

Results of the Whisper 900 Testing in Spanish Fork, Utah

Dean Davis & Craig Hansen
Windward Engineering L.L.C.

With the support of
DOE
& NREL/NWTC

Project Objectives

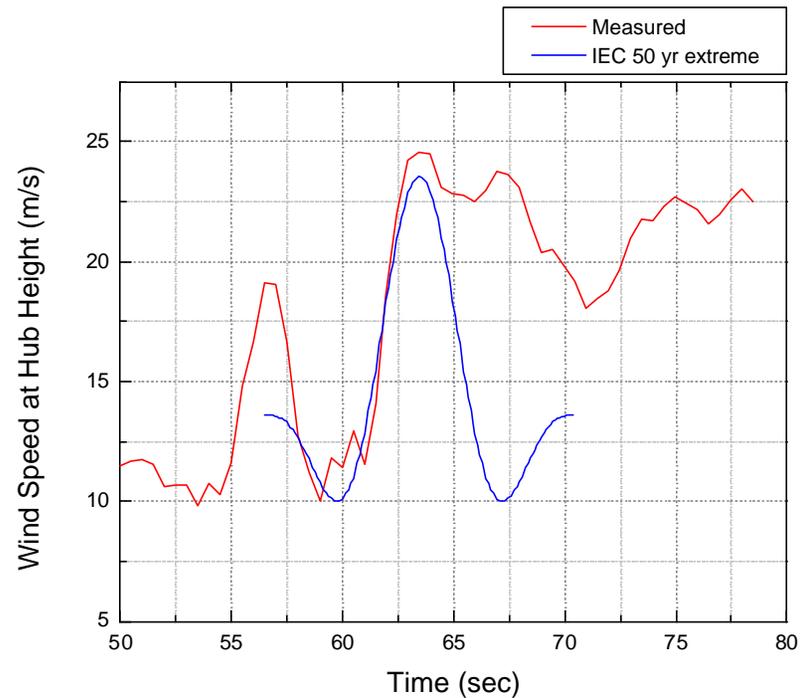
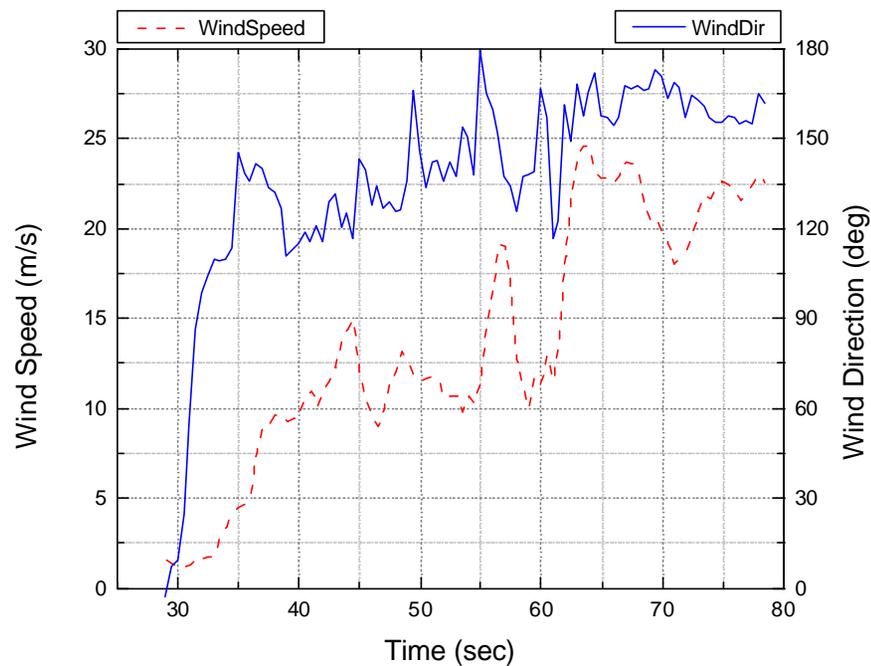
- ◆ Determine and demonstrate the reliability and energy production of a small furling wind turbine.
- ◆ Make engineering measurements and conduct limited computer modeling of the furling behavior.

Spanish Fork Test Site

- ◆ Strong canyon winds blow down canyon most nights.
- ◆ Typically calm daytime winds.
- ◆ Relatively low 6.7m/s (15MPH) mean wind speed but Class 6 due to frequency of high winds.
- ◆ Can produce severe gusts during thunderstorms.



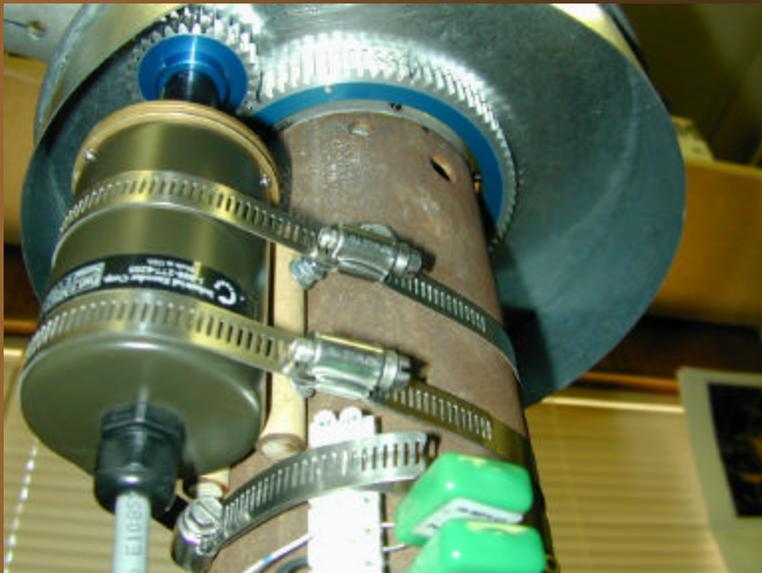
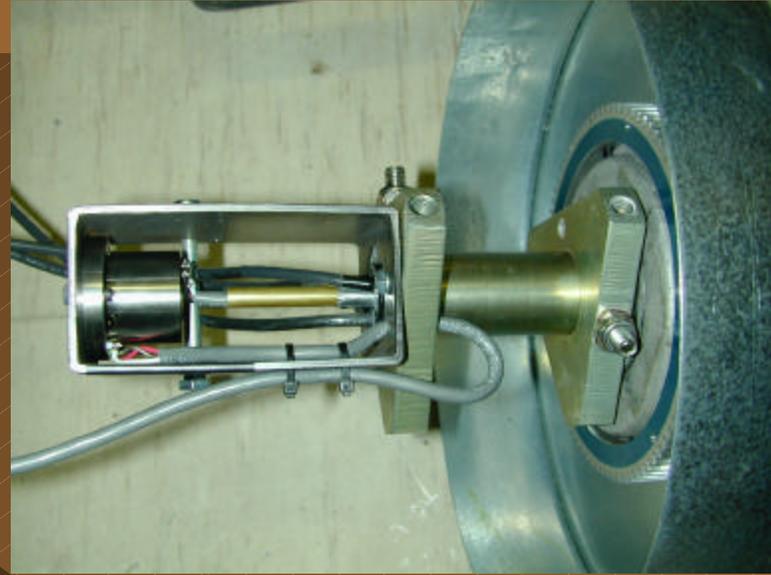
Spanish Fork Test Site (cont.)



