DNV

WHEN TRUST MATTERS

Smart class initiatives

ROC Houston

Truls Richardsen, Regional Offshore Manager, North America

05 May 2022

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DNV service development focus areas

Reduce class induced cost

Reduce downtime due to class

From fixed intervals to risk based, data driven prescriptive maintenance

Smart maintenance - Increased reliability

Reduce unnecessary inspections

Survey arrangements adapted to the owner's asset integrity system

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Digital enablers

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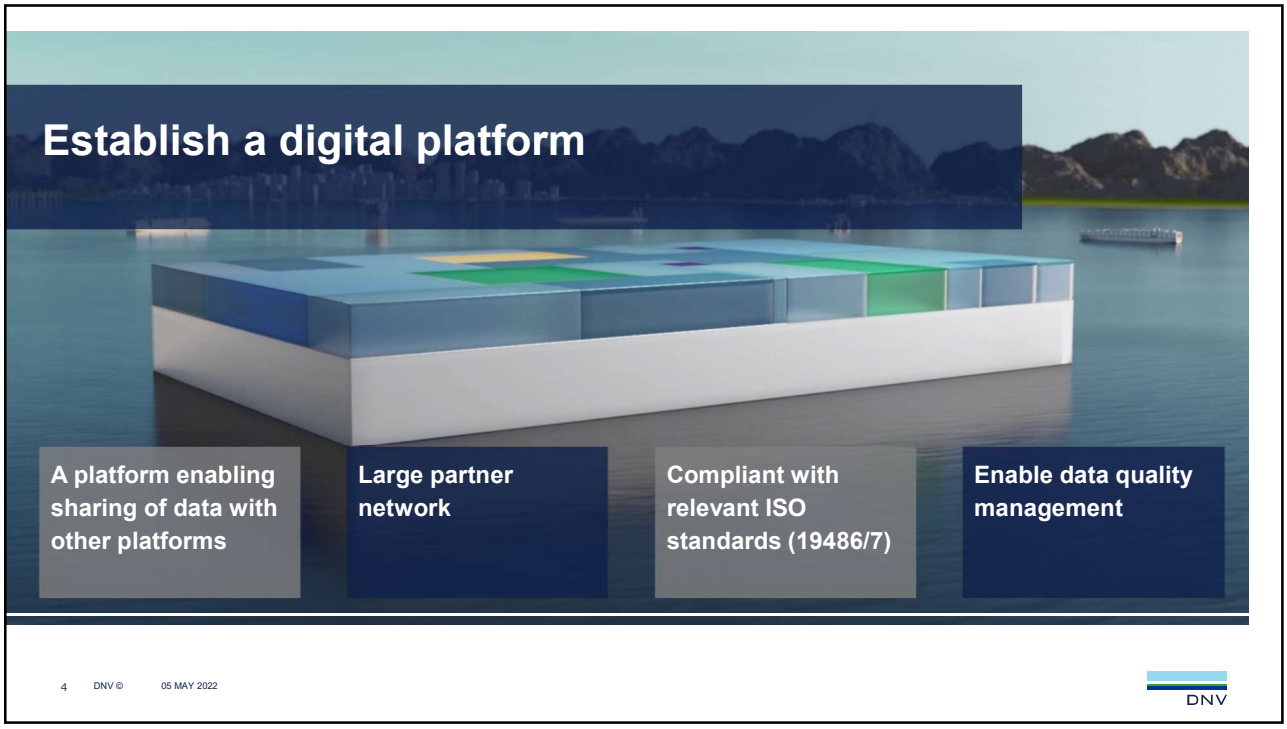

