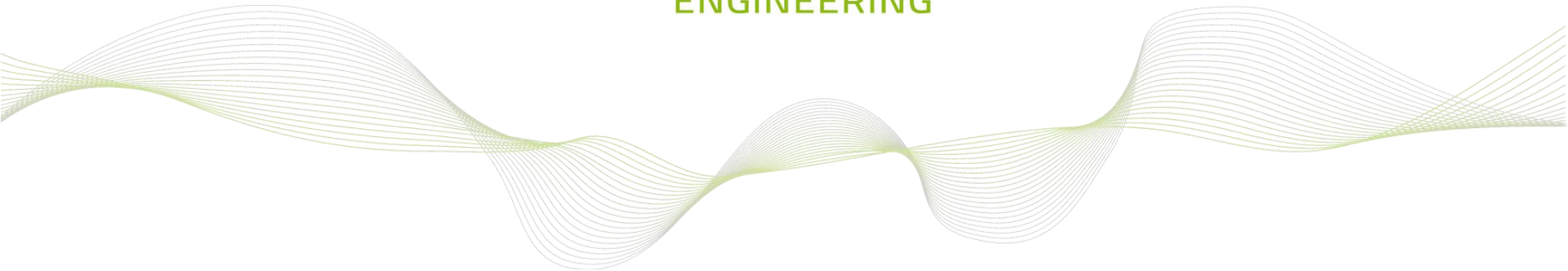
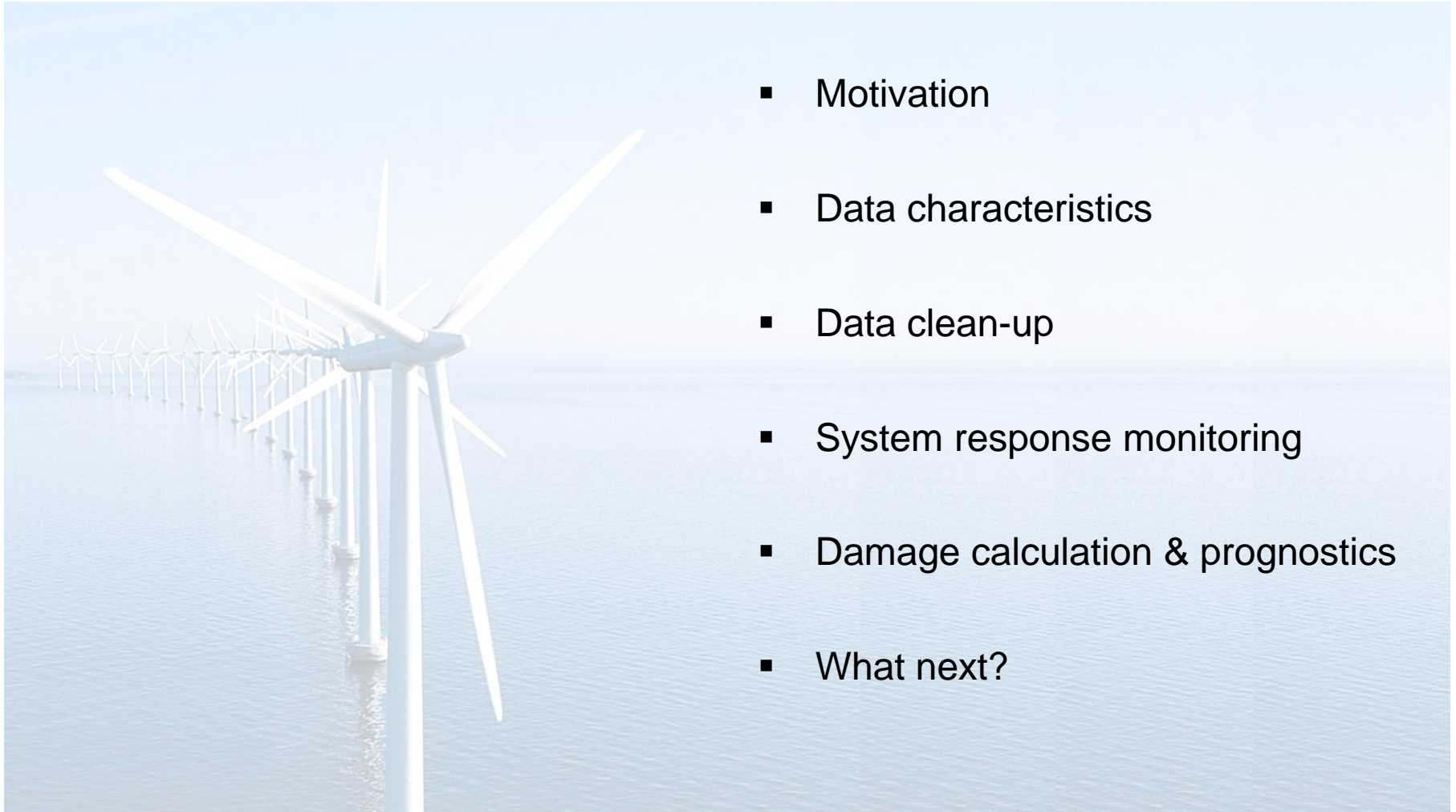


