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Gearbox Reliability Database: Data Collection and Reporting

Wind Turbine Tribology Seminar

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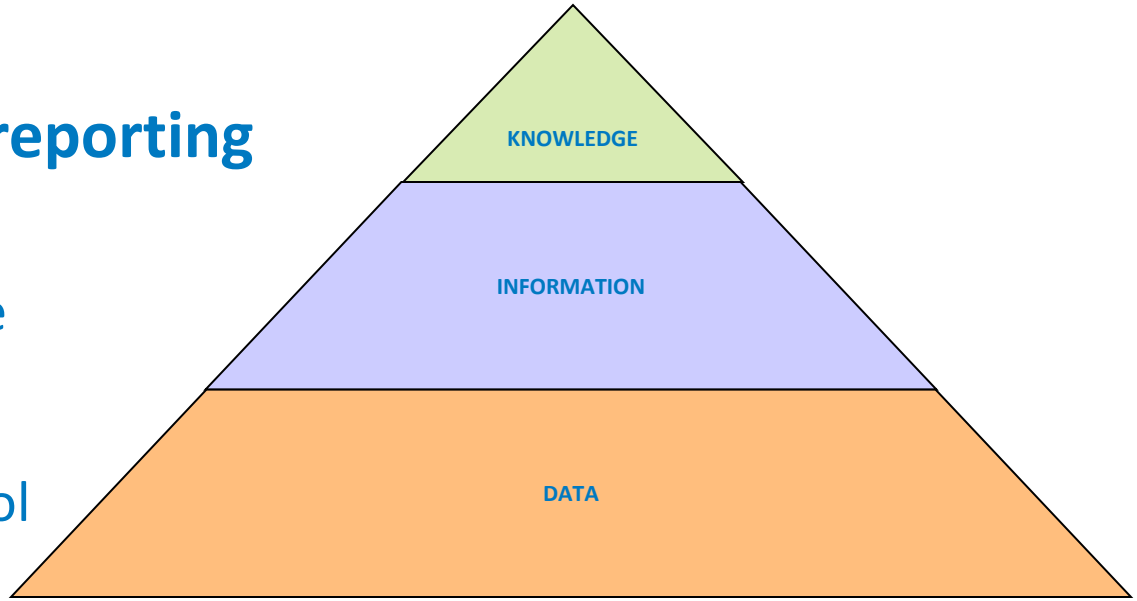
Outline

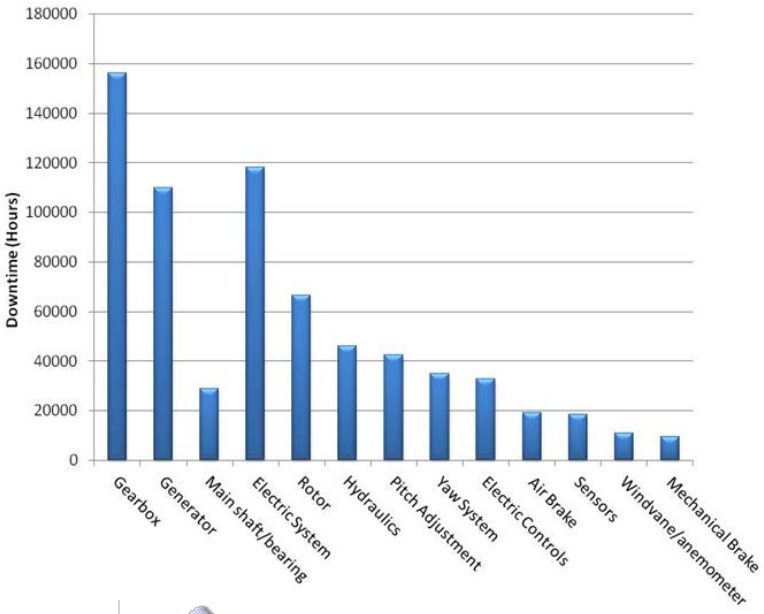
- **Project background**
- **Data protection**
- **Data collection and reporting mechanisms**
  - Stand-alone software
  - Template in Excel
  - Tablet-deployable tool
  - Web interface
- **Current observations**
- **Next steps.**



Data collection is the foundation to derive information and gain knowledge!

Project Background

- **The Gearbox Reliability Collaborative:**
  - Aims to improve gearbox reliability and availability
  - Takes a multifaceted approach that includes testing, modeling, condition monitoring, and a database
- **The Gearbox Reliability Database project:**
  - Aims to quantify the magnitude of the problem and identify top failure modes and root causes
  - Collects gearbox failure event data from project partners, all have executed nondisclosure agreements (NDAs) with the National Renewable Energy Laboratory (NREL)
  - Directs wind turbine gearbox reliability research and development (R&D) and provides a benchmark for evaluating technology advancements.
- **More Information:** http://www.nrel.gov/docs/fy15osti/63106.pdf



