

*Engineering solutions*



## **Expertise. Innovation. Value.**

AMOG is a leading global solutions provider to the energy, resources, defence, rail, and maritime construction industries.

## **Floating Energy Research Forum**

Advancing Mooring System Reliability and Sustainability for  
a Resilient Offshore Future

*Stuart Wales*

CTO AMOG

19th November 2025

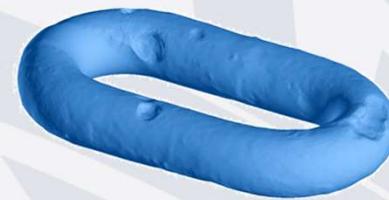




## Overview



- > Where are we coming from?
  - Aging assets...
  - Life extension?
  - Competing priorities...
- > What do we need to advance?
  - Inspection strategies
  - Anomaly assessments
  - Monitoring techniques
- > What is reliability?
  - Condition projection
  - Incurred damage
- > What is sustainability?
  - Opex vs anomalies/incidents
  - Remediation vs upgrade
- > Resiliency
  - “the ability to recover quickly from difficulties or setbacks”



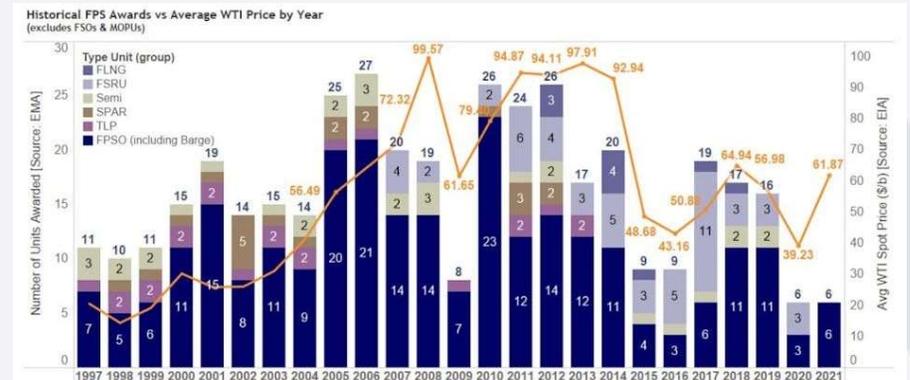


## Where are we coming from?



### Aging Assets...

- > Peak in FPS awards in early 00's
  - Nearing life extension decision/end-of-life
- > Assets built pre:
  - 2MIM, E308 and similar industry mooring integrity initiatives
  - “Big Data” , “The Cloud” , “Digital Twin”
- > Assets where Operations and Maintenance have been production centric
- > Assets which have changed operatorship, loosing
  - Facility “IP”
  - Chain of data required to enable new MIM approaches



<https://www.offshore-mag.com/field-development/article/14210926/pace-of-fps-awards-expected-to-increase> [Oct. 1, 2021]



## Where are we coming from?



### Life Extension?

- > Many assets with long production tails
- > Smaller operators able to extract value
  - O&M production focused
- > Unmanaged mooring integrity issues could be “asset-critical”
  - Common-mode threats challenge Case to Operate
  - Supply chain pressures from “O&G Majors”
- > Anomaly criticality hard to define
  - “Design” Fatigue limit vs incurred fatigue
  - Design for corrosion vs pitting fatigue
  - OEM “limits” vs actual capacities
- > Mooring design suited to refurbishment/remediation?
  - Direct hull connections
  - Infield infrastructure





## Where are we coming from?



### Competing Priorities...

- > Mooring life extension likely only one part of the puzzle
  - POB limits within a larger FPU campaign
  - Offtakes/shut-ins mid-campaign?
- > Key refurbishment enabling equipment may be
  - Unmaintained
  - Inaccessible to remediate
  - Unsupported
- > To extend or refurbish?
  - Life extension *retaining* anomalies
  - When *is* end-of-life?
- > Case-to-Operate during works
  - When facing common mode anomalies

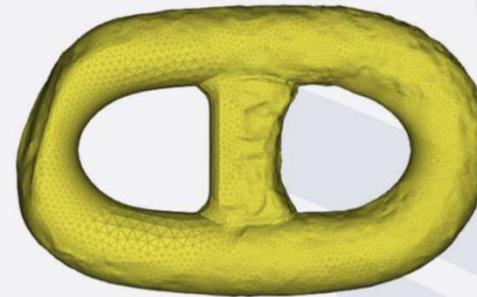
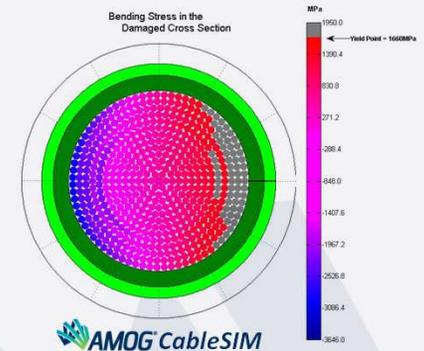




