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The Role of Benchmarking in Reliability-Centered Maintenance

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and Safety Seminar
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Sandia National Laboratories
Wind Energy Technologies
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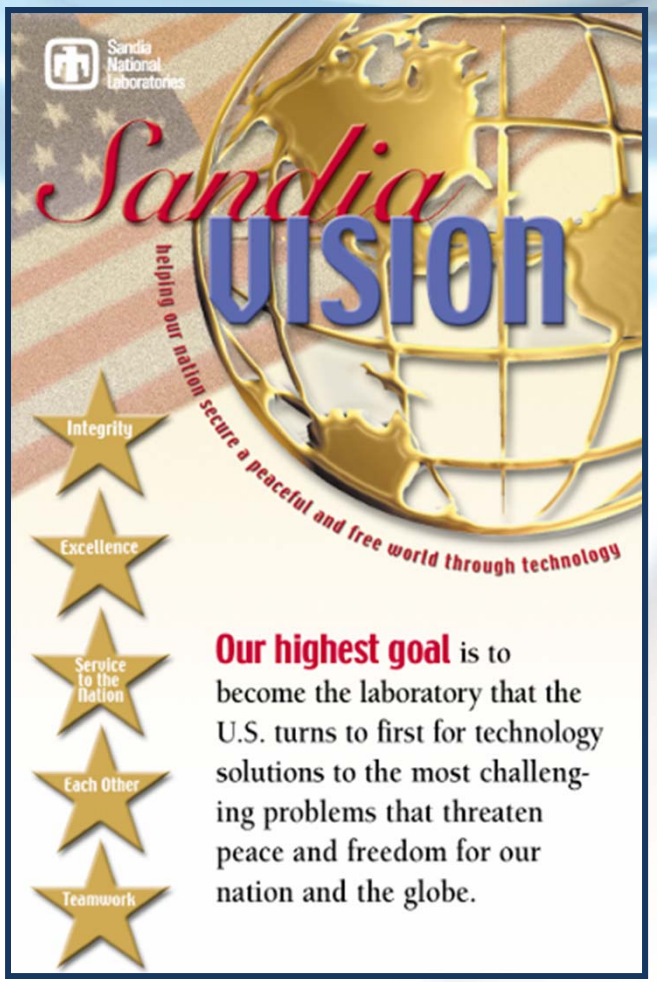

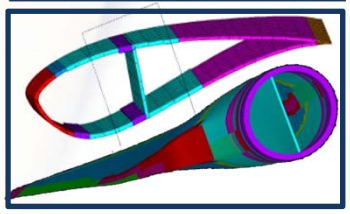

Wind Energy Technologies Department

FOCUS

- Industry needs
- Reducing energy cost
- Promoting large-scale deployment of clean, affordable energy

GOALS

- High fidelity modeling
- Blade design to eliminate barriers
- Increased energy capture & improved efficiency
- **Increased system reliability**
- Testing at reduced cost

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Reliability-Centered Maintenance

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What is Reliability-Centered Maintenance (RCM)?

- Process to define maintenance program to maintain necessary operations and operating conditions (safety, environment)
- **Goal**: Achieve inherent equipment reliability at a minimal cost
  - "Inherent" from design and manufacturing – maintenance can't change this level
- Groundwork was developed at United Airlines in the 1970s
  - Quickly adopted by military & nuclear power industry
- Defined by the standard "Evaluation Criteria for RCM Processes" (SAE JA1011)
  - 7 key questions about functions, failures, and failure prevention

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RCM Process

- Identify operating context for the equipment
  - Create a FMECA (Failure Modes, Effects, and Criticality Analysis)
- Determine maintenance activities that address items in FMECA & appropriate frequencies (bundling work)
  - One-time System Changes
  - Predictive Maintenance
  - Preventive Maintenance
  - Inspections
  - Run-to-Failure
- Re-evaluate maintenance effectiveness
  - Make adjustments as needed

