Corrosion Monitoring for the ORE Sector

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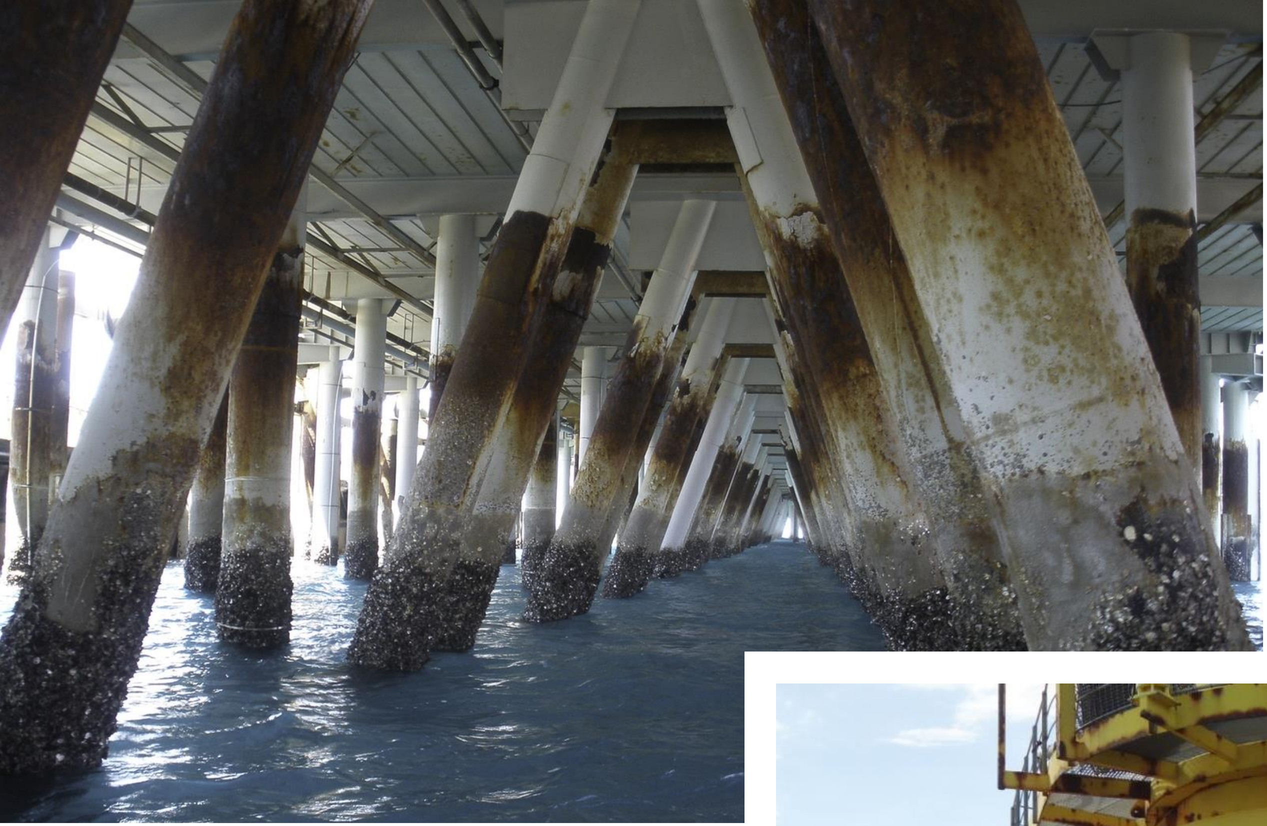
www.owi-lab.be





