WEATS O&M Issues

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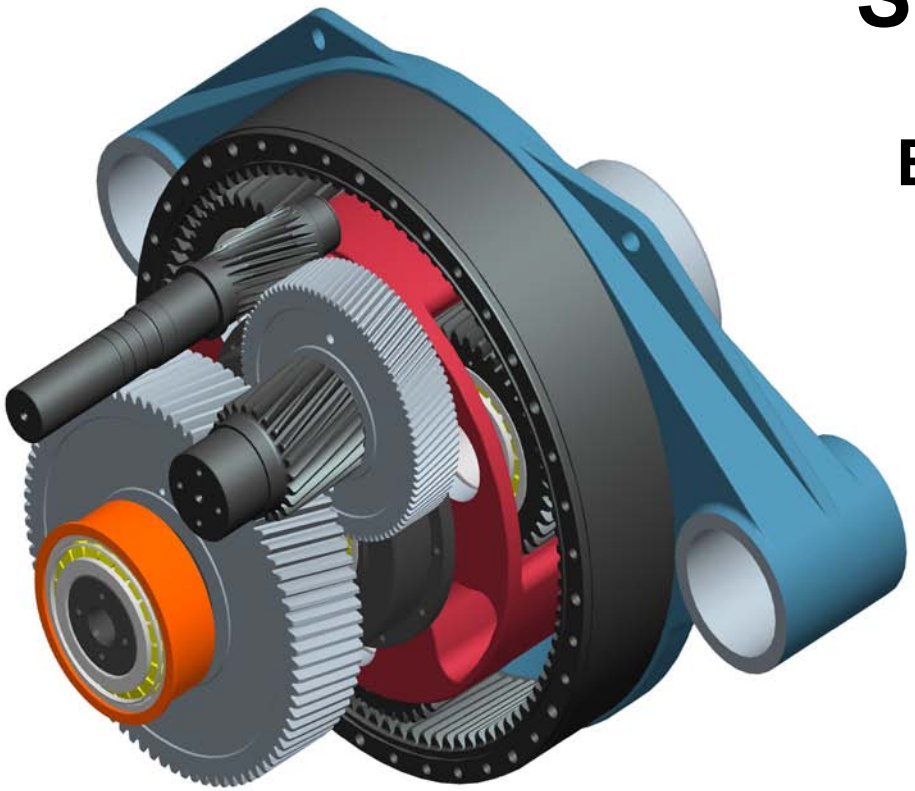


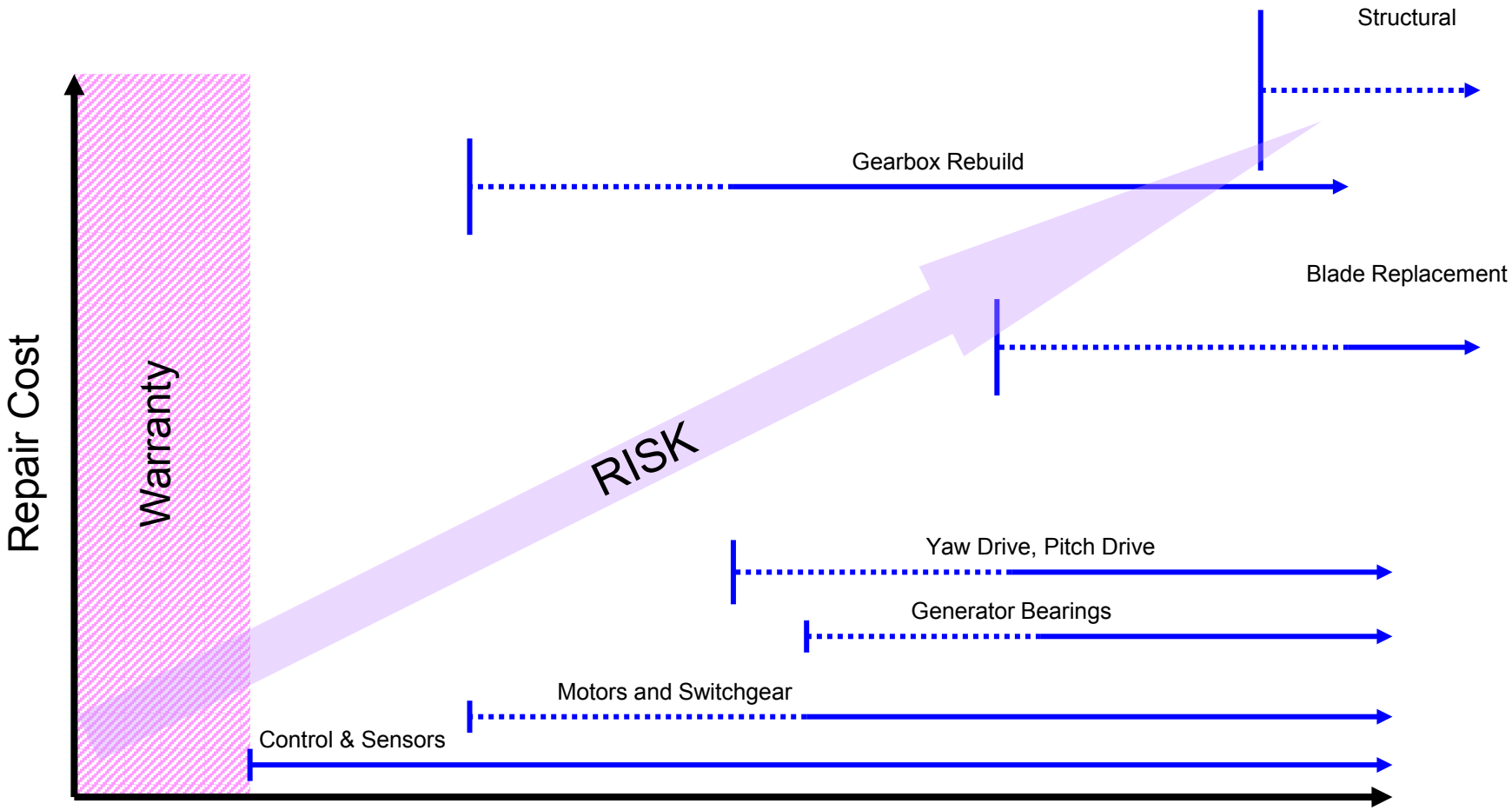
Sandy Butterfield
CEO
Boulder Wind Power