Progress

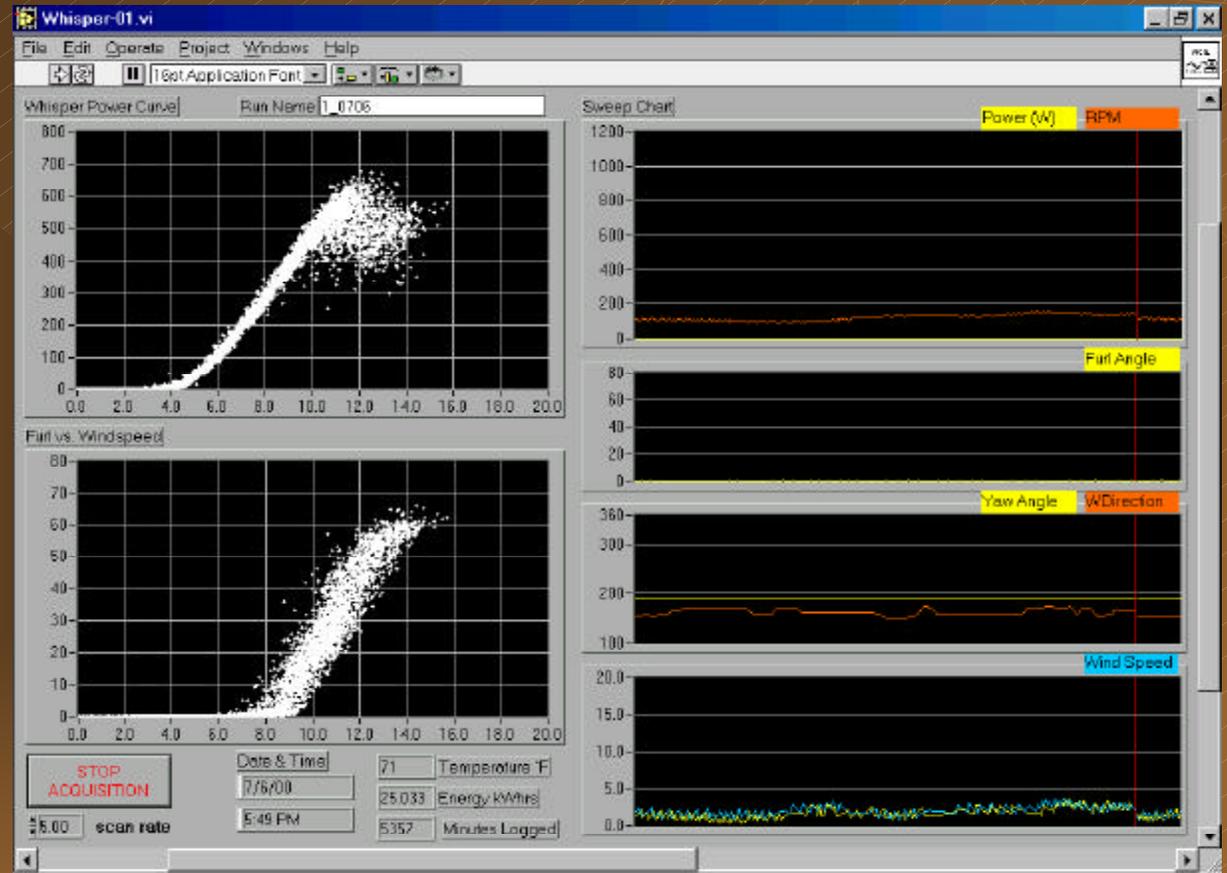
- ◆ Turbine and basic DAS operational since February 26, 2000.
- ◆ Turbine and DAS has operated without fault.
- ◆ Turbine fully instrumented and Labview operational as of June 16, 2000.
- ◆ Over 300 hours of 5Hz data collected on Labview DAS.
- ◆ Turbine properties measured and calculated & ADAMS model built.
- ◆ Very preliminary ADAMS modeling results generated.

