The innovation for life

OPEN QUESTIONS BEFORE WE CAN MAKE REAL IMPACT KOEN HERMANS, TNO WIND ENERGY

NO innovation for life



- **)** TNO Wind, no drone experts
 - Home of ~60 WE researchers (TNO in total 3650)
 - IO&M research team





WHAT AM I DOING HERE?

> How can we make the most impact with remote inspection and maintenance?





YESTERDAY'S STATE OF THE ART



CURRENT STATE OF THE ART



TOMORROW'S STATE OF THE ART



ACTIVITIES TNO

-) Digital wind farm
 - > Embedded sensors
 - Condition monitoring
 - Digital twin
 - > Extrapolate findings throughout the fleet







) Digital wind farm

> Remove technical barriers (tele-operation, cyber security, fast networks)







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5G





ACTIVITIES TNO

) Digital wind farm

- > Remove technical barriers (tele-operation, cyber security, fast networks)
- Develop tools to optimize maintenance strategy
- > What resources do I need for an ultimate uptime?
- > What costs are associated?
- > When to go and inspect?



UNIFIED WIND FARM SIMULATION ENVIRONMENT (UWISE) THE SOFTWARE LANDSCAPE



O&M PLANNER LONG TERM O&M STRATEGY

- > Simulate failures and the appropriate response
-) Scenario's
 - > Define assets & resources: Number of vessels, technicians etc
-) Results
 - Maintenance costs / Operational Expenditure (OPEX)
 - Expected wind farm availability

🖚 Install / O&M Planner				
Search or create project	● O&M readonly (O&M)⊗			
Search for inputs) <			
			North Sea	1.4
Project	Generator			
Farm	General	^		Bergen aan Zee
	Requirement (per turbine)	1		
Substations	Requirement (per offshore sub	station) 0		
C. Metocean	Requirement (per onshore sub	station) 0	\$\$\$	
Hetocouri	Part cost	500000.00€	\$\$\$\$\$ 6	Egmond aan Zee
🗩 Subsystems			666°26	
Failure Modes	Spare part	^	80990	Egmond-Bi
			<u> </u>	
🚊 Vessels	Storage location	Umuiden		
_	Initial stock size	2		th I cr
Harbours	Re-stocking threshold	1		Castric
	Re-stock quantity	1 169.00 hours		
🚺 Equipment	Re-stocking time	100.00 Hours		2.10
Technicians				Hee
	Scheduled mantenance activity	^	Mile a	20 700
				Beverwi
	Maintenance action	Replacement		
	Frequency	8760.00 days		Velsen-Zuid
	Start	2017-05-01		
	End	2020-08-31	A.	Driehuis
	Number of stages	3		Santpoort-Nooi
	Priority	2	1. Kenner	N208



HOW TO ACHIEVE HANDS-OFF MAINTENANCE?

) First: design it out

Enhance the information of technicians



Remote visual inspection



Remote manipulation





SOME TECHNICAL CHALLENGES ON THE ROADMAP

> Autonomy vs tele-operation

- > Contextual awareness, localization at an enormous white-ish blade
- Balancing (sensor/actuator) payload
- > Docking station, wireless charging, battery life
- > Turbines aware of their robotic inspectors
- > Low-latency, secure data transfer
- > Transformation of sensor readings / visual inspection data to remaining lifetime



LET'S SOLVE THESE CHALLENGES TOGETHER THANKS FOR YOUR TIME

