



Slide 1 features the DNV logo in the top left and the slogan "WHEN TRUST MATTERS" in the top right. The background is white with a decorative pattern of blue dots forming a large, stylized 'V' shape. The main title "Smart class initiatives" is centered in a large, dark blue font. Below the title, the text "ROC Houston" is displayed. At the bottom left, the presenter's name and date are listed: "Truls Richardsen, Regional Offshore Manager, North America" and "05 May 2022".

DNV

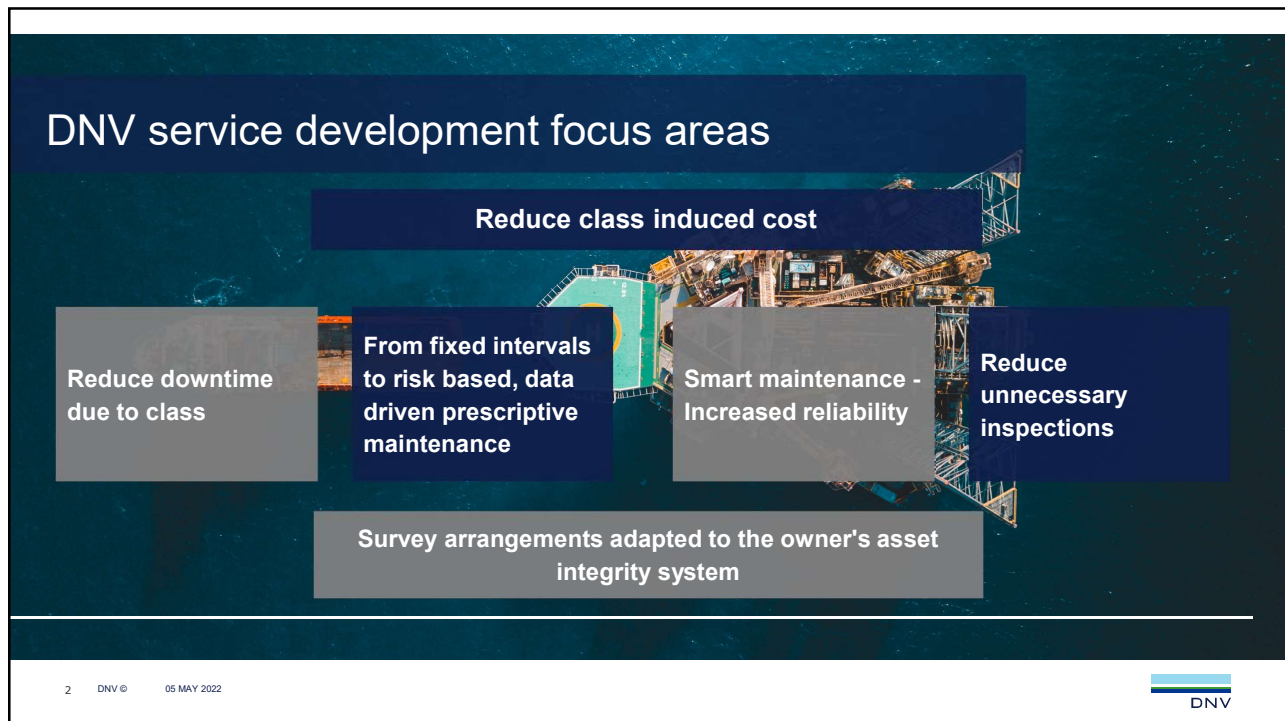
WHEN TRUST MATTERS

Smart class initiatives

ROC Houston

Truls Richardsen, Regional Offshore Manager, North America
05 May 2022

1



Slide 2 has a dark blue background with an image of an offshore oil rig. The title "DNV service development focus areas" is at the top left. A central box lists "Reduce class induced cost". Below this, four boxes describe specific initiatives: "Reduce downtime due to class", "From fixed intervals to risk based, data driven prescriptive maintenance", "Smart maintenance - Increased reliability", and "Reduce unnecessary inspections". A bottom box states "Survey arrangements adapted to the owner's asset integrity system". The footer includes the page number "2", the DNV logo, and the date "05 MAY 2022".