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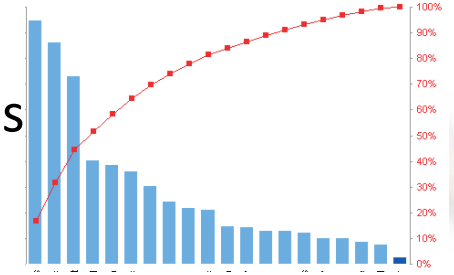
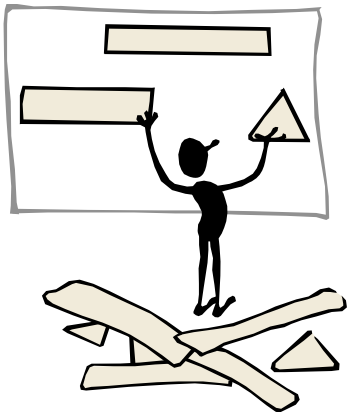
Assessing & Sustaining an RCM Program

- Determine and evaluate Key Performance Indicators (KPIs) with and without the RCM program
  - Examples: Cost, Availability, Maintenance Hours
- Identify top contributors to KPIs
  - Worst Performers & Emerging Negative Trends
  - Best Performers & Most Improved
- Adjust maintenance program
  - Add or remove tasks
  - Update maintenance intervals
  - Change criteria/parameters for prediction
  - Implement one-time changes
  - Etc.





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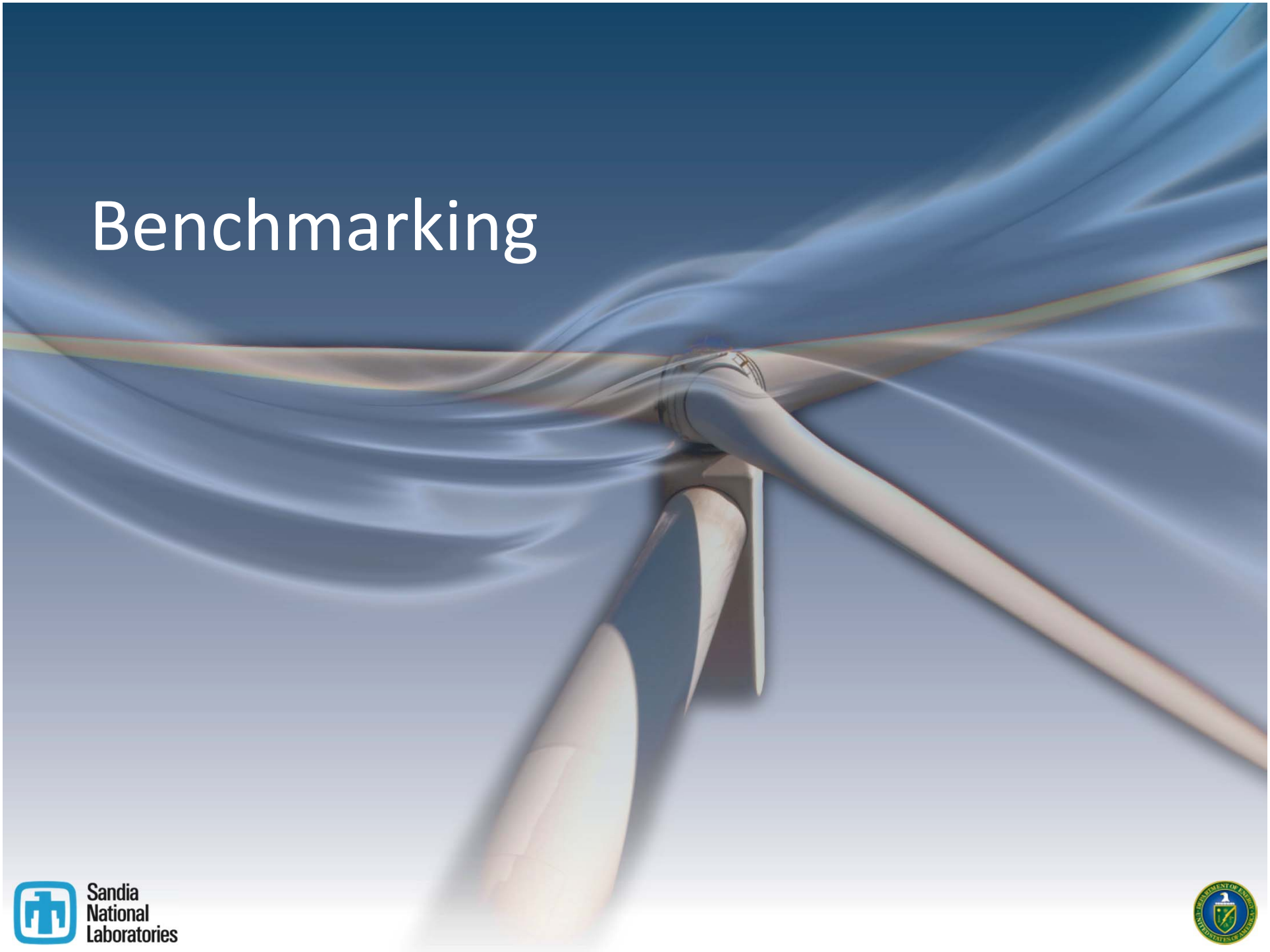
RCM Requires Benchmarking

