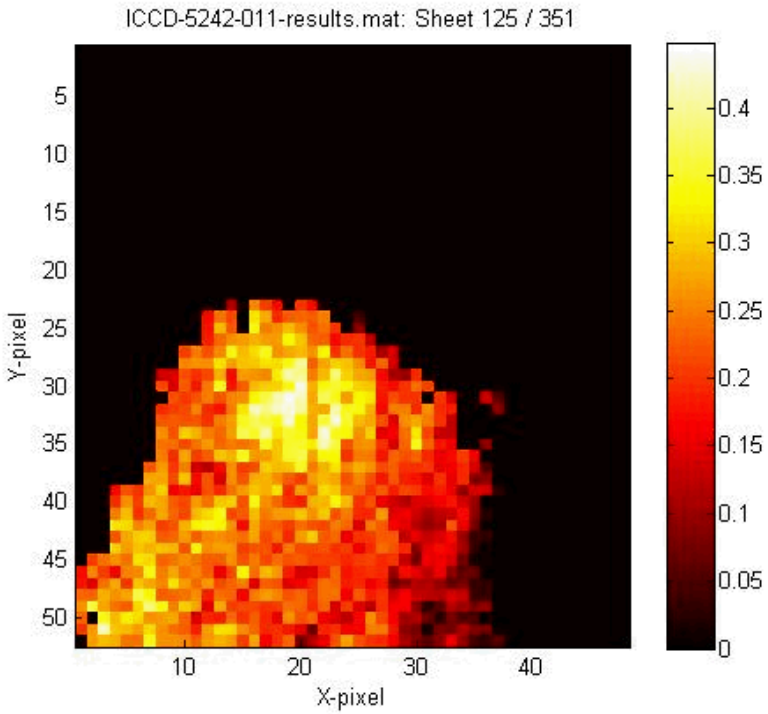
- characterized hardware
- developed software
- established proof of concept

Initial outdoor testing

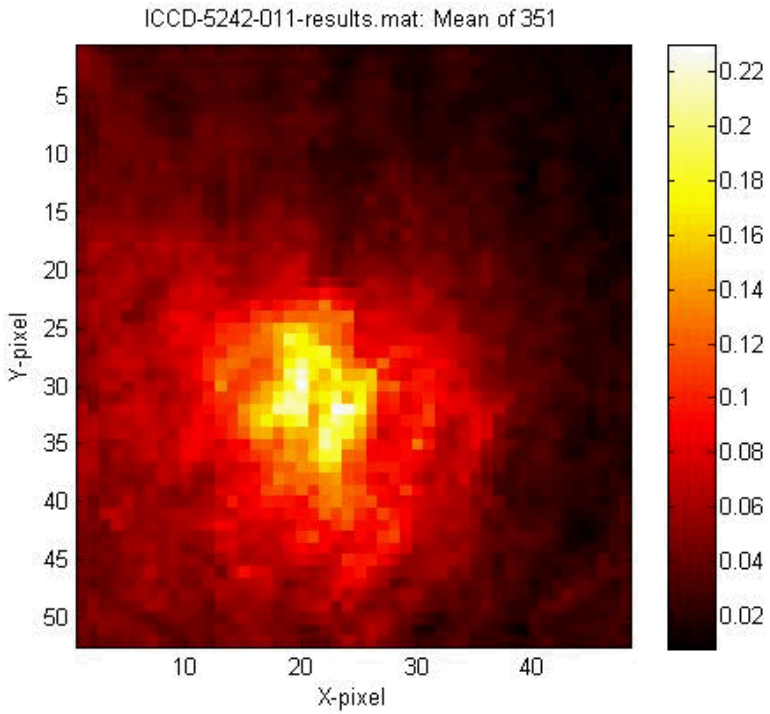
- Demonstrate scaling
- Identify field-deployment issues