WEATS
August 31, 2010

Wind Turbines Present Unique O&M Challenges
or
S!@# Happens & Things Wear Out

- Multiple large machines spread out over large area
- Maintenance planning weather dependent
- Consequences of failures can be expensive
- Most successful strategies depend on advanced notice of maintenance requirements
- Remote health monitoring is critical in planning and minimizing maintenance costs
- Research is needed
- Certification can be your friend

Major Components at Risk



Reference: Chris Walford: GEC

Land Based O&M Cost Estimations

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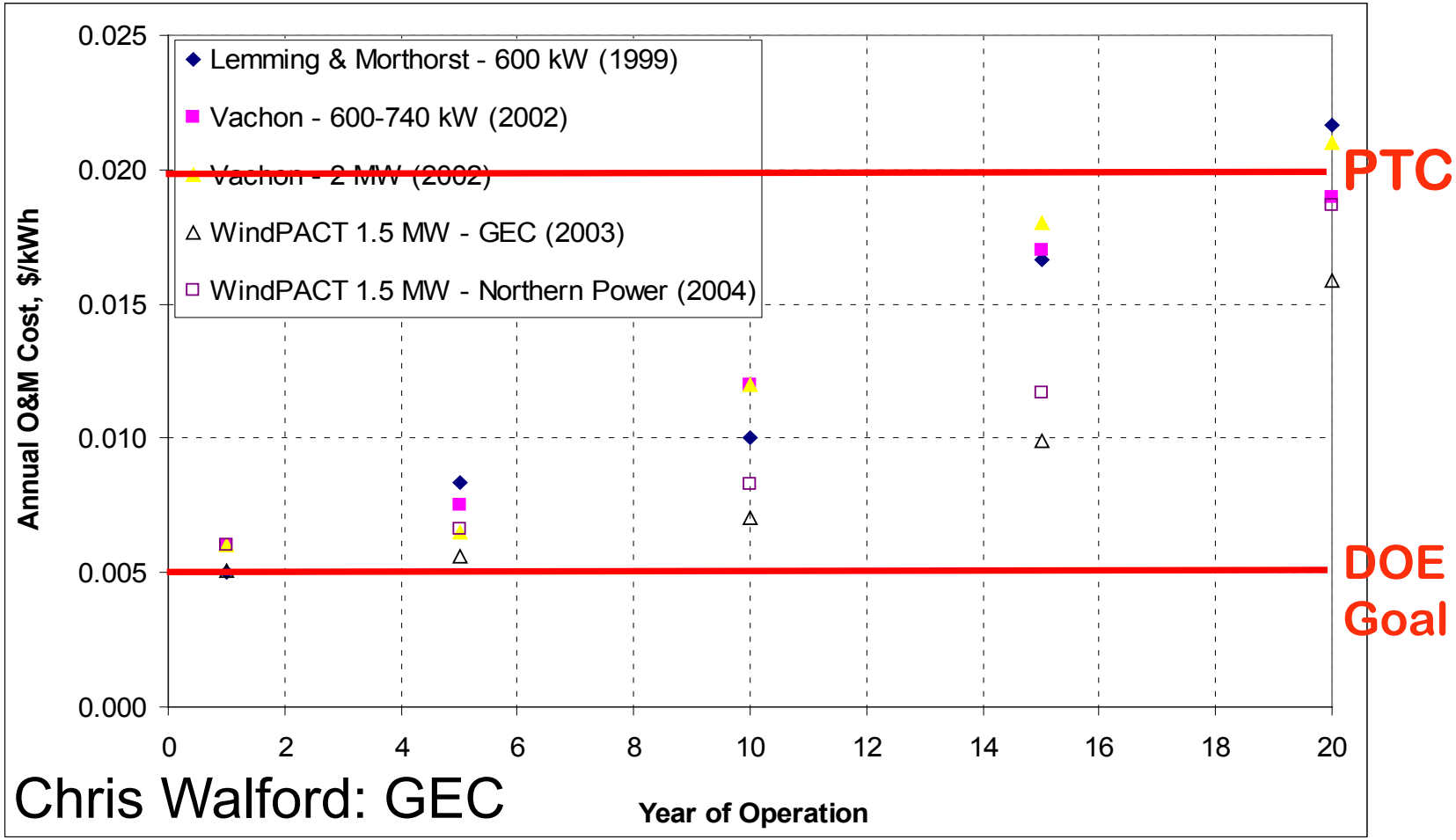
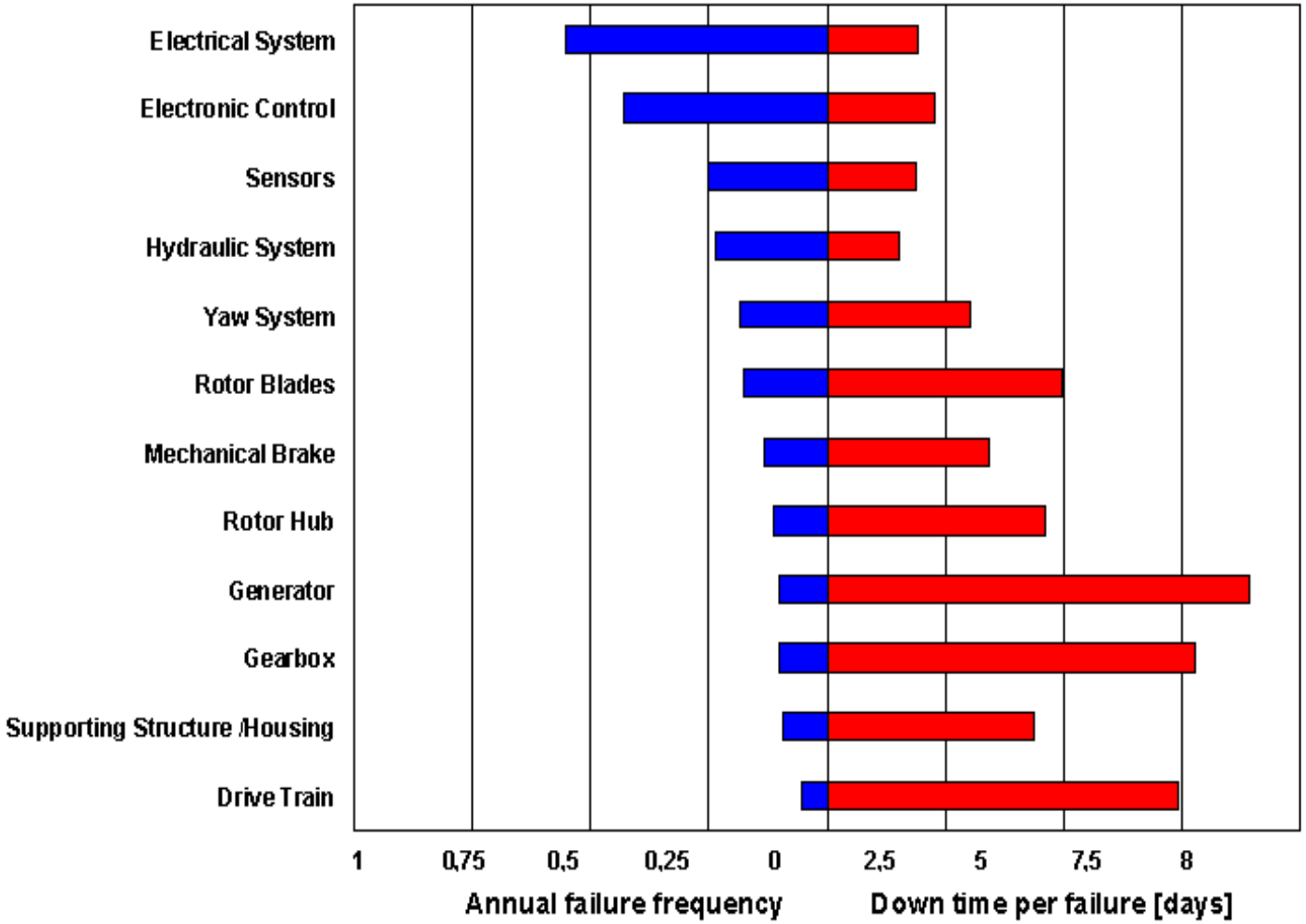


Chris Walford: GEC

Where are the Real O&M Costs?
Need an Unambiguous Reliability Data Base



Benefits of Condition Monitoring

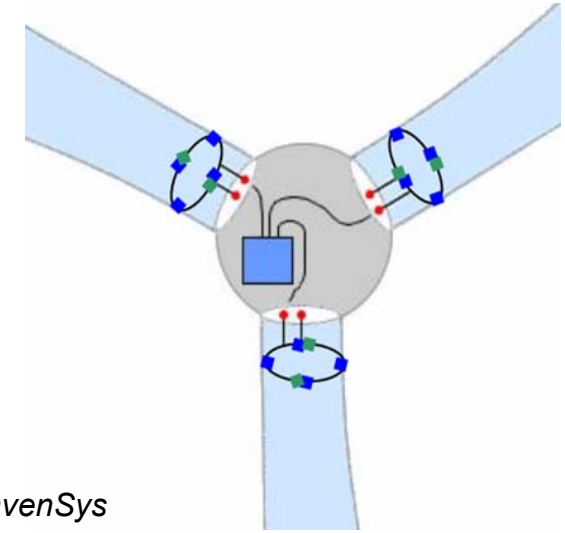
- Early deterioration detection to avoid catastrophic failure;
- Accurate evaluation of damage state of the monitored structure, and subsequently a cost effective maintenance planning or component replacement;
- Root cause analysis and subsequently, improved operational strategy to reduce chances of structure deterioration.