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Build a data collection infrastructure (D-INF)
Data collection infrastructure
Connectivity and data relay
Data security
Data quality management
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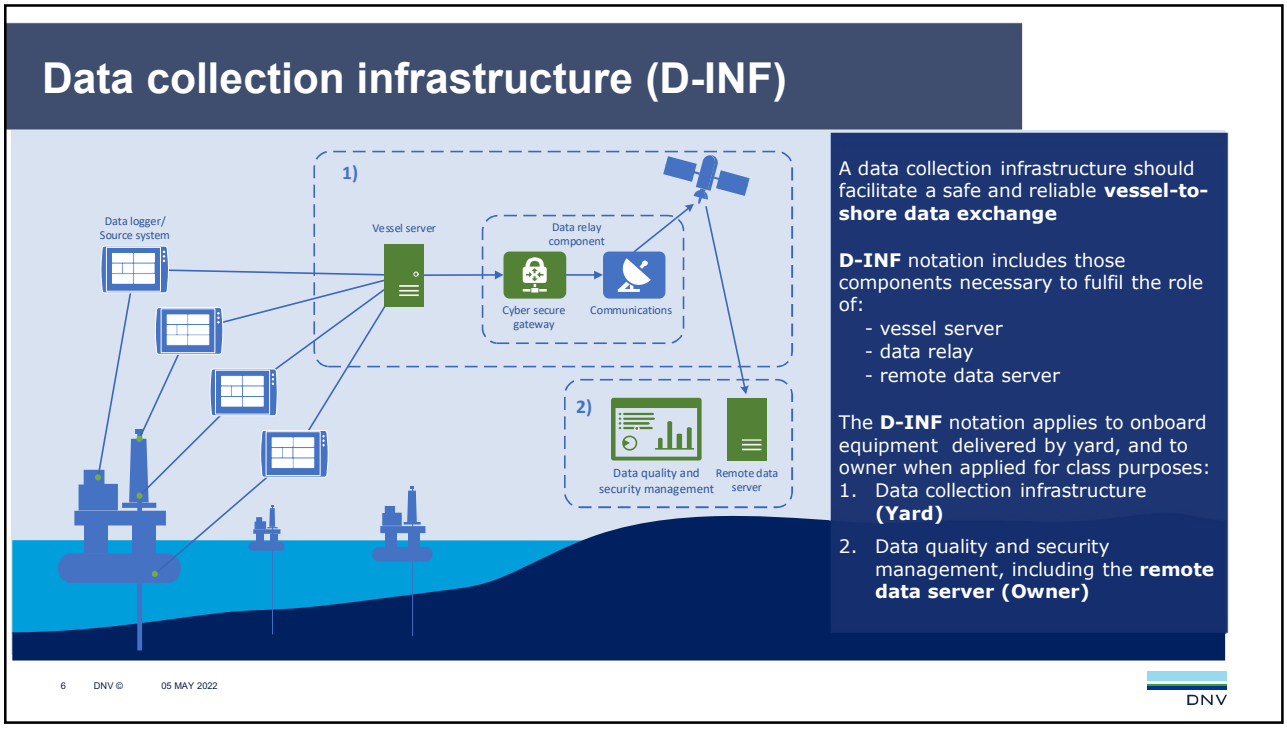
Data collection infrastructure (D-INF)
1)
Data logger/ Source system
Vessel server
Data relay component
Cyber secure gateway
Communications
2)
Data quality and security management
Remote data server
A data collection infrastructure should facilitate a safe and reliable vessel-to-shore data exchange
D-INF notation includes those components necessary to fulfil the role of:
- vessel server
- data relay
- remote data server
The D-INF notation applies to onboard equipment delivered by yard, and to owner when applied for class purposes:
1. Data collection infrastructure (Yard)
2. Data quality and security management, including the remote data server (Owner)
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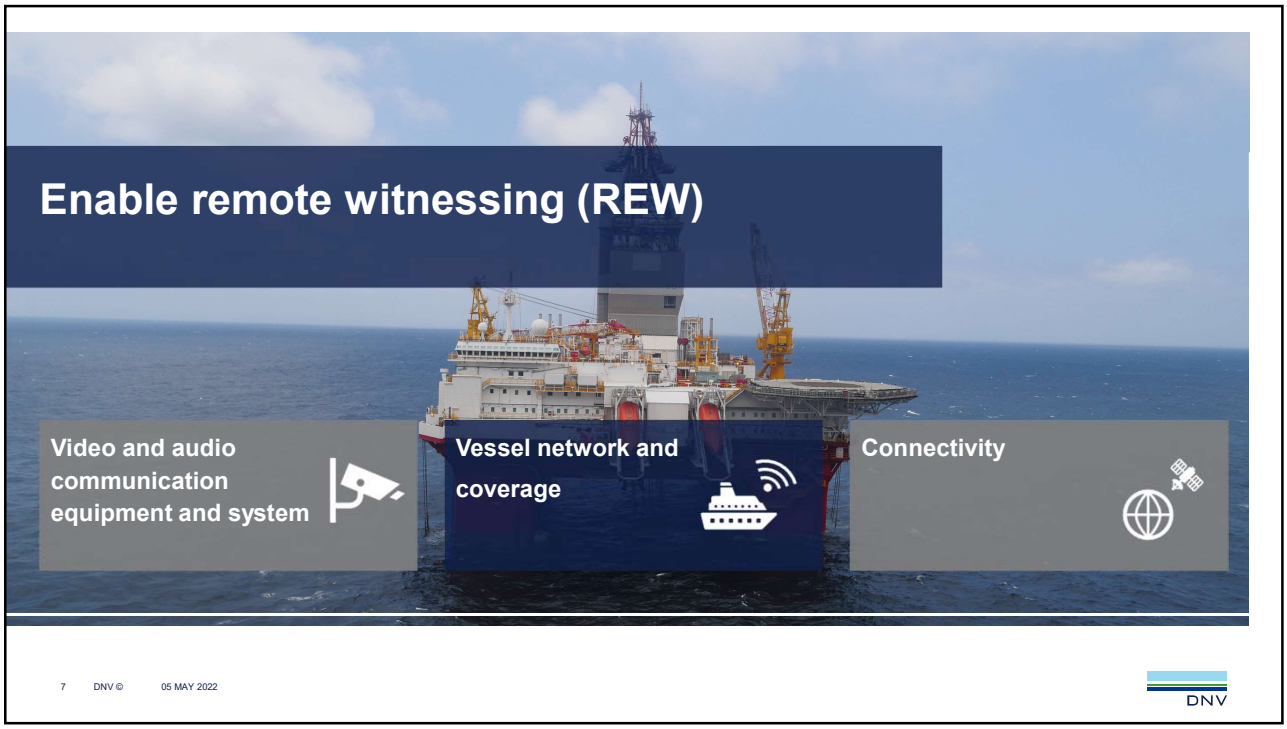
Enable remote witnessing (REW)
