



Wind Turbine Gearbox Reliability Database, Operation and Maintenance Research Update

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Drivetrain Reliability Collaborative Meeting

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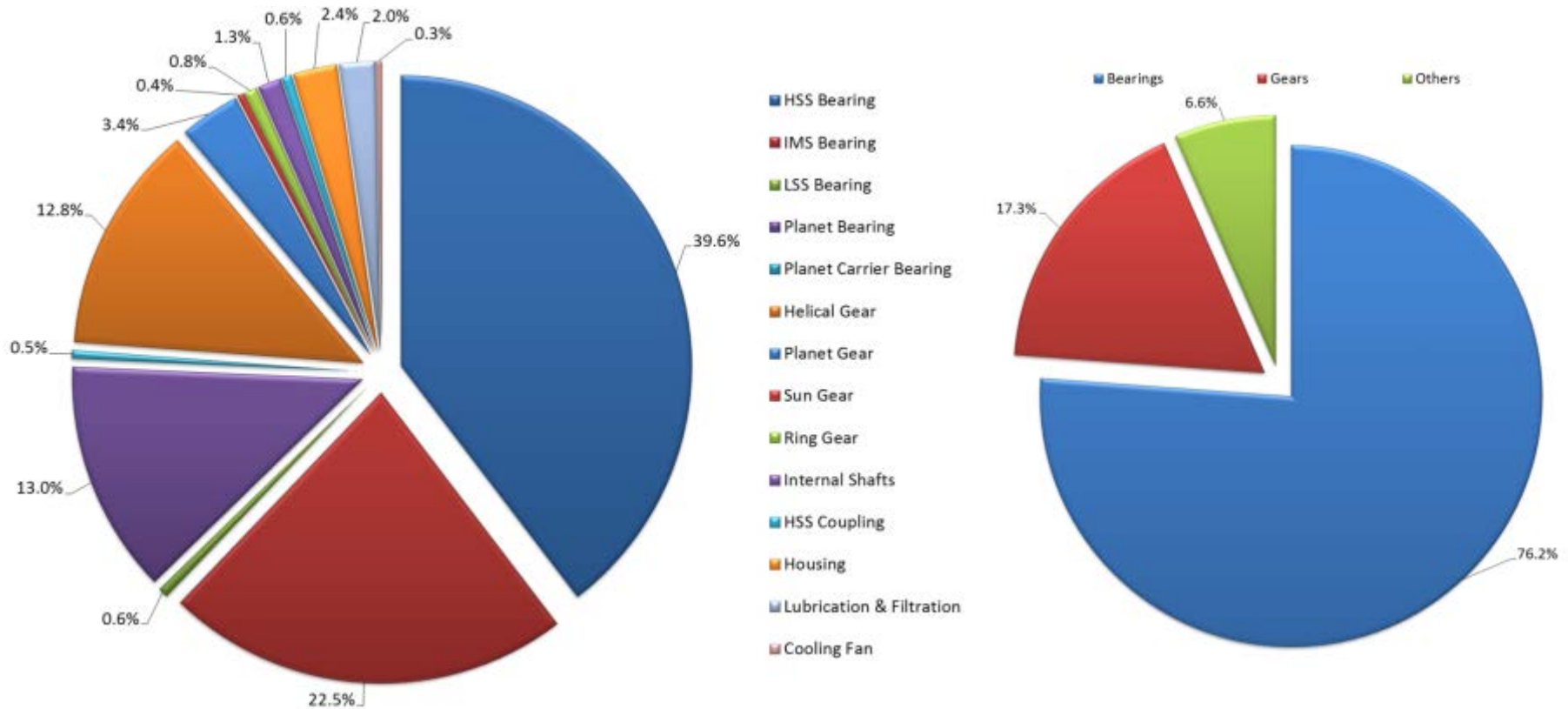
Gearbox Reliability Database: Status

- Background: <http://www.nrel.gov/docs/fy15osti/63106.pdf>

- Partners:
 - Close to 30 partners, including turbine and gearbox original equipment manufacturers, wind plant owner/operators, gearbox rebuild shops, and consulting companies
 - Assets represented by owner/operator partners are ~40% of U.S. end-of-2015 installed capacity
 - Not all partners actively submit data to the National Renewable Energy Laboratory (NREL)

- Data Records:
 - Increased to ~2,750 data entries
 - 67% of the data are on gearboxes and 33% on generators
 - Different parties use inconsistent terminologies and data collection practices
 - Template helps move data collection practices in a more standardized direction.