The challenge of corrosion
Technical and economic consequences

Structural integrity

Safety

Maintenance costs

The challenge of corrosion
Technical and economic consequences

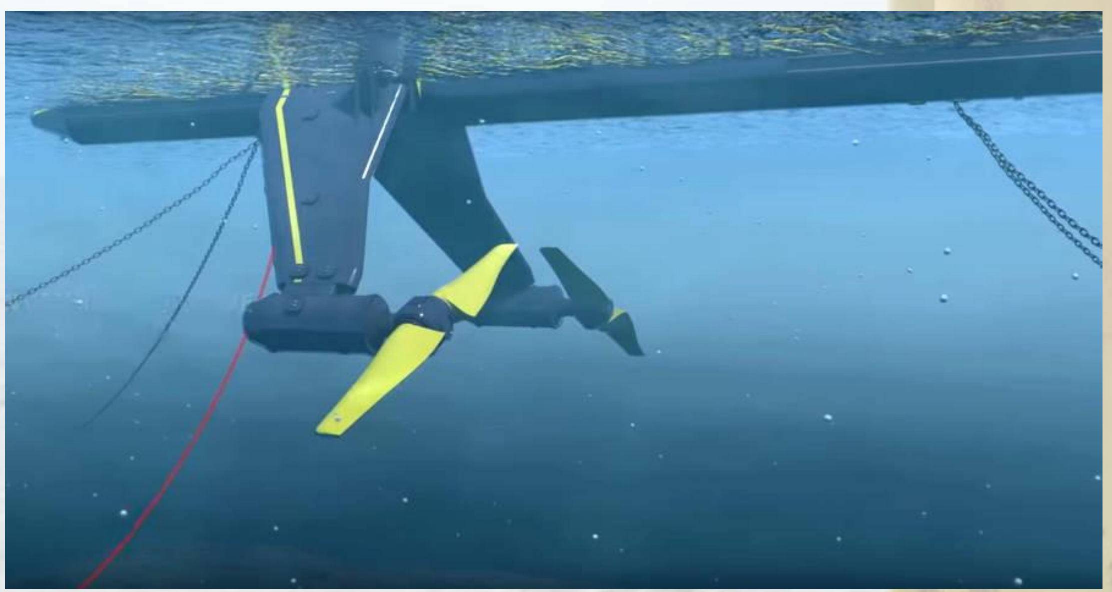
+/- 3.8% of EU GDP
500 billion EUR

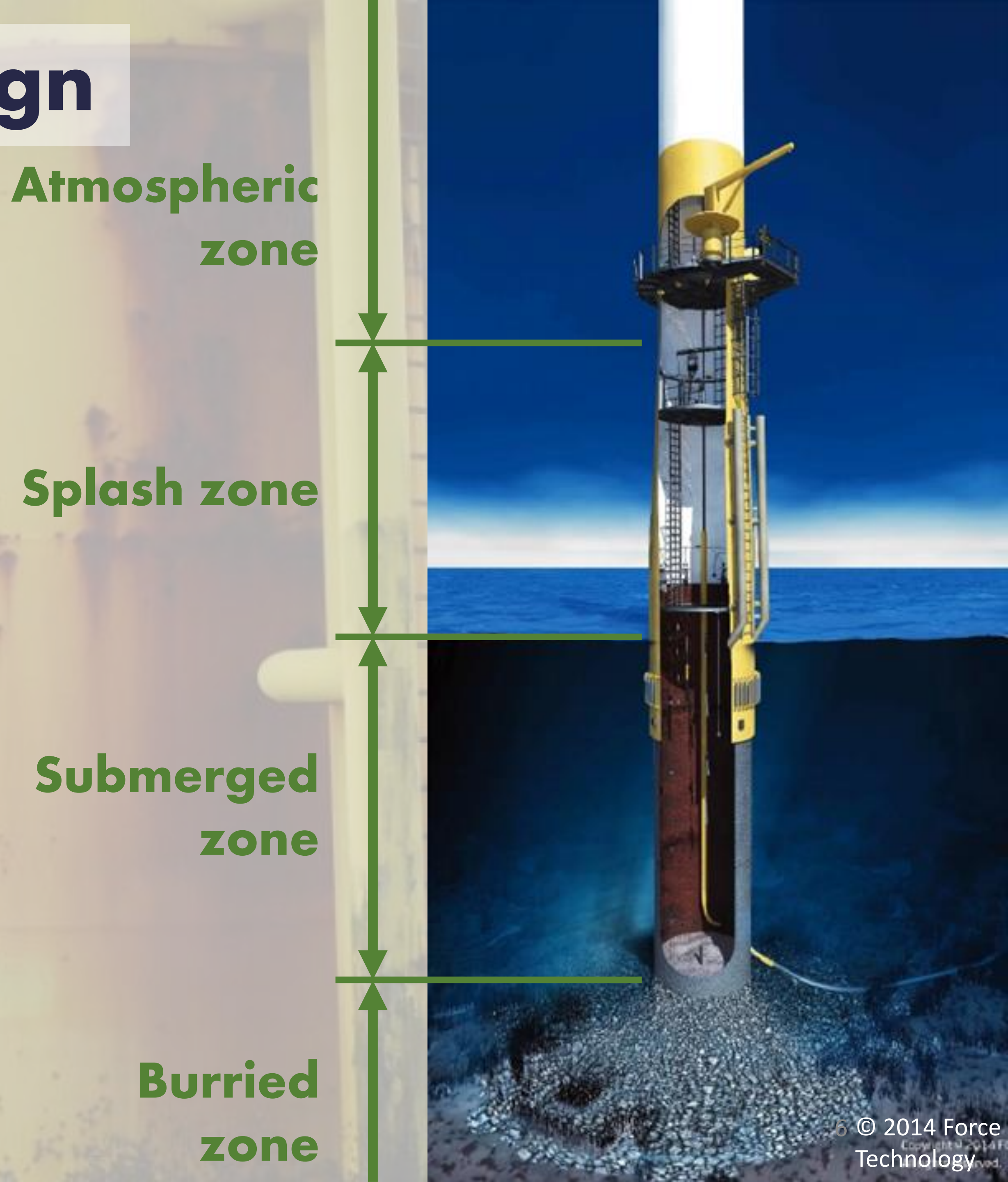
North Sea Solutions for Innovation in Corrosion for Energy