Video and audio communication equipment and system
Vessel network and coverage
Connectivity
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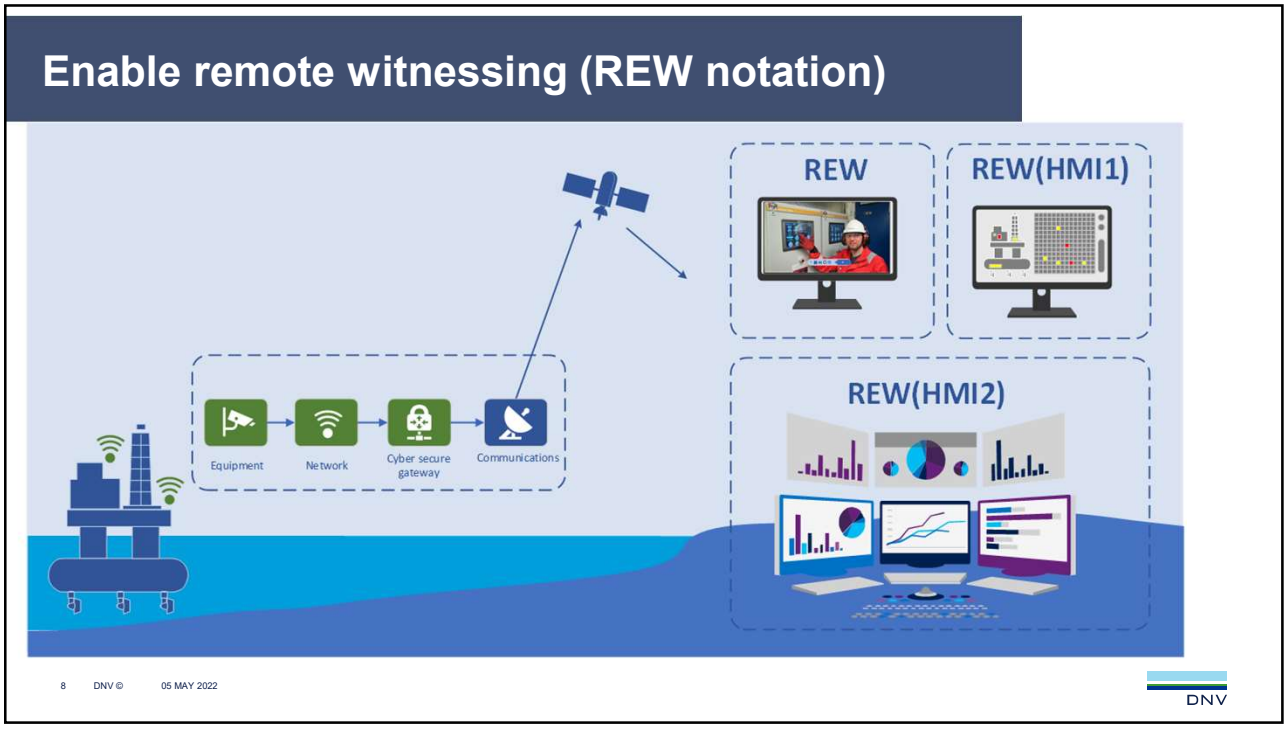
Enable remote witnessing (REW notation)
REW
REW(HMI1)
REW(HMI2)
Equipment
Network
Cyber secure gateway
Communications
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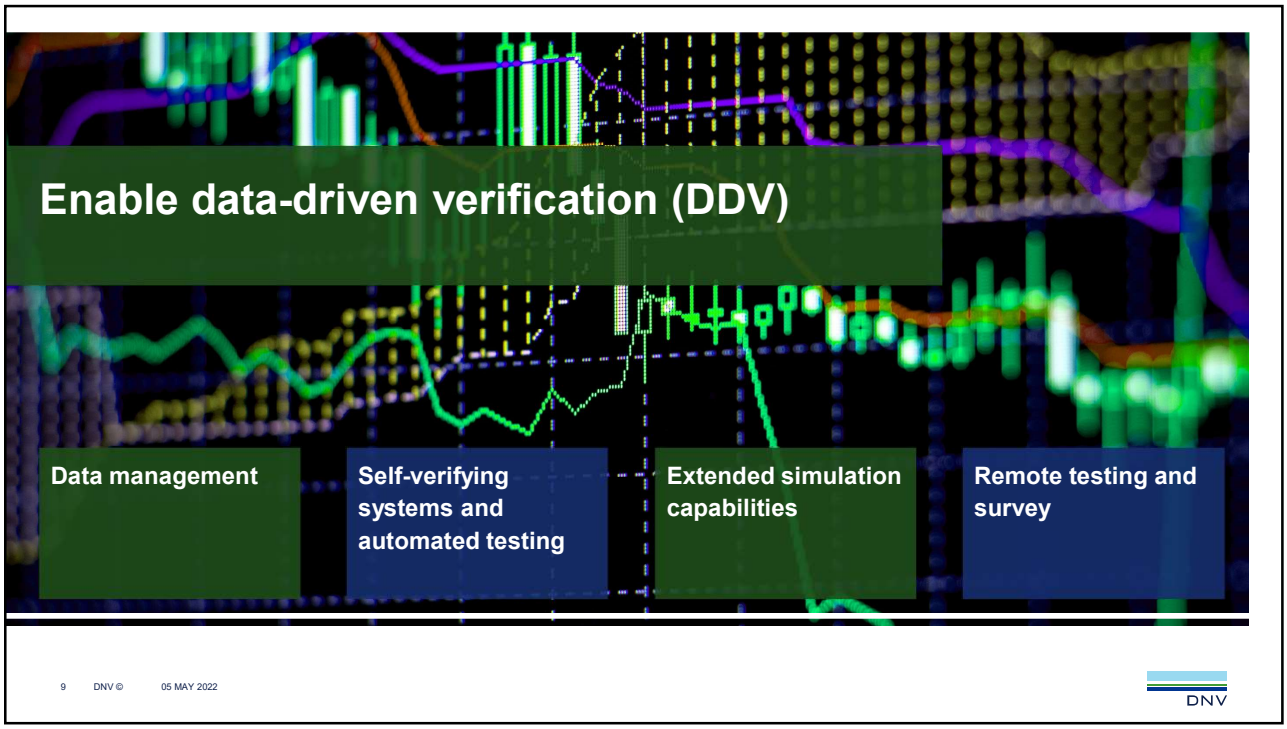
Enable data-driven verification (DDV)
Data management
Self-verifying systems and automated testing
Extended simulation capabilities
Remote testing and survey
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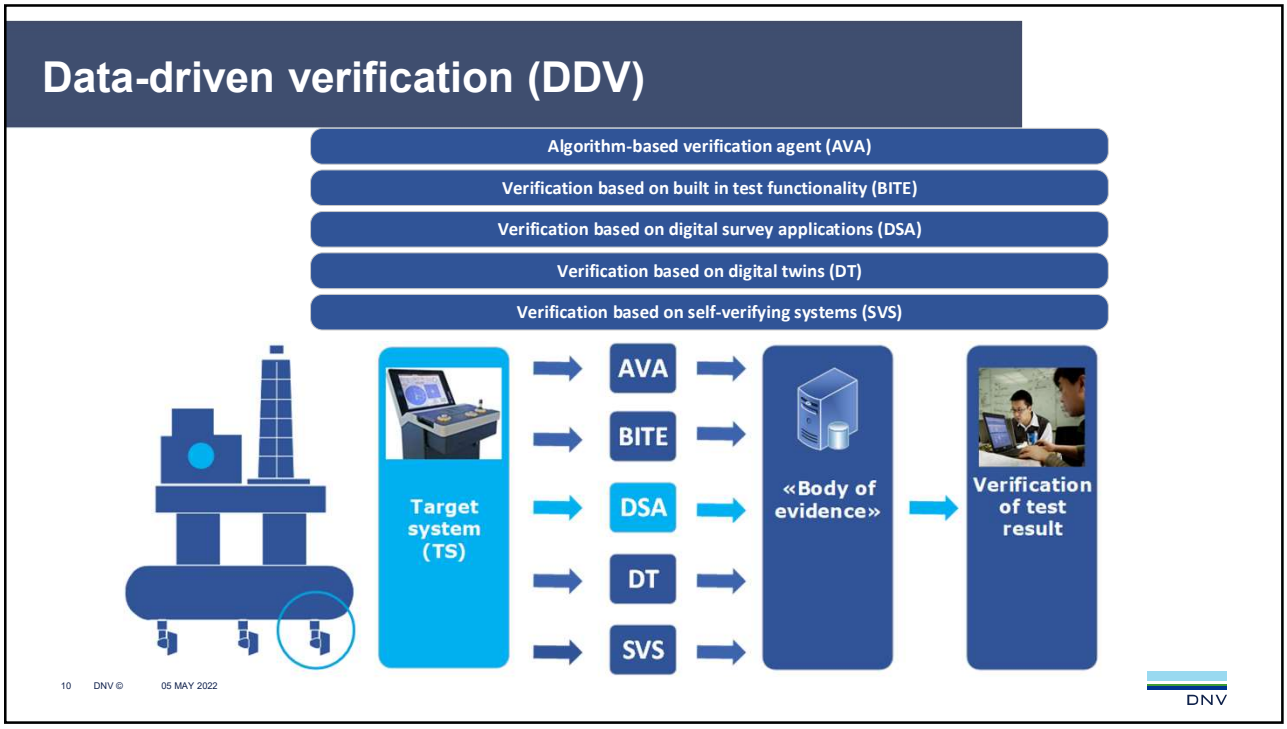
Data-driven verification (DDV)
Algorithm-based verification agent (AVA)
Verification based on built in test functionality (BITE)
Verification based on digital survey applications (DSA)
Verification based on digital twins (DT)
Verification based on self-verifying systems (SVS)
Target system (TS)
AVA
BITE
DSA
DT
SVS
«Body of evidence»
Verification of test result
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Reduced cost for asset integrity