## What do we need to advance?

### Inspection Strategies

- > API RP2MIM, RP-E308 et al represented step change in strategy
- > FOWT sector pushing further review of practices and approaches in MIM
  - Drive to improve inspection ROI, reducing OPEX
  - Integrity management “built-in”
  - Long lead on risk vs results given slowing pace of deployments
- > Renewed sharing of failure/anomaly data to ensure RBI correctly assesses the Risk





# What do we need to advance?



## Anomaly Assessment

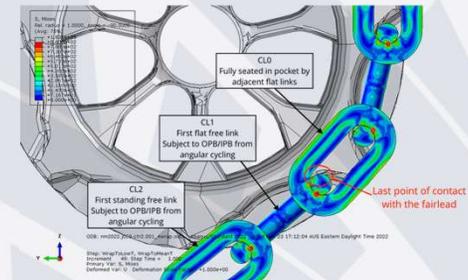
- > Richer data gathered from inspections
  - Consistency, clarity, repeatability
- > Critical, common anomalies can be stochastic in nature
  - Benefit from sophisticated inspection techniques
  - Definition of governing anomaly
- > Rate based anomalies
  - Less well understood
  - Requires highly complex understanding of “whole of system” performance



Lone et al, “Analysis of S–N data for new and corroded mooring chains at varying mean load levels using a hierarchical linear model”, Marine Structures, 91, September 2023



AMOG CPAD

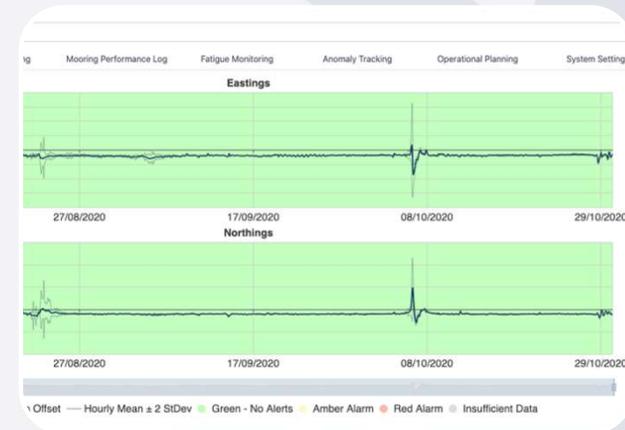
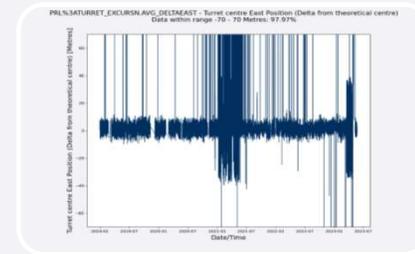




## What do we need to advance?

### Monitoring Techniques

- > Instrumentation designed for the long term
  - Consistent
  - Accurate
  - Available
  - Replaceable (physically or digitally)
- > Gather and return data without intervention
  - Subsea
  - Over the long-term
- > Get value from the data we have!
  - And plan for when that data stops...

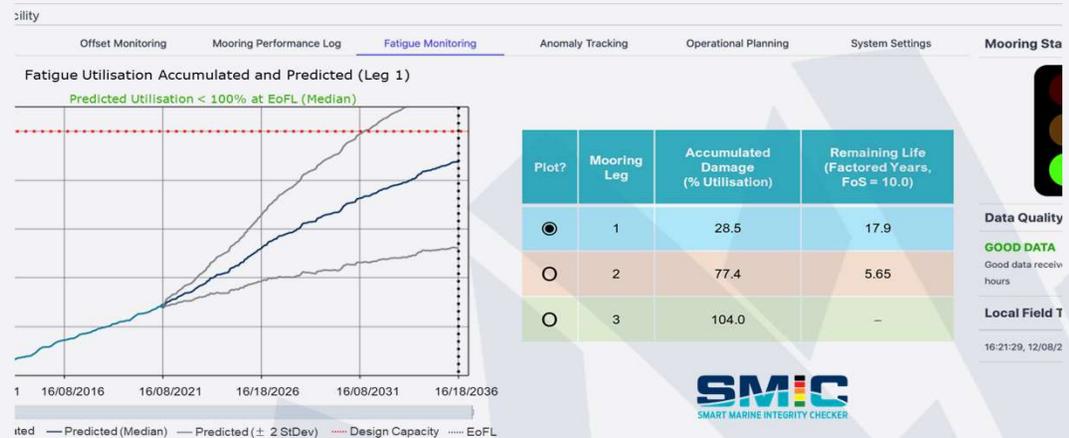




# What is reliability?

## Condition Projection

- > Get value from the data we have!
  - Consistent
  - Repeatable
  - Reliable
  - Diverse
- > Resilient when sensors do eventually fail
  - Cross calibration
  - Clear understanding of behaviours
- > Able to infer never measured states
  - Realtime physics-based not *BlackBox<sup>AI</sup>*
  - FOWT Sector innovating to improve ROI