18% of OPEX
3 billion EUR by 2030

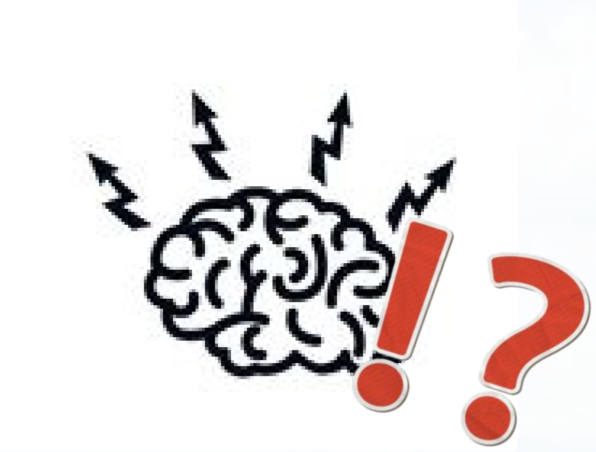
Corrosion protection design

- ✓ Coatings
- ✓ Cathodic Protection
- ✓ Corrosion Allowance
- ✓ Material Choice



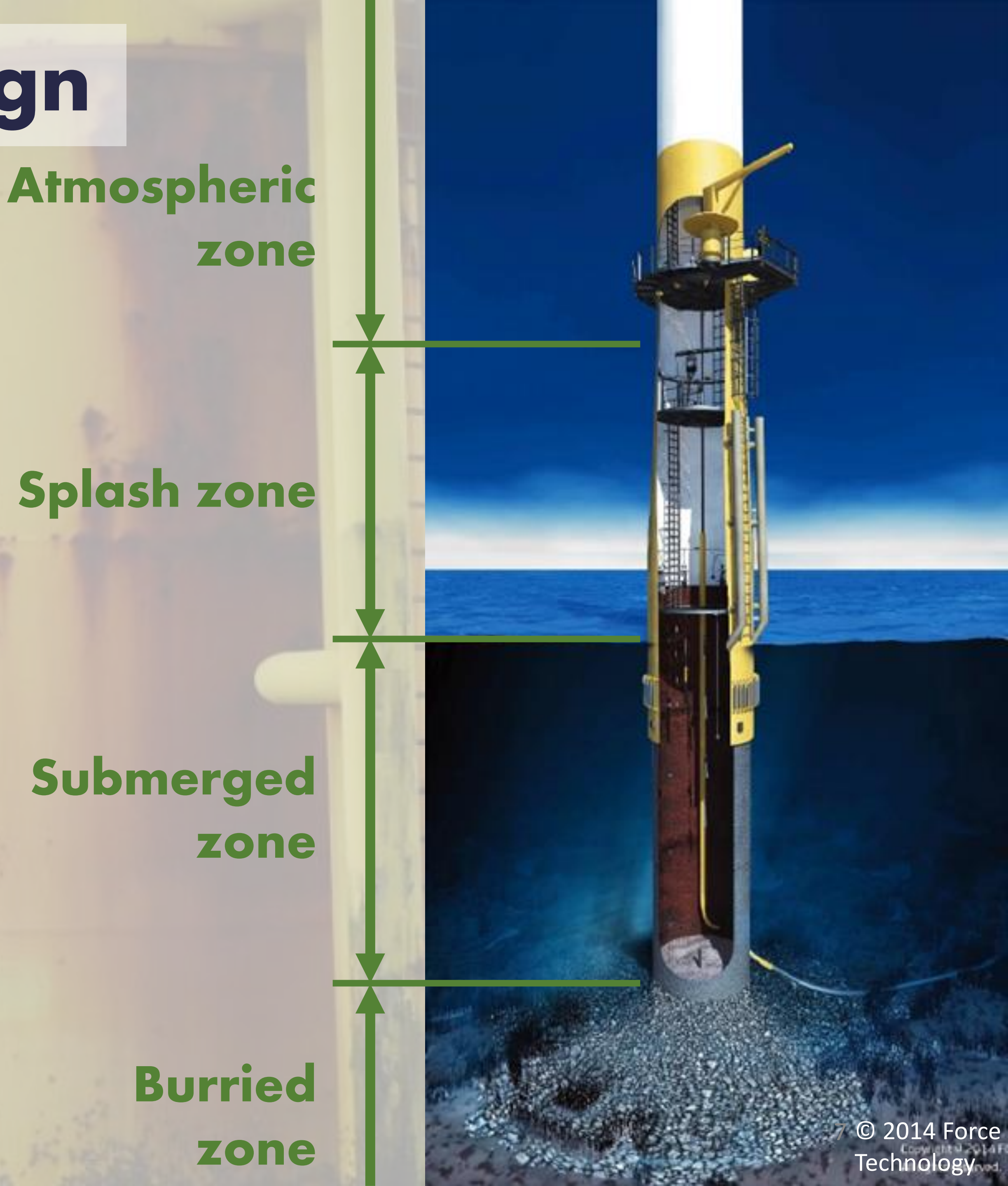


Corrosion protection design

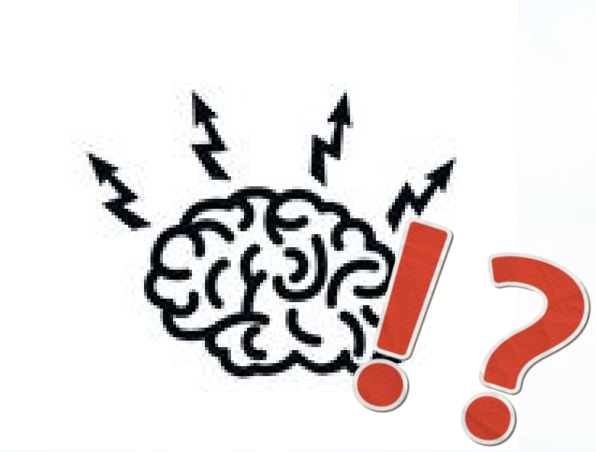


Uncertainty remains

- ❑ Design phase
- ❑ Operational phase
- ❑ Interpretation of inspection results
- ❑ Lifetime



Corrosion protection design



Uncertainty remains

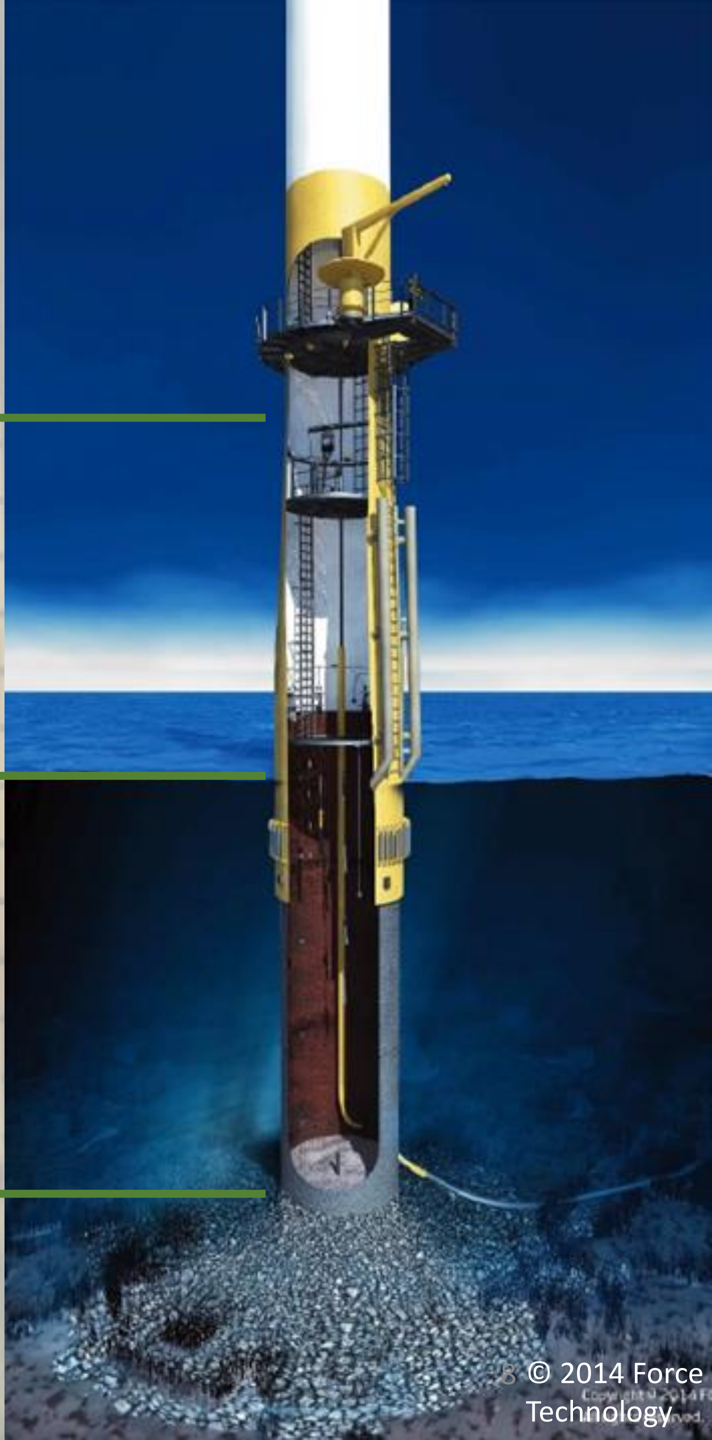
Trend towards increased monitoring in offshore wind.