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SMART Class - Arrangements and methodologies

Structural integrity

- Risk based Inspection (RBI)
- Shared Structural Inspection (SSI)
- BOTTOM SURVEY- inspection from the inside of the hull
- Corrosion management
- Remote inspection techniques (RiT)
  - Variety of techniques
  - Approved service supplier
- Fatigue utilization monitoring (FMS)
  - Site specific weather data (AIS)
  - Real sensor data

Maintenance

- Planned maintenance System (PMS)
  - Predetermined maintenance
  - Makers maintenance recommendations
- Condition Based Maintenance (CBM)
  - Machine monitoring, diagnostics and prediction (predictive maintenance)
  - Approved service supplier
- Reliability Centred Maintenance
  - RCM analysis
  - Maintenance supportability
  - Predetermined maintenance
  - Predictive maintenance *(New)*
- Spare part management

Programmes

- Dynamic Positioning (DP)
  - Continuous/distributed test scope
- POSMOOR Integrity management
  - Enhanced assurance
  - Approved service supplier
- Crane (Condition assessment)
  - Usage and condition logging
  - Condition based maintenance

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Reduced cost in operation Machinery systems

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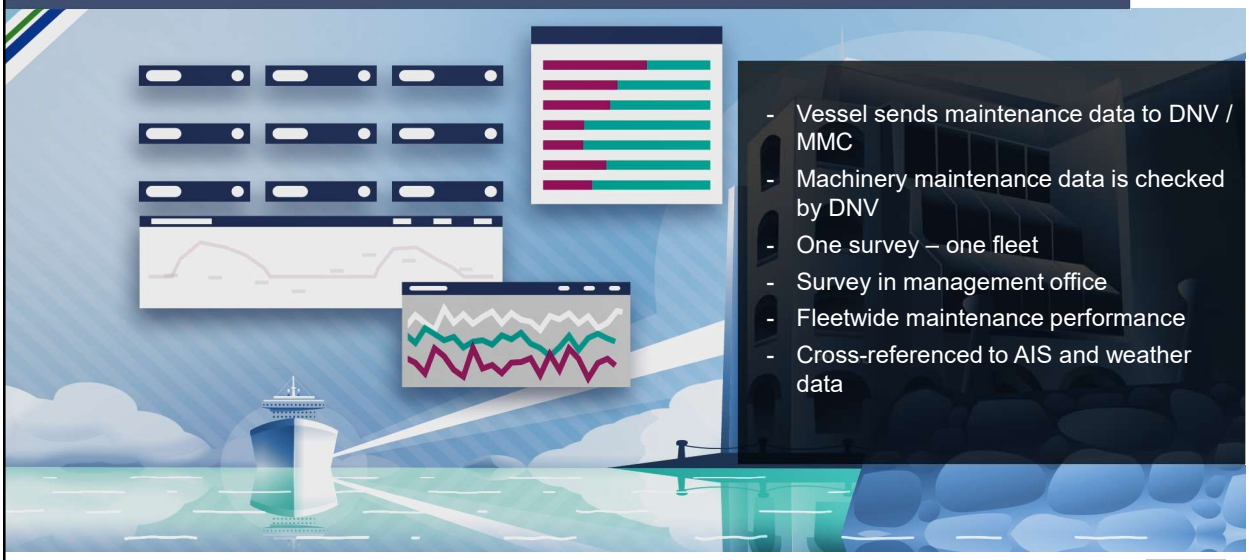
Machinery Maintenance Connect (MMC)



- Vessel sends maintenance data to DNV / MMC
- Machinery maintenance data is checked by DNV
- One survey – one fleet
- Survey in management office
- Fleetwide maintenance performance
- Cross-referenced to AIS and weather data

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MMC - Added value

Added value for users of MMC survey arrangement

- Less **time spent on surveys** (on annual and initial)
- Less **interference** with normal operation
- Detailed **insight** of vessel maintenance
- Delivering data analytics and **decision support** to owner to optimize maintenance
- Direct **feedback** to Fleet Management
  - Fleet and vessel overview
  - One survey for the whole fleet
- Available for units not in DNV class

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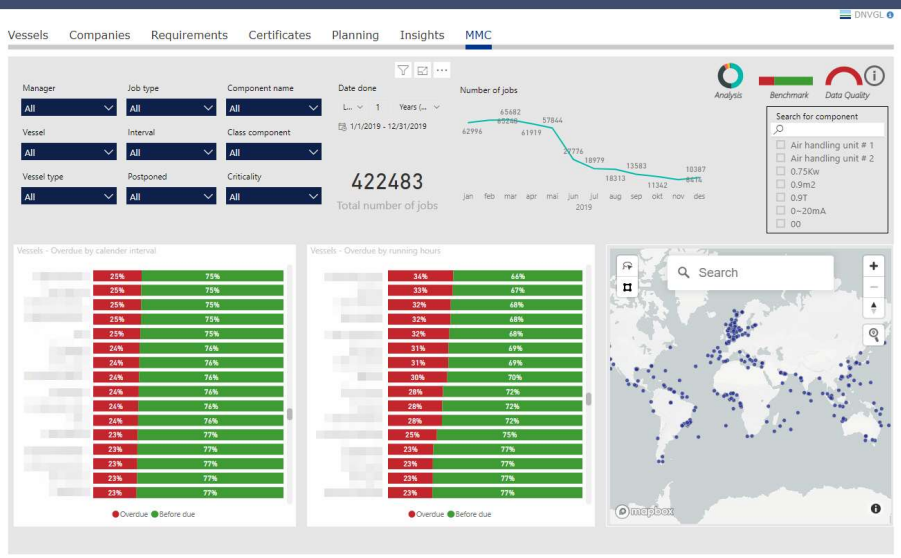
MMC - Fleet Overview



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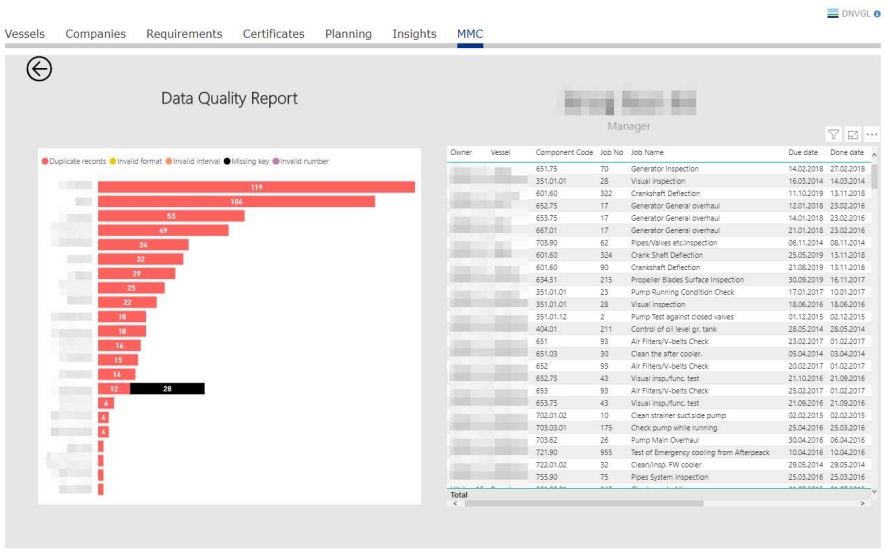
MMC - Data Quality Report



