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Smart Offshore Maintenance: Predictive Maintenance van Radarinstallaties in Windparken

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Rijkswaterstaat
Ministerie van Infrastructuur en Waterstaat

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Rijkswaterstaat MIVSP project: "onder economisch gunstige voorwaarden, realiseren van aanschaf, installatie en operatie van sensoren op TenneT platforms die nodig zijn voor bedrijfsvoering en veiligheid van Nederlandse offshore windparken"

Nautische Radar, AIS, meteo sensoren, ecologische sensoren, VHF, 5G etc. connectiviteit

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Business case Smart Offshore Maintenance

- Vergroot uptime
- Verlaag onderhoudskosten

Instandhouding 30 jaar

Logistiek beperkt beschikbaar, hoge kosten

Offshore onderhoud vele malen duurder ivm logistieke kosten

Zwaardere omgevingscondities: wind, zout en vocht

Nu geen direct zicht op conditie sensoren offshore

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Rijkswaterstaat
Offshore Expertise Centrum
Stellendam

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Pilot Predictive Maintenance Nautische Radar

Doel:
Meten en voorspellen mechanische conditie nautische radar zodat op tijd onderhoud kan plaatsvinden tegen zo laag mogelijke kosten

Hierdoor bewustwording creëren voor slim offshore onderhoud

Pilot Nautical radar innovatieve onderhoud strategie

Reactief

Correctief maintenance
Preventive maintenance (standaard vanuit leverancier)
- vaste service intervallen

Proactief

Condition based Maintenance
- (Near-) real time inschatting systeem status
- Onderhoud bij overschrijden ingestelde kritische drempelwaarde
- Gebaseerd op root cause analyse

Predictive Maintenance
- AI, modelleren, correlaties

Dashboard
- Onderhoudsplanner op basis van AI analyse real time data planning op basis van probabilistisch model

Condition Based Monitoring
Offshore Nautische Radar

Rijkswaterstaat
Ministry of Infrastructure and Water Management

Trilling radarantenne op mast offshore substation:

- windbelasting antenne
- trilling geinduceerd door:
  - mast
  - offshore substation top floor
  - antenne aandrijving (motor, gearbox)

Trilling radar op monopile:

- windbelasting antenne en platform
- trilling monopile: golven, windturbine operatie (noodstop)
- antenne aandrijving (motor, gearbox)

