F. Langmayr / E. Lichtenegger / M. Gräfe

Analytics Based Maintenance for Offshore Wind Turbines

ROMEO | Horizon 2020

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Introduction and Motivation

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ROMEO Project- The Objectives

Greater reliability, less repairs, more safety

Increase wind farm reliability and decrease the number of failures leading to downtime.

Increase the life time of key turbine components.

Reduce the WT O&M costs through the reduction of the resources required for annual inspections of the turbine.

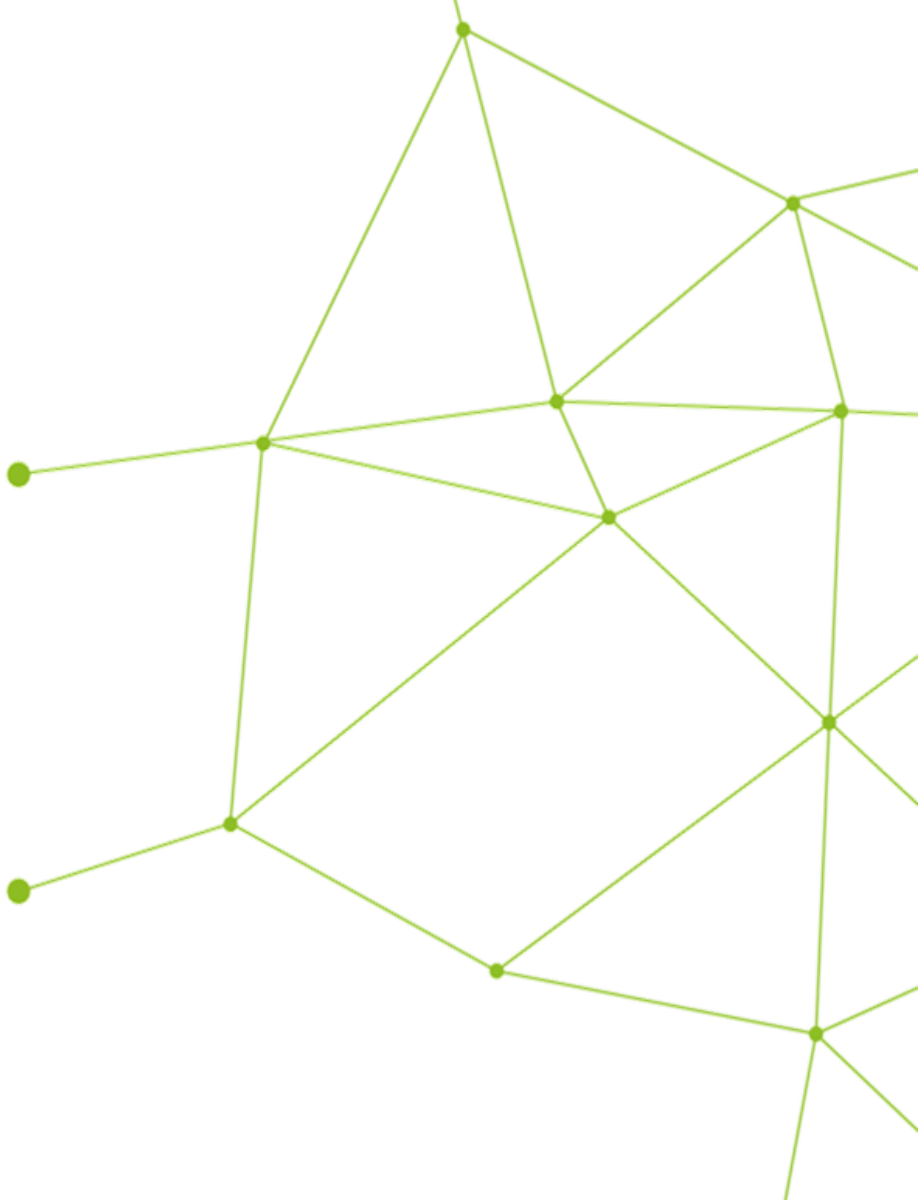
Reduce the O&M costs associated to foundation through reduction in jacket substructures inspections.