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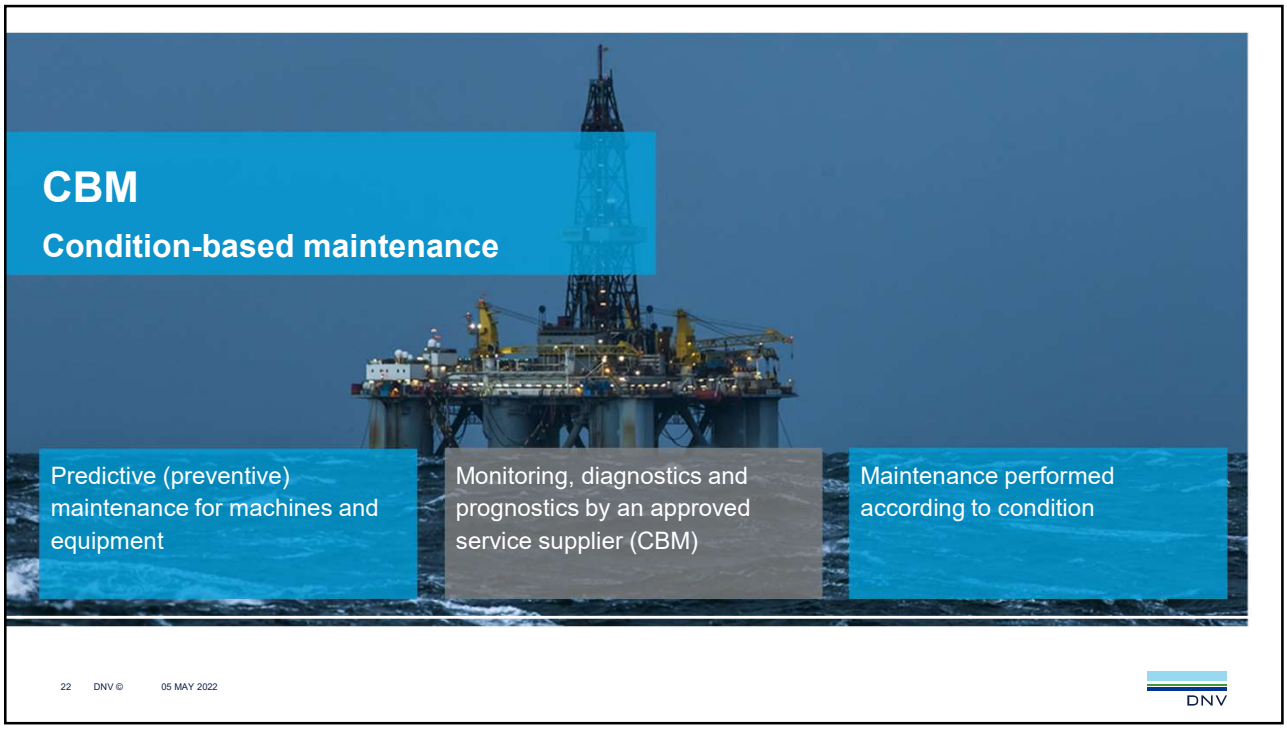

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Reduced cost in operation
Structural items

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Structural integrity – Risk Based Inspection (RBI)

	Default	RBI – qualitative	RBI – probabilistic
Level	Basic (1st)	Intermediate (2nd)	Advanced (3rd)
Application	All	All or parts	Parts or all
Scope	Generic for vessel type	Generic + design/fabrication details for unit	Tailormade for unit, utilizing historical findings and degradation mechanisms
Scope update	Rule updates	Improved design/fabrication	Continuous after inspections

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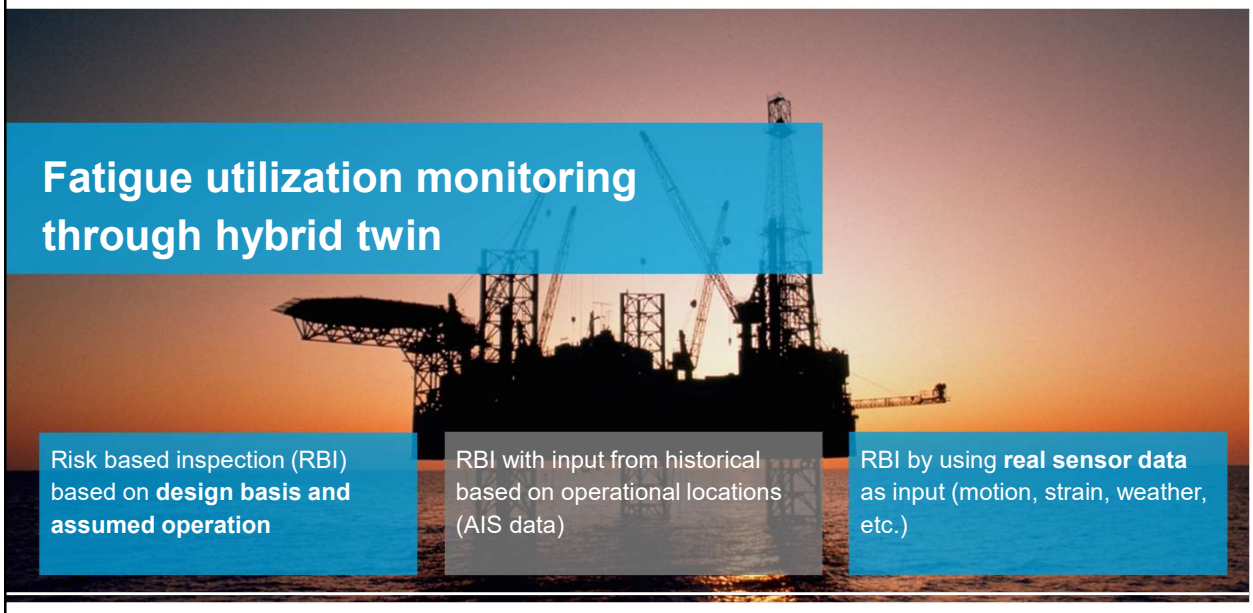

Fatigue utilization monitoring through hybrid twin

Risk based inspection (RBI) based on **design basis and assumed operation**

RBI with input from historical based on operational locations (AIS data)

RBI by using **real sensor data** as input (motion, strain, weather, etc.)