Turbine Instrumentation

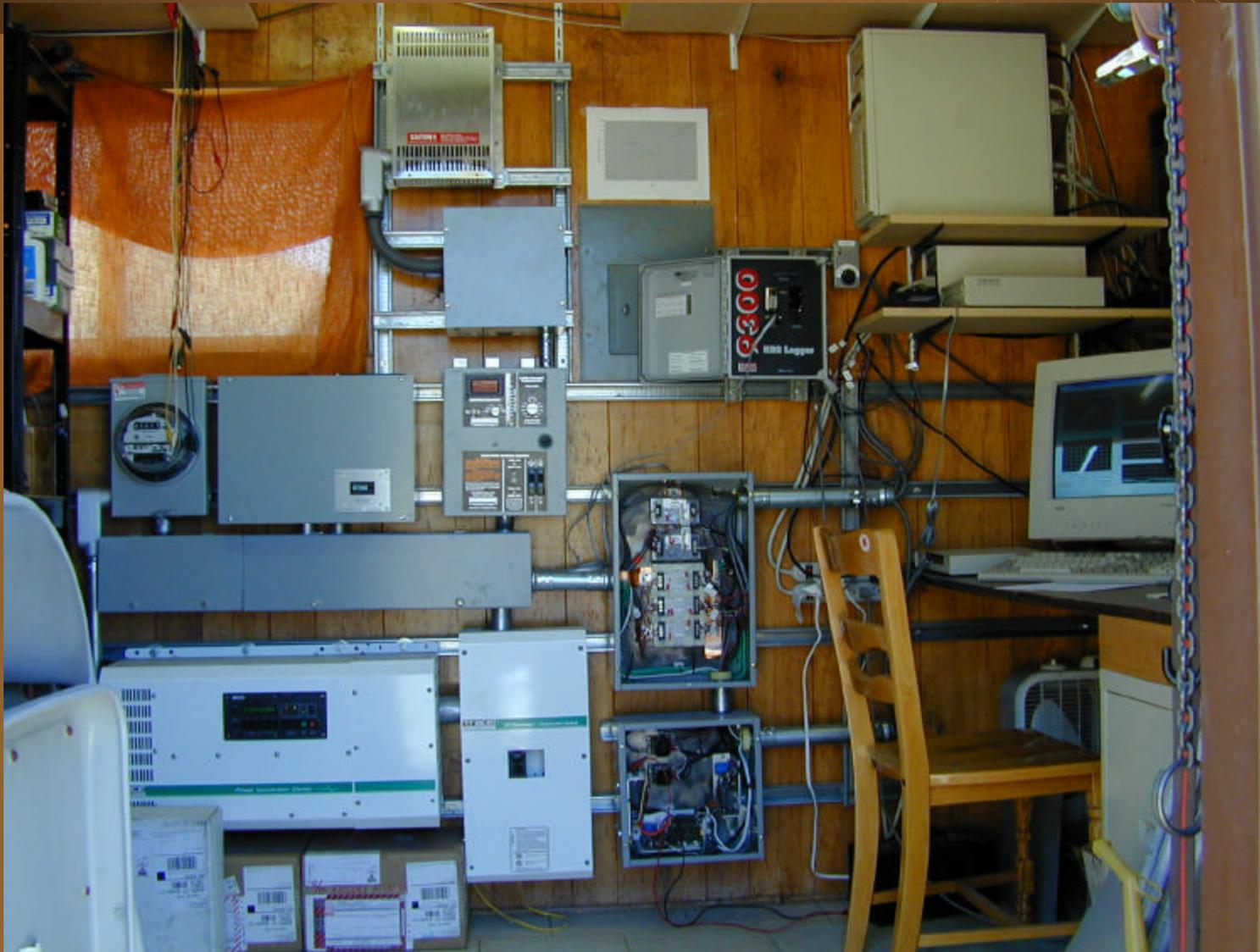


Labview DAS

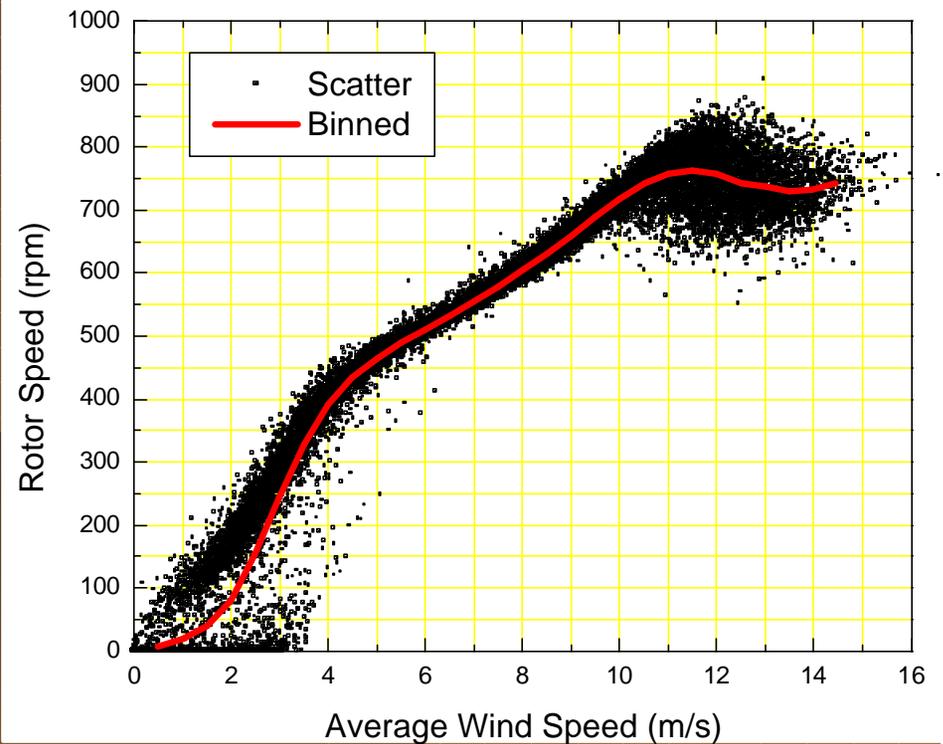
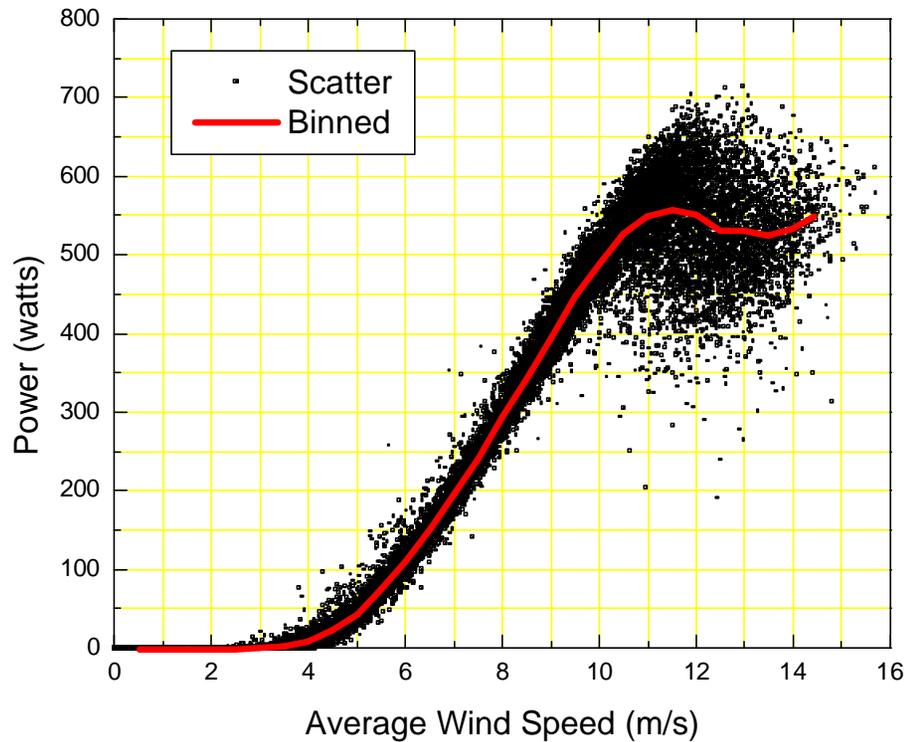
- ◆ Monitor 8 channels.
- ◆ High sample rate capabilities.
- ◆ Generate 3 files:
 - ◆ Raw data
 - ◆ 1 Minute avg.
 - ◆ Summary Info
- ◆ Will add unusual event tags.