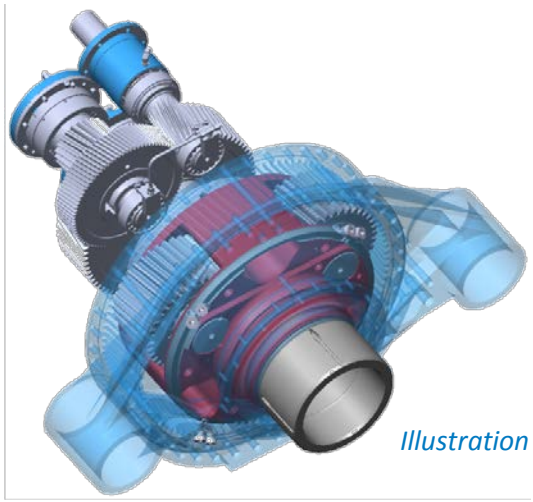
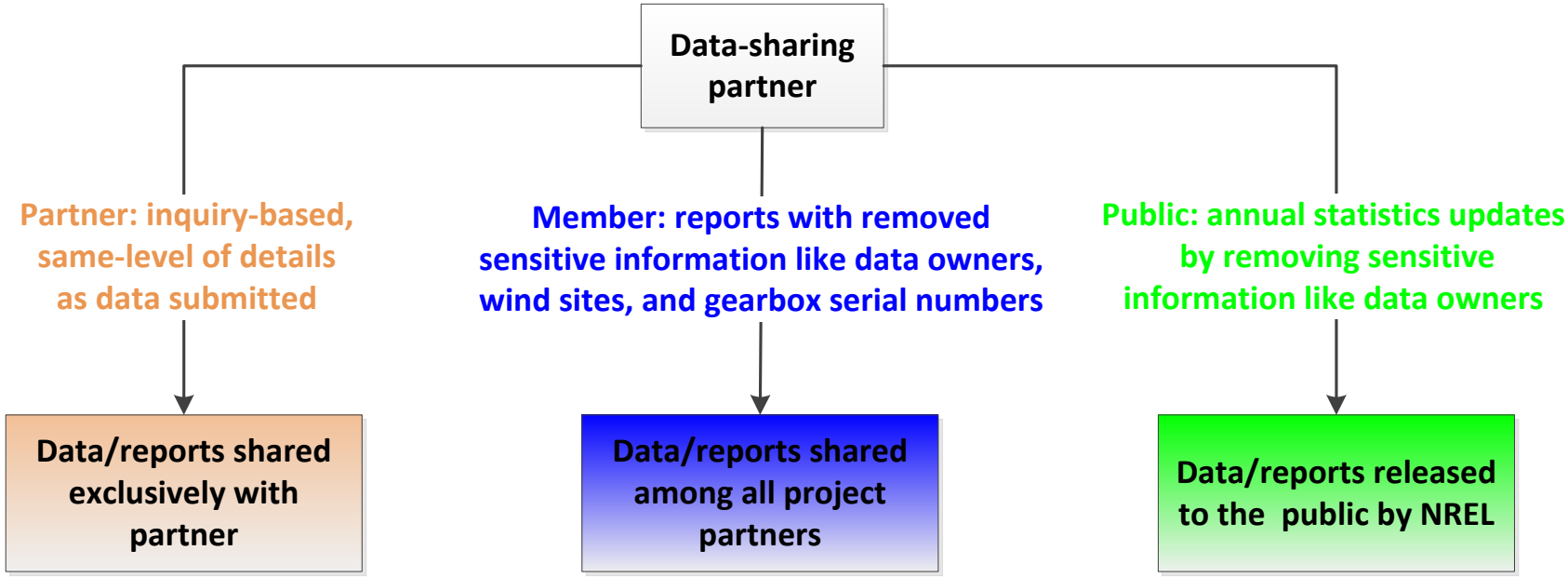


Illustration by NREL

Plot source: S. Sheng, S., Link, H., LaCava, W., van Dam, J., McNiff, B., Veers, P., Keller, J., Butterfield, S., Oyague, F. 2011. *Wind Turbine Drivetrain Condition Monitoring During GRC Phase 1 and Phase 2 Testing* (Technical Report). NREL/TP-5000-52748, National Renewable Energy Laboratory, Golden, CO (US). http://www.nrel.gov/docs/fy12osti/52748.pdf

Data Protection

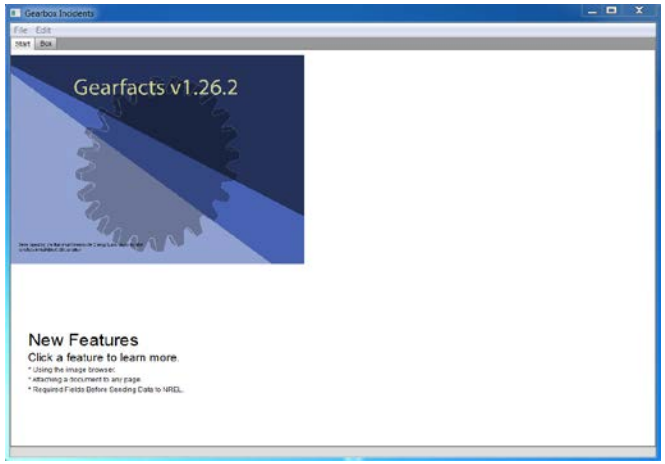
- Each partner's data is protected by NDA executed with NREL
- Protect data via a three-tier data-sharing mechanism:



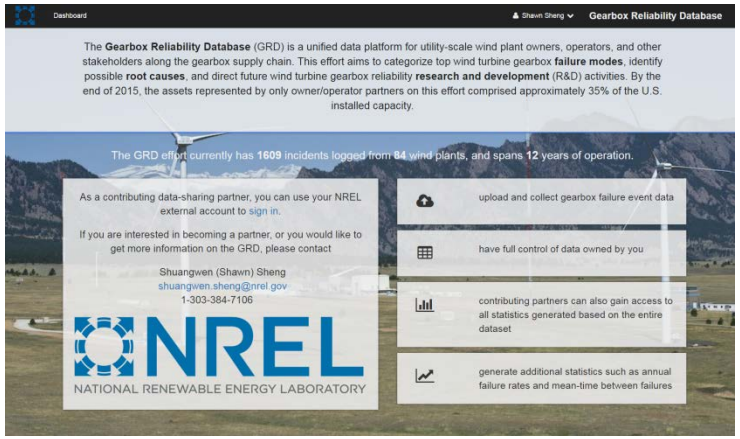
- Nonsensitive analysis results and reports are released to the public only through NREL.

Data Collection and Reporting Mechanisms

- Stand-alone software
- Tablet-deployable tool
- Template in Excel
- Web interface.



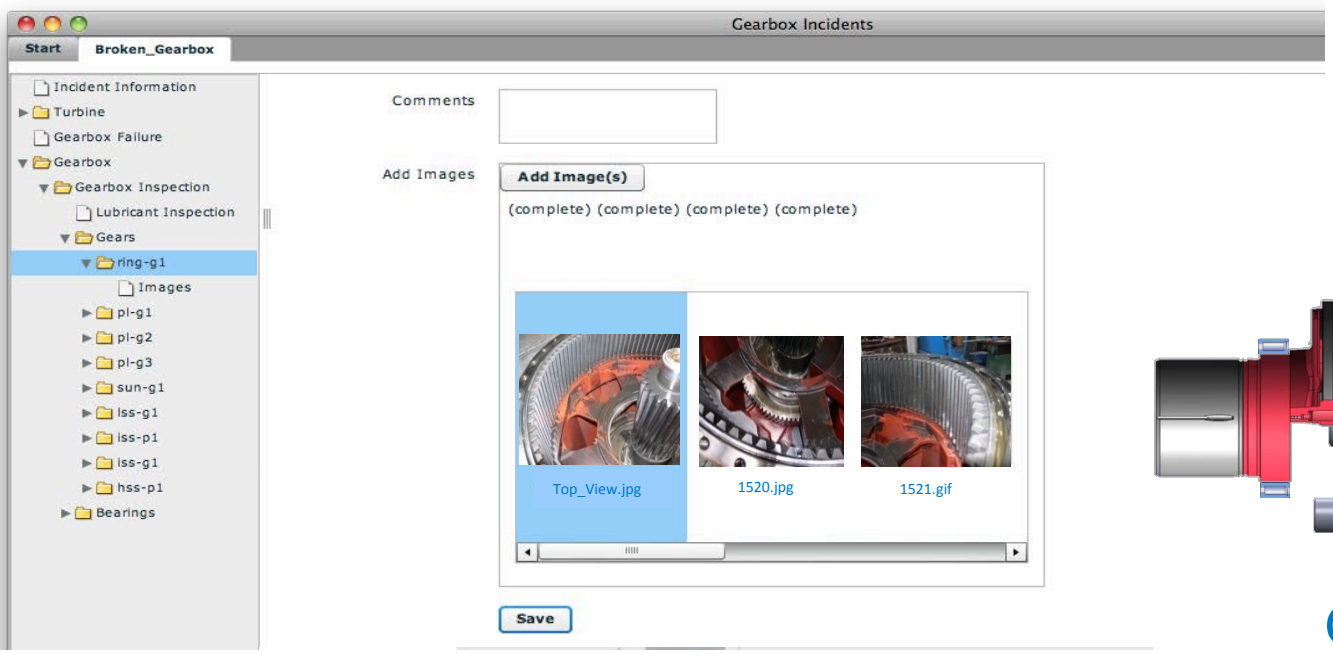
Stand-alone software



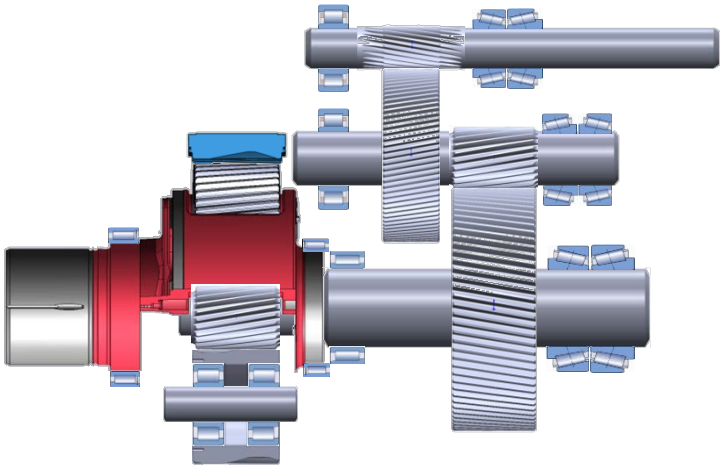
Web interface

Stand-Alone Software

- GearFacts: a gearbox rebuild event data detailed recording tool
- Structured data collection
- Embedded visual illustration of gearbox models
- High-resolution damage photos.