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Towards optimized structure inspections and operability

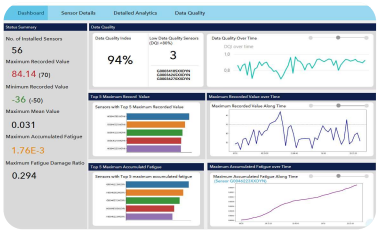
Sensors System

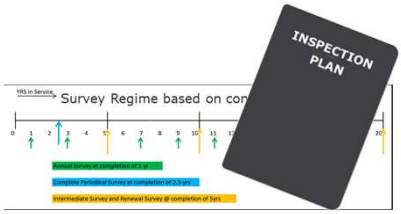
HYBRID TWIN
NUMERICAL TWIN

Global Insight and foresight
Alarms on fatigue and stress levels
Web based dashboard

SHIPMANAGER™
+
RBI

Optimized
Inspection Regime
and operability





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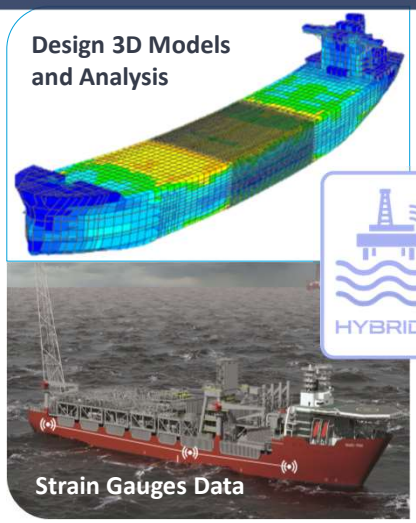
Hybrid Twin – based on sensor input



Real time response on hybrid twin

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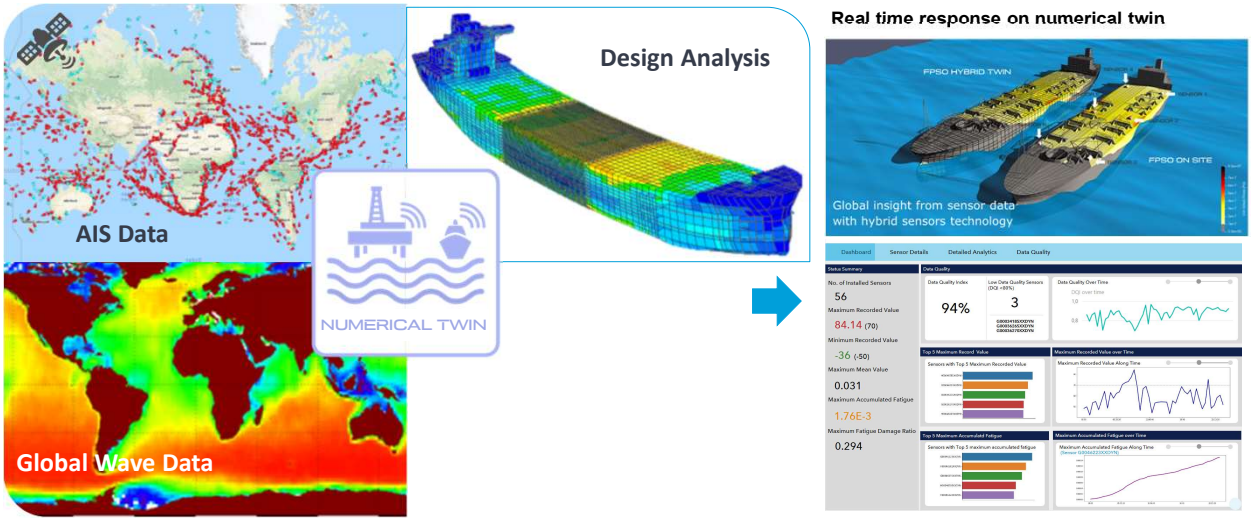
Numerical Twin – based on wave data input



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Tank inspection with remote inspection techniques

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Remote Inspection techniques - Drones

DNV has developed a survey scheme for drones and other remote inspection techniques

Can be carried out by 3rd party drone companies qualified by DNV

DNV survey scheme in place for drones and other remote inspection techniques

Autonomous Drone-based Surveys

The vision - develop an intelligent, autonomous drone

- The drone will fly, by itself, into a cargo or ballast tank
- Use artificial intelligence to spot rust, cracks or poor coating
- Measure steel thickness
- Compare with historical data to document the development of corrosion and cracks.

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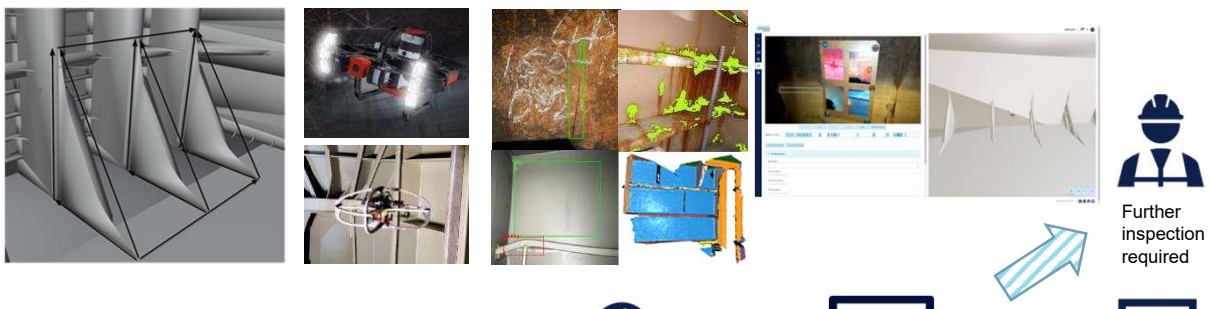
REDHUS – digitally assisted survey



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Crack detection – Drone inspection

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Defect detection algorithms – Crack & Corrosion

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Deformation detection

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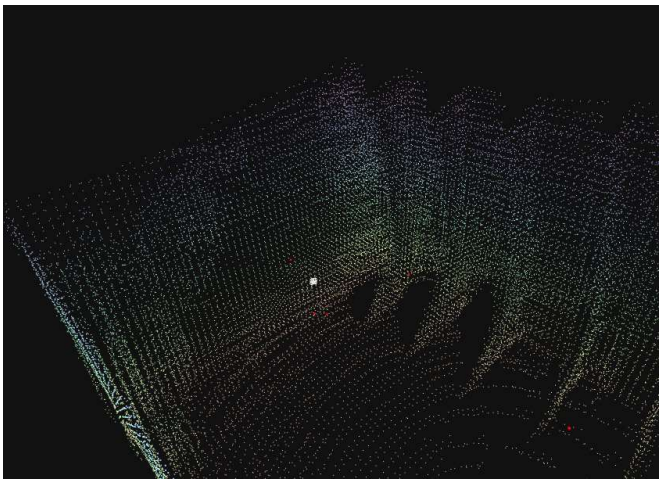
Point cloud generated by lidar on drone - Simultaneous Localization and Mapping (SLAM)



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Video inspection tool – independent verification of the AI