Atmospheric zone

Splash zone

Submerged zone

Burried zone



Sector specific challenges

https://www.marinetraffic.com

https://www.porttechnology.org

Sector specific challenges

Unmanned

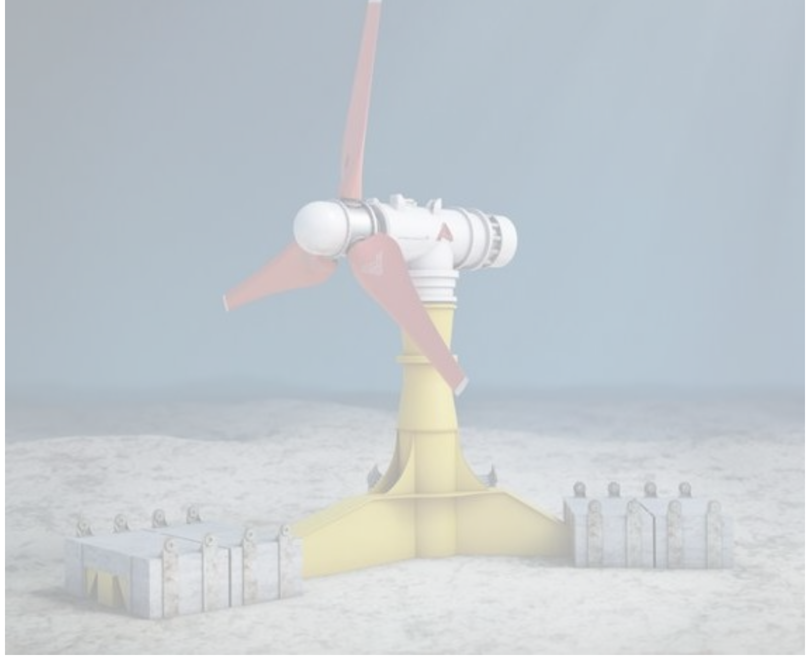
Not coming to port

Completely submerged

Window of opportunity

Wintertime

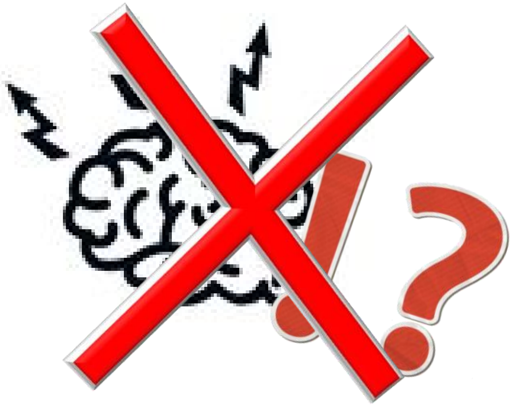
High inspection/repair cost



Why?

Industrial challenges

- Monitoring of CP efficacy
- Checking of design assumptions
- RUL and life extension
- O&M optimisation



Reduction of Uncertainty

Potential (economic) benefits

Why?

Industrial challenges

- Monitoring of CP efficacy
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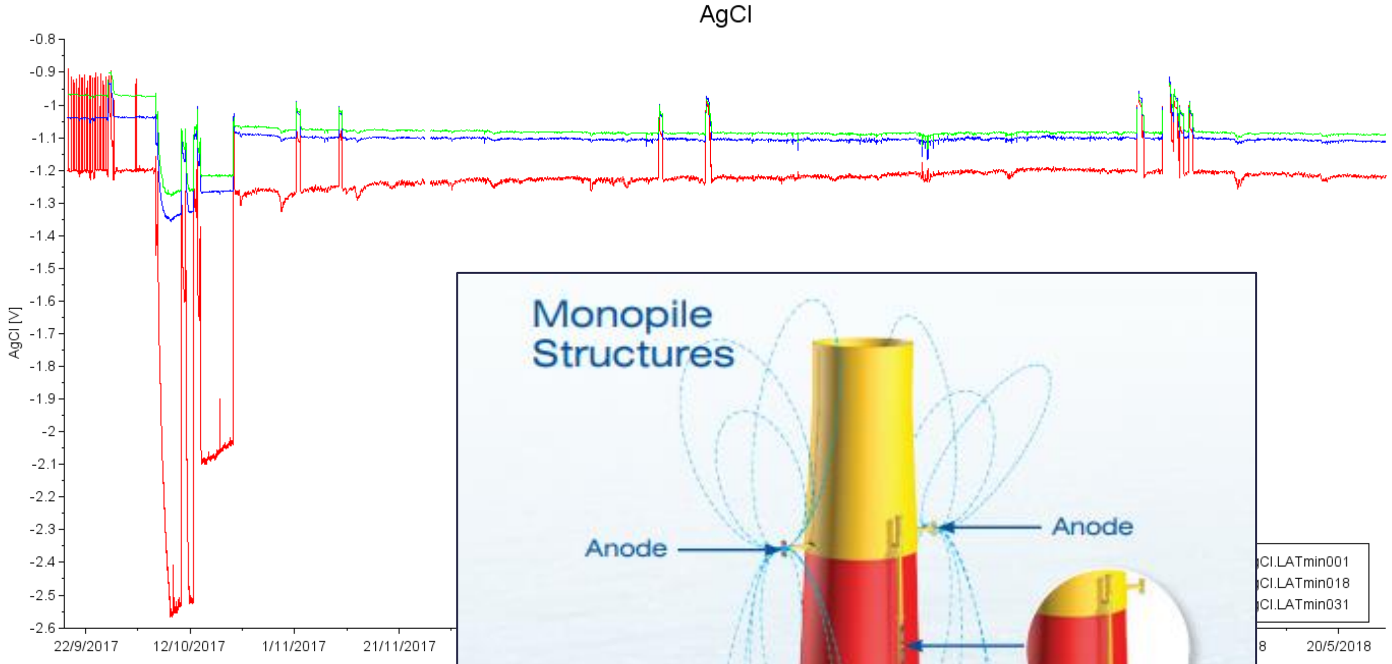