Use of SCADA Data for Wind Turbine Condition Monitoring

Chris Gray





- Motivation
- Data characteristics
- Data clean-up
- System response monitoring
- Damage calculation & prognostics
- What next?

Motivation for SCADA monitoring

Background

- Offshore O&M cost ~ €50 / kW per year (100MW wind farm = €5Mio /yr)
- High financial motivation to optimise maintenance strategy
- Traditional “CMS” → drive-train vibration, oil contamination
- Gearbox & Generator at most 20% of failures, only partly detectable with CMS

High cost of minor failures

- Access difficulties, especially winter → also minor failures are expensive
- Cost of downtime for 3MW turbine ~ €2500 /day
- Blocked oil cooling filter in winter → one week lost production: €17500

What does it look like?

- Varying naming conventions
- Varying logging frequency
- Varying statistical values
- Between 5...400 variables
- Quality issues
- **Data cleaning required**



How much of it is there?

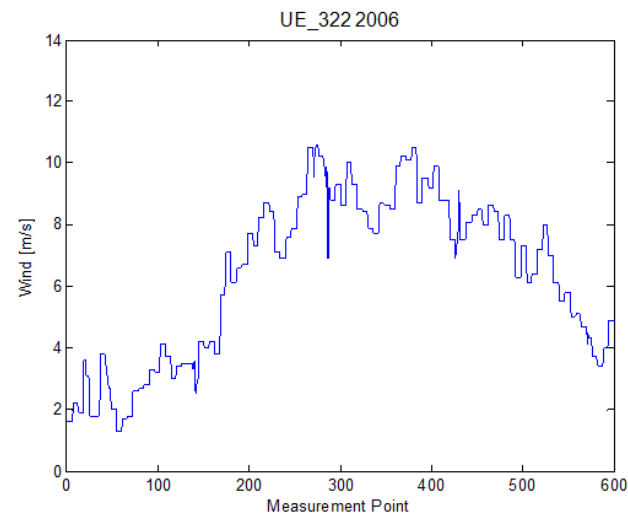
- 100 turbines, 20 years → 400GB
→ 100×10^6 entries in fact table
- Growing fast: 5-min logs, more variables...
- Distributed across wind-park servers
- Automated collection & transformation
- **Future-proof DB architecture**



Data Clean-up

- SCADA data contains many errors (like all data!)
- Sensitive monitoring algorithms → false alarms
- Data quality problems must be removed
- Auto-correction where possible, otherwise user must be informed

Turbine	Year	Variable	ConsecVals
UE_322	2006	Avg Wind Speed	75,07
UE_322	2007	Avg Wind Speed	26,68
UE_322	2008	Avg Wind Speed	8,71
UE_322	2009	Avg Wind Speed	9,51
UE_322	2010	Avg Wind Speed	9,50
UE_322	2011	Avg Wind Speed	9,95
UE_323	2006	Avg Wind Speed	72,44
UE_323	2007	Avg Wind Speed	22,28
UE_323	2008	Avg Wind Speed	8,69
UE_323	2009	Avg Wind Speed	9,03
UE_323	2010	Avg Wind Speed	10,63
UE_323	2011	Avg Wind Speed	8,71
UE_324	2006	Avg Wind Speed	71,24
UE_324	2007	Avg Wind Speed	22,06
UE_324	2008	Avg Wind Speed	22,03
UE_324	2009	Avg Wind Speed	8,85
UE_324	2010	Avg Wind Speed	11,74
UE_324	2011	Avg Wind Speed	9,70