- Identify top contributors to KPIs
  - Requires internal benchmarking
  - Is the data available to perform an analysis of top contributors?
- Determine if maintenance is “too good” or too much is being spent
  - Requires external benchmarking
  - Could those resources have more impact elsewhere?

Benchmarking



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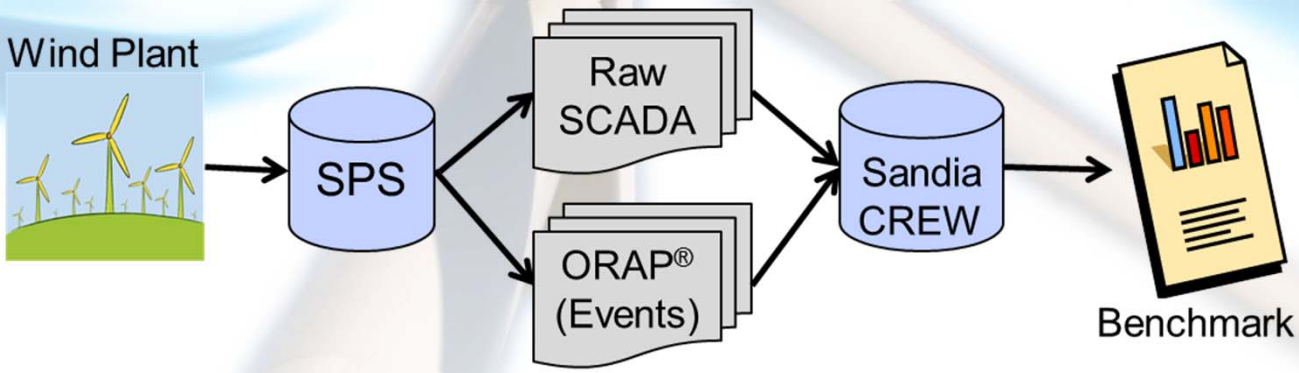
CREW: Continuous Reliability Enhancement for Wind

Goal: Create a national reliability database of wind plant operating data to enable reliability analysis

Method:

Sandia partners with Strategic Power Systems (SPS), whose ORAPWind® software collects real-time data from wind plant partners



Key Objectives:

- **Benchmark reliability performance**
- Track operating performance at a system-to-component level
- Characterize issues and identify technology improvement opportunities
- Protect proprietary information
- Enable operations and maintenance cost reduction
- Increase confidence from financial sector and policy makers