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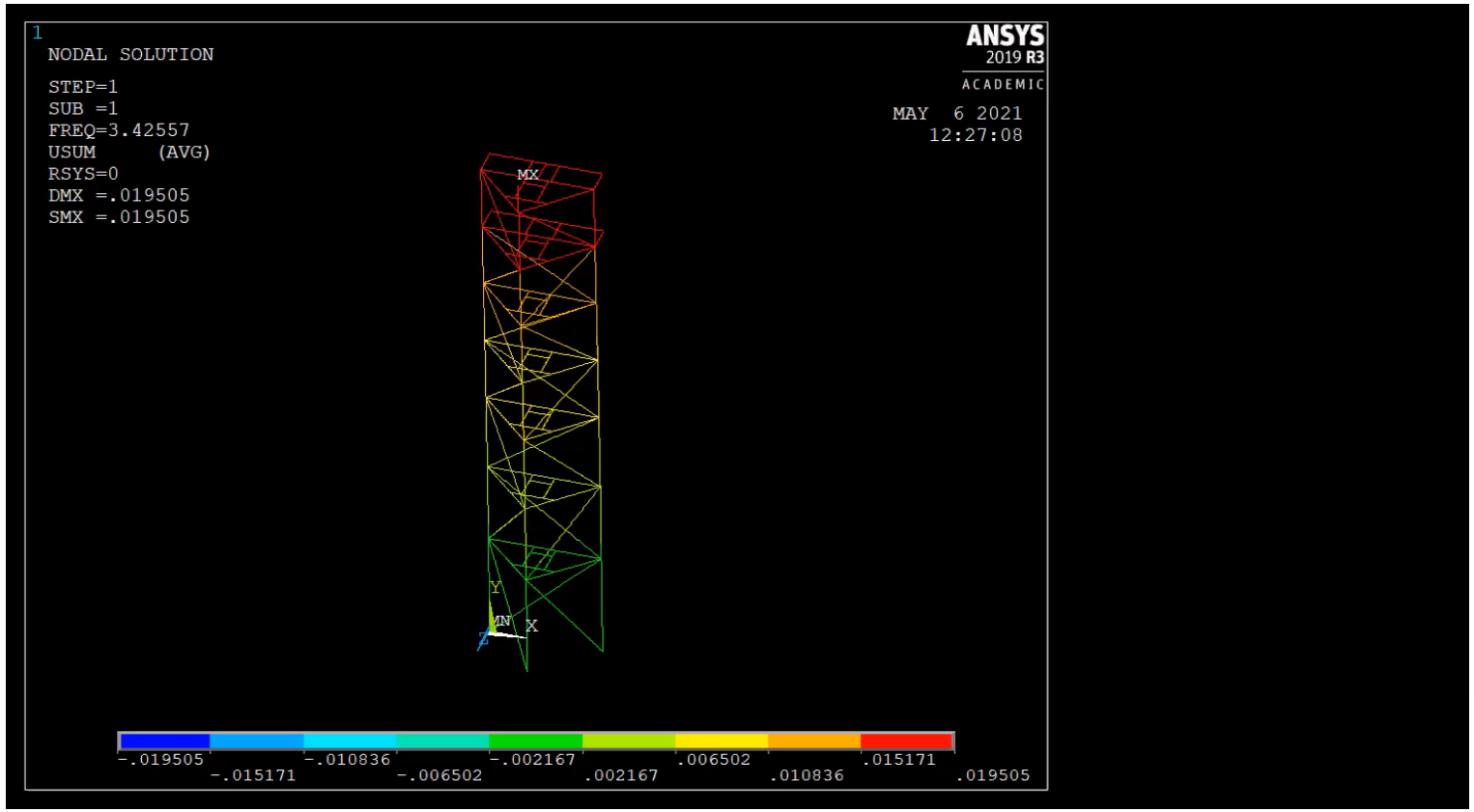
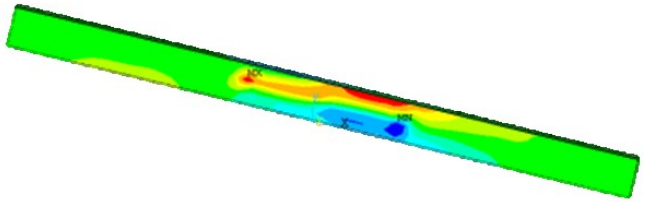
Eindige Elementen modelering mast



Resultaat EE-modelering:

- Trilling geïnduceerd door de mast is verreweg dominant
- Belasting bodem radome het grootst