Source: http://jcwinnie.biz/wordpress/?p=2445

Source: Alstom Power

Wind Turbine CM

- Components:
  - Blade
  - Drive train
- Techniques:
  - Acoustic emission (or stress wave) analysis
  - Vibration analysis
  - Lubricant condition monitoring
- Typical Practice:
  - Integration of vibration or stress wave with oil CM



Source: InvenSys

Source: SKF

NREL Reliability Research Strategy

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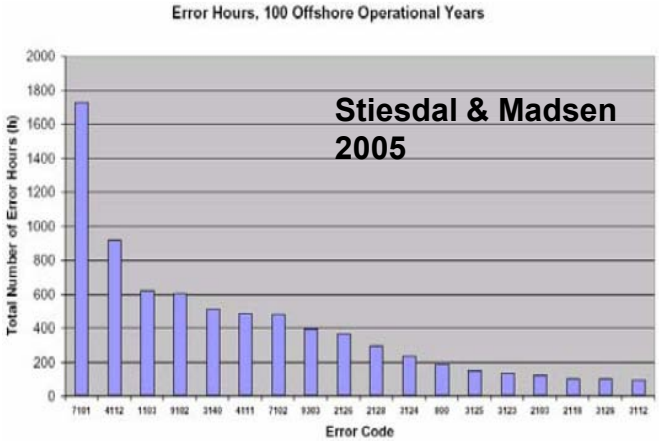
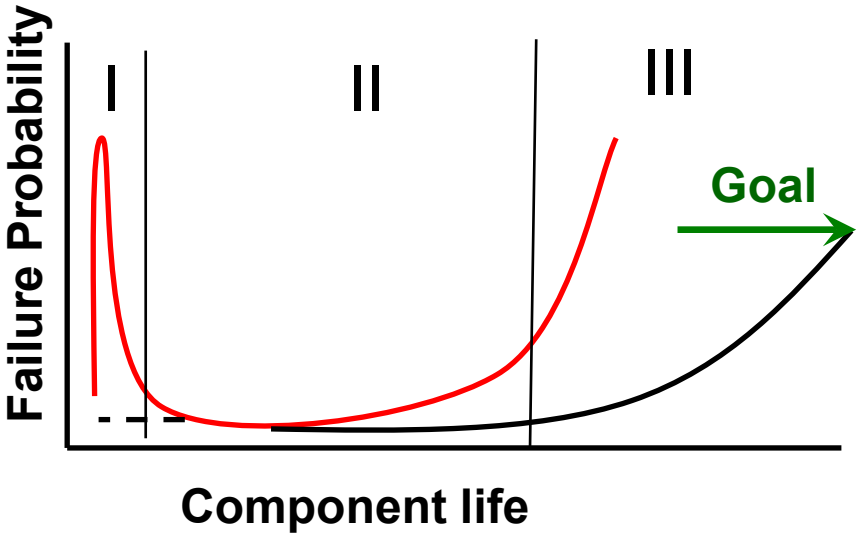
- Identify the high O&M cost issues (data base)
- Quantify failure probability statistics (data base)
- Develop reliability driven design and O&M COE model(s)
- Understand the component root causes of failures (GRC)
- Develop O&M management tools
- Design high reliability solutions
- Test solutions and O&M tools at reference sites
- Integrate long term solutions into the design process



g. 5: ACE Tracking Data – Hours at various error codes



Reliability Program Objectives

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- Short Term
  - Understand reliability issues for current fleet
  - Help reduce O&M cost of current fleet through end of life.
- Long Term
  - Develop high reliability solutions for design integration
  - Design high reliability next generation turbines (land based and offshore)

NREL Gearbox Reliability Collaborative

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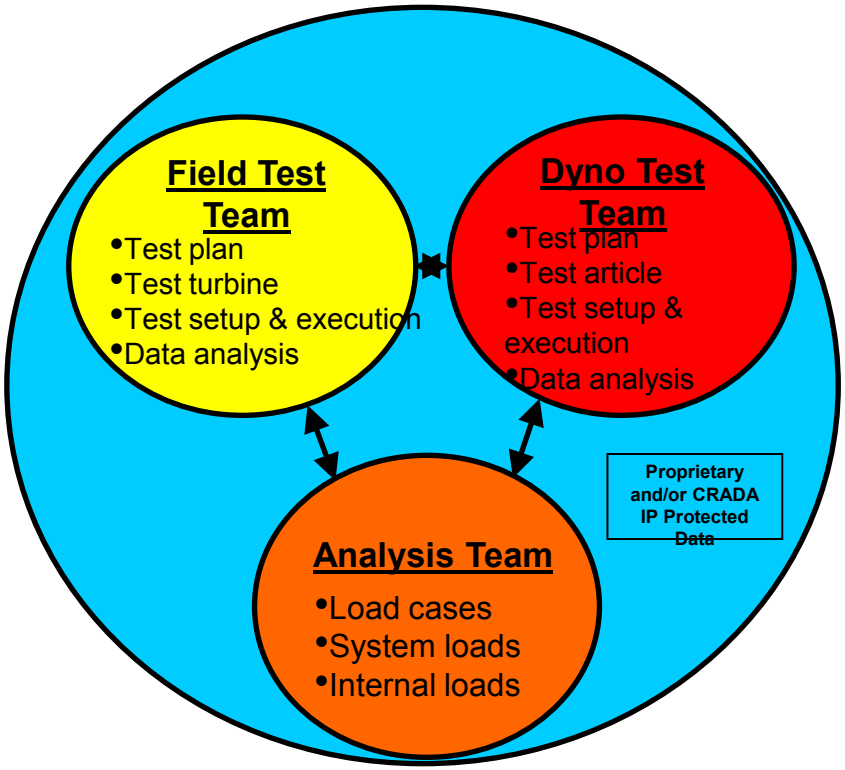
Objectives