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

2 DNV © 05 MAY 2022



DNV

2

Digital enablers

3 DNV © 05 MAY 2022



3

Establish a digital platform

A platform enabling sharing of data with other platforms

Large partner network

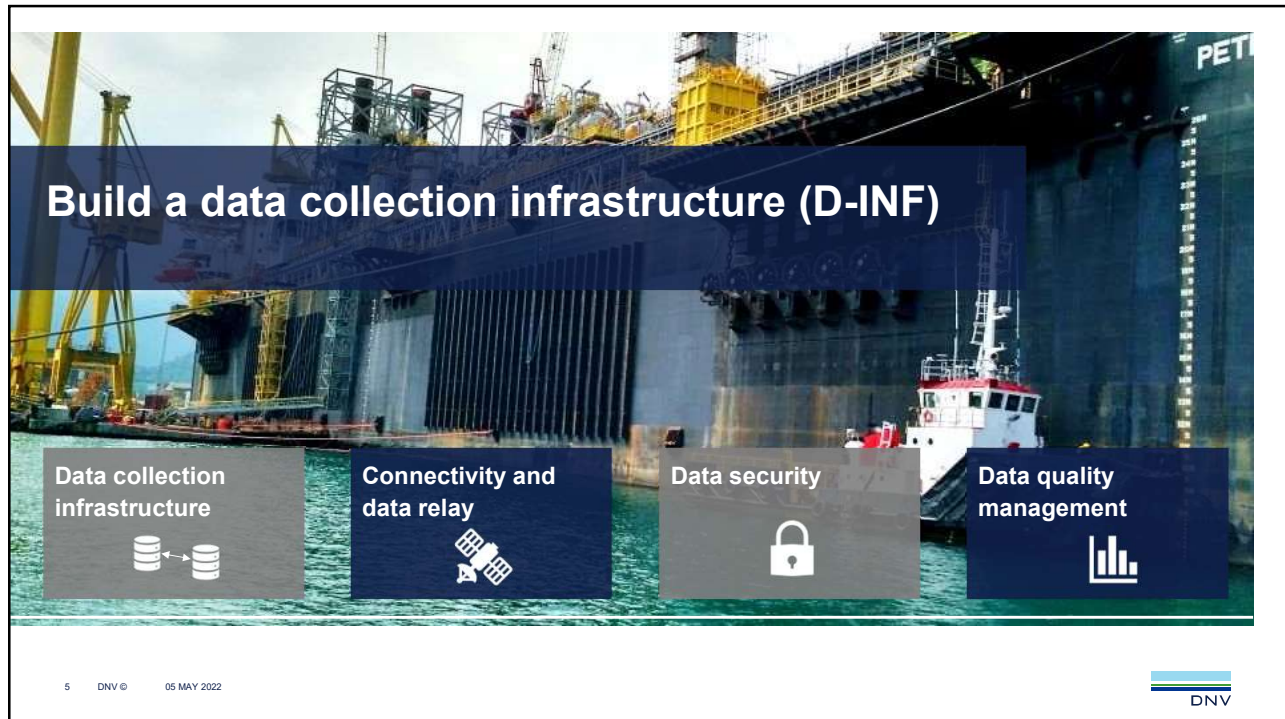
Compliant with relevant ISO standards (19486/7)

Enable data quality management

4 DNV © 05 MAY 2022




4




Build a data collection infrastructure (D-INF)