Pilot Nautische Radar

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Metingen

Radar on mast OEC

Radar on offshore substation

Radar on offshore wind turbine

Digital twin

Digital twin rotating radar and mast +wind load

Radar and mast modelling + wind load

Radar on wind turbine modelling +wind load & vortex turbine blades

Operational Dashboard

AI Condition Predictor

Mitigating Measures

VR & AR toepassingen

Spin off

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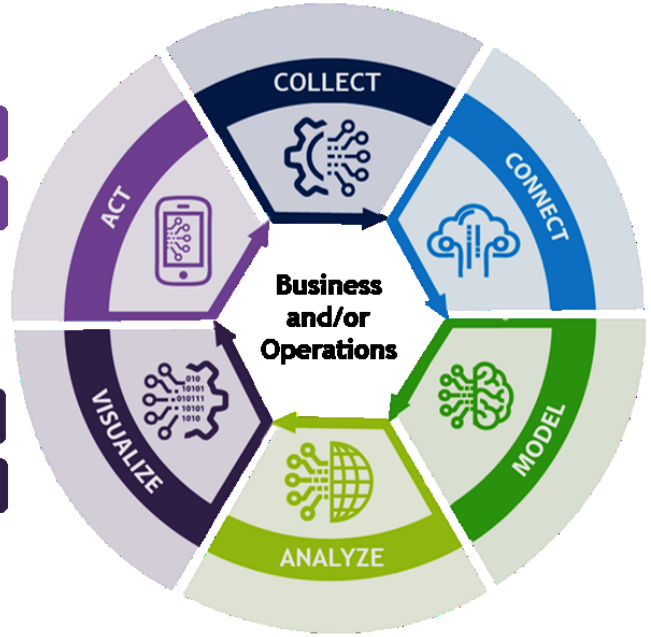
Verdere aanpak ……

- Real Time / Sensors / Data Streaming
- Data Governance and Security
- Enterprise Data Architecture



- Business Intelligence and Strategy
- Natural Language Processing
- Data Visualization and Presentation
- Key Performance Indicators
- Cloud and Distributed Computing
- Database Management
- Data Warehousing
- Data Engineering
- Unstructured Data / Semantics
- Master Data Management
- Data Mining and Statistical Analysis
- Machine Learning / Cognitive Computing Development

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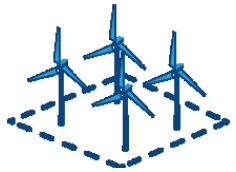
Welke strategie is noodzakelijk?

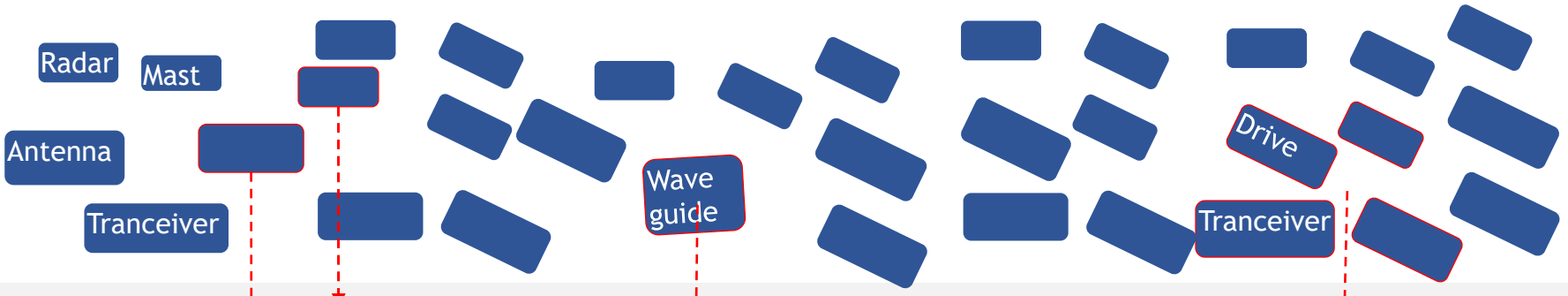
Objective	Asset type	Equipment type	Failure mode	Strategy for pre-selected assets	Overall strategy & business case
		Drive	**Bearing Wear** • Fatigue …	• Run to failure • Time Based Maintenance • Periodic Inspections(offline)	**Business case for a plant** **Benefits and investment for a roll out** **People** **Organization** **Data** **Processes**
		Tranceiver	**Seals** • Leaks • …		
		Wave guide		• Condition Monitoring (online) • Data analytics • Machine Learning	
		Antenna			