Turbine Electrical

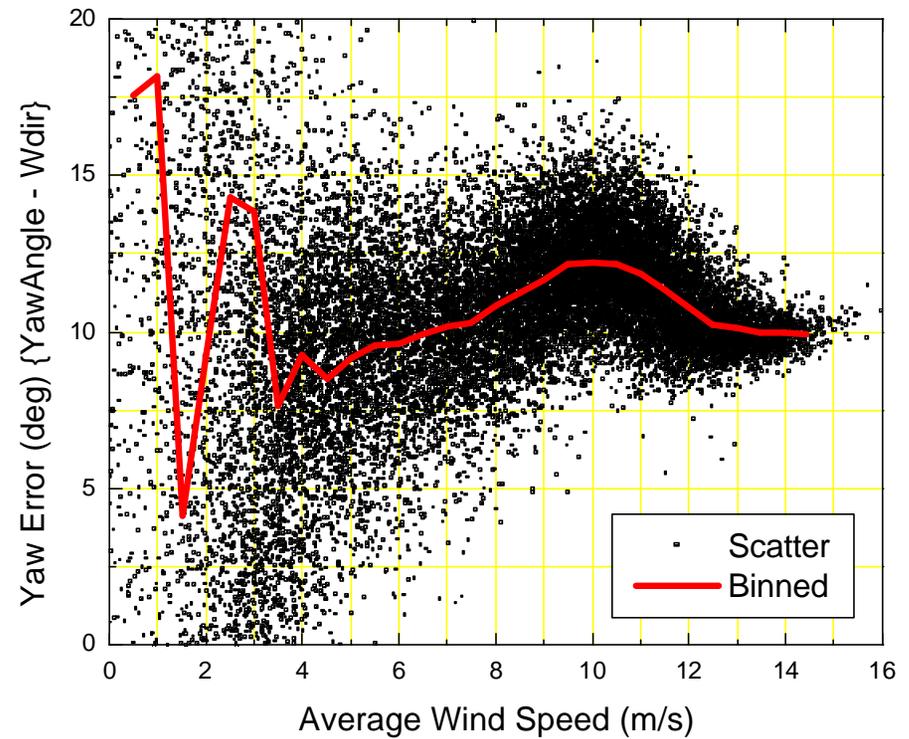
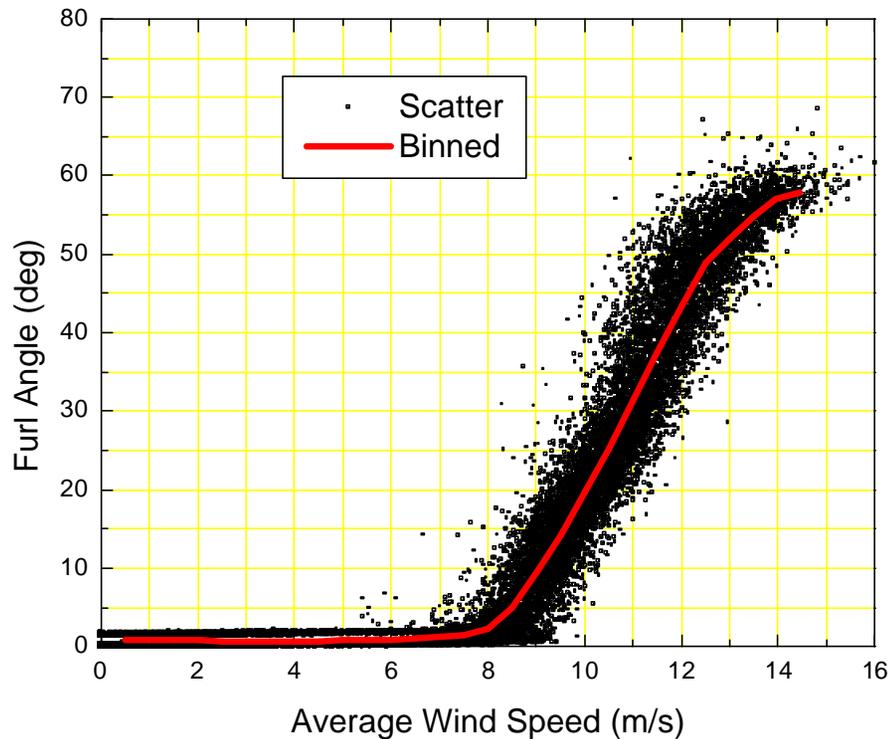


Binned Test Data



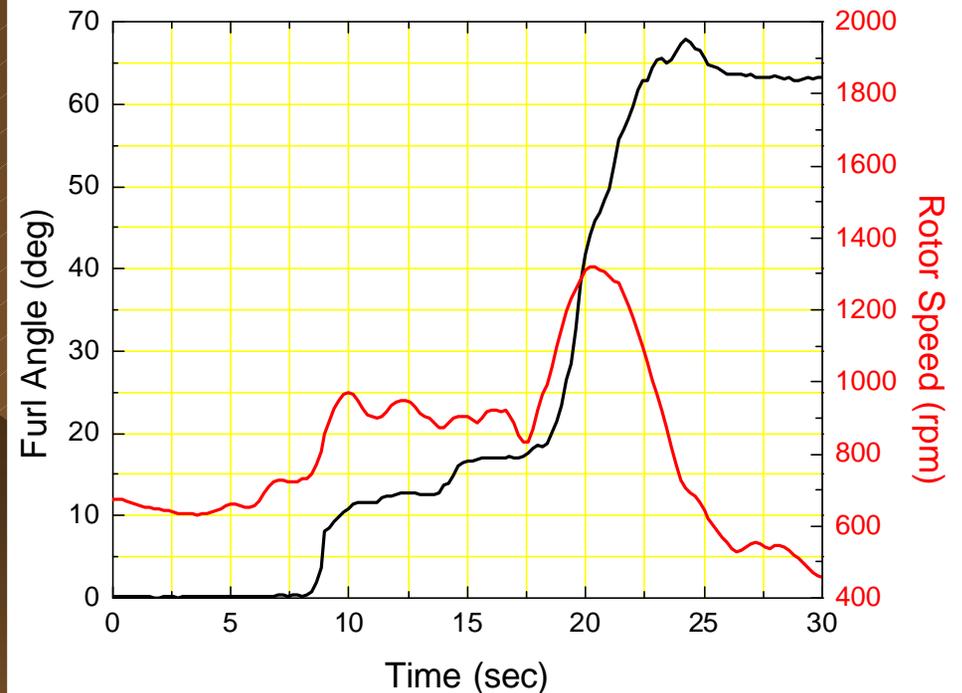
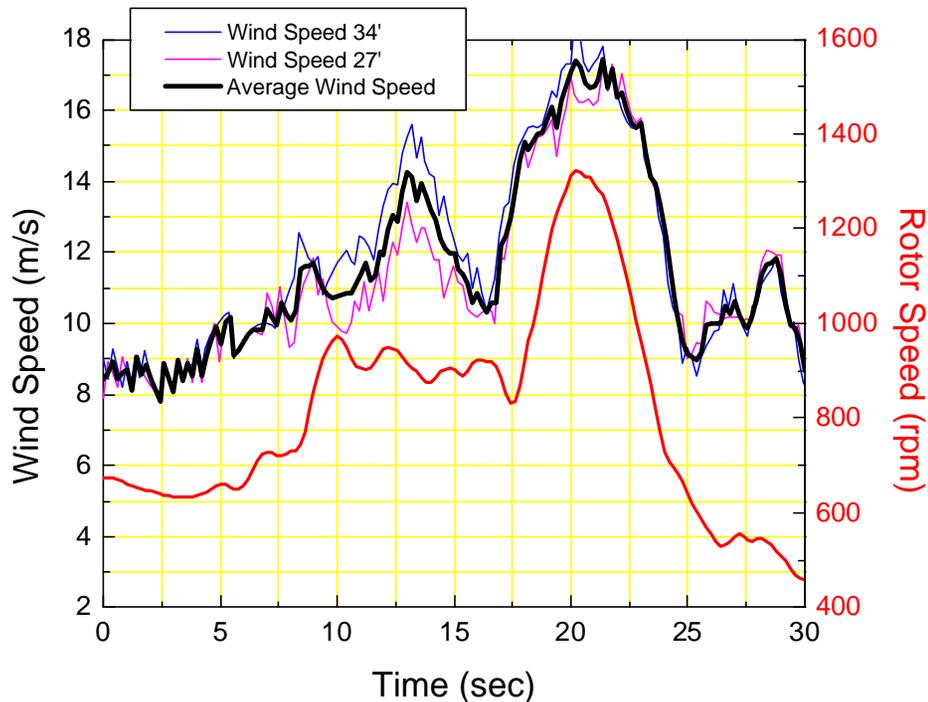
- ◆ 392 hours of 1 minute averaged data.
- ◆ 310 hours with operational winds.