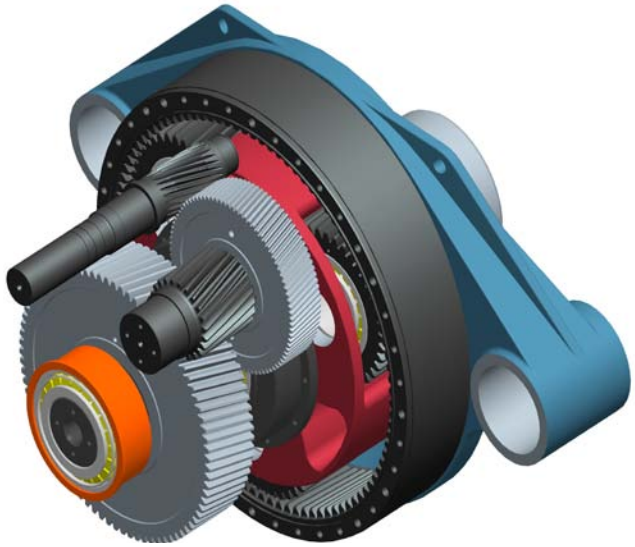
- Understand and isolate sources of gearbox failures.
- Suggest solutions leading to greater reliability
- Develop dynamometer testing capability to assess gearbox/ drivetrain problems and solutions
- Understand how gearbox loads translate to bearing response, stress, slip, and other gearbox problems.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