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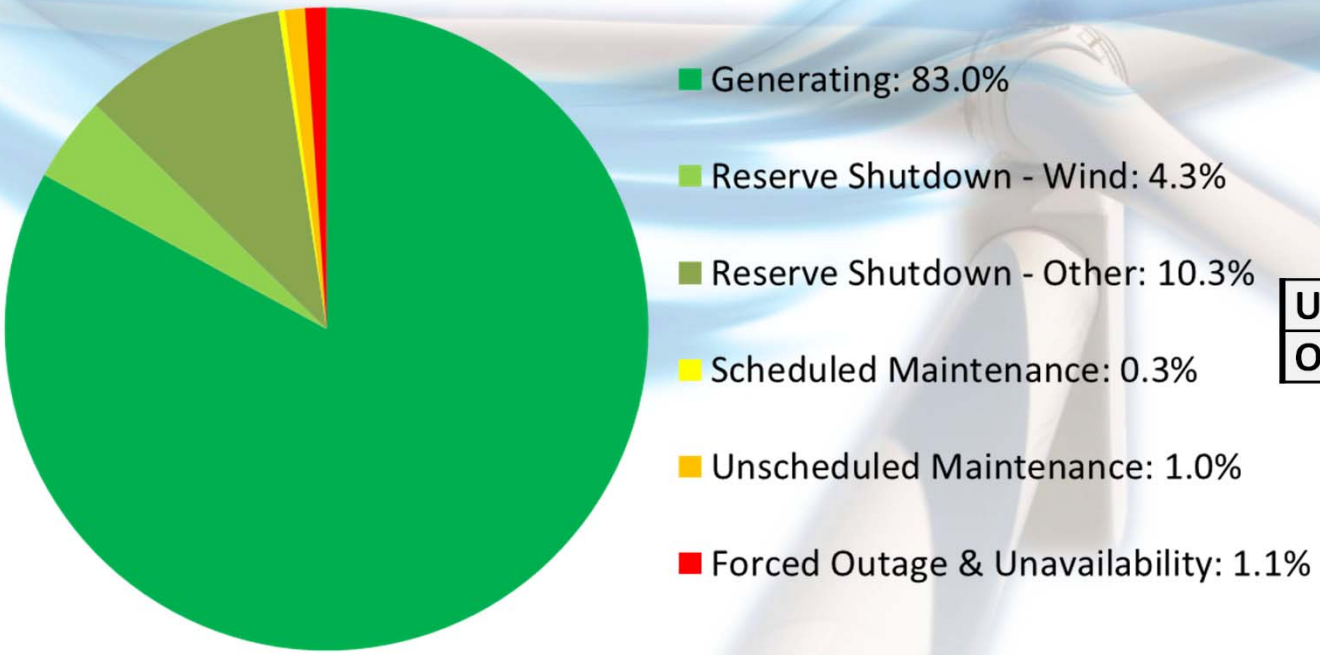
ORAPWind™ Performance Dashboard

- Cloud based online analysis – 24x7
- RAM and Performance data analysis
- One minute statistical data – everyone else uses 10 minute data
- ORAP® Transformed data
- Fault / Event analysis
- Industry benchmarks
- IEC / IEEE Availability reporting
- NERC GADS reporting
- Data Completeness and Quality monitoring metrics

ORAPWind.spsinc.com

Availability Time Accounting

Information Available



Utilization	83.0%
Operational Availability	97.6%

- Utilization = Generating
- Operational Availability
  = Generating + Reserve Shutdown Wind + Reserve Shutdown Other
- Can calculate other metrics of interest from these categories
  - Example: Technical Availability
    = (Generating + Reserve Shutdown Wind + Reserve Shutdown Other)
    /(100%-Scheduled Maintenance)