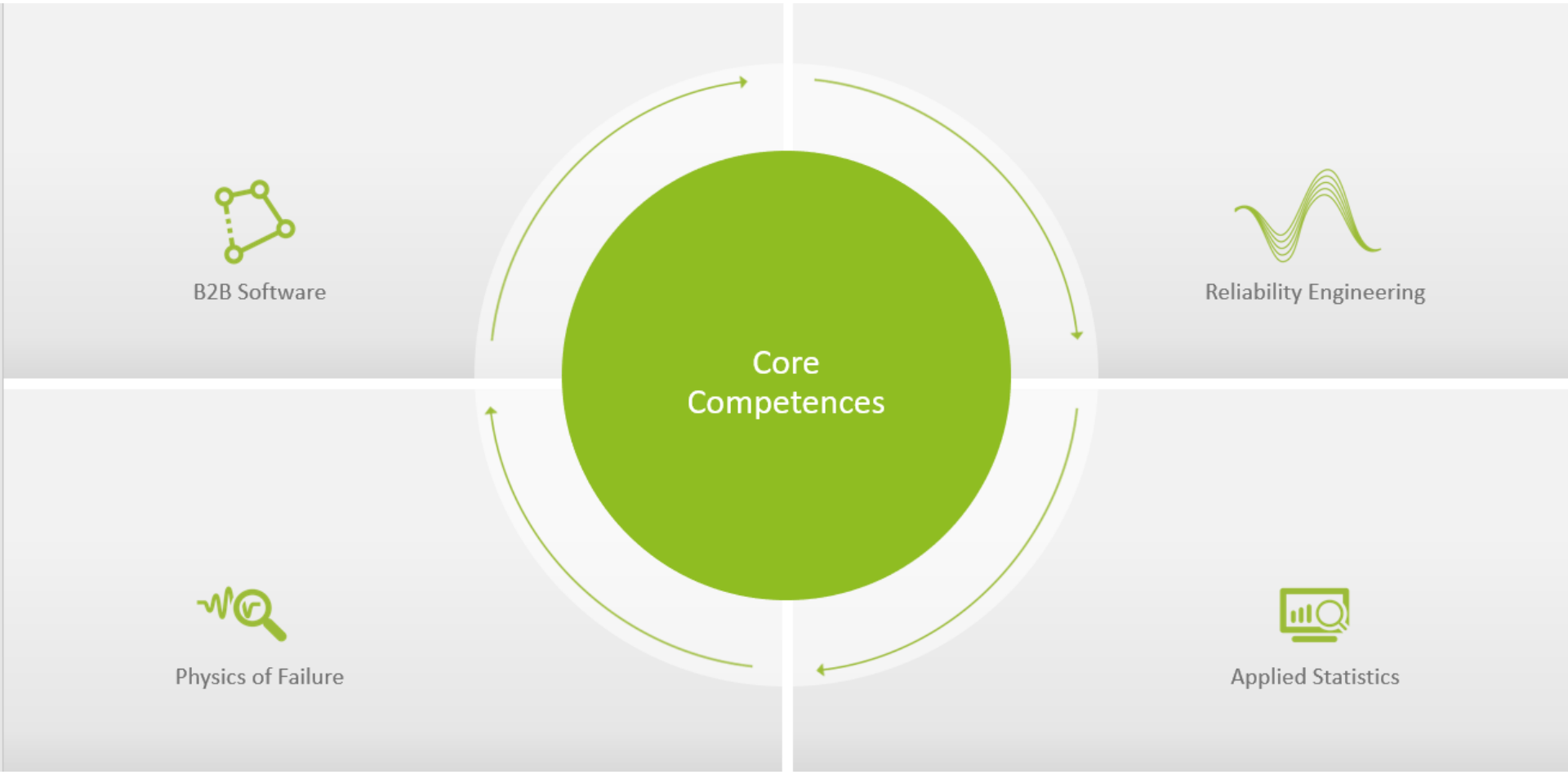
Uptime Engineering GmbH - The Experts for the Reliability Process

- Founded in 2010 by Franz Langmayr et al.
- A team of **18 employees**
- Based at **two European Locations**

- We provide Reliability Solutions, i.e.
  - Consultancy & Software for Analytics, Diagnostics and Prognostics
- We support the entire lifecycle of mechatronic systems:
  - Verification & Validation & Operation.