3D viewer placeholder

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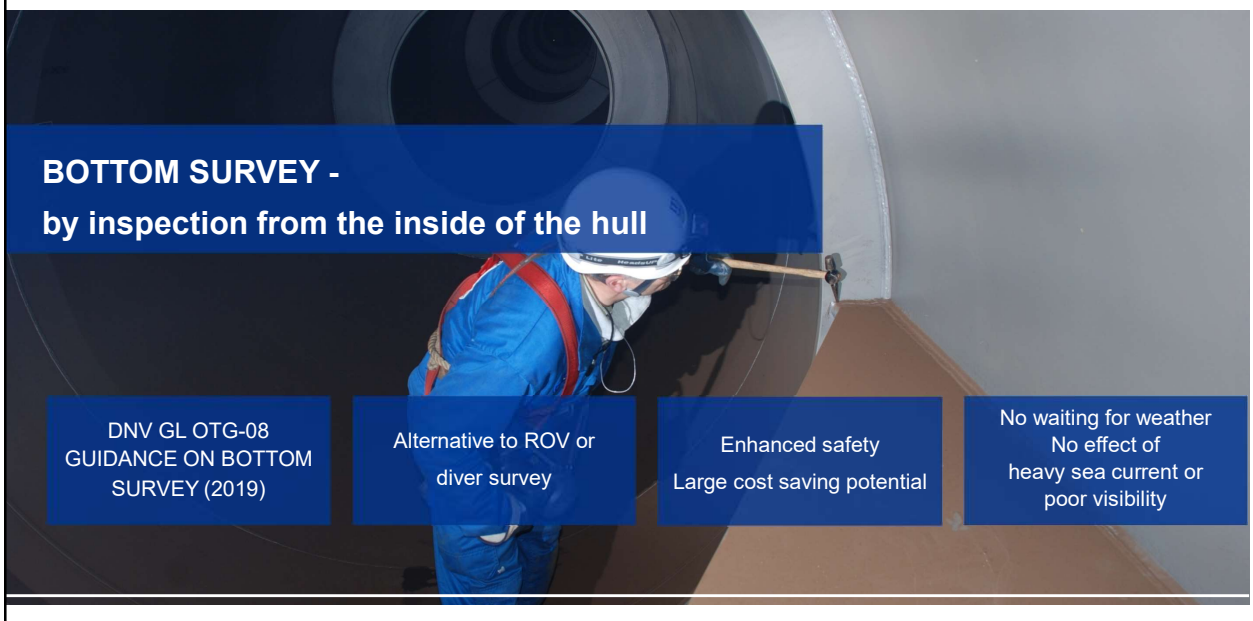

BOTTOM SURVEY - by inspection from the inside of the hull

DNV GL OTG-08 GUIDANCE ON BOTTOM SURVEY (2019)

Alternative to ROV or diver survey

Enhanced safety
Large cost saving potential

No waiting for weather
No effect of heavy sea current or poor visibility

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BOTTOM SURVEY -
by inspection from the inside of the hull

Applicability
- All types of units
- Similar level of safety - to fulfil regulations

Main Benefits
- Beneficial in areas of pour visibility or harsh environments
- Significant cost saving potential

DNV-CG-0608

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Reduced cost in operation
Mooring systems

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POSMOOR integrity management

Logging usage and operational parameters to determine utilization and condition

Reduced cost due to inspection and line change out based on usage and condition

Reduced cost due to maintenance and testing based on condition

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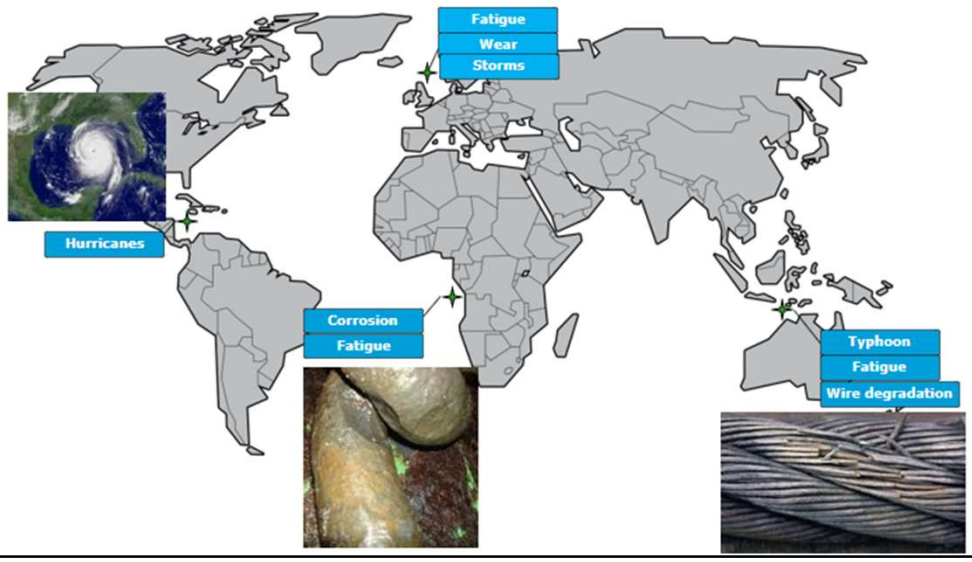
Understanding specific risks – by location



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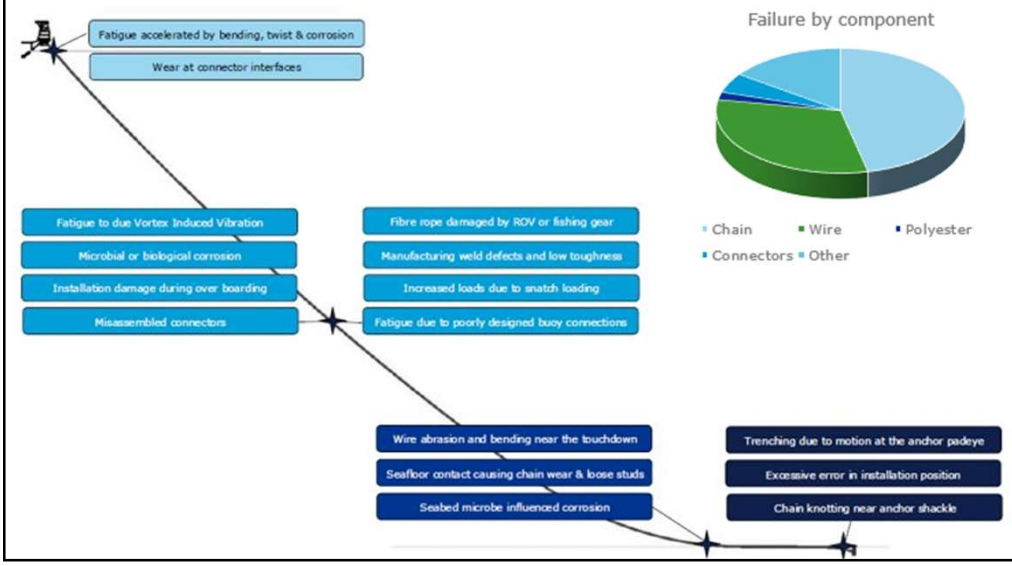
Understanding specific risks – by position in the line