Accomplishments

Single Pulse Image

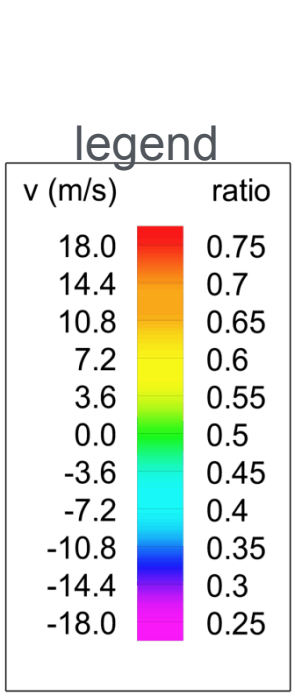


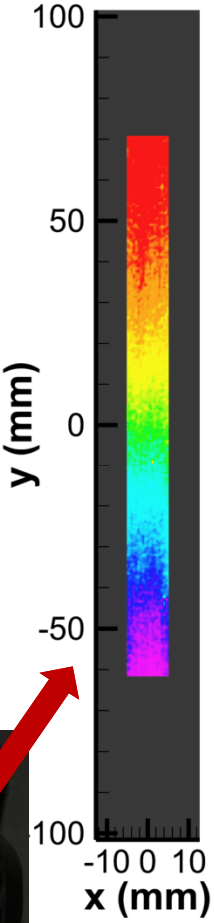
351 Frame Averaged Image

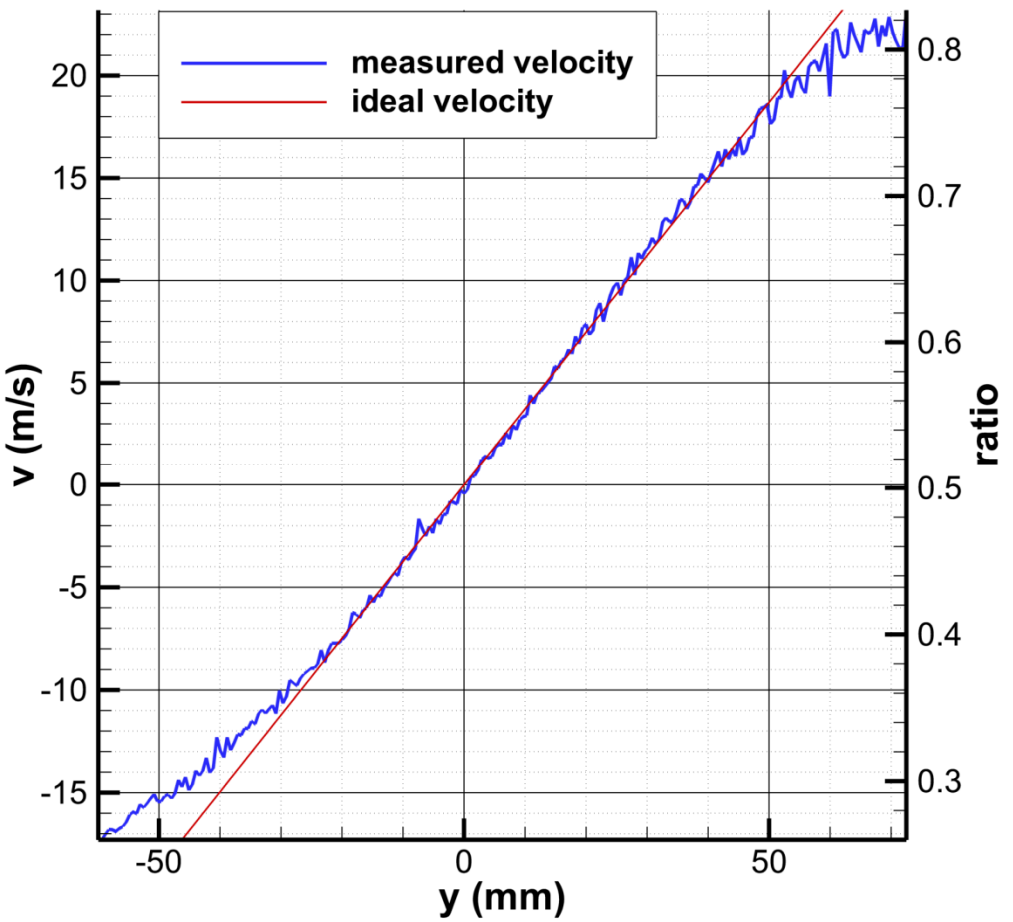


Intensity images of a dust plume were captured. Insufficient laser stability and camera calibration existed to convert intensity to velocity images.

Accomplishments







Extensive calibration procedures produced a validated velocity image

Project Plan & Schedule

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Summary	Legend
WBS Number or Agreement Number **2.1.0.4**	Work completed
Project Number	Active Task
Agreement Number **23437 (FY13)**	Milestones & Deliverables (Original Plan)
	Milestones & Deliverables (Actual)

Task / Event	FY2013 Q1 (Octt-Dec)	FY2013 Q2 (Jan-Mar)	FY2013 Q3 (Apr-Jun)	FY2013 Q4 (Jul-Sep)	FY2014 Q1 (Octt-Dec)	FY2014 Q2 (Jan-Mar)	FY2014 Q3 (Apr-Jun)	FY2014 Q4 (Jul-Sep)
Project Name: Wake Measurement System								
Q1 Milestone: Experimental Design for Laboratory Readiness Experiment								
Q2 Milestone: Draft Report on Laboratory Readiness Experiments								
Q3 Milestone: Project review and risk mitigation meeting with DOE								
Q4 Milestone: Field-deployable system major component specification								
Current work and future research								
Demonstrate system on calibrated target to obtain velocity image								