- Our methods are based on a broad expertise in failure physics and applied statistics
- We have implemented more than 100 projects with leading OEMs and fleet operators
- We optimize product development
- We support cost reduction via optimization of service and maintenance activities




B2B Software
Reliability Engineering
Core
Competences
Physics of Failure
Applied Statistics

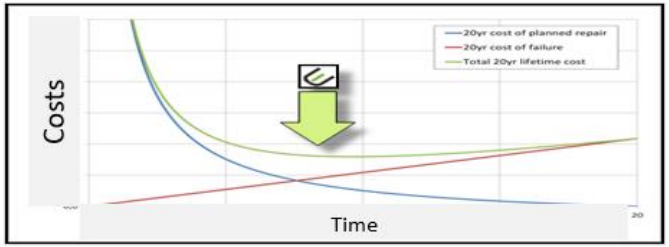
Challenges: Unmanned operation in harsh environment

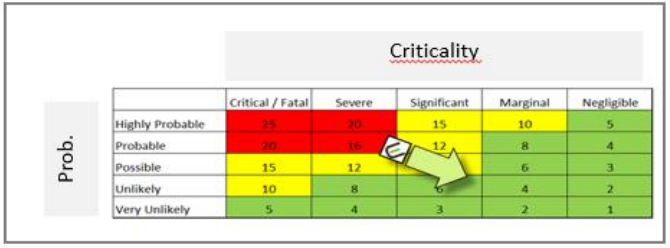
- Innovative, mechatronic systems
- Accessibility (location, environmental influences)
- Transportation distances
- Availability of spare parts and special technical equipment
- Available educated maintenance staff

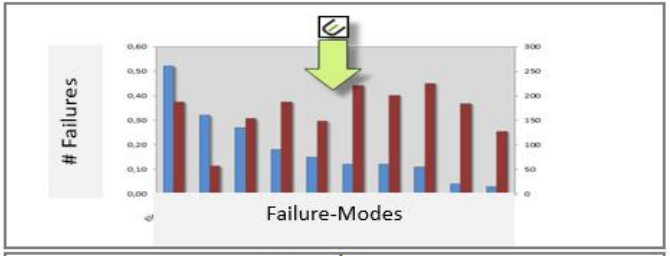
Source: Wikipedia

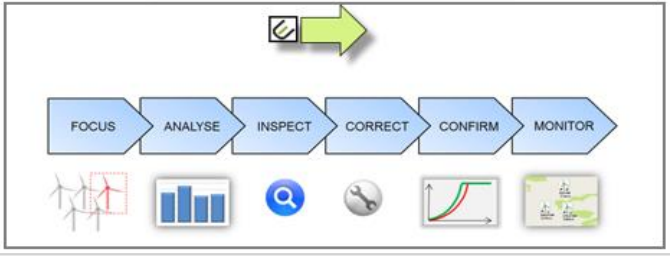
Maintenance Objectives for Operators

- Sustainable Cost Reduction
  - Efficient Use of Man Power
  - Efficient travelling & transporting
- Risk Mitigation
  - Identification of most critical and most probable failures
- Failure Minimization
  - Monitoring of critical Subsystems
- Performance Improvement
  - Process Definition
  - Agile Actions