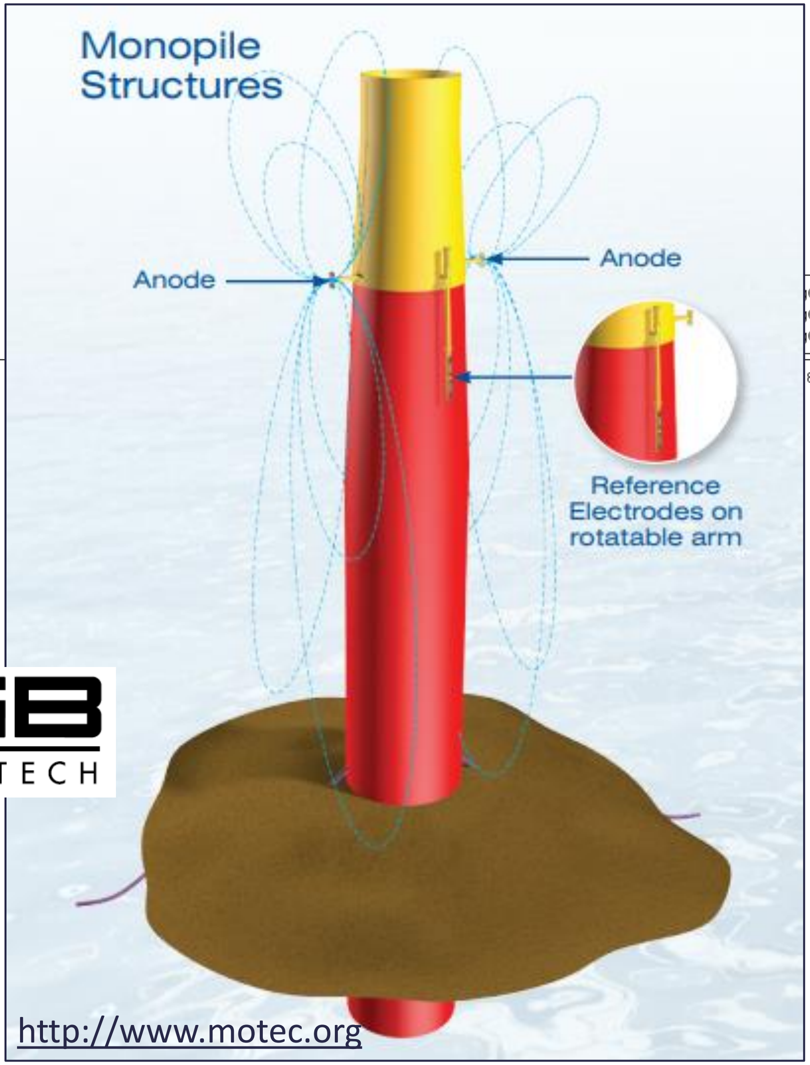

BUREAU VERITAS

VGB POWERTECH

DNV·GL

Why?

Industrial challenges

- Monitoring of CP efficacy
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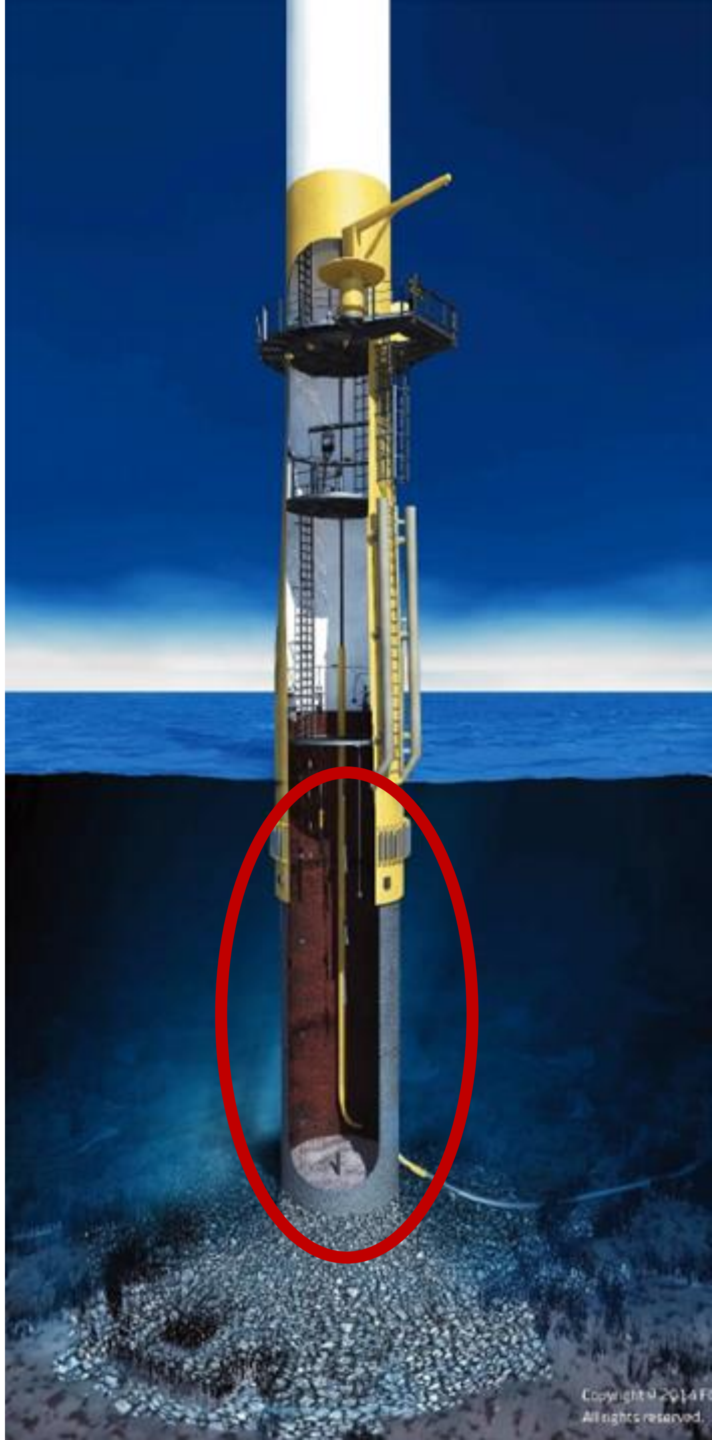
- RUL and life extension
- O&M optimisation

Oxygen depletion?
Changing water conditions?
Below mudline? MIC?
Corrosion rates?



Why?

Industrial challenges

- Monitoring of CP efficacy
- Checking of design assumptions
- RUL and life extension
- O&M optimisation

Risk reduction/control

Philosophy of good documentation

Knowing the history of the structure

Confirm corrosion allowance not exceeded

Why?

Industrial challenges

- Monitoring of CP efficacy
- Checking of design assumptions
- **RUL and life extension**
- O&M optimisation

Pit shape and size

Why?