GearFacts

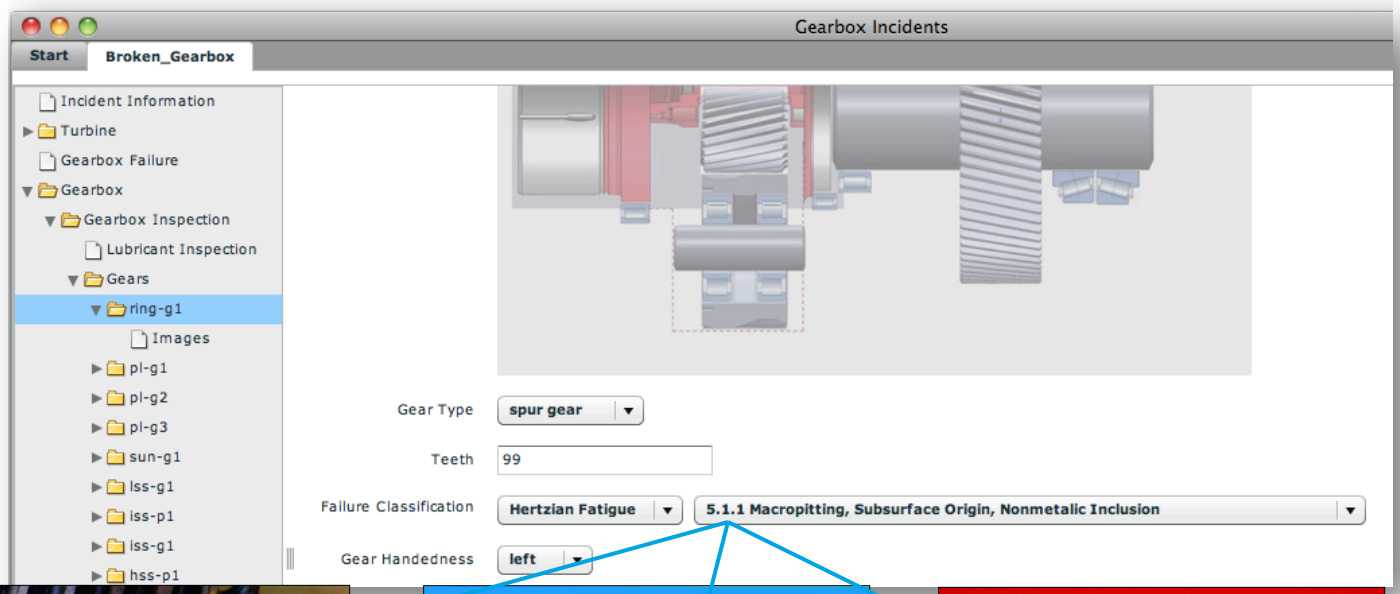


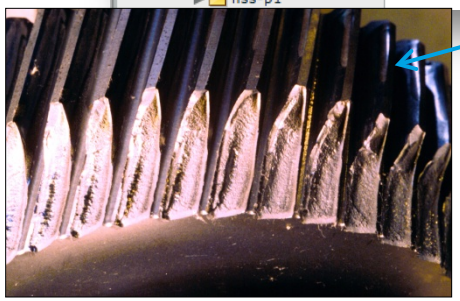
Gearbox model

Illustrations and Photos from Mark McDade, NREL

Stand-Alone Software (Cont.)

- Integrated gear and bearing failure atlases
  - Interactively support preliminary failure mode classifications.





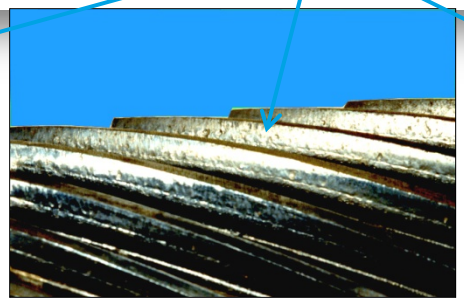


Illustration and Photos from Mark McDade, NREL

Stand-Alone Software (Cont.)

- Generation of reports
- Data transmission:
  - One event file size: ~ 1 gigabyte
  - Sharepoint site
  - Mail of portable storage media
- Opportunities:
  - An option offered to data sharing partners for detailed gearbox rebuild event data recording
  - Customizable for gearbox rebuild shops.