Reliability Database: Damage Distribution



The above charts were released December 30, 2016, and are based on ~1,050 damage records with confirmed components or locations:

- Bearings: 76.2%, dominated by high-speed-shaft and intermediate-shaft bearings
- Gears: 17.3%, dominated by helical gears
- Others: 6.6%, dominated by housing and the lubrication and filtration system
- Both bearing and gear faults are concentrated in the parallel section.

<https://grd.nrel.gov/#/stats>

Reliability Database: Web Interface

- Address: <https://grd.nrel.gov>
- Provides a centralized location featuring
 - Automated data collection and interactive statistical analysis results reporting
 - Accommodation of multiple gearbox configurations by following International Electrotechnical Commission 61400-4 nomenclature
 - Release of sanitized and aggregated information to the general public
 - **Granted access to more insightful statistics for partners with contributed data**
 - In-depth statistics on own data and all data contained in the database by removing data owner and source information

Web Interface: Landing Page

Statistics Dashboard

Shawn Sheng

Gearbox Reliability Database

The **Gearbox Reliability Database (GRD)** is a unified data platform for utility-scale wind plant owners, operators, and other stakeholders along the gearbox supply chain. This effort aims to categorize top wind turbine gearbox **failure modes**, identify possible **root causes**, and direct future wind turbine gearbox reliability **research and development (R&D)** activities. By the end of 2015, the assets represented by only owner/operator partners on this effort comprised approximately 35% of the U.S. installed capacity.

Wind Turbine Gearbox Damage Distribution Statistics 2016

The GRD effort currently has **1613** incidents logged from **84** wind plants, and spans **13** years of operation.

As a contributing data-sharing partner, you can use your NREL external account to [sign in](#).

If you are interested in becoming a partner, or you would like to get more information on the GRD, please contact:

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upload and collect gearbox failure event data



have full control of data owned by you



contributing partners can also gain access to all statistics generated based on the entire dataset



generate additional statistics such as annual failure rates and mean-time between failures

Web Interface: Average Downtime

- Interactive updating based on gearbox, turbine, and component choices
- Partner-owned data compared with global data.



Web Interface: Data Table

- Full control over own data with interactive editing
- Download own and global data, only nonidentifiable fields.

Dashboard Shawn Sheng ▾ Gearbox Reliability Database

incidents missing critical information 🔍 🔄 ⬇️

| | Failure Date | RTS Date | Component | Failure Mode | Failure Location |
|--|--------------|------------|-----------|--------------|------------------|
| | 04/20/2013 | 05/10/2013 | Gear | | |
| | 03/12/2011 | 03/26/2011 | Bearing | | |
| | 08/14/2012 | 10/19/2012 | Bearing | | |
| | 08/14/2012 | 10/25/2012 | Bearing | | |
| | 04/12/2013 | 05/02/2013 | Bearing | | |
| | 05/02/2012 | 06/02/2012 | Bearing | | |
| | 08/09/2011 | 11/28/2011 | Bearing | | |
| | 07/01/2010 | 08/05/2010 | Bearing | | |
| | 12/23/2013 | 01/24/2013 | Bearing | | |

Form Fields:

- Gearbox ID: 2444-21
- Failure Date: 08/09/2011
- RTS Date: 11/28/2011
- Component: Bearing ▾
- Failure Mode: Select a Failure Mode ▾
- Failure Location: Select a Failure Location ▾
- Gearbox Manufacturer: Select a Gearbox Manufacturer ▾
- Turbine Manufacturer: Select a Turbine Manufacturer ▾
- Root Cause:

Web Interface: Data File Uploads

- Standardized data collection template in CSV format
- Automatic database population and data validation.

File Upload Help

If you prefer to have NREL import your data into GRD please send your files to Shuangwen (Shawn) Sheng at shuangwen.sheng@nrel.gov