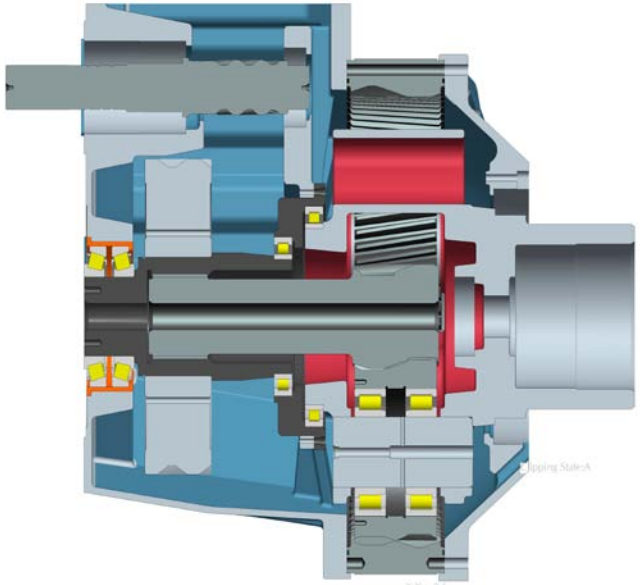
Project Strategy



Test Articles

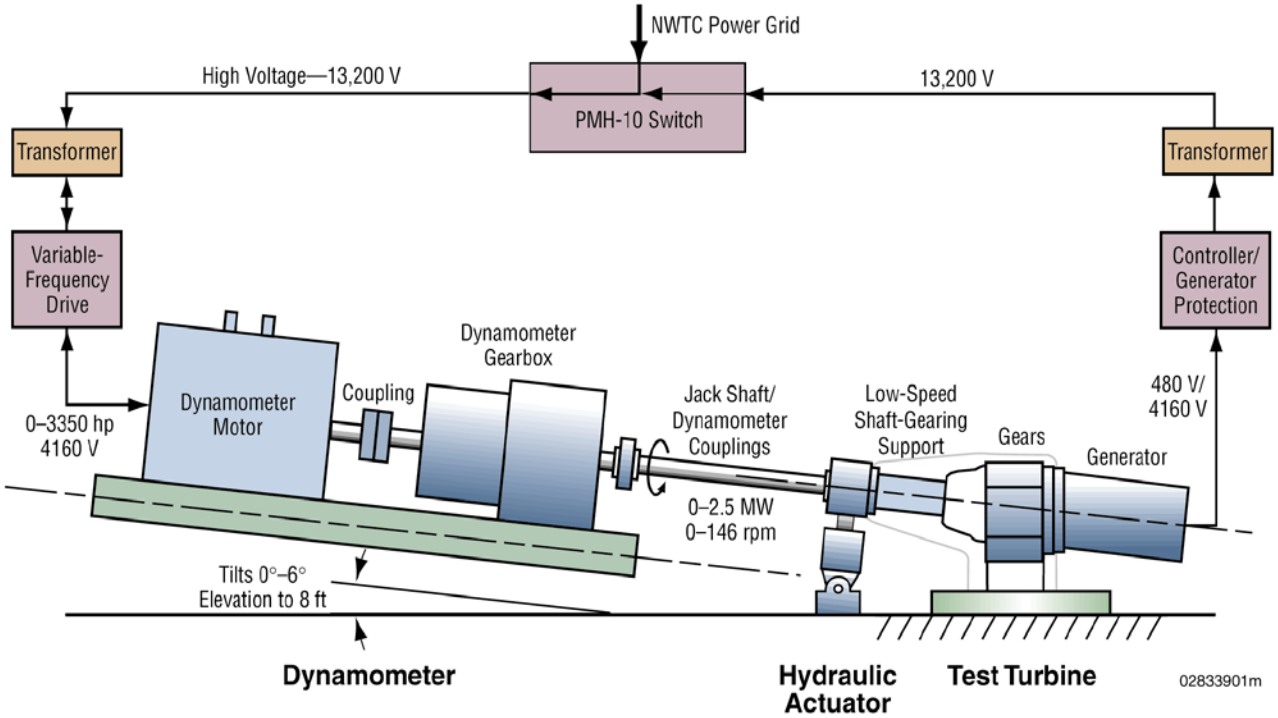
- Test platform between 600-kW and 900-kW.
- 2 gearboxes with identical instrumentation.
- Upgrade both units to state-of-the art.
  - Cooling, filtration, gear finish, lubrication, and bearing types.
- Measure External and internal loads and displacements.
- Thermal measurements
- Condition monitoring
- Expert failure analysis and forensics





NREL Dynamometer Specifications

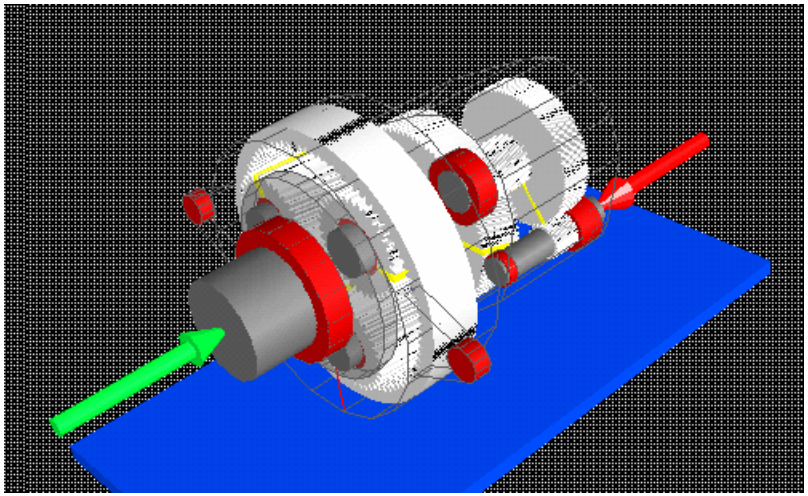
- 2.5 MW power delivery
- Full power regeneration at 480/575/690 or 4160 volts
- Torque input range 0 - 1.62 million N-m.
- Speed range from 0 - 2250 RPM
- ~500 kN non-torque shaft loads capacity.
- SCADA and automated torque/speed controls

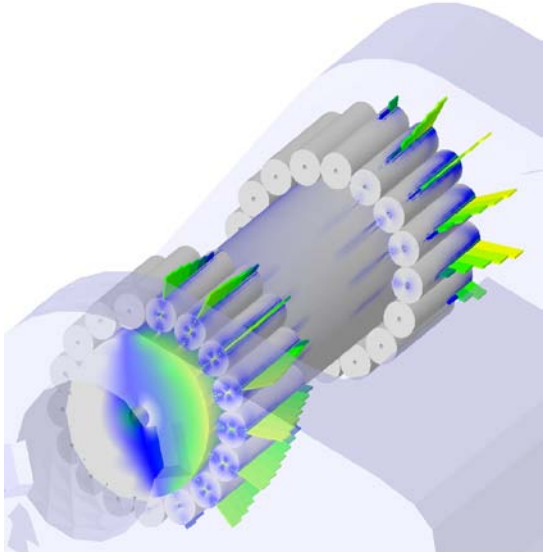


Field Testing

- Ponnequin Xcel Windfarm in Northern Colorado USA
- Extensive measurements on a single turbine.
- Characterize load events
- Correlate loads with component internal gearbox responses.
- Site-wide failures and statistics.