Industrial challenges

- Monitoring of CP efficacy
- Checking of design assumptions
- RUL and life extension
- O&M optimisation

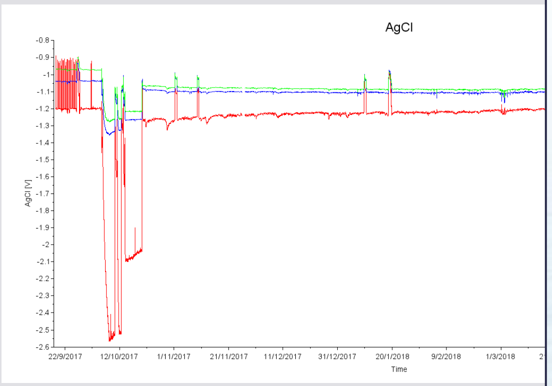
Corrosion Monitoring

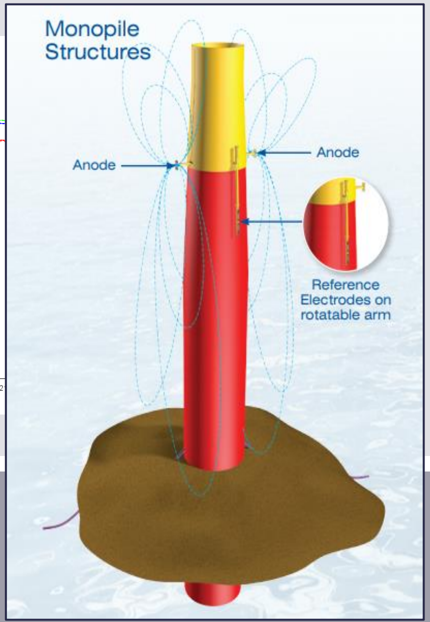
Reduction of Uncertainty

What? (Parameters)
How? (Technology)

Corrosion Monitoring

Cathodic Protection





Corrosion rate

Environment

Direct Corrosion Monitoring

Coupons

- ✓ Reliable (weight loss)
- ✓ Type of corrosion
- ✓ Good reference for other methods

- × Need for retrieval
- × Slow response rate
- × Only historic data

Electronically connected to the structure

ER-probes

- ✓ Easy and reliable
- ✓ Low maintenance
- ✓ Real-time data

(Response rate ~ Element thickness)

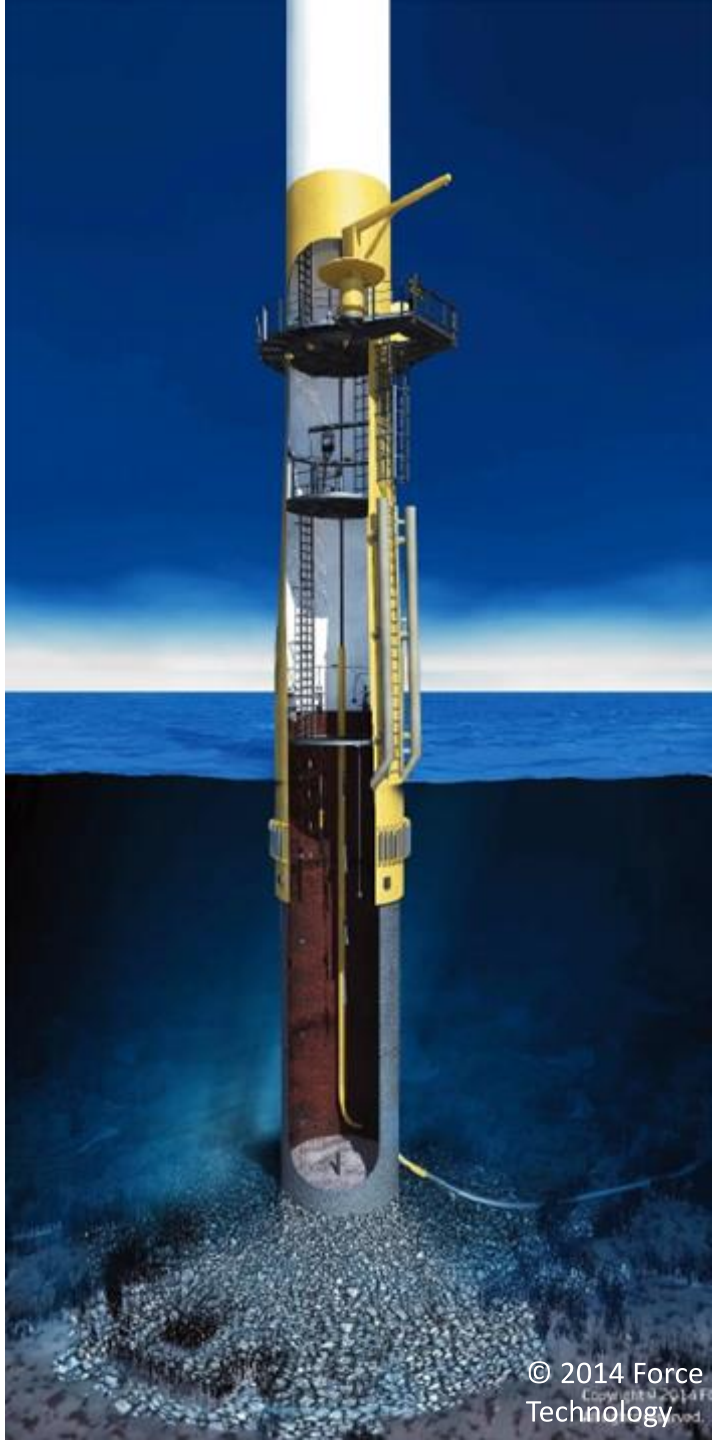
- × No info on pitting

Electronically connected to the structure

Lessons learned

Corrosion coupons	ER sensors
▪ Location/Position ▪ Exposure time ▪ Starting conditions ▪ Electrical connection to structure	▪ Location/Position ▪ Element material ▪ Pitting/Fouling/MIC/Conductive scales ▪ Combination with CP ▪ Have a ‘disconnected’ sensor as a reference

“Corrosion coupons and ER sensors measure the corrosivity of the marine environment rather than actual changes in wall thickness.”



Direct Corrosion Monitoring

LPR-Probes

- ✓ Immediate measurement
- ✓ Qualitative pitting tendency

- × More complex
- × Representative for structure?

