Definition of a Foundation Monitoring Strategy Based on Criticality

Session 5.6 H2020 Project: ROMEO

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Balancing CAPEX and OPEX can only be achieved with a lifecycle view

Maintenance strategy needs to be developed from detailed design on - to cut LCOE.

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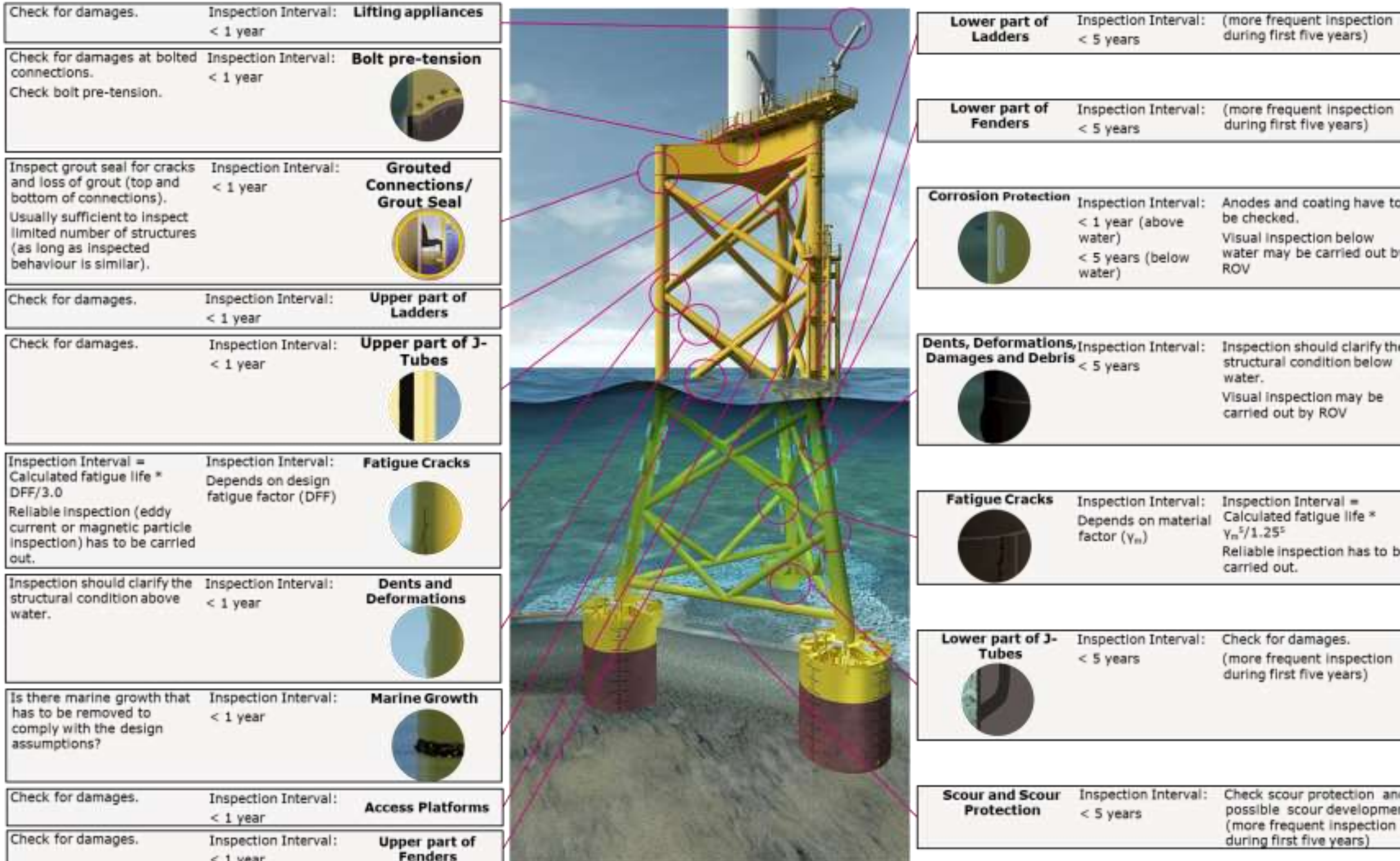