Data collection infrastructure




Connectivity and data relay




Data security



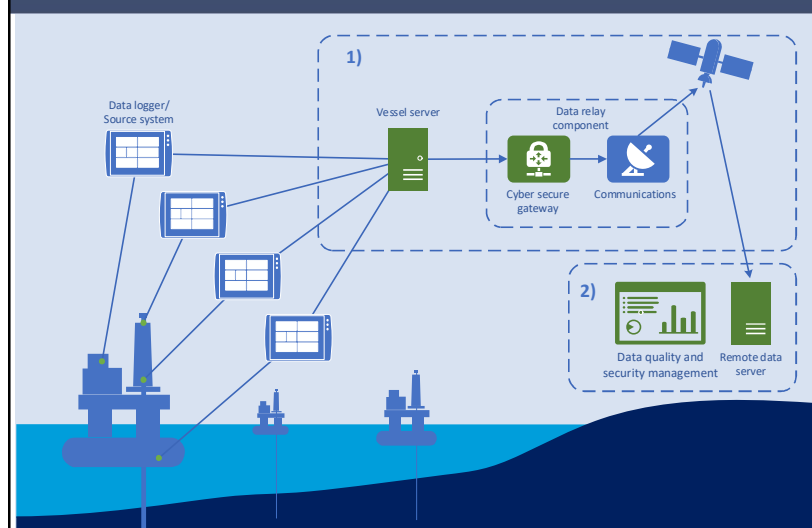
Data quality management



5 DNV © 05 MAY 2022


5

Data collection infrastructure (D-INF)




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)**

6 DNV © 05 MAY 2022


6

Enable remote witnessing (REW)