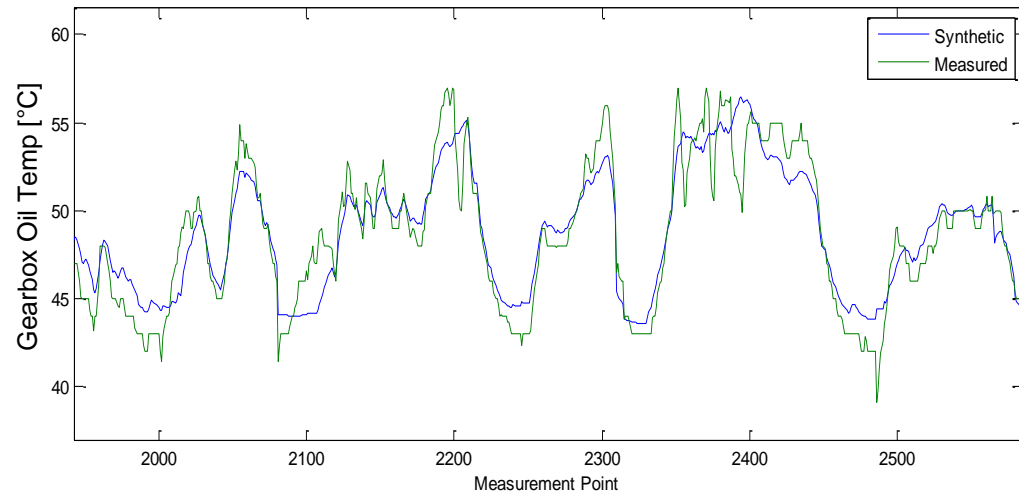
Observation: Values in all signals in blocks
 Each block with 6 consecutive values
 Affected files: 2006 (all turbines), partly 2007 (all turbines)

Performed action: Files excluded from further analysis



System Response Monitoring

- Analytical models of system behaviour
- Hybrid: physical modelling & regression analysis
- Semi-automatic model training
- Online monitoring of system response
- Multivariate residual analysis → reliable alarm system
- Fault diagnostic based on observations



Date from: 01.08.2010
Date to: 31.08.2010

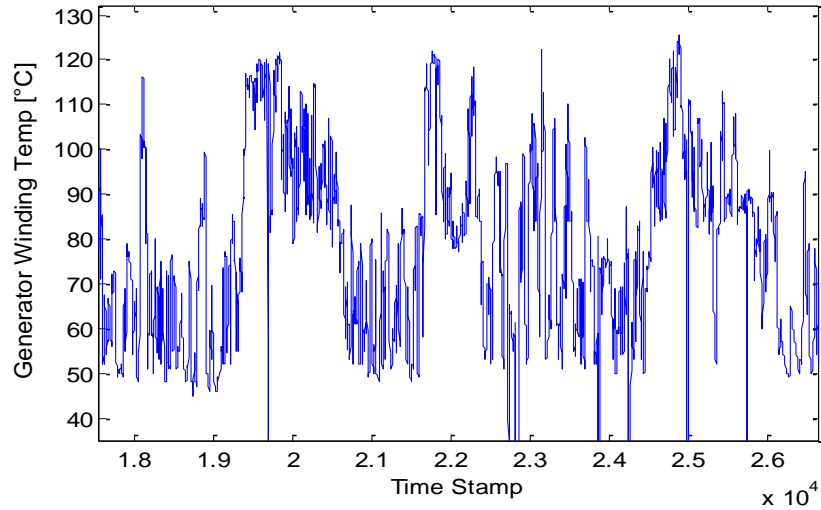
[History](#) [Daily Report](#) [Analysis](#) [Data Quality](#)

Turbinen Status: History

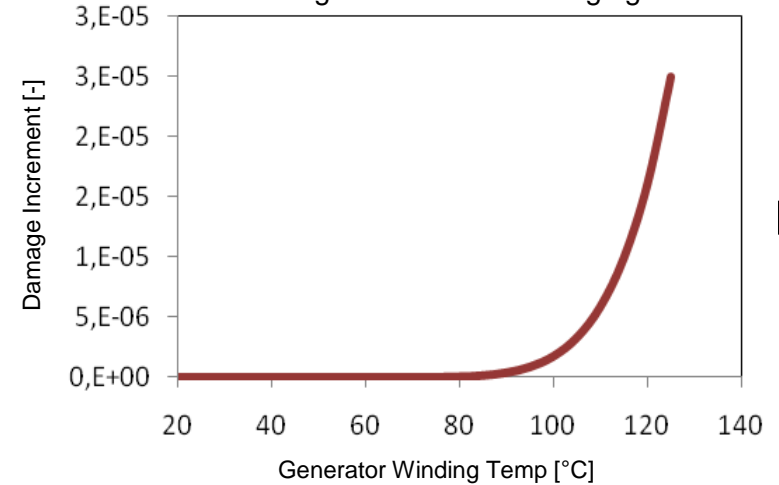
Windpark	Turbine	01.08.2010	02.08.2010	03.08.2010	04.08.2010	05.08.2010	06.08.2010	07.08.2010	08.08.2010	09.08.2010	10.08.2010	11.08.2010	12.08.2010	13.08.2010	14.08.2010	15.08.2010	16.08.2010	17.08.2010	18.08.2010	19.08.2010	20.08.2010	21.08.2010	22.08.2010	23.08.2010	24.08.2010	25.08.2010	26.08.2010	27.08.2010	28.08.2010	29.08.2010	30.08.2010	31.08.2010	
TXS27	UE_322	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	UE_323	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	UE_324	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
RSZ21	UE_117	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	UE_118	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	UE_119	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
SHU12	UE_120	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	UE_967	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	UE_968	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