Gearbox Failure Report

Gearbox Make: GRC-1.0

Gearbox Serial: MC-54-235.0

Time of operation: 75000 hours

Date of Failure: 01/20/2010

Figure 1: Gearbox Failure location

Intermediate Shaft Pinion:

Failure type: Scuffing

Illustration and Photos from Mark McDade, NREL

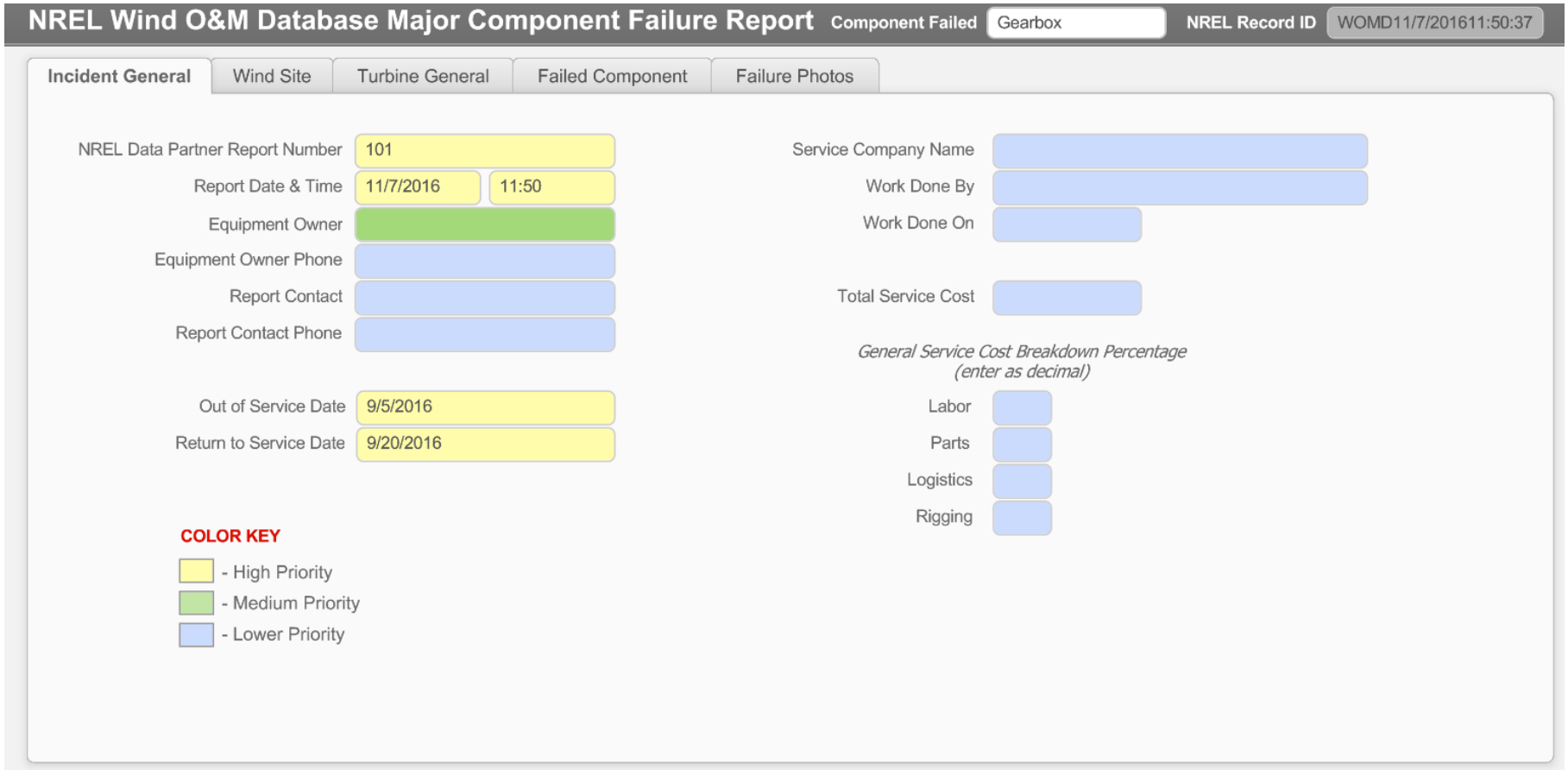
Template in Excel

- Examined data fields collected by GearFacts and prioritizing them into three categories: high, medium, and low
- Introduced Microsoft Excel spreadsheet template for data collection with only high-priority fields
- Accessible by data sharing partners
  - Updated when needed to support new research
  - Dominant means for data sharing so far.

Wind Site Name
Wind Site State Province Region
Wind Site Country
WTG Make/Model
WTG Pad No.
WTG Total Run Hours Estimation
WTG Total Production kWh Estimation
WTG Type of Power Conversion
WTG Type of Generator
Gearbox Maker/Model (if you are not comfortable sharing this with NREL, please skip)
Gearbox Serial No. (if you are not comfortable with the full description of the serial No., please share the last three digits.)
Gearbox Originally New or Rebuilt
Install Date
Failure Date
Gearbox Run Hours Estimation
Gearbox Production Estimation (kWh)
Original Lubricant Type
Current Lubricant Type
Inline Filter Rating (50 mirons, 20 microns, 10 microns, or 5 microns)
Offline Filter Rating (3 microns)
How was Damage Detected
Dominant Failure (Worst) Location
Secondary Failure (2nd Worst) Location
Dominant Failure (Worst) Mode
Secondary Failure (2nd Worst) Mode
Corrective Actions (Uptower repair, internal component replacement, or gearbox replacement)
Other Drivetrain Component Failures Before this damage
Other Drivetrain Component Failures After this damage
Additional Notes