Information Merging

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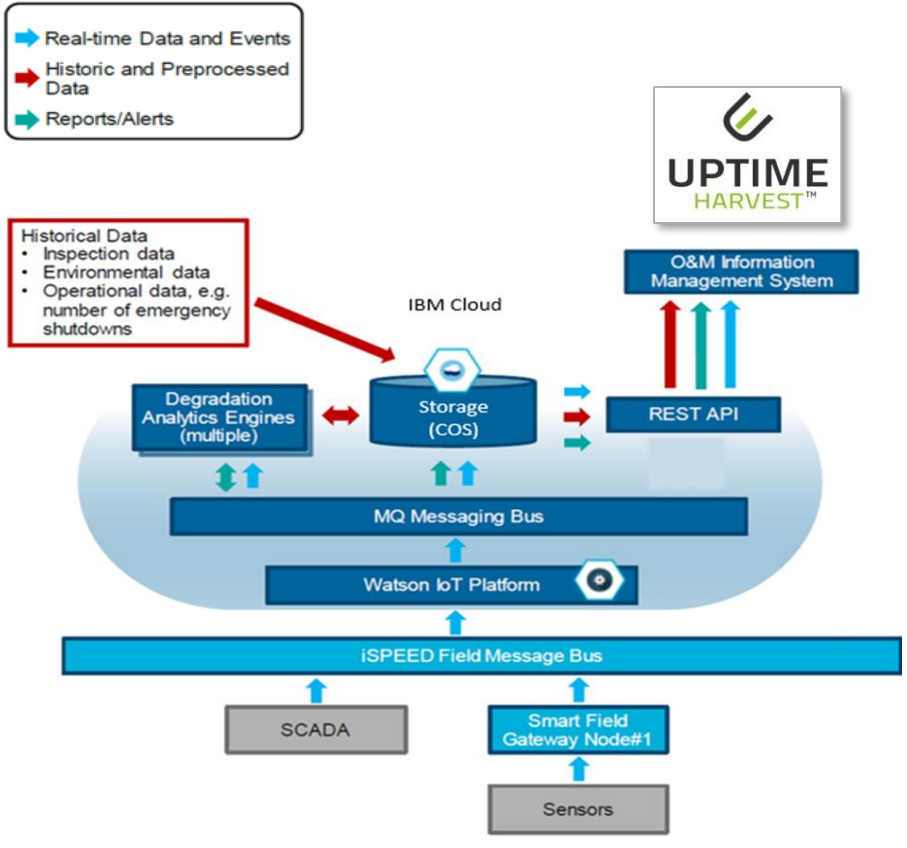
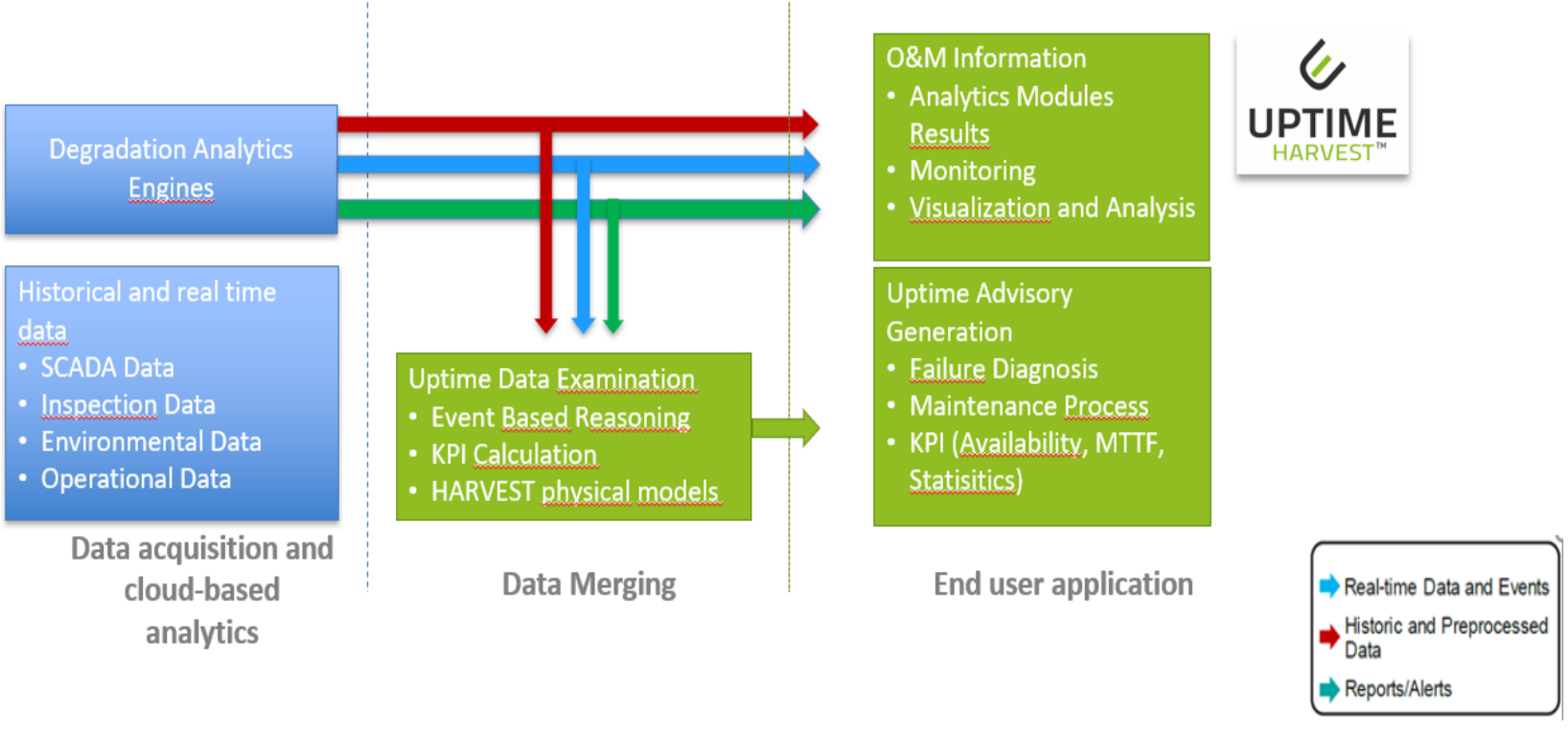
Uptime Engineering in ROMEO
Making Information usable