DE JUISTE STRATEGIE VOOR ELKE ASSET
VAN OFFLINE NAAR ONLINE OF PREDICTIVE

All assets

Objectives

- Critical assets
- Bad actors
- KPI's
- External factors



1: Offline
- Periodic onsite inspection
- Trend analysis & troubleshooting

2: Online
- Remote trend analysis
- Remote troubleshooting

3: APM 4.0
- Predictive models
- Recommendation

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ASSET HEALTH MONITORING: OPTIONS LIBRARY
MANAGING THE P-F CURVE

Very early detection: Long leadtime

Data analytics / Machine learning

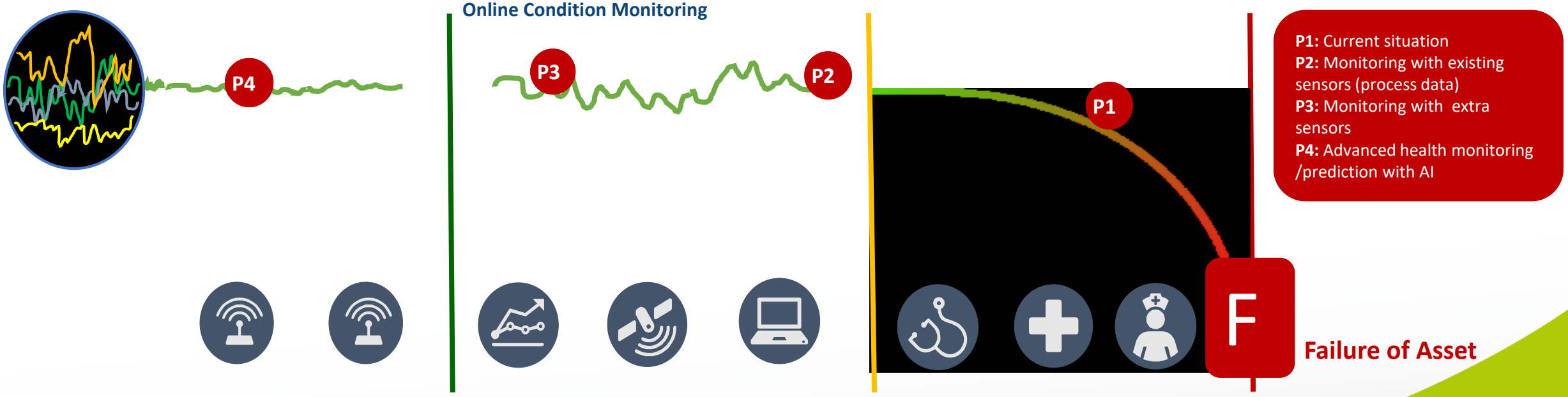
Extra Lead Time

Next step in Asset Health prediction

Online Condition Monitoring

Short Lead Time

Offline Condition Monitoring



P1: Current situation
P2: Monitoring with existing sensors (process data)
P3: Monitoring with extra sensors
P4: Advanced health monitoring /prediction with AI

Failure detection

Anomaly detection

Trends analysis

Wireless hardware

Analysed with monitoring software

Diagnoses

Healthcare

Preventing previous incidents

Failure of Asset

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ASSET HEALTH MONITORING: OPTIONS LIBRARY

EXAMPLE OF DIFFERENT STRATEGIES FOR BEARING FAILURE

Advanced health prediction

Next step for increased ability to predict asset health and developing failures will imply use of **anomaly detection** that identifies deviation of datapoint from a dataset's normal behavior

To detect bearing failures the anomaly detection will use the combination of all sensors relevant to the bearing (vibration, speed (shaft), ultrasonic, temperature, oil / grease analysis, ambient temperature) and train a specific mathematical model based on data sets from “normal operation”

P4

PF4: 3-10 weeks

Basic health prediction with additional sensors

Bearing temperature sensor:
Monitor the bearing temperature for a maximum value and rate of change and set threshold such that bearing temperature cannot exceed its design limit. However, monitoring of bearing temperatures as indicator of wear is not straight forward, as there are many variables (ambient temperature, speed, load, runtime, etc.) which all have a pronounced influence on bearing temperature.

Vibration sensors:
Normal wear of the bearing induces vibration in the bearing housing. Vibration analysis (i.e., measuring the radial vibration in x,y,z direction (and frequencies)) of the bearing with an accelerometer allows analysis and early detection of failure.