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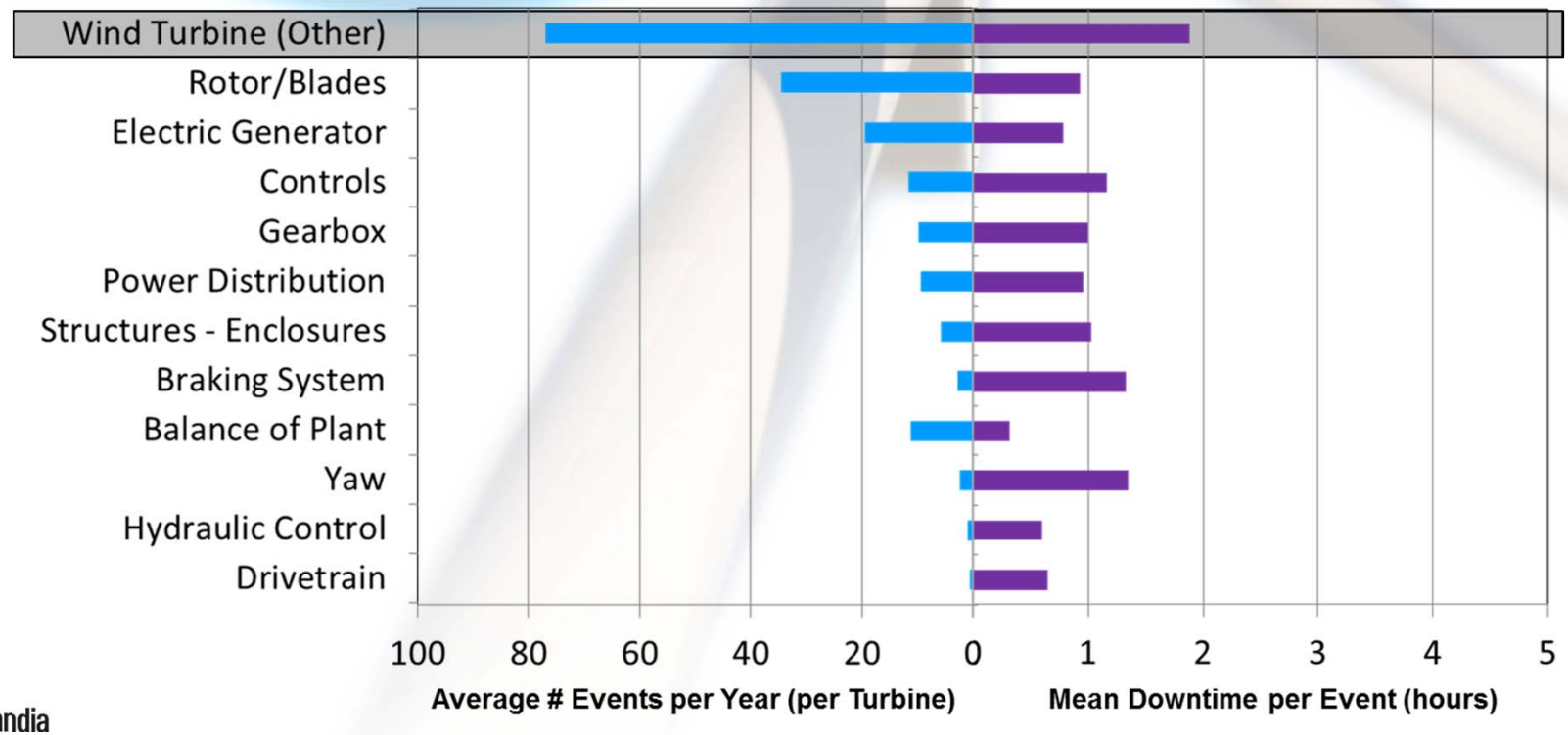
Event & SCADA Data Source: SPS ORAPWind

Event Frequency vs. Downtime

- Dominated by “Wind Turbine (Other)” events
  - Mainly when technician has turbine in maintenance/repair mode
- Work Orders or Technician Logs are critical for differentiating within this category



