



Wind Turbine Gearbox Reliability Collaborative

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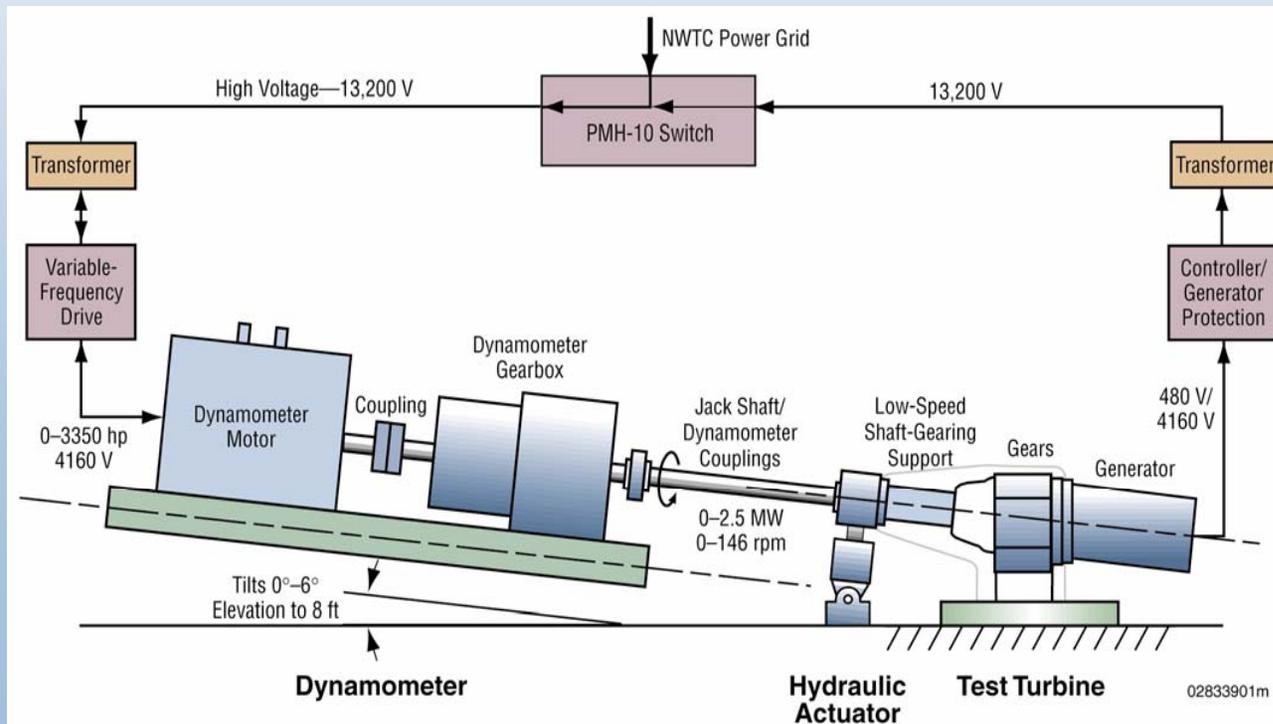
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Background

- Wind Turbine Gearboxes do not meet their design life.
- Standards and improved industry practices have helped but wind system costs are still rising.
- Failures are not specific to one machine type or application.
- NREL's 2.5 MW dynamometer has completed most of the scheduled backlog.
- NREL/DOE will address drivetrain reliability as a significant new area for long term R&D.