Binned Test Data (cont.)



- ◆ 392 hours of 1 minute averaged data.
- ◆ 310 hours with operational winds.

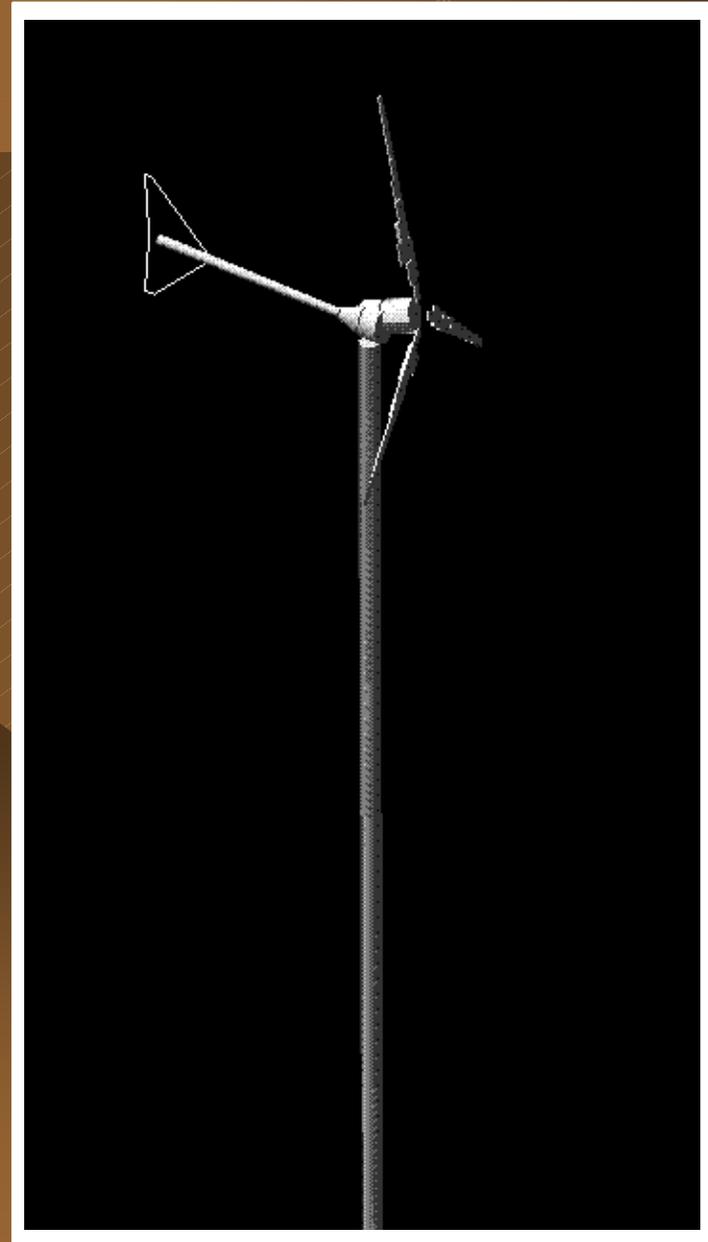
Peak RPM Time Series - Test Data



- ◆ Raw 5Hz test data
- ◆ Peak rotor speed of 1322 RPM
- ◆ Peak binned rotor speed was ~750 RPM

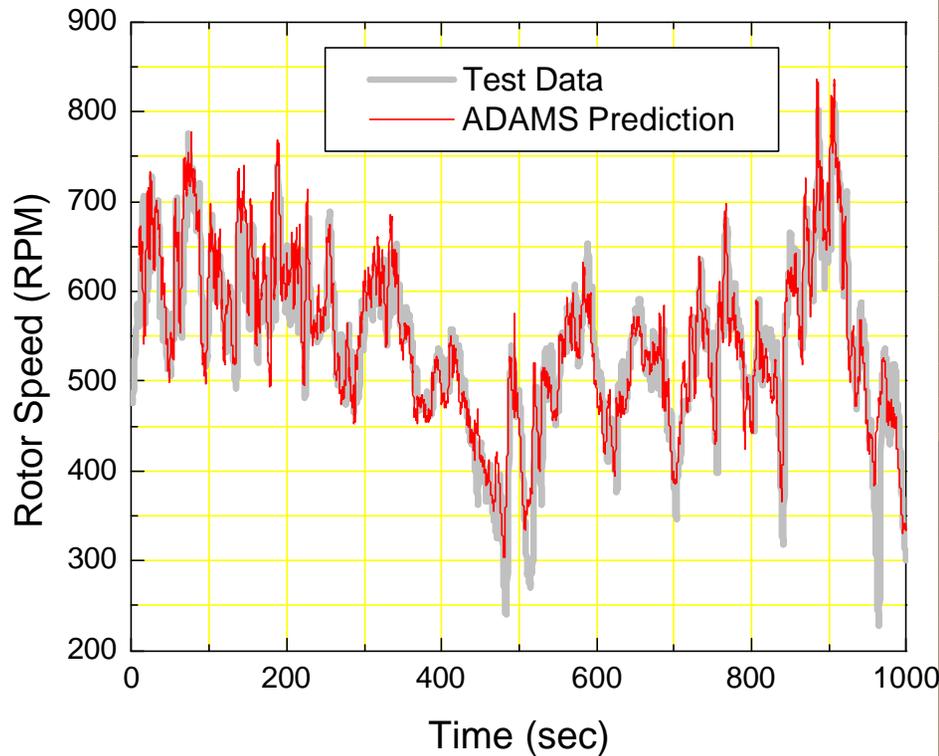
ADAMS Model

- ◆ 6 DOF
 - ◆ 3 flapping hinges
 - ◆ RPM (variable speed)
 - ◆ Free yaw
 - ◆ Free furl
- ◆ AERODYN calculated tail aerodynamics