Video and audio communication equipment and system 

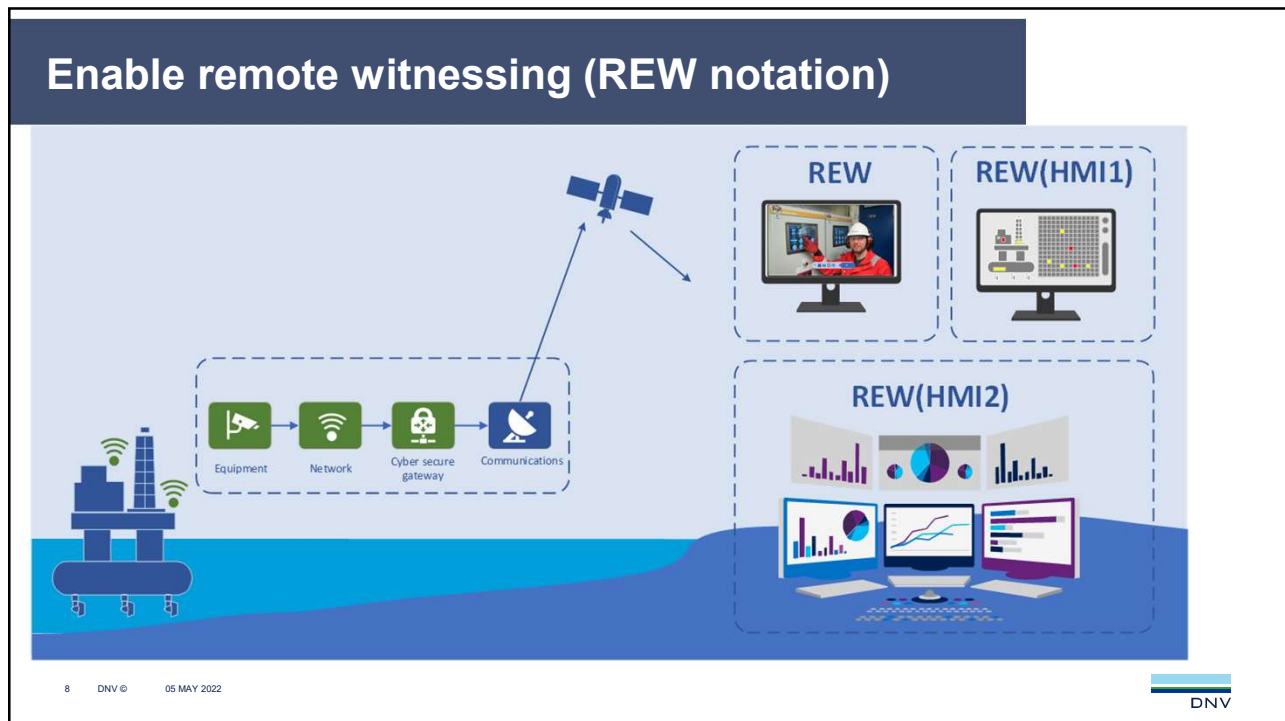
Vessel network and coverage 

Connectivity 

7 DNV © 05 MAY 2022 


7

Enable remote witnessing (REW notation)



The diagram illustrates the REW notation architecture. On the left, an offshore vessel is connected to a system consisting of four components: Equipment (video camera), Network (Wi-Fi), Cyber secure gateway (lock icon), and Communications (satellite). A satellite in orbit receives data from the vessel and transmits it to three remote monitoring stations:

- REW:** A single monitor displaying a live video feed of a worker on the vessel.
- REW(HMI1):** A monitor displaying a control room interface with various data points and charts.
- REW(HMI2):** A workstation with multiple monitors displaying comprehensive data dashboards, including bar charts, pie charts, and line graphs.

8 DNV © 05 MAY 2022 

8

Enable data-driven verification (DDV)

Data management

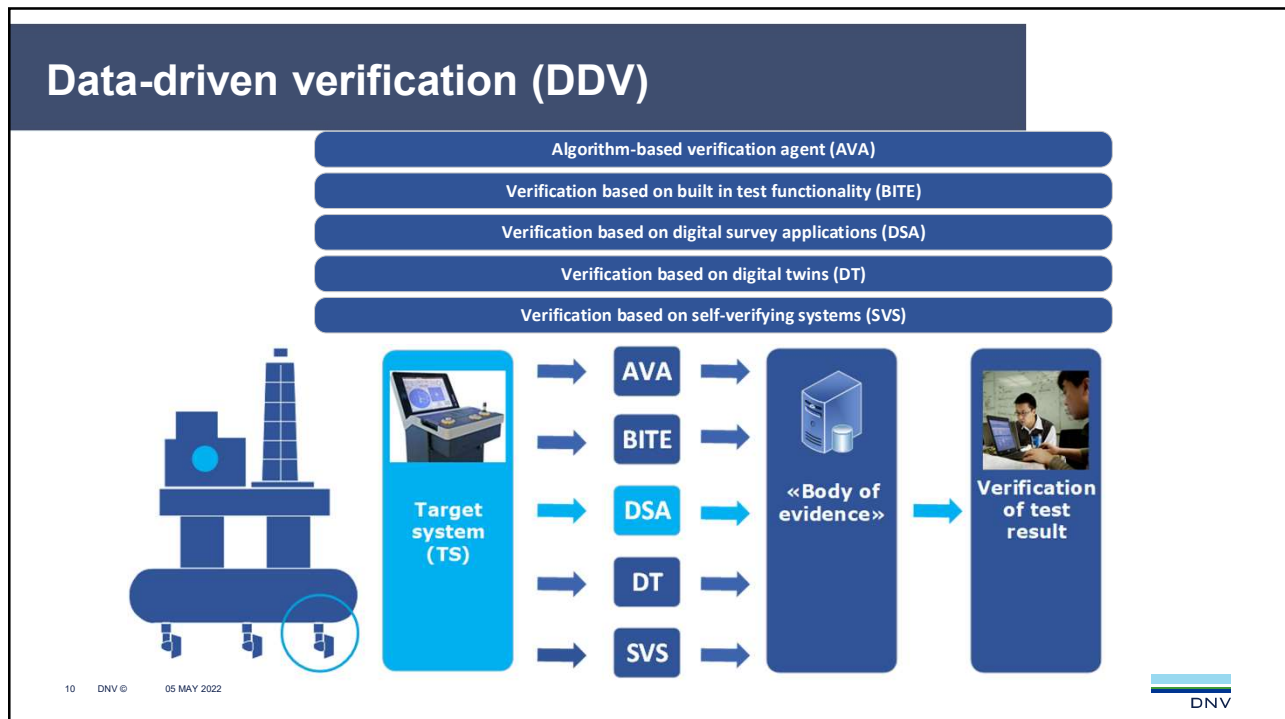
Self-verifying systems and automated testing