Please **download this template** to get started

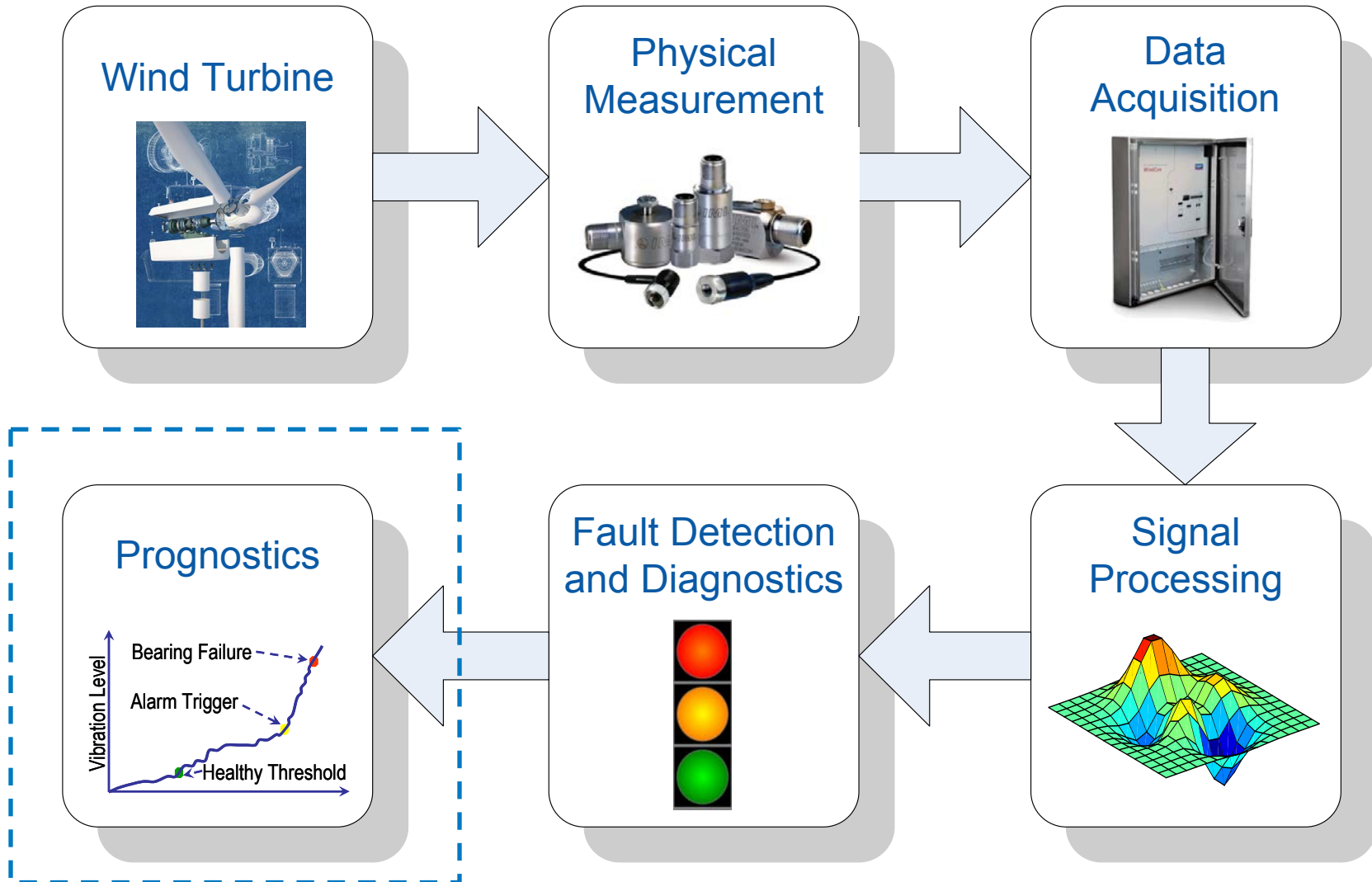
The first row of the CSV must contain the following headers:

| |
|--|
| failure_date <small>required</small> <i>-MM/DD/YYYY</i> . The failure date of this turbine |
| rts_date <small>required</small> <i>-MM/DD/YYYY</i> . The return to service date for this turbine |
| root_cause <small>optional</small> <i>-string</i> . The identified root cause of the failure |
| report_source <small>optional</small> <i>-string</i> . The source of the report |
| wtg_mfg <small>required</small> <i>-string</i> . The manufacturer of the turbine |
| wtg_model <small>optional</small> <i>-string</i> . The model of the turbine |
| wtg_total_run_hours <small>optional</small> <i>-number</i> . The turbine total run time in hours |