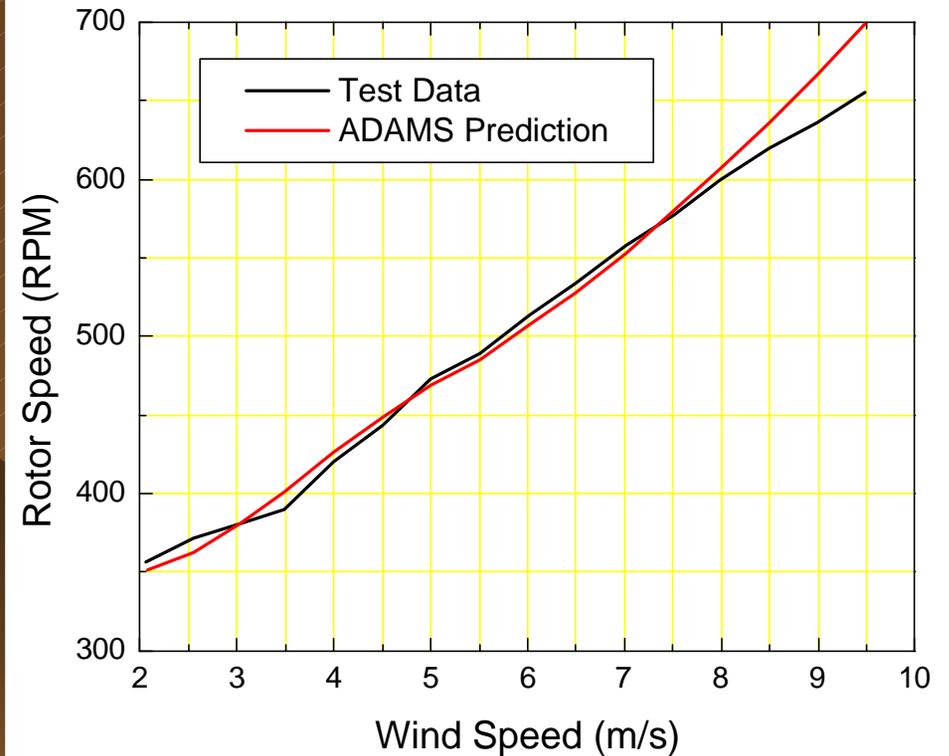


ADAMS (Rotor Speed Prediction)

{ low wind, very little furling }



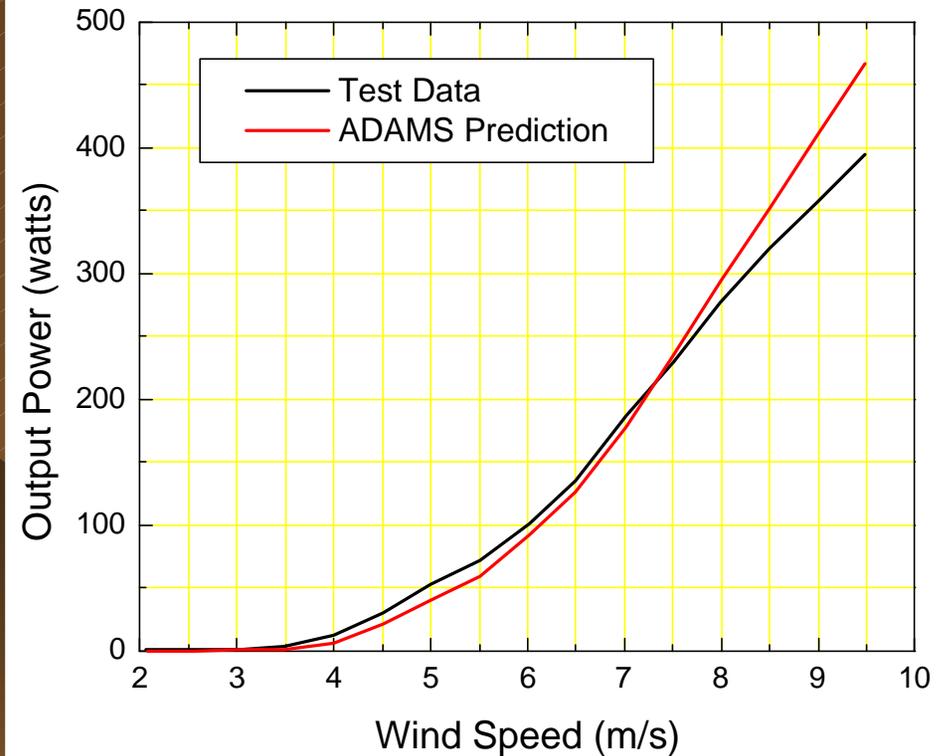
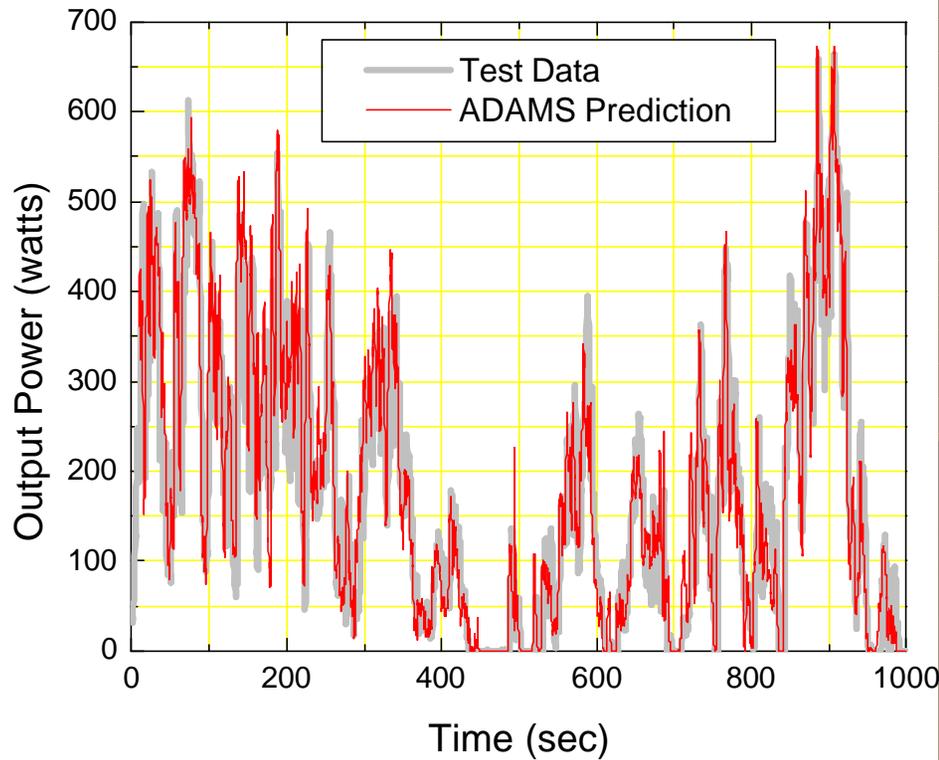
Rotor Speed Prediction
Time Series



Binned RPM over 1000 sec.
vs. wind speed

ADAMS (Output Power Prediction)