Extended simulation capabilities

Remote testing and survey


9 DNV © 05 MAY 2022

9



10

Invest in cyber security to reduce risk of intentional and un-intentional events



- Remote access
- Zone boundaries
- Patch management
- ID and authentication of endpoints
- Auditable events
- Security functionality verification
- Malicious code protection
- Use control for portable and mobile devices
- Protection in transit
- Human user ID and authentication
- Account management

To be integrated in management system




Secure operational, safety and control systems



Cover components, systems and FPSO



Secure design and supplier integration



OUR SERVICES

11 DNV © 05 MAY 2022 

11

Reduced cost for asset integrity

12 DNV © 05 MAY 2022 

12



Reducing the OPEX by using more effective systematics and methodology

The choice of systematics and methodology need to be based on the **capacity** in the organization and **volume**

Right **balance** between the **effect** (reduction in OPEX) and the **resources** (cost, people, systems, etc.) needed to achieve it

Cost

Resources

OPEX


Complexity

13 DNV © 05 MAY 2022 

13

SMART Class - Arrangements and methodologies

Structural integrity	Maintenance	Programmes
<ul style="list-style-type: none"> ▪ Risk based Inspection (RBI) ▪ Shared Structural Inspection (SSI) ▪ BOTTOM SURVEY- inspection from the inside of the hull ▪ Corrosion management ▪ Remote inspection techniques (RiT) <ul style="list-style-type: none"> – Variety of techniques – Approved service supplier ▪ Fatigue utilization monitoring (FMS) <ul style="list-style-type: none"> – Site specific weather data (AIS) – Real sensor data 	<ul style="list-style-type: none"> ▪ Planned maintenance System (PMS) <ul style="list-style-type: none"> – Predetermined maintenance – Makers maintenance recommendations ▪ Condition Based Maintenance (CBM) <ul style="list-style-type: none"> – Machine monitoring, diagnostics and prediction (predictive maintenance) – Approved service supplier ▪ Reliability Centred Maintenance <ul style="list-style-type: none"> – RCM analysis – Maintenance supportability – Predetermined maintenance – Predictive maintenance (<i>New</i>) ▪ Spare part management 	<ul style="list-style-type: none"> ▪ Dynamic Positioning (DP) <ul style="list-style-type: none"> – Continuous/distributed test scope ▪ POSMOOR Integrity management <ul style="list-style-type: none"> – Enhanced assurance – Approved service supplier ▪ Crane (Condition assessment) <ul style="list-style-type: none"> – Usage and condition logging – Condition based maintenance