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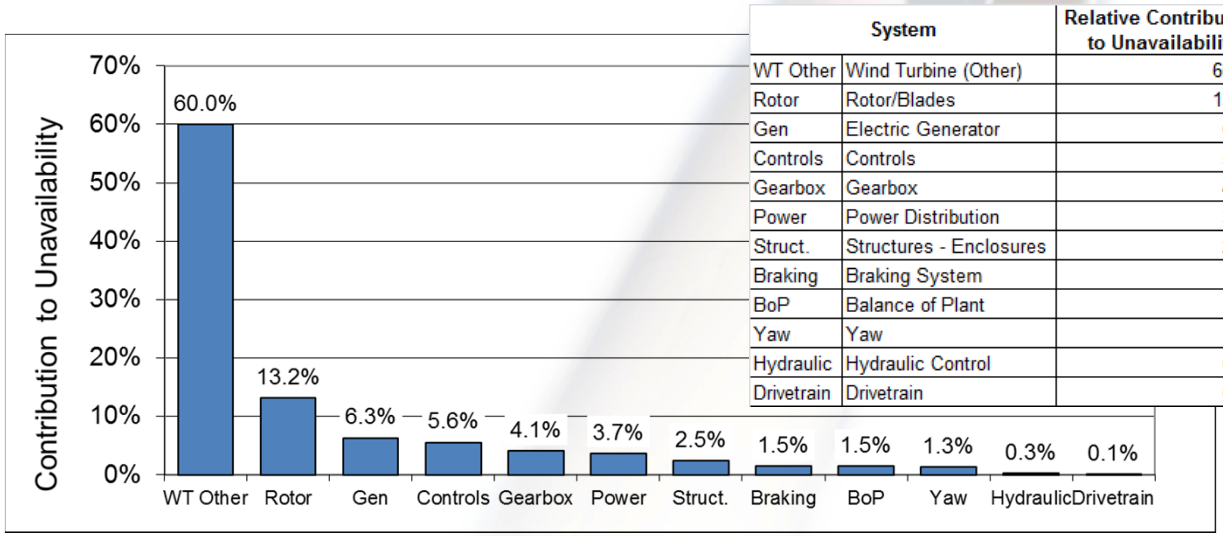
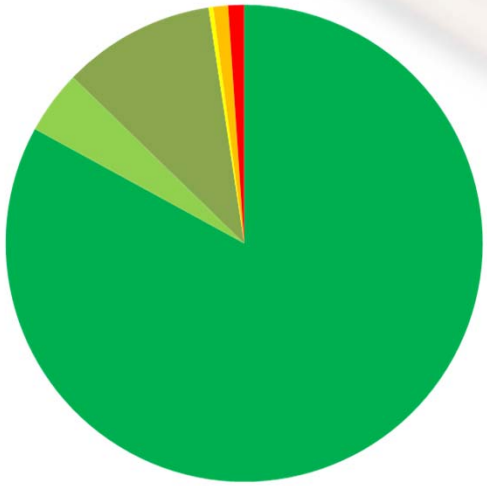
Event & SCADA Data Source: SPS ORAPWind

Conclusions

- RCM requires internal Benchmarking
  - Determine the best and worst contributors to KPIs
    - These are the components/activities that warrant changes
  - The right data is critical to performing this assessment
- RCM requires external Benchmarking
  - Is performance poor, better-than-necessary, or just right
    - Are too much resources being spent? Are they better utilized elsewhere?



System		Relative Contribution to Unavailability
WT Other	Wind Turbine (Other)	60.0%
Rotor	Rotor/Blades	13.2%
Gen	Electric Generator	6.3%
Controls	Controls	5.6%
Gearbox	Gearbox	4.1%
Power	Power Distribution	3.7%
Struct.	Structures - Enclosures	2.5%
Braking	Braking System	1.5%
BoP	Balance of Plant	1.5%
Yaw	Yaw	1.3%
Hydraulic	Hydraulic Control	0.3%
Drivetrain	Drivetrain	0.1%