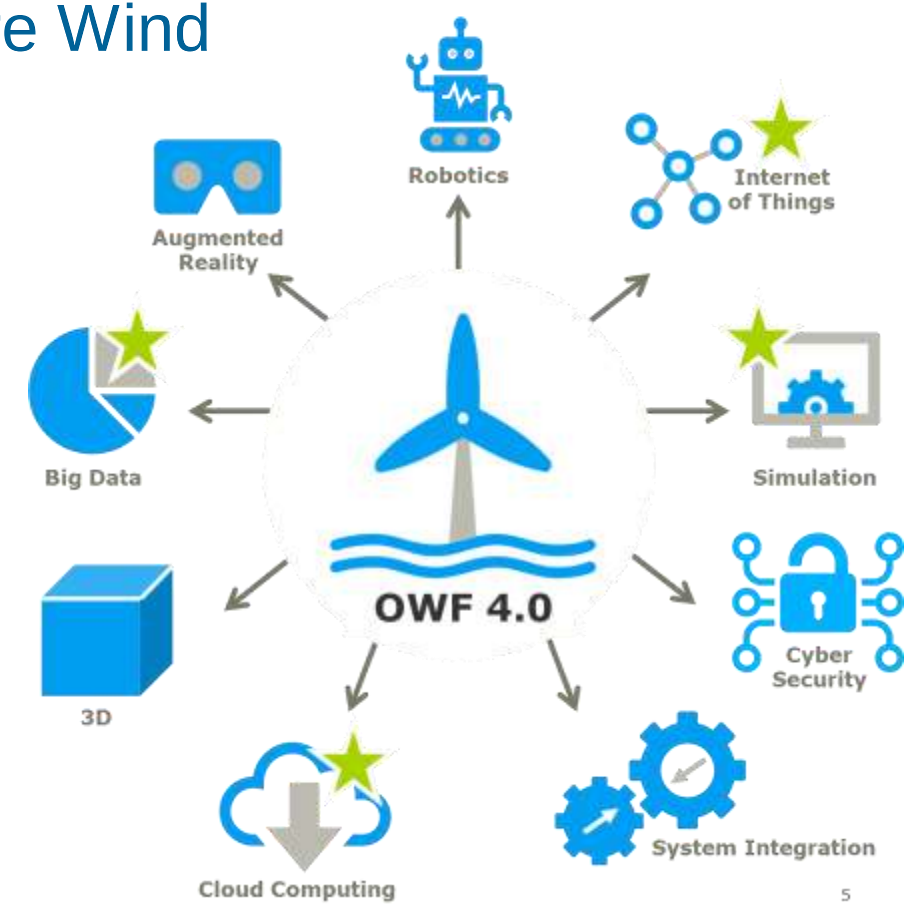
Periodic Inspection OFW Support Structures (DNV)

Industry 4.0 entering Offshore Wind

What is the economic value of conditon based maintenance?

- ✓ reduce OPEX: 10-40%
- ✓ reduce downtime: 50%
- ✓ lower CAPEX: 3-5%

From: *McKinsey Global Institute report, The Internet of Things: Mapping the value beyond the hype*



Source: McKinsey Global Institute report,
The Internet of Things: Mapping the value beyond the hype