Dynamometer Background/Specifications

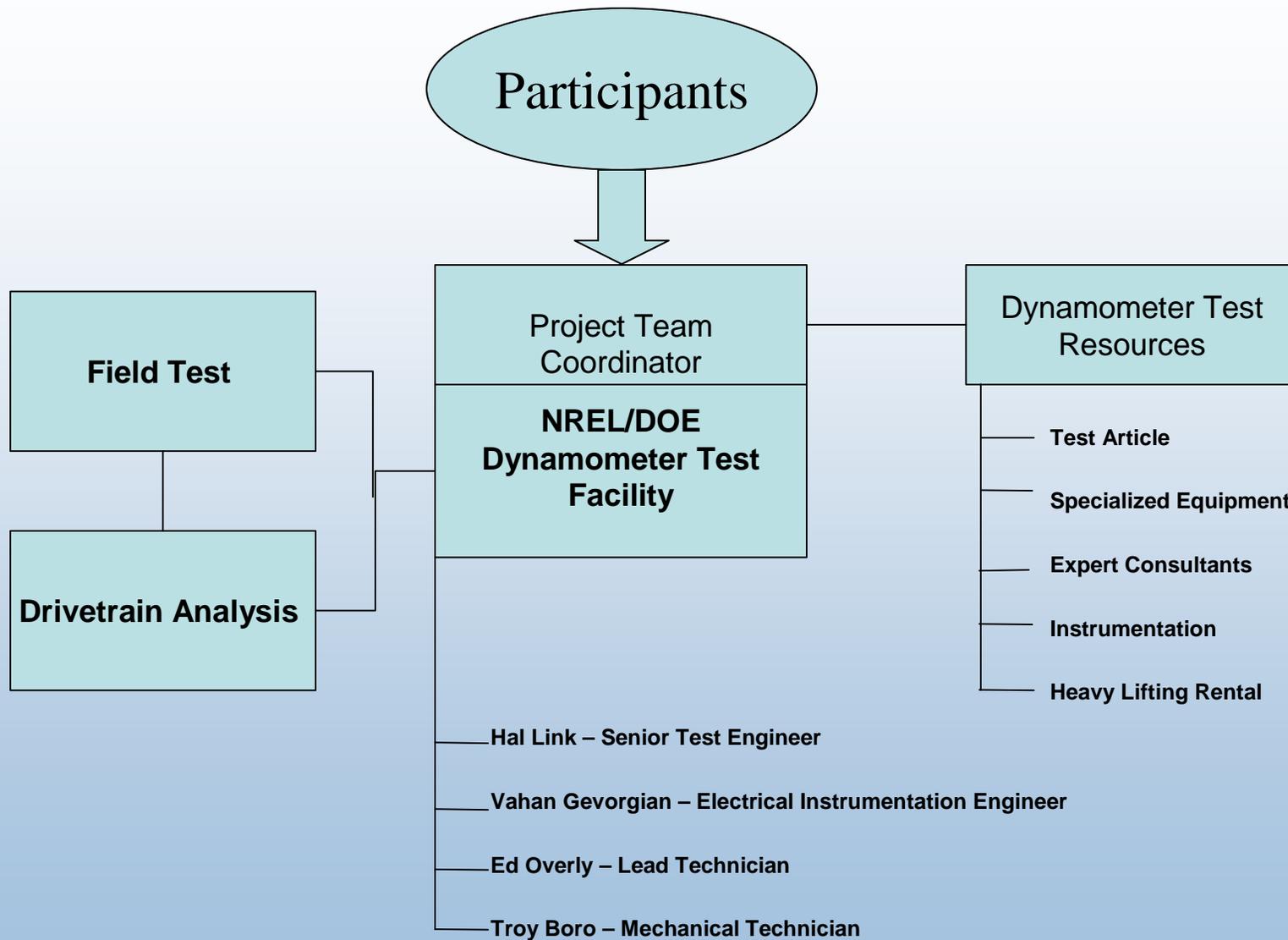
- 2.5 MW rated power capacity -Power regeneration at 480 volts or 4160 volts.
- Torque range 0 - 1.62 million N-m (13.5 million in-lb).
- Speed range from 0 - 2250 RPM
- 488 kN (110 kip) force capacity for dynamic shaft bending with servo-hydraulic controls.
- Fully automated SCADA torque/speed controls