Measure current between two electrodes

Ultrasound

- ✓ Direct wall thickness measurement

- × Measure from non-corroding side
- × Lower accuracy
- × Less good for pitting

Environmental Monitoring

Oxygen

Driving force for corrosion and one of the most critical environmental factors to monitor

- Optical sensors for best accuracy and long-term stability (vs. electrochemical)
- Especially for confined spaces

NGI

(BSEE Offshore Wind Recommendations)

pH

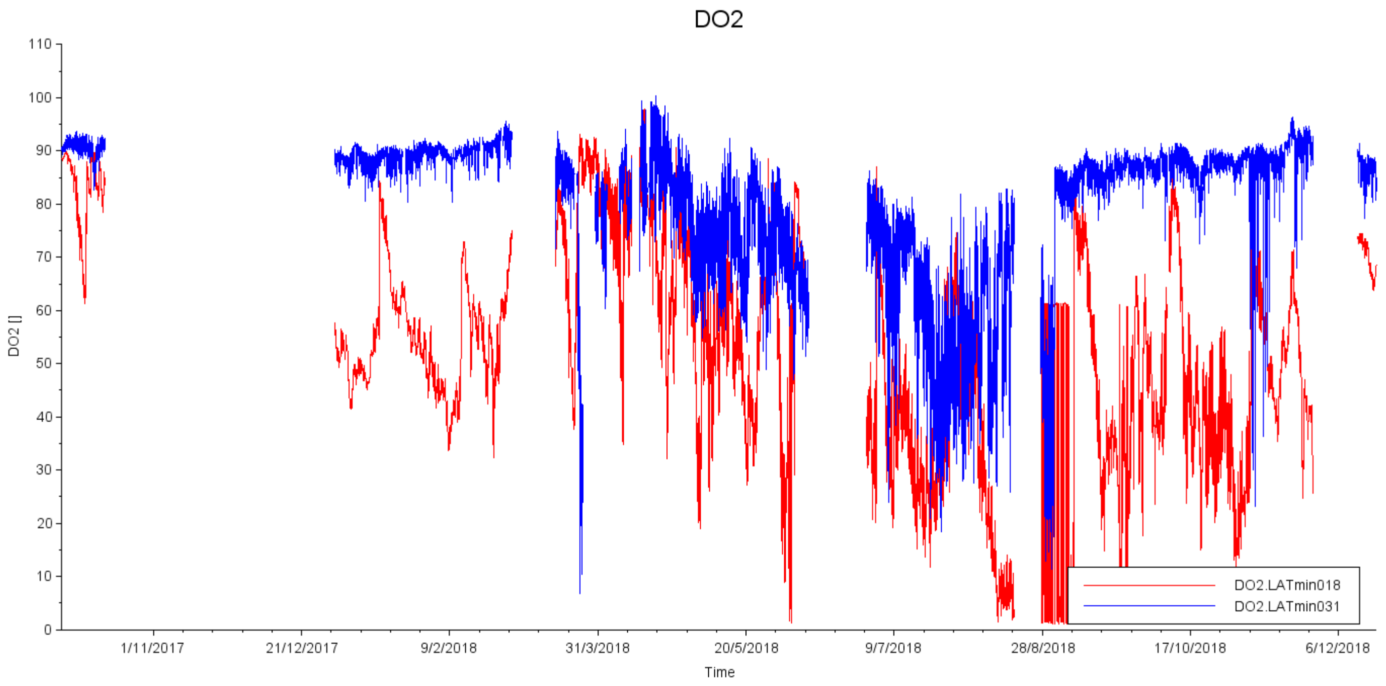
Important in case of CP in a confined body of water

- Typically using pH-sensitive glass electrodes
- Often drifts slowly with time
- Development of solid state pH sensors

Lessons learned

Lifetime of sensors should be very long, because corrosion is a slow process.
Maintenance interval >> periodic inspection interval

- Energetically active sensors imply the presence of cables in the structure under monitoring
- Impact of fouling
- Need for frequent re-calibration (every few months)
- Include drop cell inspections
- Robustness of sensors and data acquisition
- Data quality



Lessons learned

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"The sensors need more maintenance than the structure."

"Reduce uncertainty, not increase it."

Environmental Monitoring

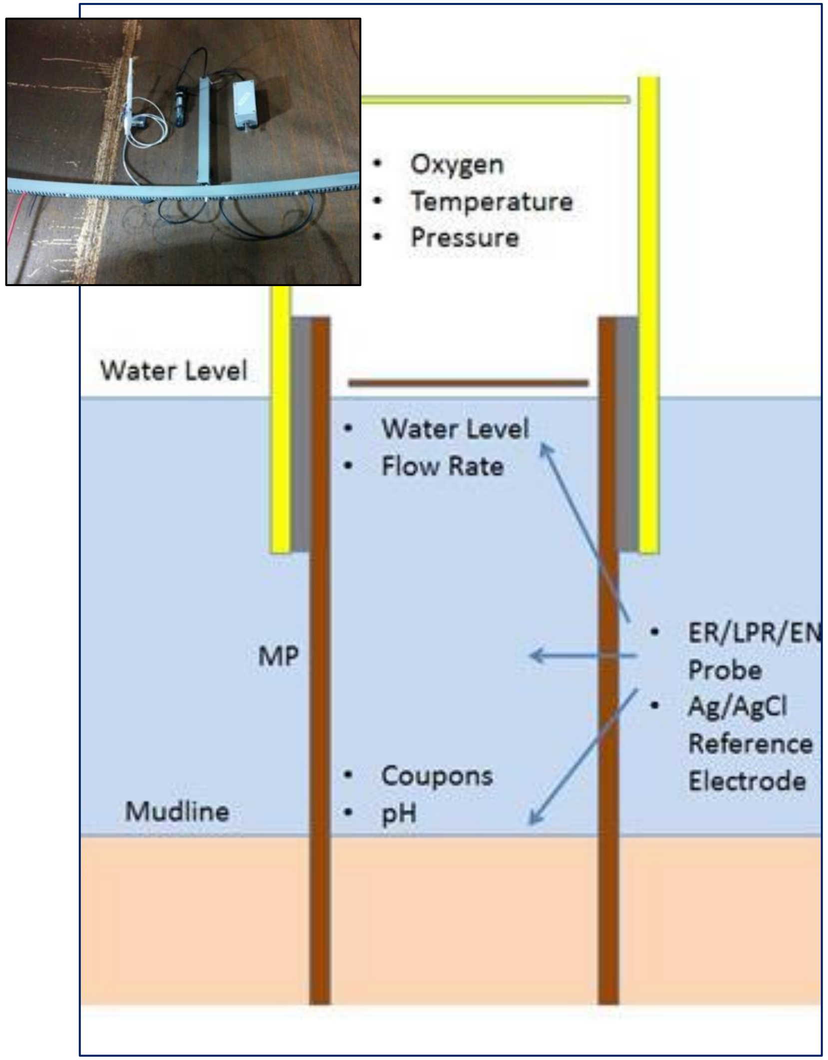
Multi-sensor probes are available
Some with anti-fouling measures

Multi-sensor

Anti-fouling measures

- ✓ Cleaning brush
- ✓ UV
- ▪ Biocides (legal issues?)
- × Increased cost
- × Not maintenance free

Monitoring Strategy



What sensors and where?