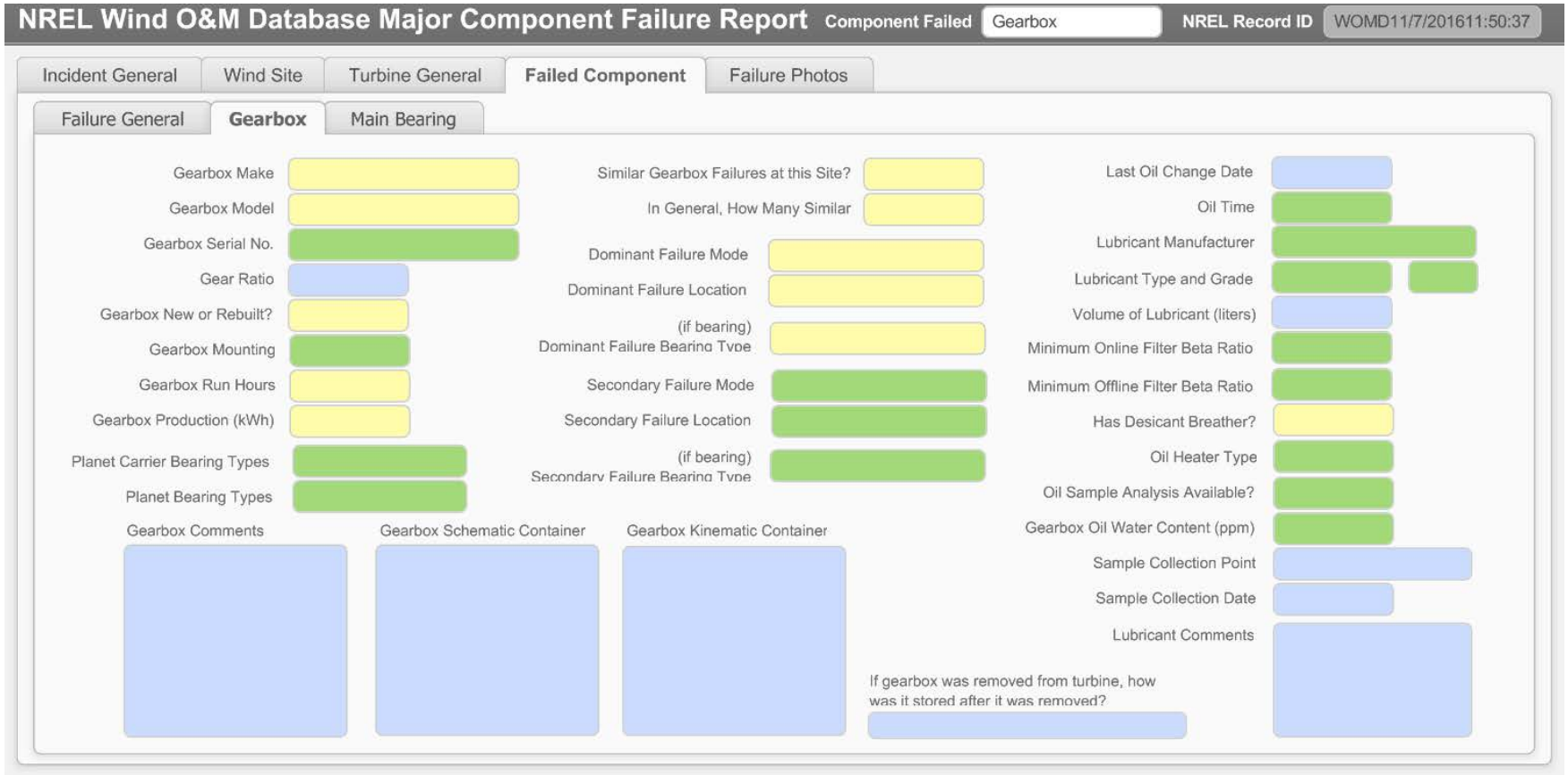
Tablet-Deployable Tool

- Based on the data fields used by the Excel template
- Deployable on portable devices.



Tablet-Deployable Tool (Cont.)

- Synchronize with a central server
- Interface with popular asset management platforms
- Opportunities: same as GearFacts.



Web Interface: Key Features

- A centralized location that provides objective and interactive benchmarking of gearbox reliability
- Terminology based on International Electrotechnical Commission, International Standards Organization, and American Gear Manufacturers Association standards
- Update interactive statistics narrowing down to bearings or gears
- Partners with wind assets older than 30 turbine years and contributed data can sign up with NREL through NDAs and access the interface
- All data accessed by partners through the web interface are:
  - Protected by NDAs and can only be used for internal references
  - Cannot be shared with the general public.

Web Interface: Welcome Page

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.