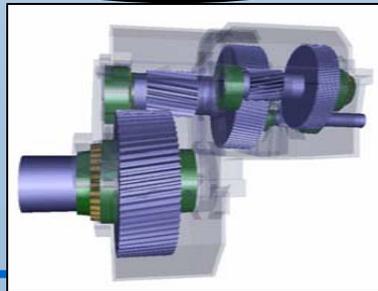
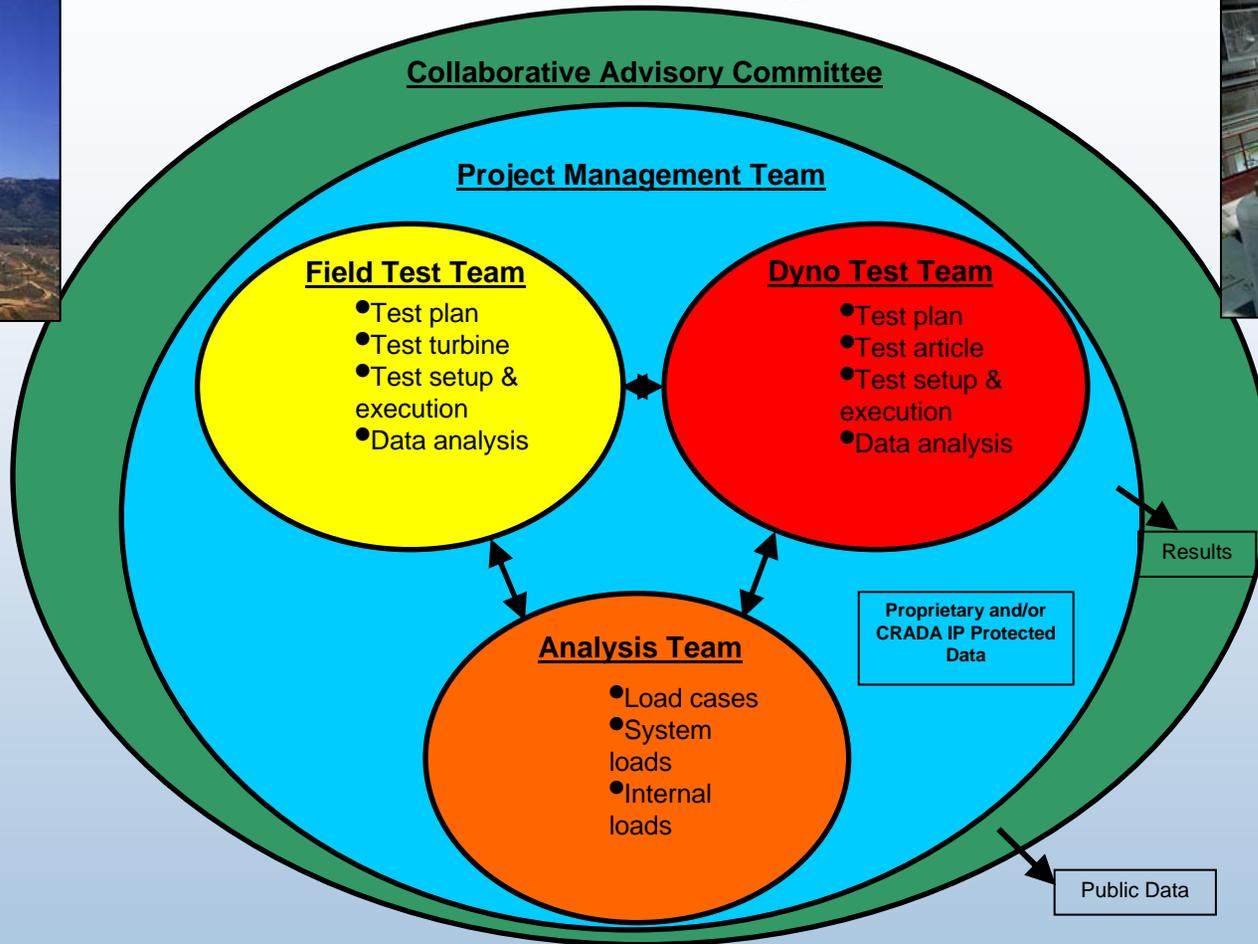
Gear Reliability Collaborative Objectives

- Develop dynamometer testing capability to assess gearbox/ drivetrain problems and solutions
- Understand how gearbox loads translate to bearing response, stress, slip, and other gearbox problems.
- Develop a more comprehensive gearbox design load case matrix.
- Evaluate and validate current drive train analytical tools.

Project Organizational Chart



Wind Turbine Gearbox Reliability Collaborative Organization



Intellectual Property Protection

Participants shall not use their membership in the collaborative as a means to promote or advance litigation against other participants or potential participants.