- Integration of multiple data sources
- Analysis and combination of information
- Centralized O&M Platform for access by multiple stakeholders
- Support of maintenance process
- Intelligent Reporting and Communication



Details on Information Merging



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Analytics Based Maintenance

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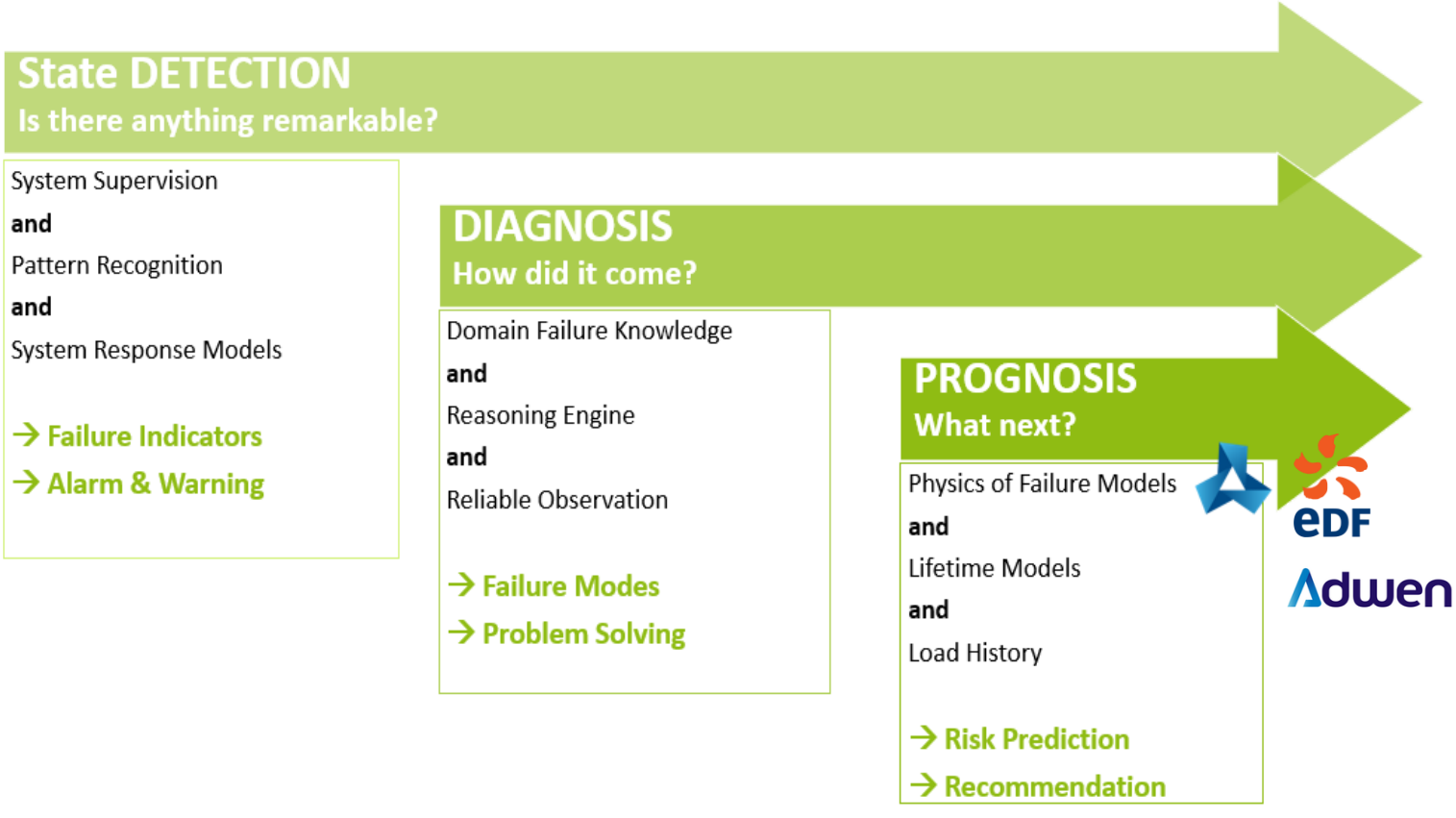
The UPTIME Engineering Route to Predictive Maintenance