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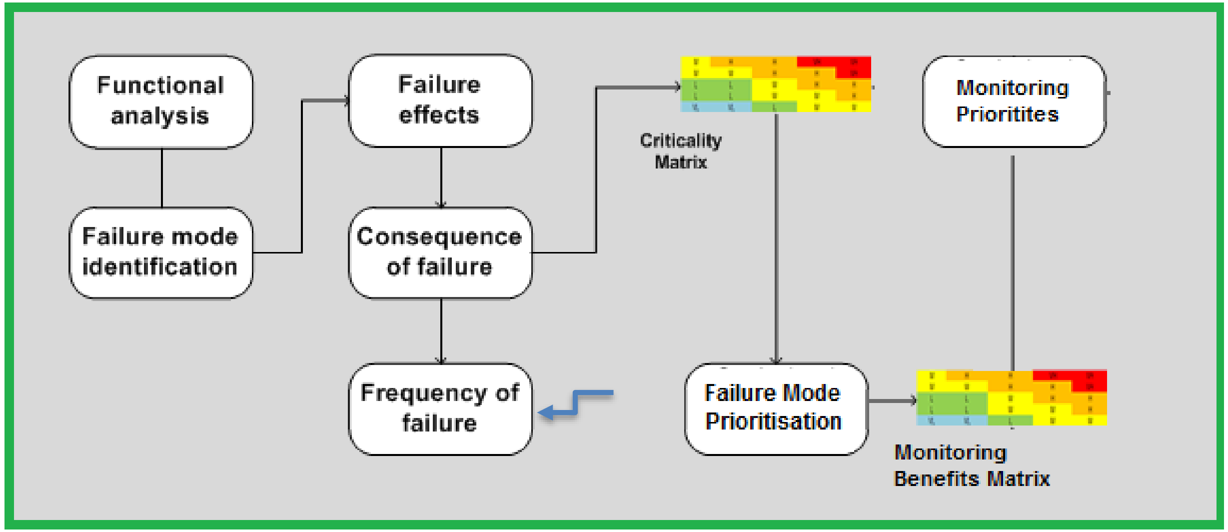
Statement:

There are sufficient technological solutions. It is about mastering the process.

Failure Modes and Effect Analysis

Customised FMECA focused on those mechanisms that take sufficient time before a failure materialises.

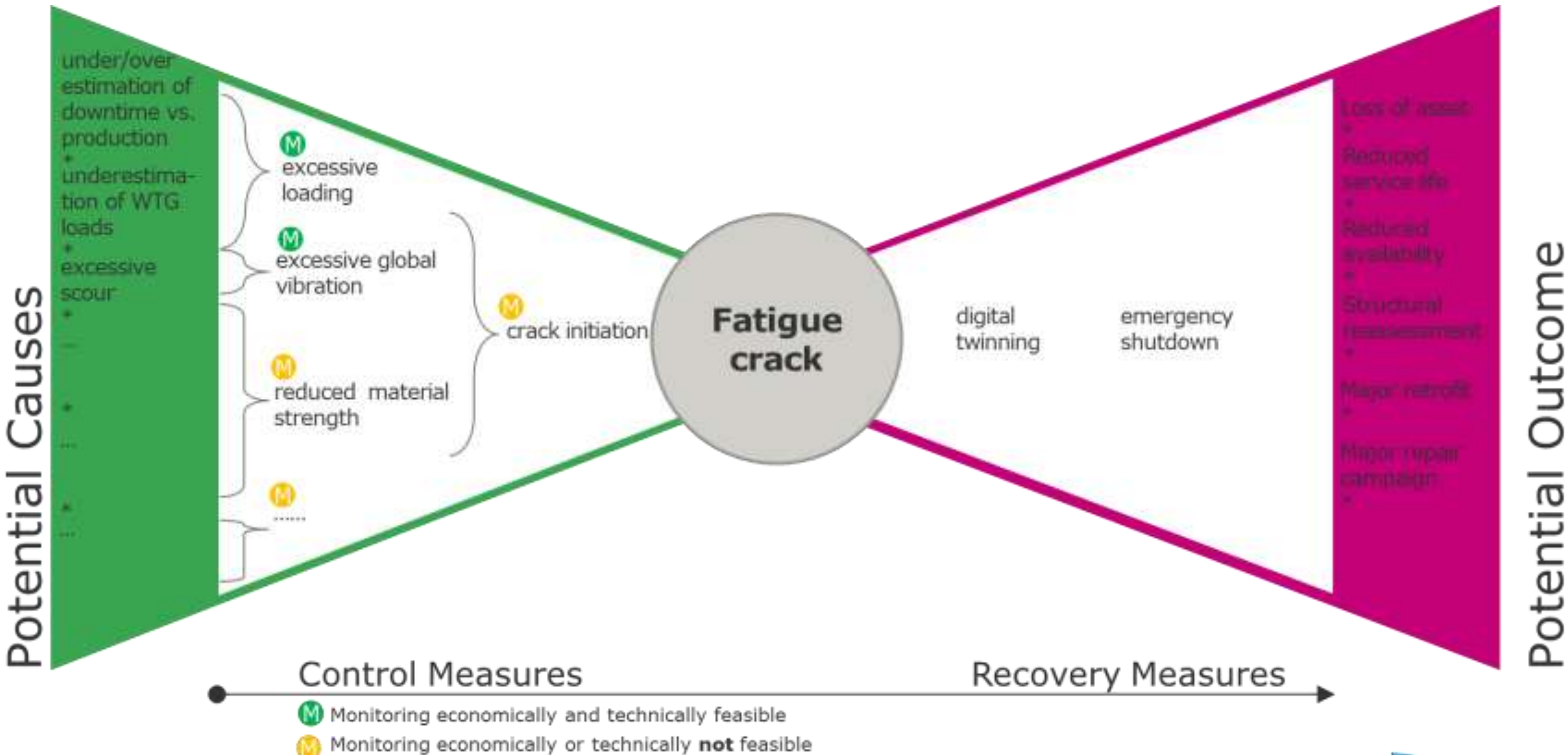
Hence allow sufficient time to react and plan for maintenance mobilization / failure prevention or mitigation.