14 DNV © 05 MAY 2022 

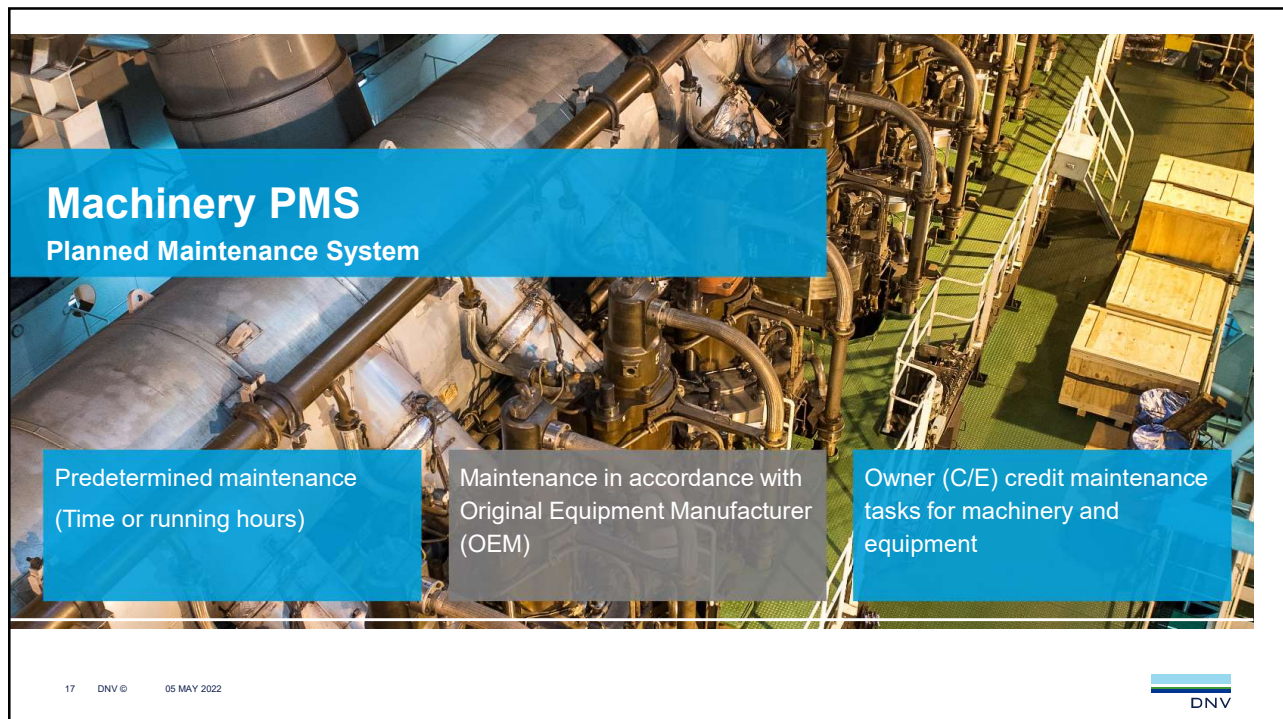
14

Reduced cost in operation Machinery systems

16 DNV © 05 MAY 2022



16




Machinery PMS
Planned Maintenance System

Predetermined maintenance
(Time or running hours)

Maintenance in accordance with
Original Equipment Manufacturer
(OEM)

Owner (C/E) credit maintenance
tasks for machinery and
equipment

17 DNV © 05 MAY 2022



17

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

18 DNV © 05 MAY 2022 

18

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

19 DNV © 05 MAY 2022 

19

MMC - Fleet Overview

DNVGL

Vessels Companies Requirements Certificates Planning Insights **MMC**

Manager: All | Job type: All | Component name: All

Vessel: All | Interval: All | Class component: All

Vessel type: All | Postponed: All | Criticality: All

Date done: 1 Years

422483
Total number of jobs

Number of jobs: 42996, 45882, 49248, 57844, 61919, 61776, 69279, 13583, 11342, 10387

Vessels - Overdue by calendar interval

25%	75%
25%	75%
25%	75%
25%	75%
25%	75%
24%	76%
24%	76%
24%	76%
24%	76%
24%	76%
24%	76%
23%	77%
23%	77%
23%	77%
23%	77%
23%	77%

Vessels - Overdue by running hours

34%	66%
33%	67%
32%	68%
32%	68%
32%	68%
31%	69%
31%	69%
30%	70%
29%	71%
29%	71%
28%	72%
28%	72%
28%	72%
25%	75%
23%	77%
23%	77%
23%	77%
23%	77%

Search for component

- Air handling unit # 1
- Air handling unit # 2
- 0.75kw
- 0.9m2
- 0.9T
- 0-20mA
- 00