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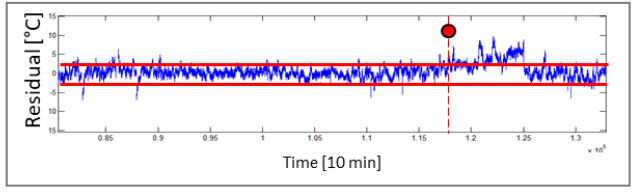
STATE DETECTION | Formalizing Observations

- Alarm, Particle Content above expectation:
  - CNT_PRT_NULL_GBX_VAL(H,SPEC)
- Threshold Analysis, Temperature outside expected range:
  - T_GBX_BRG_NULL_VAL(H,SPEC)
- ROMEO Model: Damage Propagation
  - D_GBX_BRG_NULL_VAL(H,SPEC)
- Inspection, No Burn marks
  - NOT SP_BURNMARKS_SURF_SEAL_VAL(H,SPEC)

Turbine Alarms

	Uptime HARV...	Generator fault: Rotor current phase imbalance	555	0
	Uptime HARV...	Blade alarm: Vibrations above expected level	558	0
	SCADA Alarm	Turbine in operation	0	0
	Service and M...	Maintenance	8	0

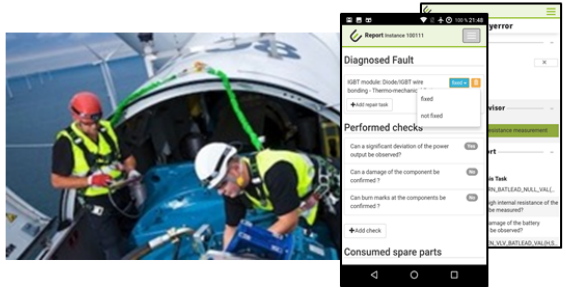
Time Series Deviation: Threshold functions