- Depends on the purpose
- Build-in redundancy
- Higher risk of CP underprotection near seabed

Key elements

✓ Reference electrodes

✓ Coupons

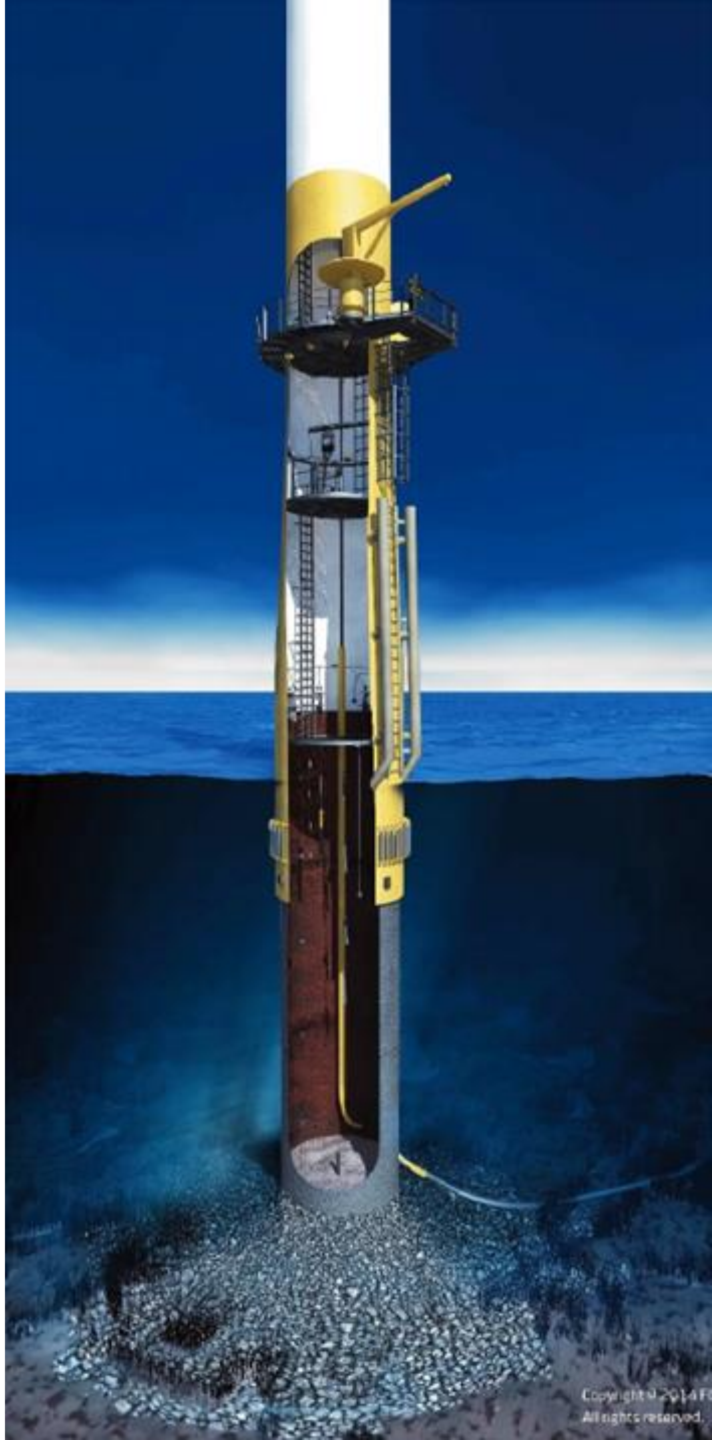
✓ ER/LPR-probes

✓ Oxygen

✓ Temperature

✓ Conductivity

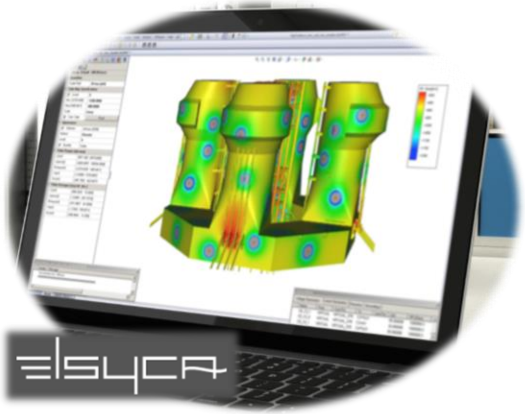
~~✓ pH~~



Monitoring Strategy

Corrosion is a localized phenomenon.
It is therefore necessary to identify the most critical points on the structure.

Corrosion models

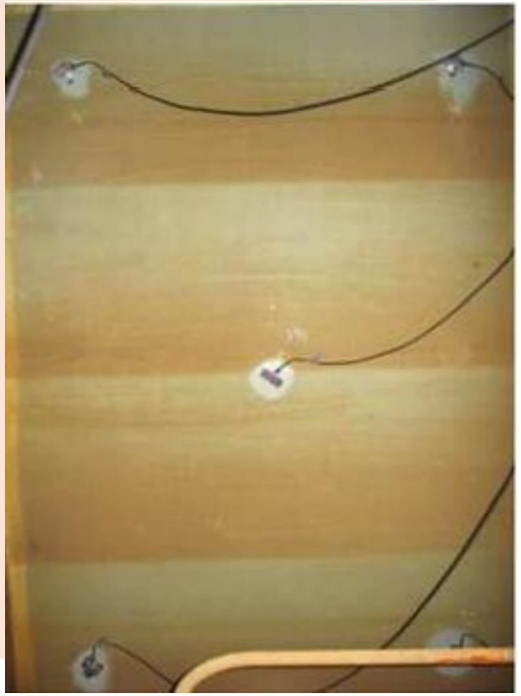


Inspections

What could the future bring?

New Sensor technology

- ✓ More reliable sensors needed for environmental parameters
- ✓ ***Sensors for pitting needed***
- ✓ Solutions for mudline corrosion monitoring/inspection
- ✓ Sensors for MIC? (Bio film thickness?)
- ✓ Monitoring of bolt corrosion?
- ✓ ***Acoustic emission as a promising technology?***



What could the future bring?

Monitoring Strategy & Data interpretation

- Direct corrosion monitoring vs. environmental parameters
- Local vs. volume
- Environmental data to support interpretation of corrosion data
- Combination will likely yield the best result needed

- Accumulated corrosion risk as a means for RBI (based on corrosion and/or environmental monitoring)


Questions?