Draft design specifications for aerosol dispersion system at SNL TA3 test site								
Deliver report to DOE HQ on completed sensitivity test plan at SNL TA3 test site								
Draft SWiFT EH&S site plan for laser safety and aerosol dispersion system								

Comments

- Project start: May 2012. Anticipated completion of instrument: September 2015.
- Significant uncertainty in developing a research instrument has led to unanticipated issues requiring additional time to resolve and in some cases, adjust milestones.

Project Budget

Budget History			
FY2013		FY2014	
DOE	Cost-share	DOE	Cost-share
$1,100,000 (FY12)	$0	$1,000,000 (FY13)	$0

- Project funding has come mid-year for both FY12 (May 2012) and FY13 (August 2013)
- Project has leveraged millions in Sandia equipment and facilities and decades of non-wind program investments in staff expertise

Research Integration & Collaboration

Partners, Subcontractors, and Collaborators:

- 3 Sandia Groups (Wind Technologies, Aerosol Sciences & Laser Sensing)
- Jim Meyers - NASA Langley PDV Developer
- Collaborators include the SWiFT /Texas Tech researchers, and simulation work at University of Minnesota.

Communications and Technology Transfer:

- AIAA SciTech 2015 (anticipated)
- Provisional patent filed 2013
- Field data will be publically available on swift.sandia.gov.