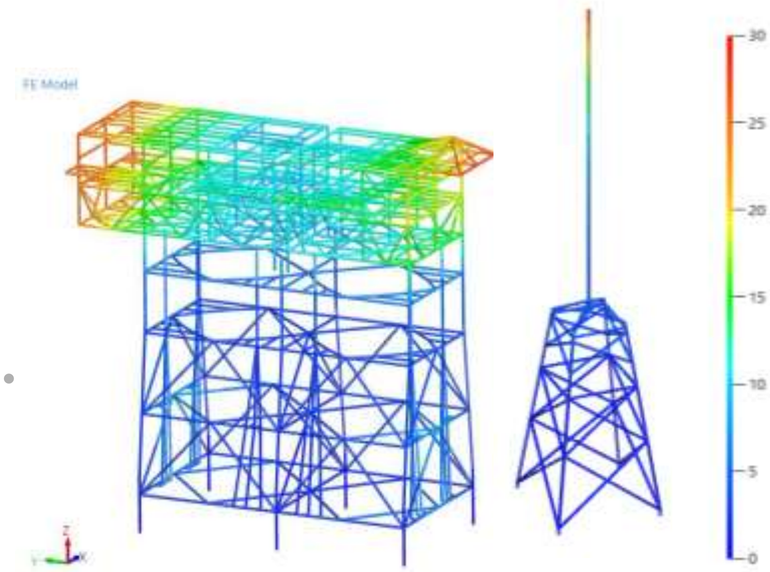
Conclusions

1) More than 60 failure modes have been investigated related to substructures
2) For almost half of them, a value creating potential for the use of monitoring systems was identified

Assess potential for monitoring for high criticality items



Virtual sensing
Optimal Sensor Placement Analysis



Average displacement modulus at OSS and WTG

Approach

1) Analysis of current sensor set up through Modal Assurance Criterion
2) Definition of possible sensor placement locations
3) Optimisation of the sensor layout by adding/removing sensors. Sensor elimination technique – max. accepted coupling is 25%.