The GRD effort currently has **1609** incidents logged from **84** wind plants, and spans **12** 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

Shuangwen (Shawn) Sheng
shuangwen.sheng@nrel.gov
1-303-384-7106

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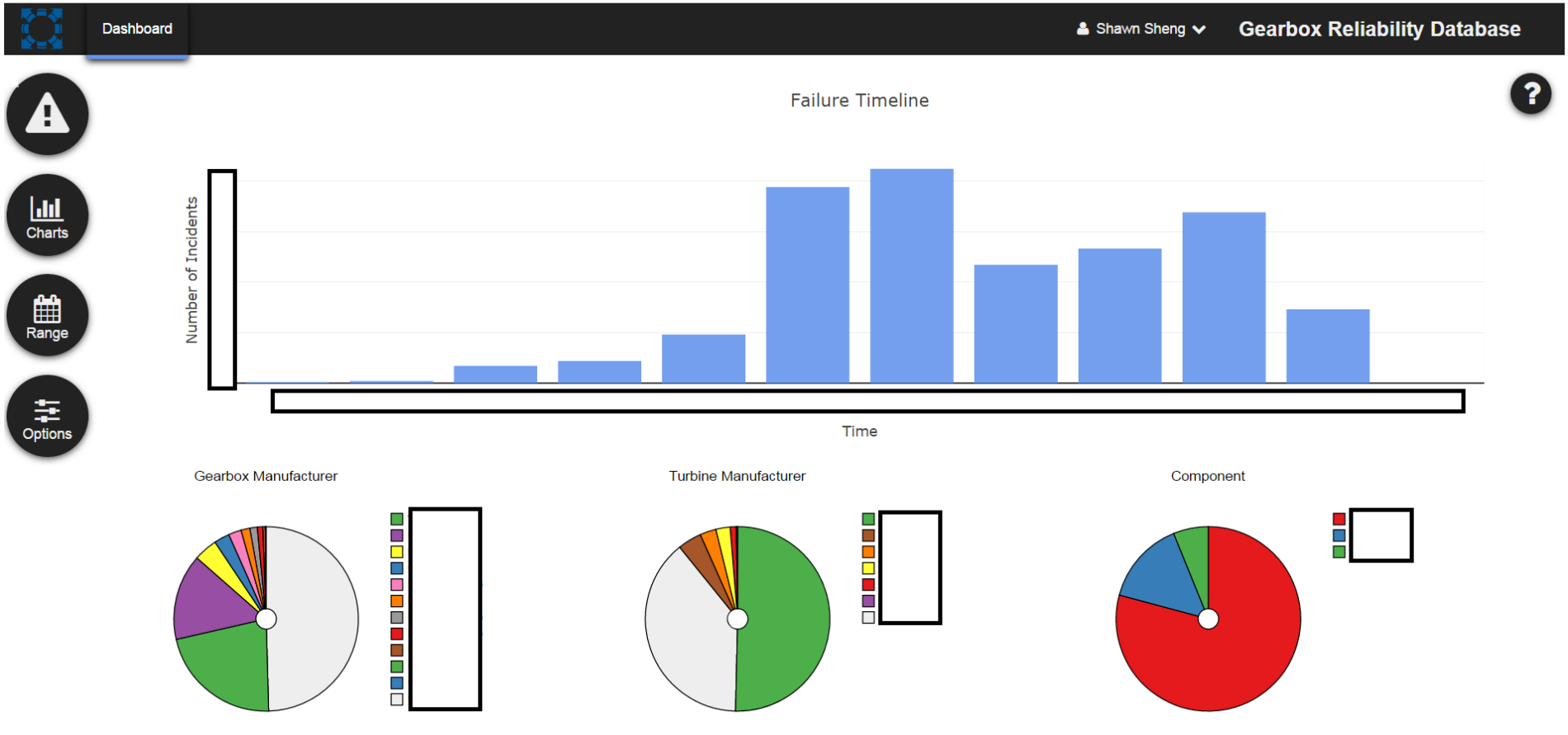
- upload and collect gearbox failure event data
- have full control of data owned by you
- contributing partners can also gain access to all statistics generated based on the entire dataset
- generate additional statistics such as annual failure rates and mean-time between failures

Web Interface: Failure Timeline

- Global data: number of incidents vs. time
- Interactive updating based on gearbox, turbine, and component choices.



Web Interface: Average Downtime

- Partner-owned data compared with global data
- Handy tools for plot capturing, sharing, reporting, and so on.