Next Steps and Future Research

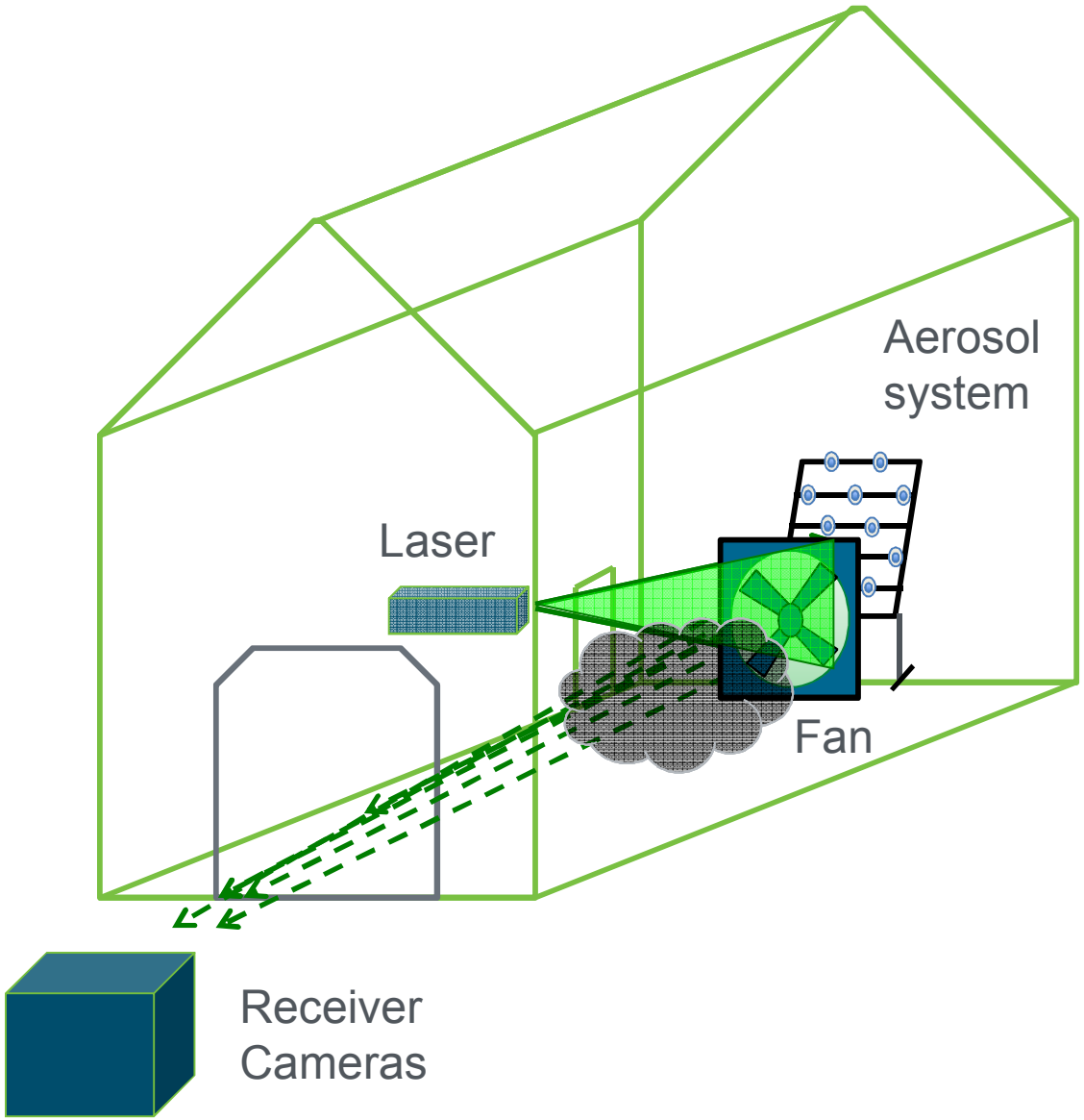
FY14/Current research:

- **Lab tests** to calibrate cameras and obtain velocity image of known target
- **Outdoor testing** to work through seeding methods and determine system capabilities
- **Environmental, Safety & Health** plans to ensure personnel safety, environmental protection and laser operations outdoors (FAA)
- Determine **budget and timeline** to construct and calibrate a field-deployable system at SWiFT in FY15.

Primary objective of FY14 work has been on identifying, prioritizing and reducing technical and ES&H risks.

Next Steps and Future Research

Next Steps and Future Research



Objectives:

- Test system on more representative scale
- Refine aerosol dispersion system
- Determine system sensitivity
- Address any field-deployment issues that might arise