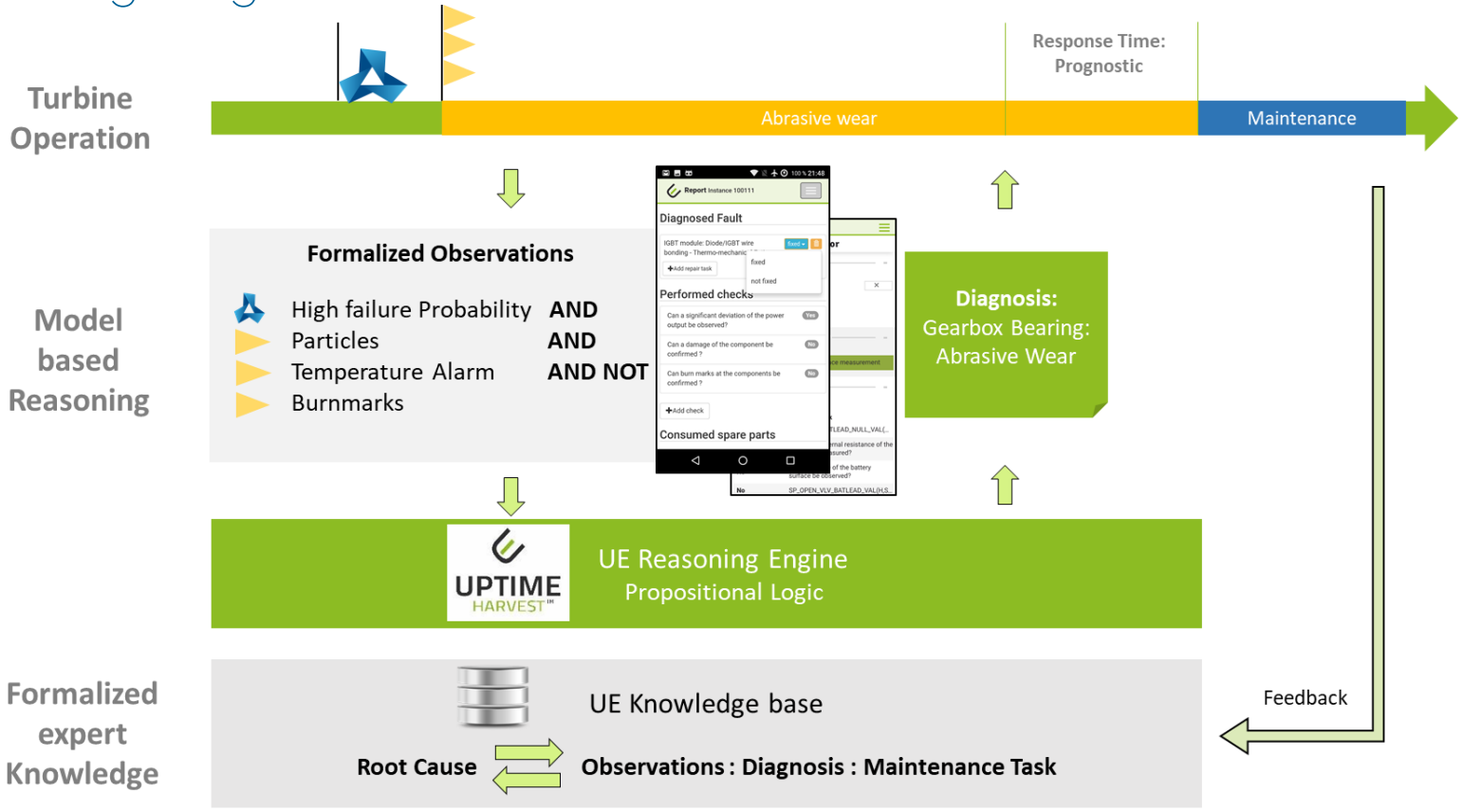
ROMEO Physical & Statistical Models

COMMON Attributes	Value/Example	Format	Description
Model name	101	integer	Unique identification of Model (e.g.
timestamp	1525051560	long	Unix timestamp
Instance	WK23	string	Identifies the affected turbine
RDSPP	=MDK10 UP10-UP1	string	RDS-PP Code of the affected component
State / Phase	3	integer	Failure phase from 0: no failure to x: failure likely
expected time to failure	250	integer	Indicates the time until failure occurrence is expected in hours

Field Inspections



DIAGNOSIS | Model based Reasoning Engine



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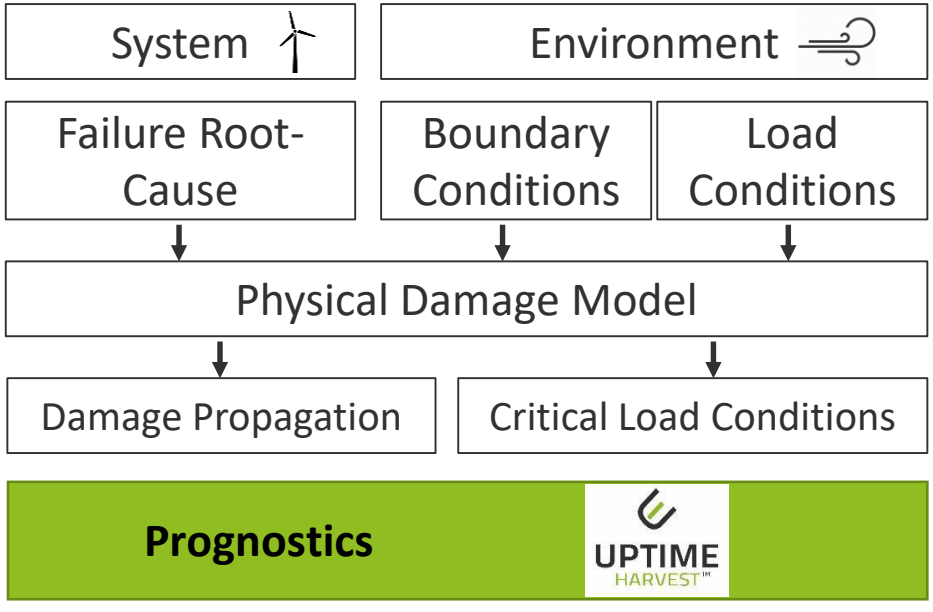
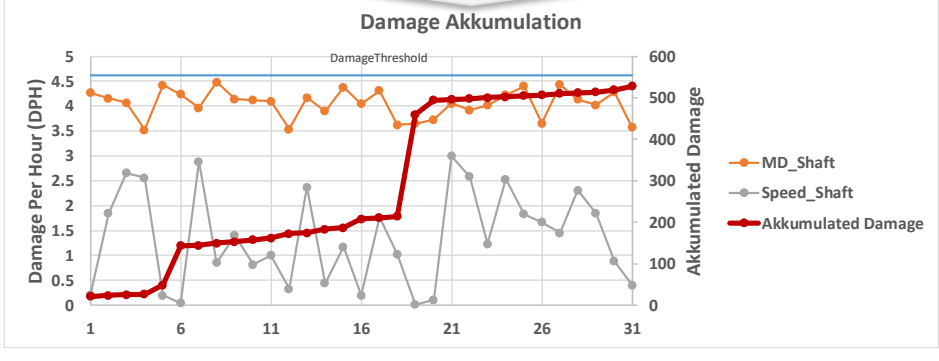
PROGNOSIS| Physical Modelling