{low wind, very little furling}

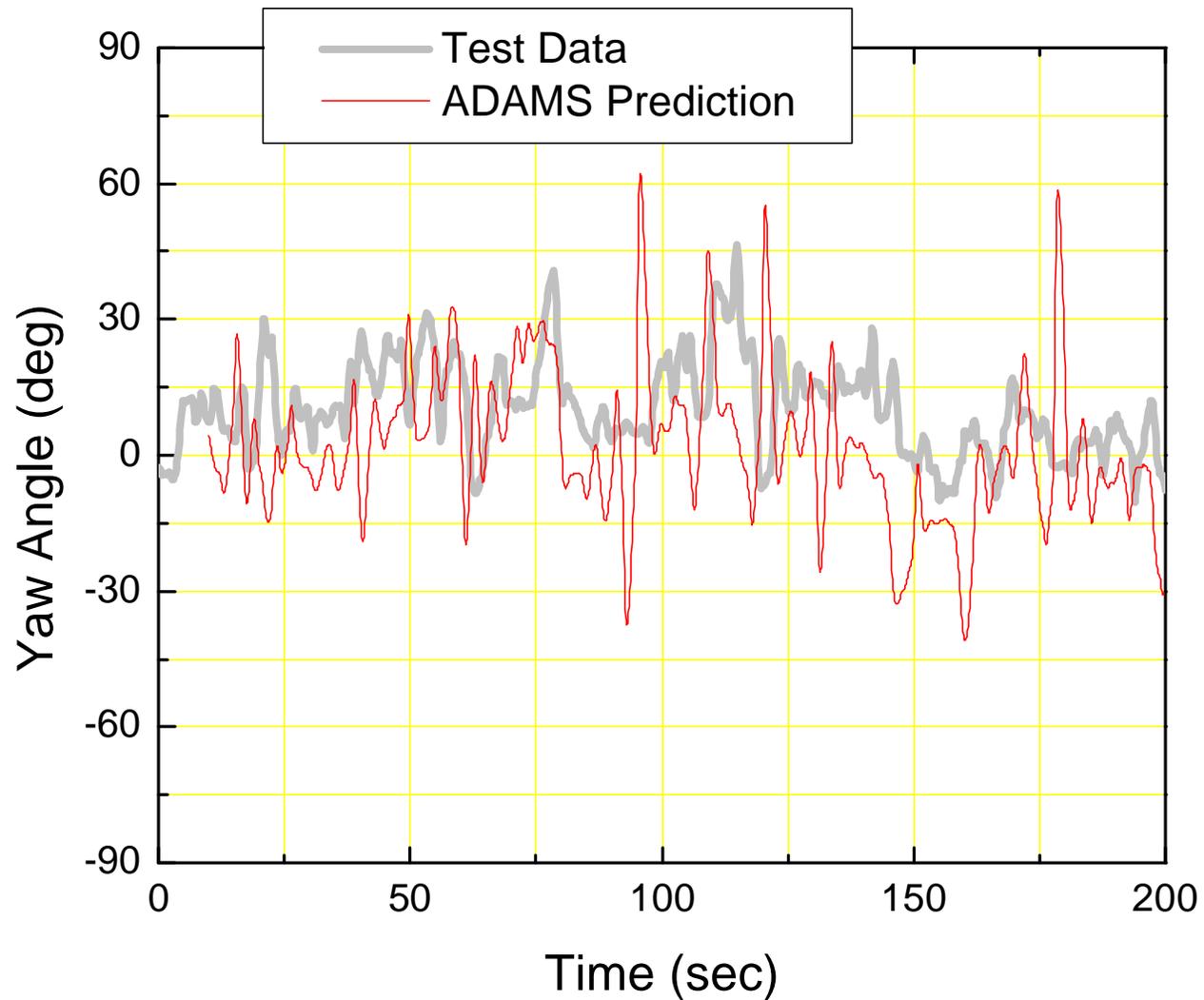


Output Power Prediction
Time Series

Binned Power over 1000 sec.
vs. wind speed

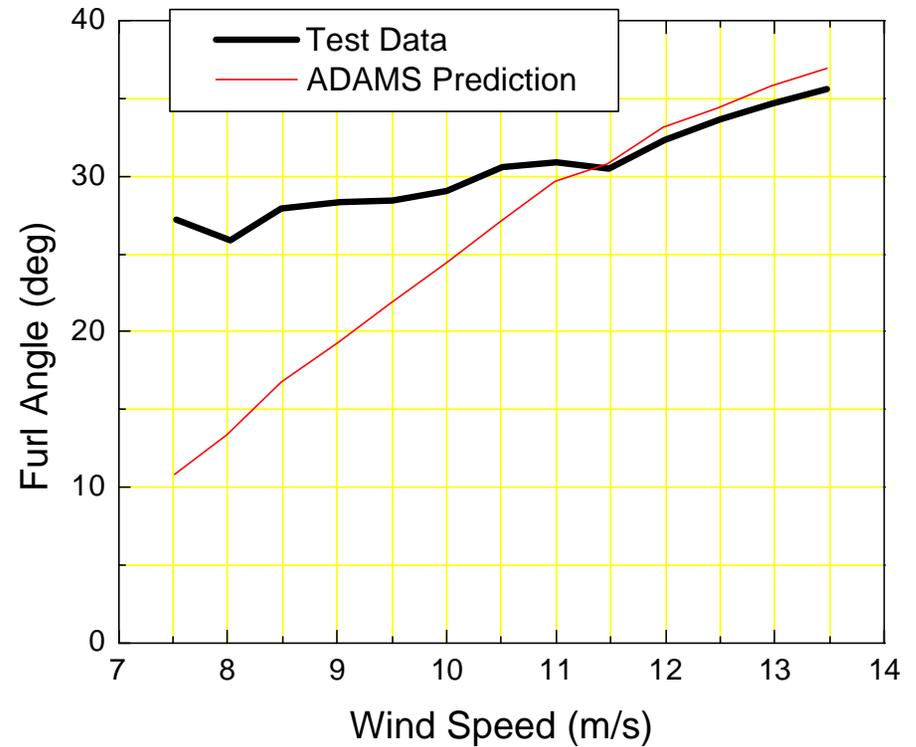
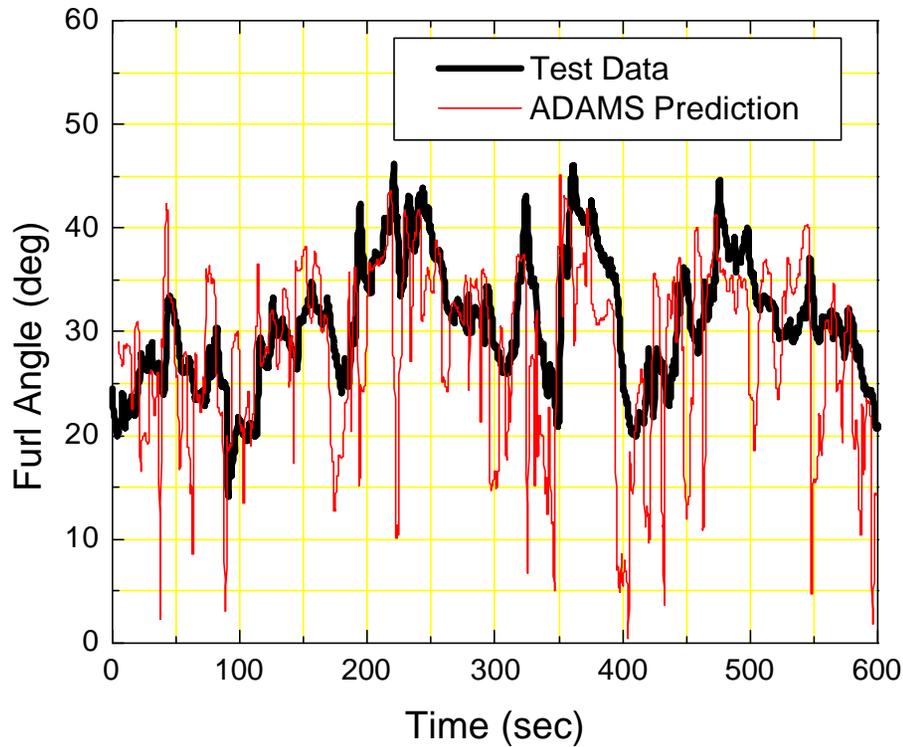
ADAMS (Yaw Angle Prediction)