Ultrasonic /AE Sensor including G2 sensor eg ABB
As the roller or ball elements begins to fatigue, a subtle deformation will occur. This deforming of the metal will produce irregular surfaces, which will cause an increase in the emission of ultrasonic sound waves. Ultrasonic sensors can therefore detect the beginning of fatigue failure, brinelling of bearing surfaces and flooding of or lack of lubricant.

P3

PF3: 2-8 weeks

Basic health prediction with existing process data

No direct bearing monitoring possible with basic process data but bearing failure is indirectly detectable on the motor amperage.
An alert can be set up if >XX% deviated from normal operations.
However, such alarm will typically only be triggered in a late stadium. The sound of the bearing that is worn out will be heard much earlier (applicable for RPM > 1500)
Also good to be aware that several failure modes are linked to the motor amperage. Therefore, detecting bearing failure based on amperage alone is not reliable.

P2

PF2: 1-2w (no improvement)

Failure mode

Wear of the bearing (ball bearing)

P1

PF1: 1-2 weeks

Bottom up approach

- Onderhoudsstrategieën
  - Data gedreven strategie
    - Keuze sensoren
    - Connectiviteit
- Update Business Case
- Installatie hardware
- Modelleren en analyseren
- Visualiseren

Accelero sensors

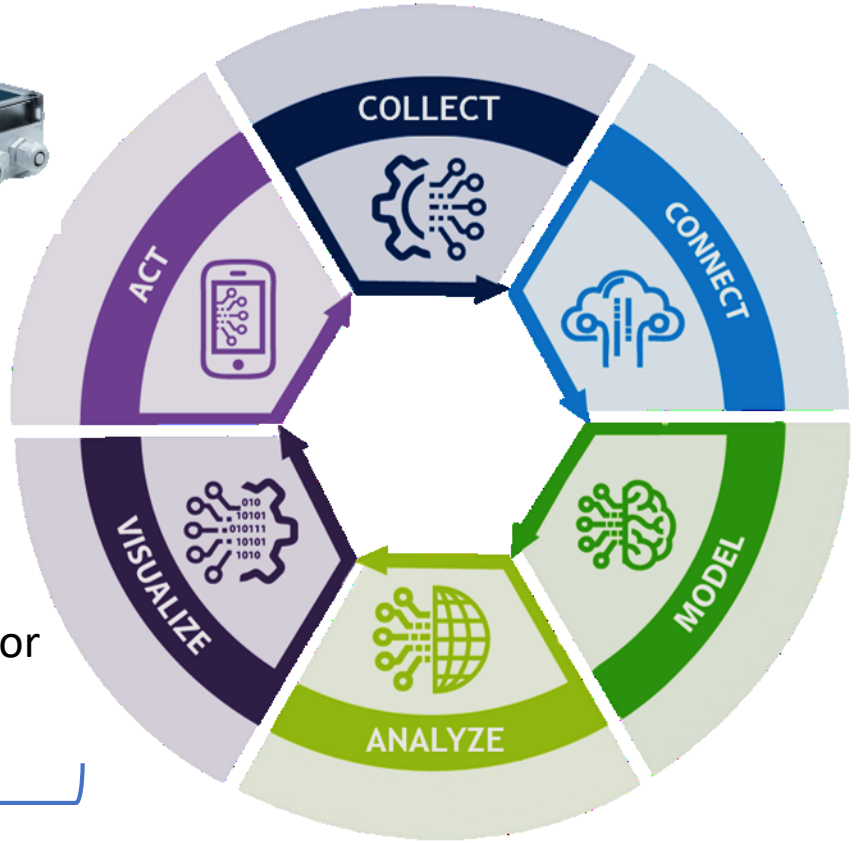
Force sensors

Current sensors

Torque sensors

Temperature sensor

Low freq vibration sensor



- Specificatie obv standaardisatie

Vragen ?

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