Drivetrain Analysis



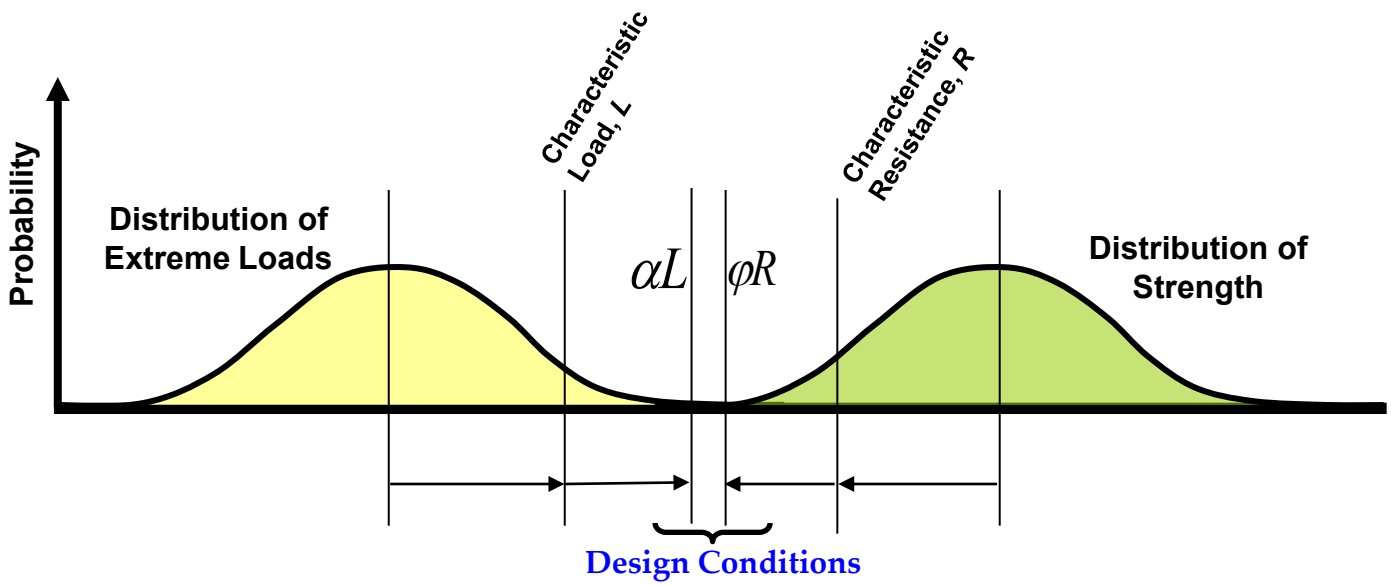


- Multi-body dynamic analysis of test article.
- Codes: FAST, Simpack, LVR, FEA (OSU Gear Lab), BEAST (SKF), ADAMS (CENER)
- Model bearing response under various load conditions measured in Dyno and Field.
- Model drivetrain solutions with tuned model.
- Verify design assumptions and basic design process.

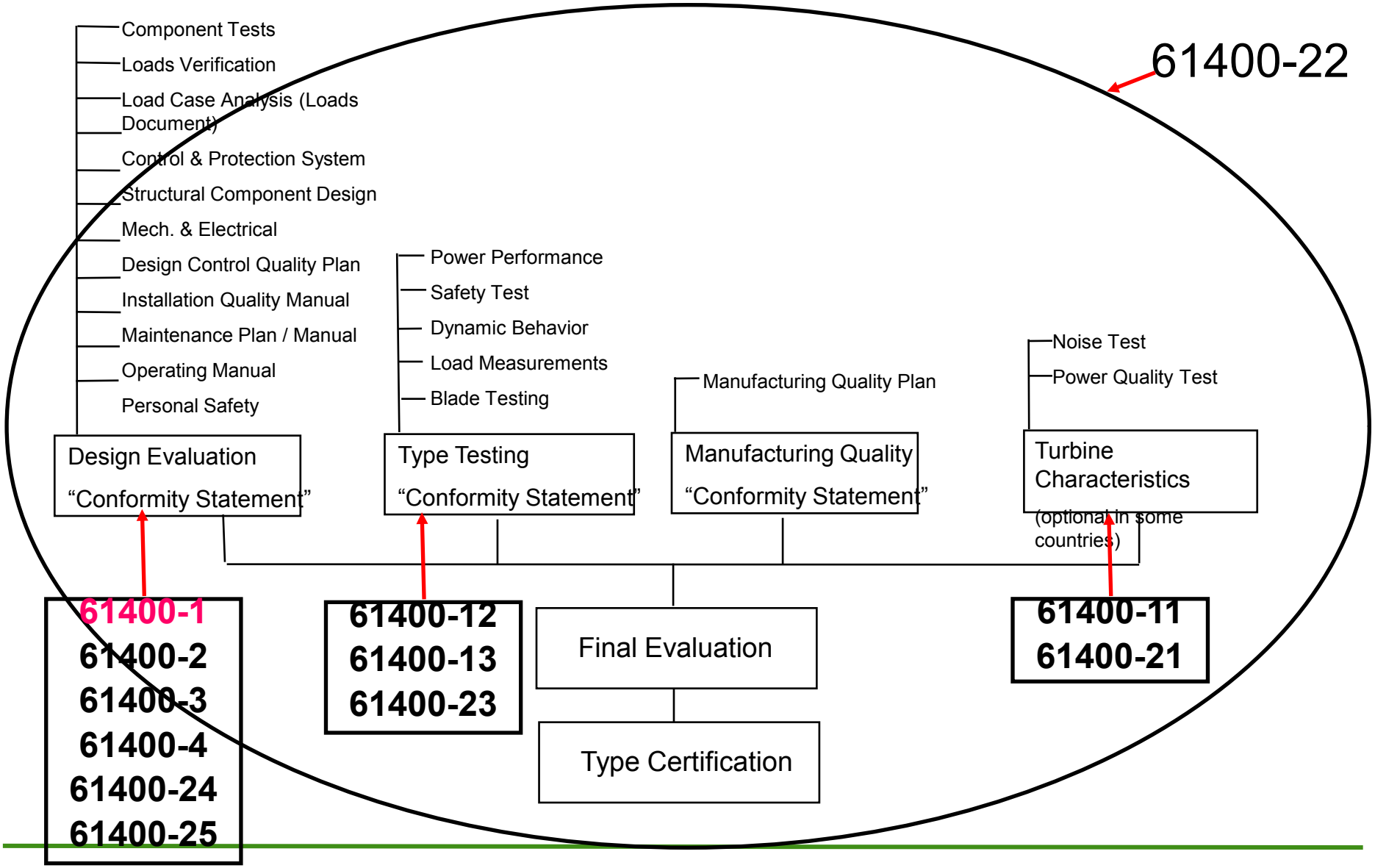
Standards and Certification
IEC Turbine Design Classes