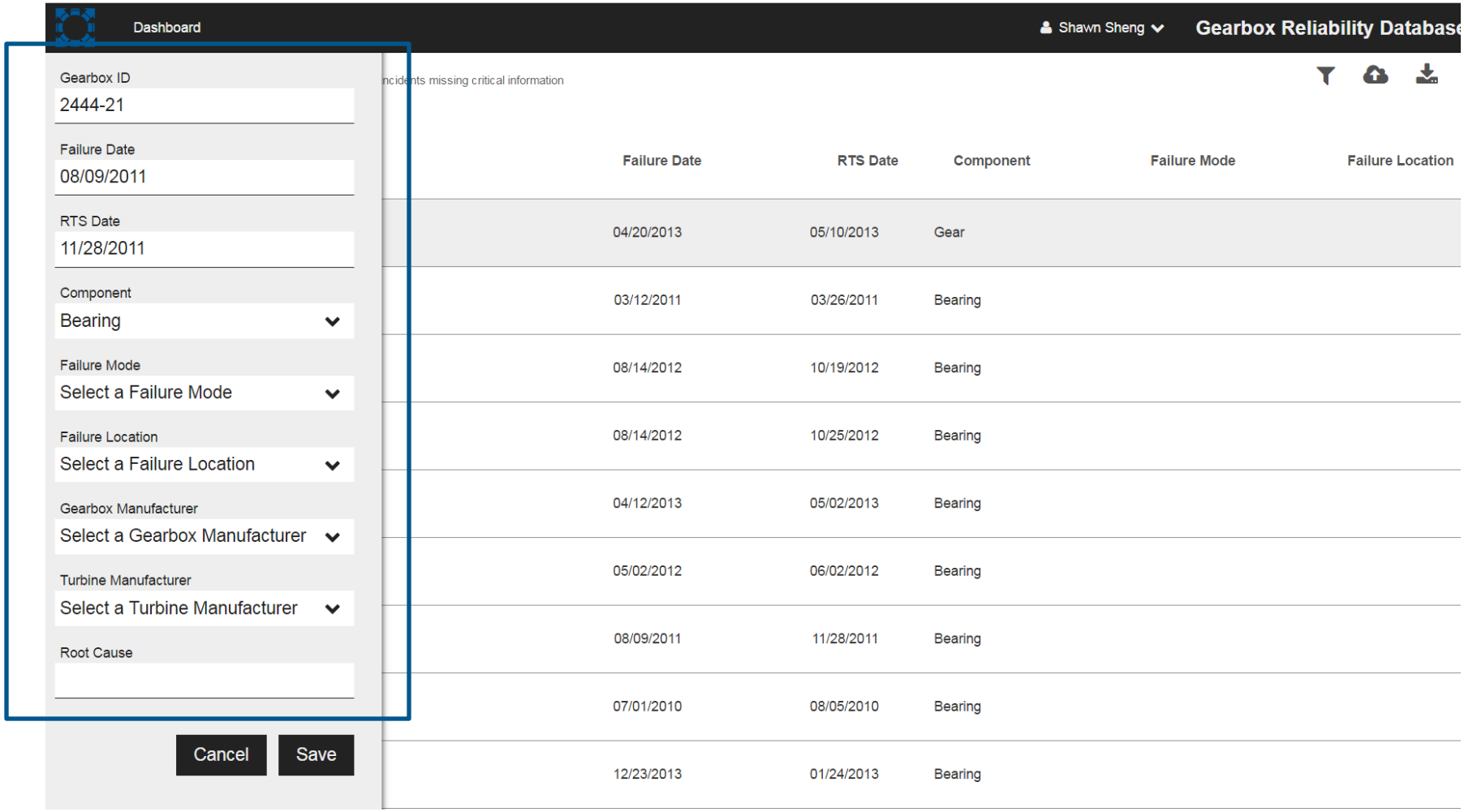
Web Interface: Data Table

- Full control over own data
- Interactive editing.

Edit	ID	Gearbox ID	Failure Date	RTS Date	Component	Failure Mode
	4194	5431-01	04/20/2013	05/10/2013	Gear	
	4198	2444-35	03/12/2011	03/26/2011	Bearing	
	4202	2444-6	08/14/2012	10/19/2012	Bearing	
	4203	2444-5	08/14/2012	10/25/2012	Bearing	
	4204	2444-18	04/12/2013	05/02/2013	Bearing	
	4206	2444-48	05/02/2012	06/02/2012	Bearing	
	4208	2444-21	08/09/2011	11/28/2011	Bearing	
	4210	2444-34	07/01/2010	08/05/2010	Bearing	

Web Interface: Data Table (Cont.)

- Data validation and warning if critical information is missed
- Download own and global data, only nonidentifiable fields.



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 required-*MM/DD/YYYY*: The failure date of this turbine

rts_date required-*MM/DD/YYYY*: The return to service date for this turbine

root_cause optional-*string*: The identified root cause of the failure

report_source optional-*string*: The source of the report

wtg_mfg required-*string*: The manufacturer of the turbine

wtg_model optional-*string*: The modle of the turbine

wtg_total_run_hours optional-*number*: The turbine total run time in hours

Current Observations

- Value of and need for a reliability database demonstrated by:
  - Participation of more than 25 partners
  - Inquiries on gearbox reliability information from the global wind community
  - Direction of R&D on reliability and mitigation strategies.

- Challenges:
  - Standardized reliability data collection practices for not only gearboxes but also other major components/subsystems
  - Lack of representative data of a bigger population to better reflect the reality
  - Actively engage partners to submit data.

Next Steps

- Focus more on data collection and analysis
- Add annualized failure rates and interactive Weibull distribution fitting to the web interface, if feasible
- Expand the scope of data collection to main shaft bearings and other major components/subsystems.
- Opportunities:
  - An objective party for reliability data collection and analysis to support benchmarking of gearbox reliability and help improve operation and maintenance practices
  - Customized tool development through funded projects.

Thanks for Your Attention!

Special thanks go to the U.S. Department of Energy and project partners working with NREL on reliability!

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

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