Operation and Maintenance: Status

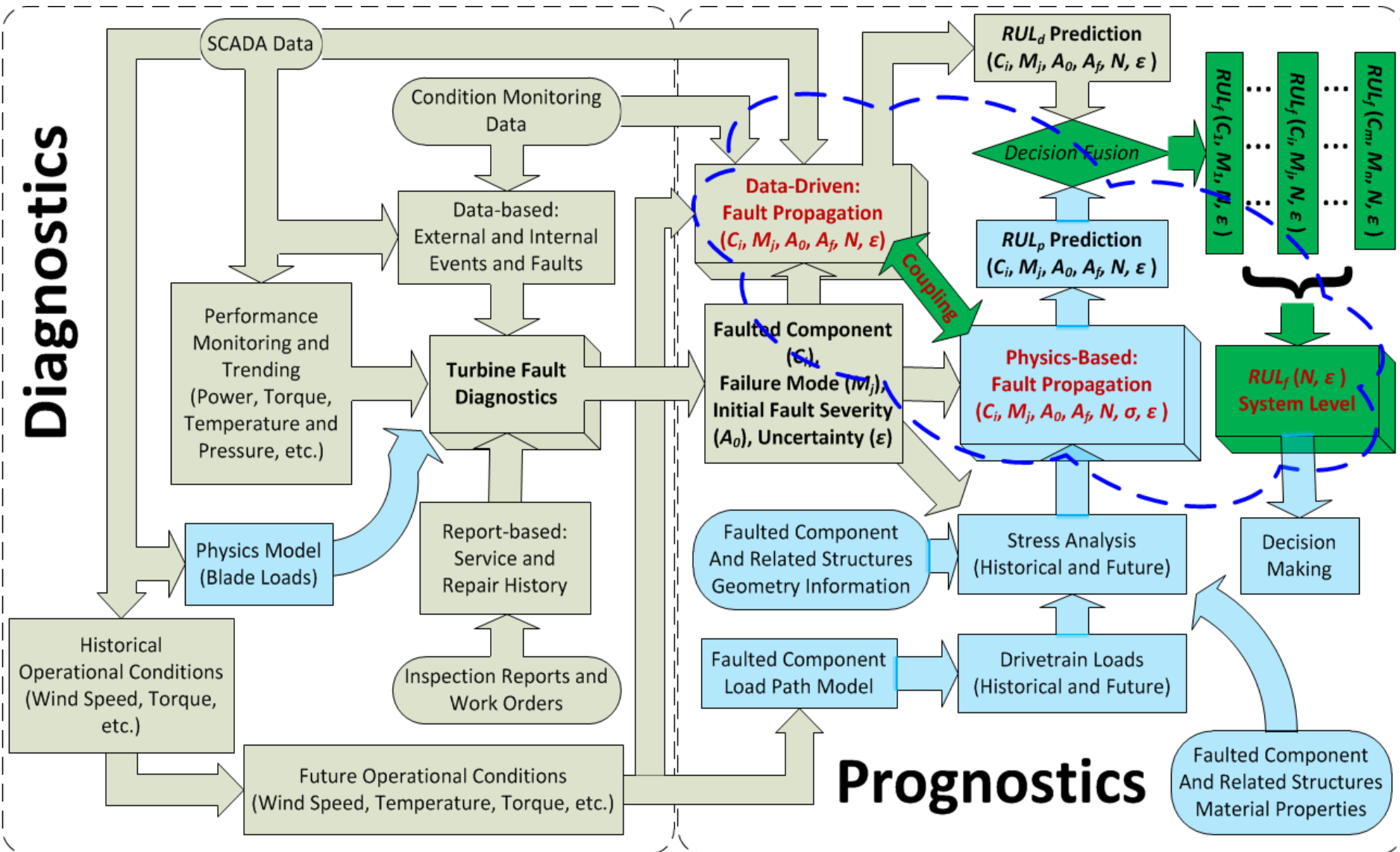
- Vibration benchmarking data set inquiries around the globe
- *Compact filter field testing with first six units completed and three more underway*
- Operation and maintenance research agreement reached with two universities and an owner/operator; intellectual property management plan and scope of work being developed
- Publications:
 - A journal article on oil and wear debris analysis—published and featured as an editor’s choice paper in Tribology and Lubrication Technology magazine
 - A book chapter on prognostics and health management of wind turbines—currently being processed by the publisher
 - A book chapter on wind turbine reliability—being finalized within NREL
- Presentations:
 - Wind energy research workshop organized by the University of Massachusetts Lowell
 - Prognostics and Health Management (PHM) Society annual conference 2016
 - Wind power big data and IoT forum Berlin 2016 (joint work with Dr. Jan Helsen of Vrije Universiteit Brussel).

An Abstract Description of a Typical Continuous Condition Monitoring System



(Photos courtesy of: wind turbine [upper left], Joshua Bauer, NREL 500057; physical measurement [upper middle], IMI Sensors, a division of PCB Piezotronics, Inc.; data acquisition [upper right], SKF).

A Wind Turbine PHM Framework



Future Plans

- Near term:
 - **Hybrid data-driven and physics-based modeling approach for high-speed bearing remaining useful life prediction**
 - Evaluate compact filter testing and make a GO/NO-GO decision
 - Continue investigation of promising condition-monitoring techniques
- Long term:
 - **Wind plant data management, analysis, and modeling by considering big data techniques and physics-based modeling for improved operation and maintenance practices**
 - Identify gaps in PHM for wind and conduct needed research to make it more beneficial to the industry.

Thank You!

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The Block Island Wind Farm—the first offshore wind farm in the United States. *Photo by Dennis Schroeder, NREL 40389*

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