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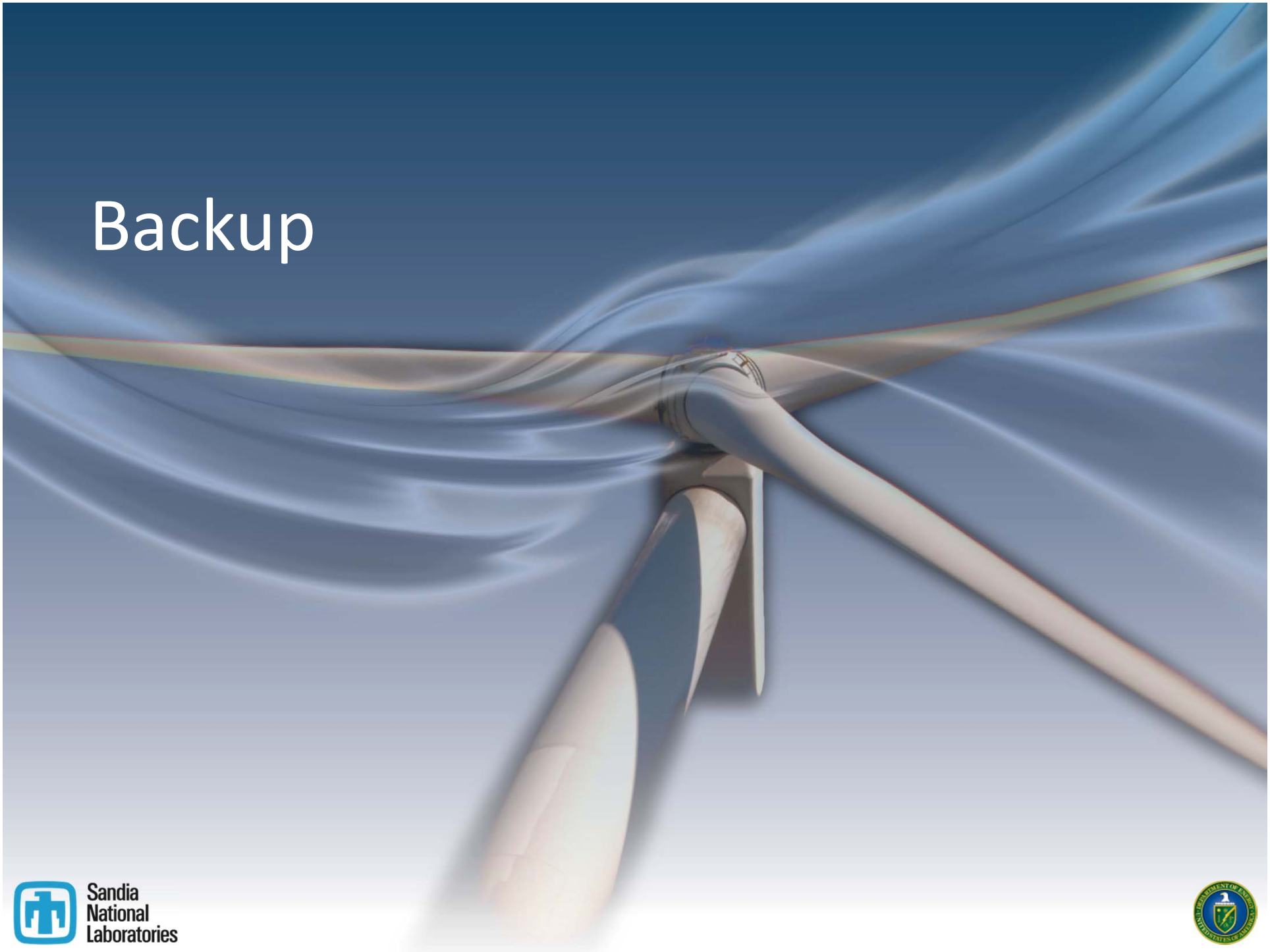
Backup



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CREW - Accessing More Information

- The benchmarks and companion technical reports for 2011-2013 can be found at http://energy.sandia.gov/crewbenchmark
- Sandia keeps an archive of our past wind plant reliability publications at http://energy.sandia.gov/?page_id=3057#WPR

- All U.S. wind plant owners, operators and OEM's are invited to participate. Please contact:

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RCM References

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