Table 1 - Basic parameters for wind turbine classes[1]

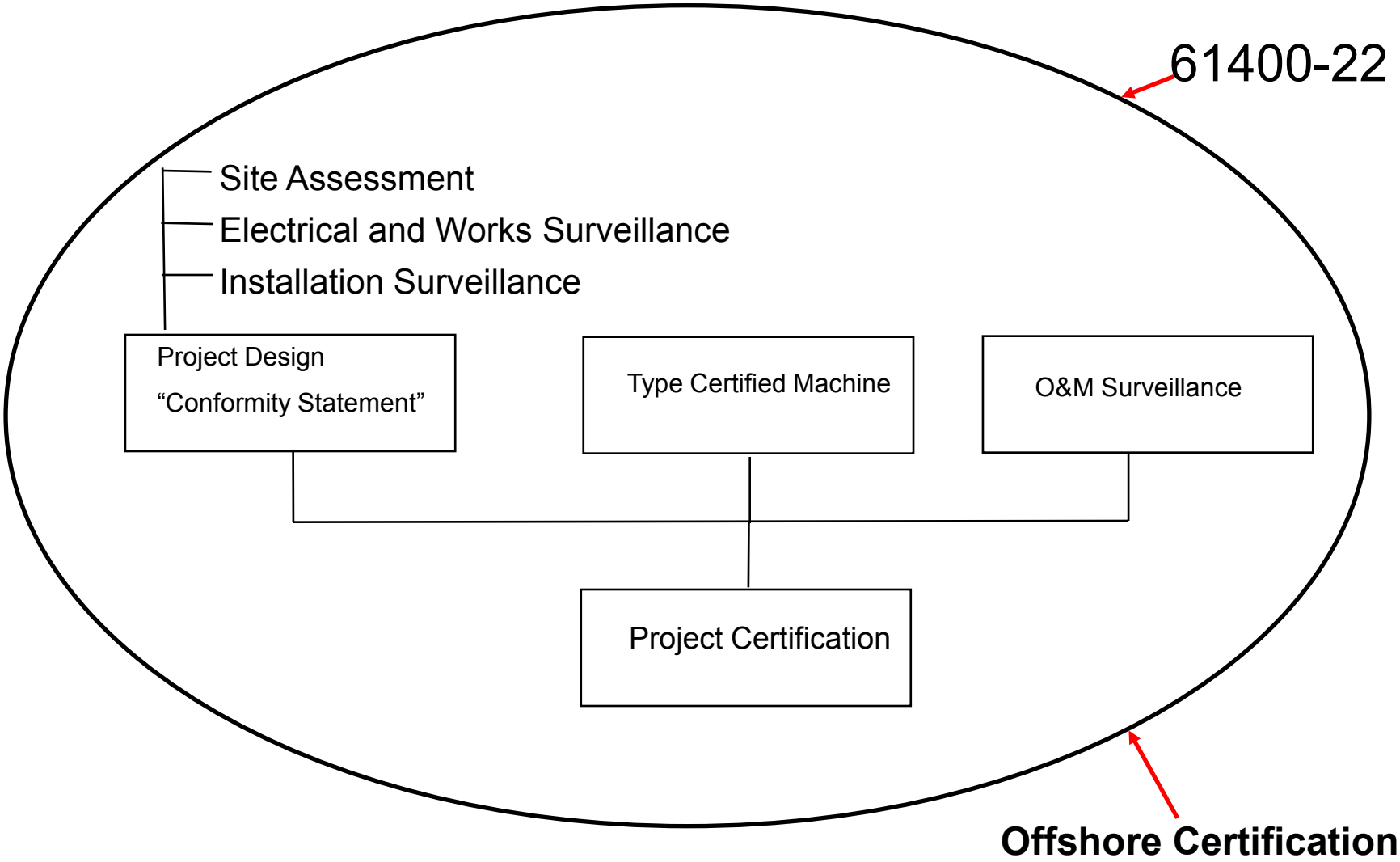
Wind Turbine Class		I	II	III	S
V_{ref}	(m/s)	50	42,5	37.5	Values
A	I_{ref} (-)	0,16			Specified
B	I_{ref} (-)	0,14			by the
C	I_{ref} (-)	0,12			Designer



General Arrangement of IEC Standards



Project Certification



Thank You!

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