{low wind, very little furling}



ADAMS (Furl Angle Prediction)

{high wind, furling}

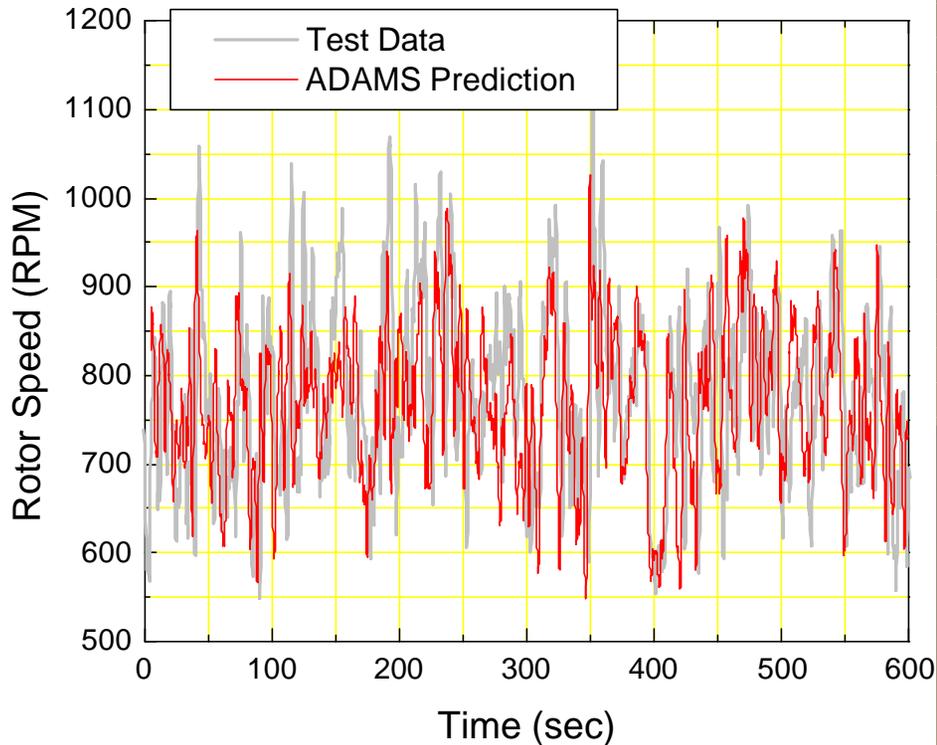


Furl Angle Prediction
Time Series

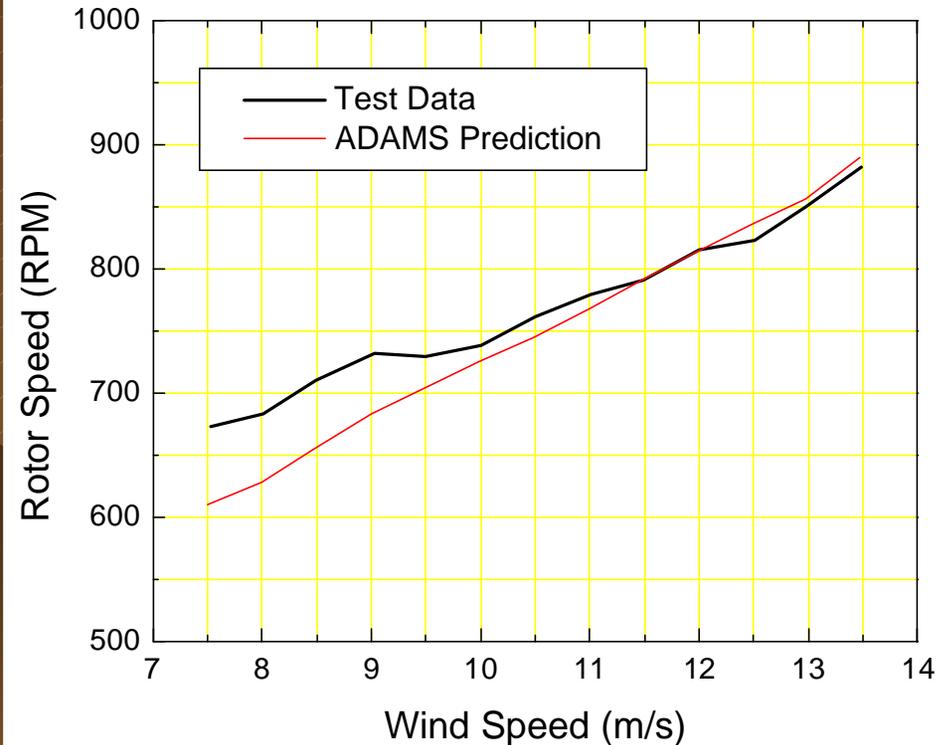
Binned Furl Ang. over 600 sec.
vs. wind speed

ADAMS (Rotor Speed Prediction)

{high wind, furling}



Rotor Speed Prediction
Time Series



Binned RPM over 600 sec.
vs. wind speed

Summary

- ◆ Whisper H900 furling wind turbine installed and operating.
- ◆ Performance data being collected on NRG data-logger.
- ◆ Furling data being collected on Labview system.
- ◆ ADAMS model has been built (turbine properties have been measured but engineering drawings would improve accuracy).
- ◆ Preliminary ADAMS model comparisons have been generated.

Future Work

- ◆ Continue to collect test data using NRG data-logger and Labview.
- ◆ Include flags in Labview to signal high turbulent wind events or peak RPM events.
- ◆ Acquire accurate ADAMS model properties and update model.
- ◆ Run dynamometer test to determine accurate torque vs. speed curve.
- ◆ Continue to compare ADAMS model to test data.
- ◆ Present results at wind conferences.