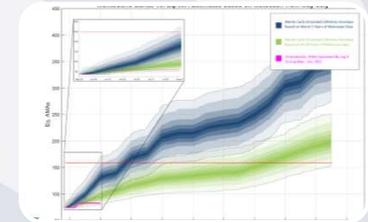
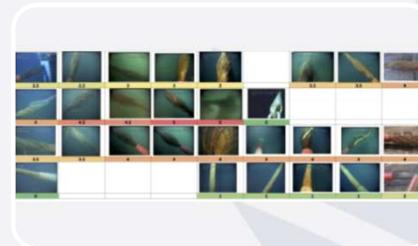
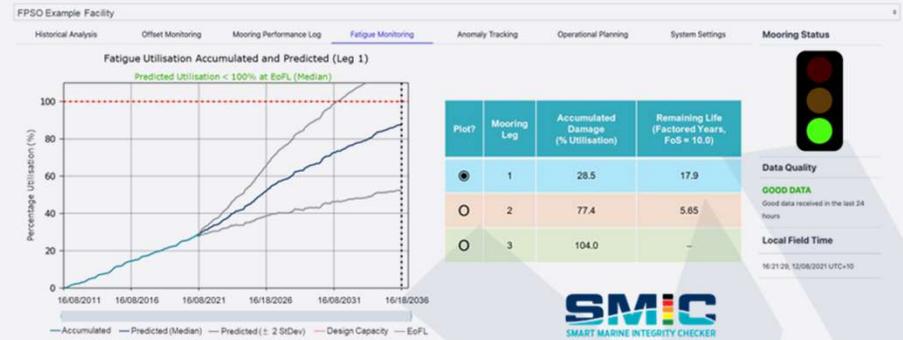




# What is reliability?

## Incurred Damage

- > Inferring rate-based degradation
  - Fatigue
  - Wear
- > Model and track specific event-based threats or changes in anomalies
  - Particularly important when end-of-life state can be defined
- > Using the prior techniques to get from
  - Inspect-Inspect-Anomaly-React, to
  - Predict-Inspect





## What is sustainability?

### *OPEX vs Anomalies/Incidents*

- > Managing inspection effort in late life
  - What you do and don't need to inspect
- > Knowing where in the bathtub-curve you mooring components are
  - Towards the sampling methodologies proposed for FOWT arrays
- > Long term planning for refurbishment/adjustment
  - For facilities with >25 year in-service goal
- > Contingency planning for an incident
  - Reinforcing to management what key infrastructure is
  - Ramping up to a change out takes time, especially in lean organisations



World Forum Offshore Wind e.V.

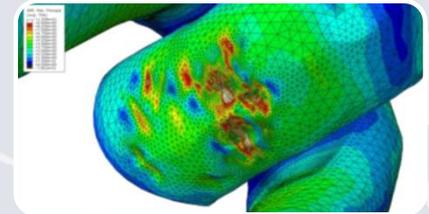




## What is sustainability?

### *Remediation vs Upgrade*

- > Is like-for-like even possible?
  - And is there time and bandwidth to redesign?
- > Addressing the anomaly within the original performance requirement
  - Anomaly is because of a design compromise/challenge?
- > Early life anomalies
  - What does management look like?
  - Consequences of compounding anomalies





## How Do We Achieve Resiliency?



### > When?

- Data driven insights into rate and event-based anomalies
- Data driven justification to defer inspections
- The data must be there...

### > Where?

- High quality, considered, inspections are repeated from a known baseline
- Inspection prioritizes quality over quantity – based on a clear understanding of the threats
- A plan and intent exists to manage any arising threats

### > What?

- Anomalies are threats which are tracked through out life against know thresholds
- Refurbishment is planned and simple
- Life extension is possible based on clearly demonstrable performance predictions

### > Why?

- An existing facility is an implied case to operate
- Larger deeper more complex moorings nearing end of life
- Failure is significant late-life unplanned, uninsured CAPEX, often in an O&M focusses organisation
- Success allows OPEX reduction or reassignment

*Engineering solutions*



**Expertise. Innovation. Value.**