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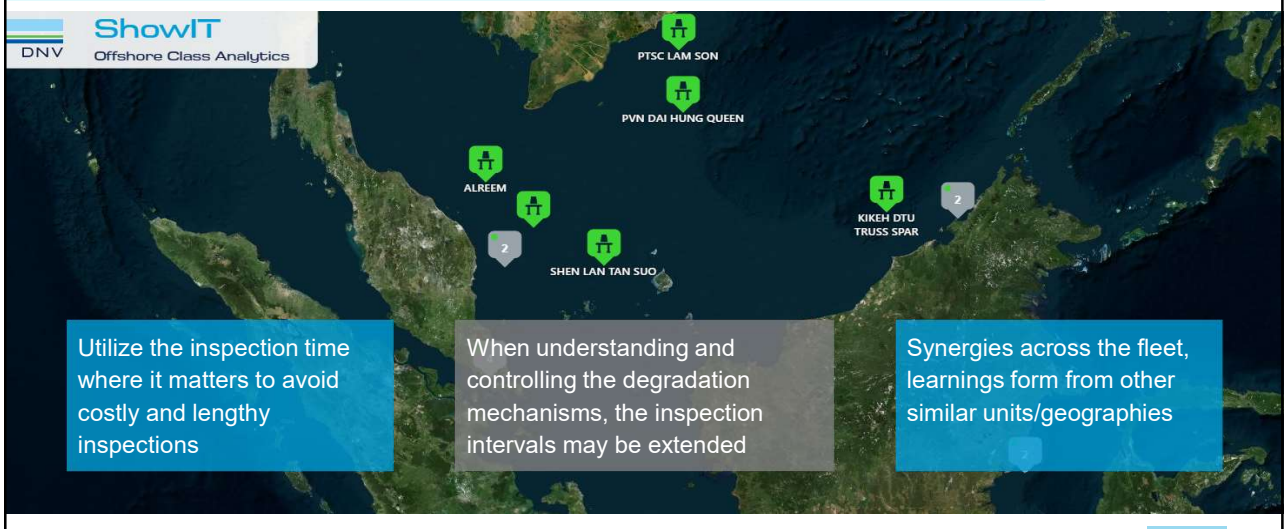
Benefits of a unit specific mooring program



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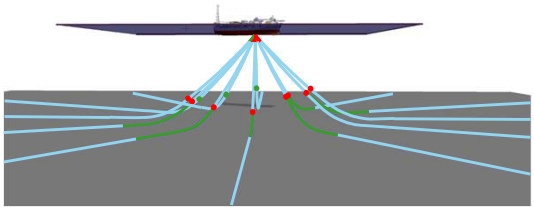
MOORING INTEGRITY DASHBOARD

Next inspection*: 2023



Line summary

Line	Utilization	Overall condition index (1 to 4)	Remaining (ULS) service life	Remaining fatigue life	Target in-service time	Time to next inspection*	
Line 1		1.7	14.2 years	16.2 years	13	--	See details
Line 2		1.8	16.1 years	15.9 years	13	--	See details
Line 3		2.4	16.2 years	14.1 years	13	--	See details
Line 4		2.6	13.7 years	14.0 years	13	2023	See details
Line 5		2.1	14.0 years	13.8 years	13	2023	See details
Line 6		1.8	25.3 years	22.1 years	13	--	See details
Line 7		1.6	18.8 years	17.6 years	13	--	See details
Line 8		2.0	14.1 years	15.2 years	13	--	See details
Line 9		2.3	13.6 years	12.1 years	13	2023	See details
Line 10		2.3	12.5 years	12.8 years	13	--	See details
Line 11		1.9	15.2 years	13.2 years	13	--	See details
Line 12		1.5	19.6 years	19.6 years	13	--	See details

* Suggested inspection planning
Last updated on 1 December 2020

Access condition-based inspection plan | Access inspection planning

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MOORING INTEGRITY DASHBOARD

FPSO XXXXXXXX – IMO XXXXXXXX

Vessel age	10.7 years	**Age at next mandatory survey**	15 years
Age at previous survey	9.9 years	**Age at next suggested survey**	13.4 years

Condition-based inspection plan

The condition-based inspection (CBI) plan is established according to the Mooring Integrity Dashboard (MID) engine which will select mooring lines to inspect based on the minimum scope engine and the MID statistics engine (machine learning based on previously reported findings on this and similar units). The engine goal is to reduce the uncertainty in the fatigue damage estimation. The inspection plan is continuously updated.

Line	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Line 1										GVI+CVI
Line 2										
Line 3										
Line 4			GVI+CVI+NDT			GVI+CVI				
Line 5			GVI+CVI+NDT							GVI+CVI
Line 6										
Line 7						GVI+CVI				
Line 8						GVI+CVI				
Line 9			GVI+CVI+NDT							
Line 10										
Line 11										GVI+CVI
Line 12										GVI+CVI

GVI: General Visual Inspection | CVI: Close Visual Inspection | NDT: Non-Destructive Testing | LT: Line tension measurement

Last updated on 1 December 2020

Access inspection planning | Back

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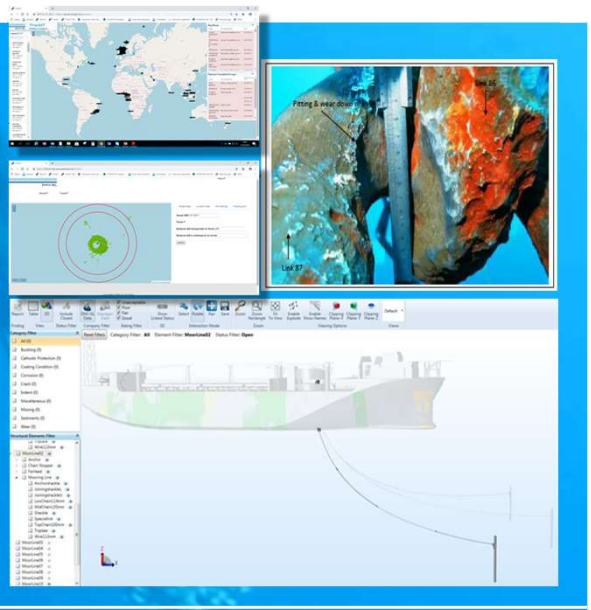
From Reactive to Proactive:

- Utilizing experience/data to forecast potential hazards and service life
- Survey scope is defined as targeted actions increases survey quality
- DNV-RU-OU-0300, Mooring Integrity Management



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Smart class initiatives

Truls.Richardsen@dnv.com

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