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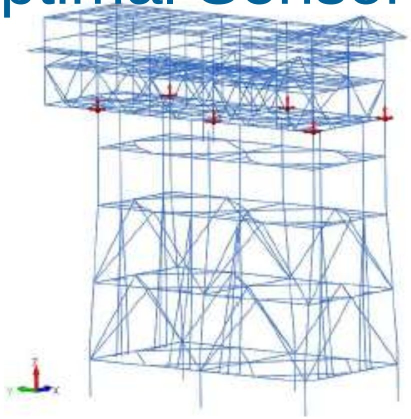
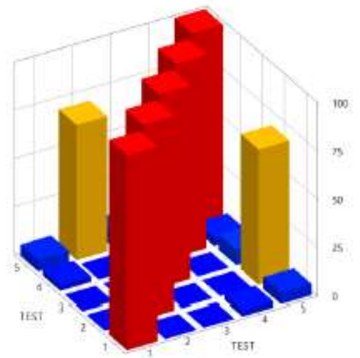
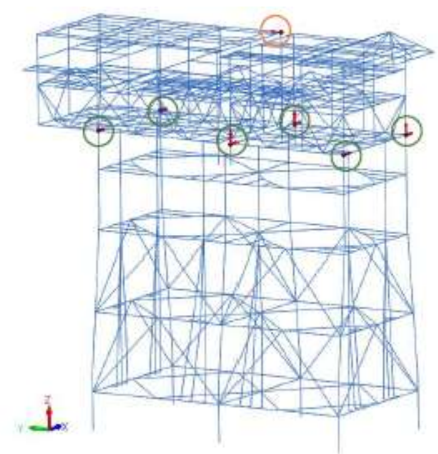
Optimal Sensor Placement Analysis

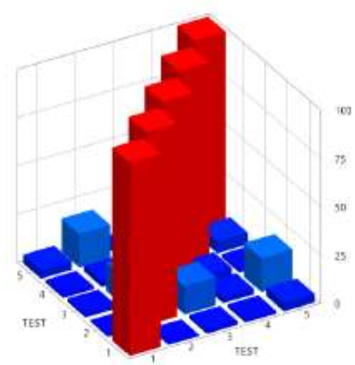




Current OSS CMS:

- Sensors not located in areas where highest displacements are expected.
- Approx. 60% of coupling between 2nd and 5th mode.
- Too many DOFs leading to coupling.

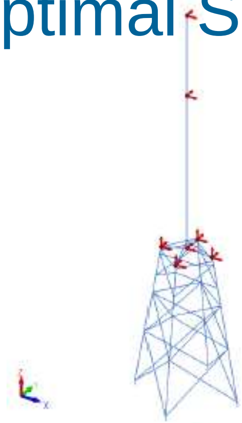


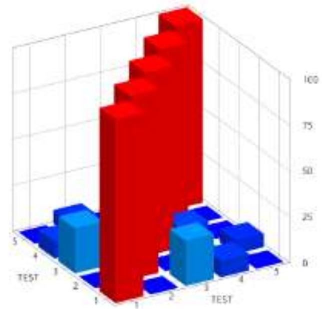


Optimised variant of OSS CMS:

- Disregarding 9 DOFs lead to better results with addition of 1x ACC at roof deck.
- Coupling is reduced to a max. of 17.5%.

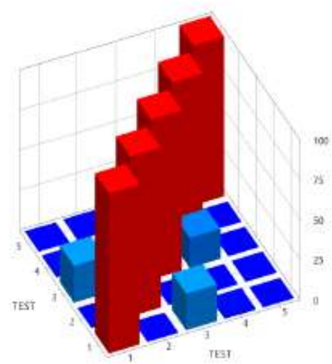
Virtual sensing
Optimal Sensor Placement Analysis





Current WTG CMS:

- Approx. 25% correlation between 1st and 3rd mode shape – just at the acceptable limit.
- Others pairs with a maximum 10% correlation.



Optimised variant of WTG CMS:

- Slight improvements with 4x acc. sensors.
- Coupling is reduced to a max. of 17.5%.

Summary

1. Always start with Failure Mode and Criticality Analysis
2. Define purpose and objectives of monitoring based on highest criticalities
3. Develop failure mechanisms and match with currently existing monitoring technology
4. Assess capabilities of virtual sensing.
5. Assess capabilities of direct monitoring
6. Benchmark solutions economically and technically.
7. Develop monitoring concept for entire wind farm based on parameter variation

- ✓ Purpose driven monitoring system
- ✓ With cost effective sensor layout
- ✓ Condition based maintenance enabled

Thanks for your attention.

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