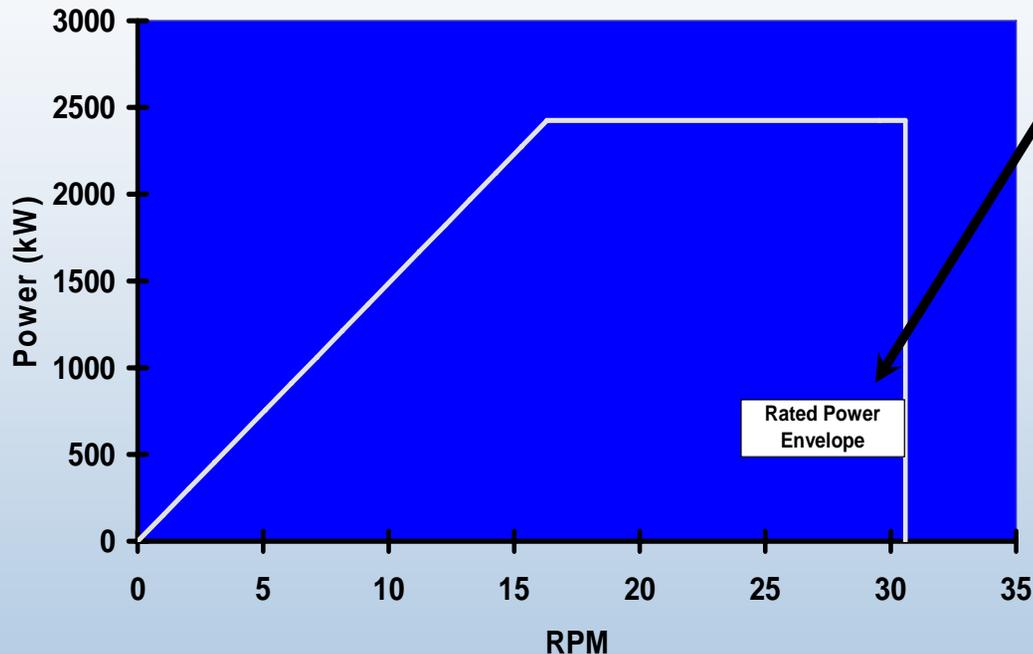
- IP protection highest priority
- Cooperative Research and development Agreements (CRADA) can protect data brought in.
- Data exchange among members will be limited as needed.

Dynamometer Testing

- Gearbox system instrumented to measure strain, deflections, shaft displacements, and loads.
- Simulated field loading to replicate gearbox failures.
- Failure modes will be correlated with external loading.
- Root cause forensics

Dynamometer Test Envelope

Target Test Article



- 600 to 900 kW Gearbox
- Failures are representative of current fleet
- Cheaper
- Failure database established
- 3X loading possible

Test Platform Options

- V-47 – 660-kW
- NM -750 – 750 – kW
- GE 1.5 kW bedplate with rebuilt Flender gearbox. (default option)



Field Testing

- Drivetrain the same as dynamometer system.
- Tests will correlate damaging internal bearing loads with external loads.
- Forensic verification
- Field test partners wanted.



Gearbox Analysis

- Provide modeling support to the testing groups.
- Use project field data or dynamometer test data to model dynamometer test article response.
- Correlate Dyno response to turbine response.
- Use test data to gain confidence in codes.

Project Schedule

- Workshop was held at NREL July 11-12, 2006.
- Draft plan distributed September 28, 2006
- Comments, feedback, and commitments through end of 2006.
- Dynamometer testing to begin in early 2007 depending on commitments.
- Annual reviews to determine project continuation.

Project Teams Minimum Requirements

- Group with Common Purpose (preferable established working relationship)
 - Bearing Manufacturer
 - Turbine Manufacturer
 - Owner/Operator
 - Gearbox Manufacturer
- Articulated Problem
- Benefits larger Industry with basic conclusions
- Example: *Investigating response of SRB in LS planets*

Methods of Participation

- Cash is always accepted.
- In kind equipment
- In-kind labor and support
- Data, Data, Data (value negotiable)
- Minimum thresholds of participation to be determined.

Conclusions

- New collaborative to address gearbox reliability.
- Generic root causes to be addressed.
- Confidentiality top priority
- 20 year gearboxes???