Online Damage Calculation, Failure Prognostics

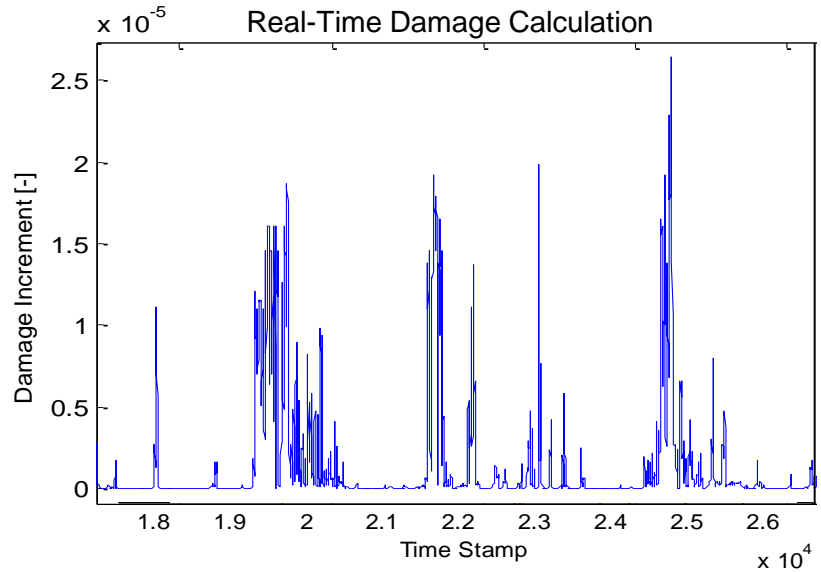
Measured Data



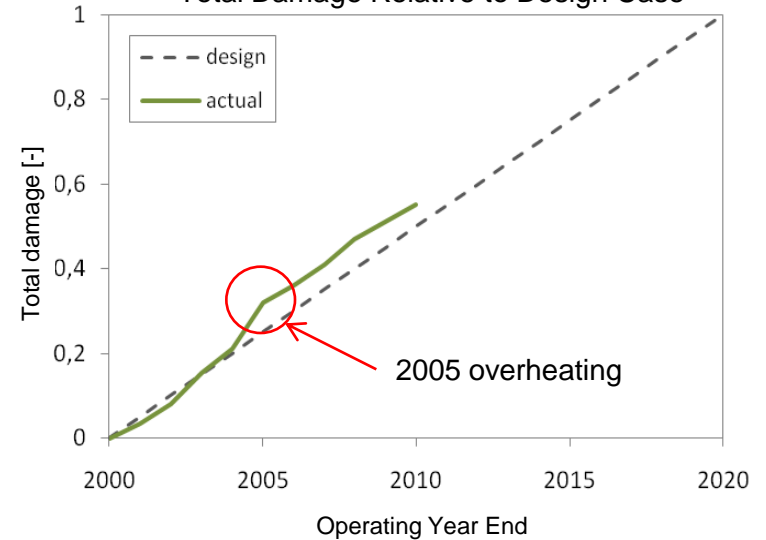
Damage Model: Thermal Aging



Real-Time Damage Calculation



Total Damage Relative to Design Case





- Integrated systems
 - Operating data (high & low frequency)
 - Field failures
 - Turbine configuration
 - Service activities
- Built-in Intelligence
 - Detailed diagnostics, operator feedback
 - Automatic training of response models
 - Failure model training
- Combined prognostics & diagnostics
- Maintenance management



Thank You!



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