- Analysis of system components and its possible failure modes
- Consideration of boundary and most damaging load conditions
- Physical Modelling of damage (irreversible damage of micro-structure)
  - Damage Accumulation terminates Lifetime
- Validation of Algorithms | Inspection
- Identification of critical Assets
- Integration in O&M Process





Process Development

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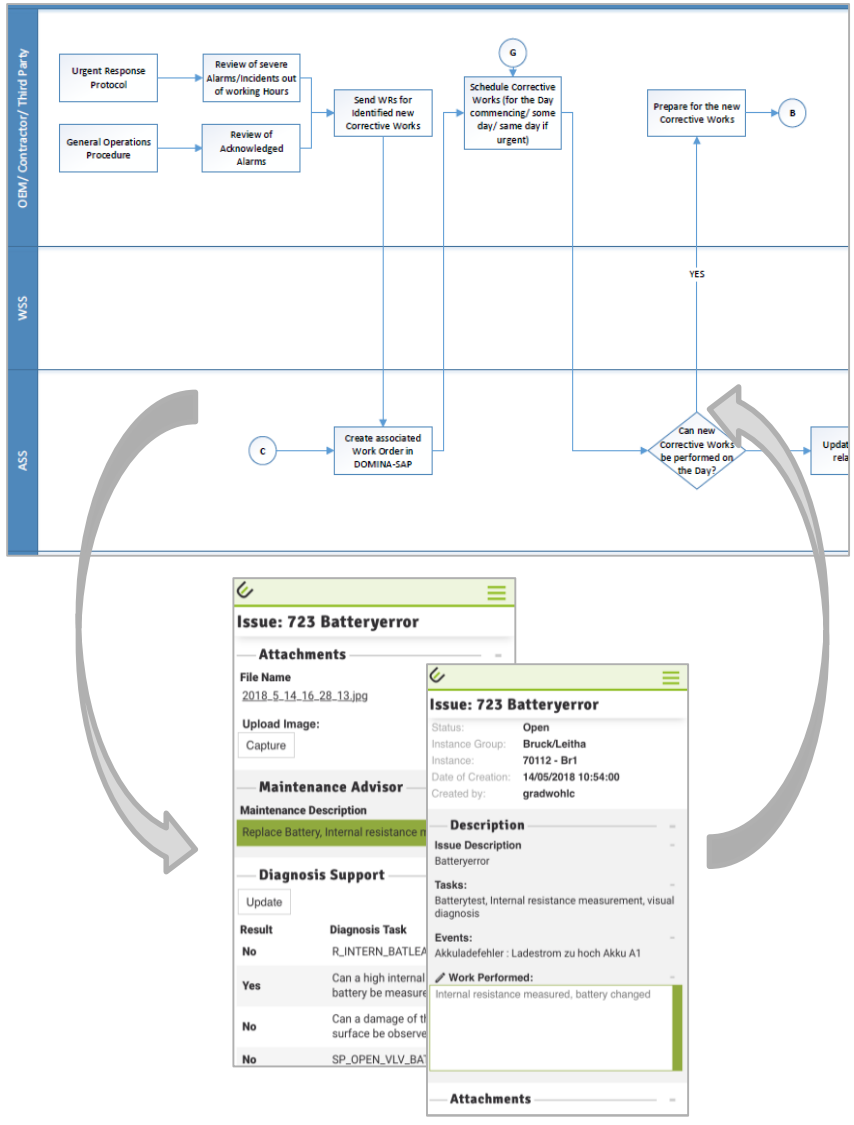
Service Process | Design

- Identify Objectives and **BUSINESS CASE(S)**
- Map organisation in **PROCESS**
- **INVOLVE** all contributing parties
- Provide **BENEFIT** for each involved party



Project Benefits

- State Detection based on **multiple data sources**
  - Create Value from available data
- **Adaptive Advisory System**, incorporating field observations
  - Feedback drives quality and involves the staff
- Continuous growth of **formalized operational knowledge** in the organisation
  - Focus on Risk-Drivers
- **Involvement** of O&M staff increases acceptance of process
- **Optimized O&M processes**
  - Less Downtime
  - Sustainable Cost Reduction

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www.romeoproject.eu

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