Map: Search [] [+] [-] [x]

20 DNV © 05 MAY 2022 DNV

20

MMC - Data Quality Report

DNVGL

Vessels Companies Requirements Certificates Planning Insights **MMC**

Data Quality Report

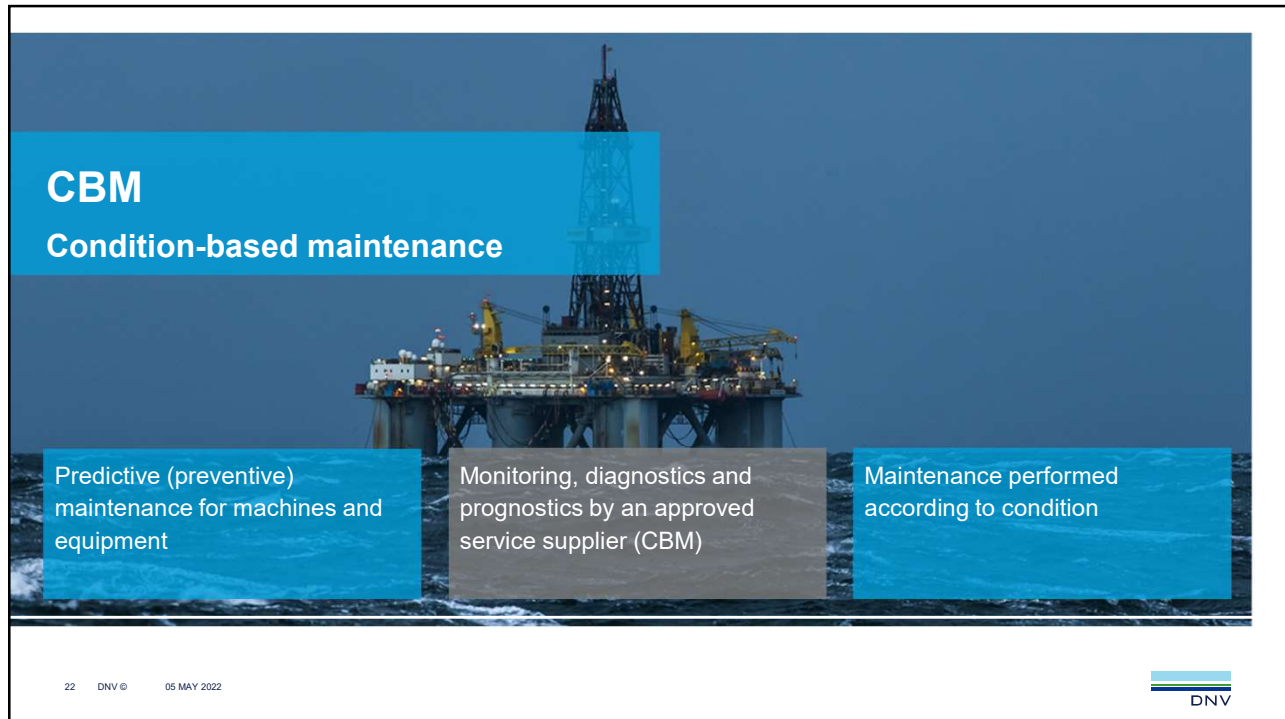
Legend: Duplicate records (red), Invalid format (yellow), Invalid interval (orange), Missing key (grey), Invalid number (black)

Owner	Vessel	Component Code	Job No	Job Name	Due date	Done date
[redacted]	[redacted]	651.75	70	Generator Inspection	14.02.2018	27.02.2018
[redacted]	[redacted]	351.01.01	28	Visual Inspection	16.03.2014	14.03.2014
[redacted]	[redacted]	601.60	322	Crankshaft Deflection	11.10.2019	13.11.2018
[redacted]	[redacted]	652.75	17	Generator General overhaul	12.01.2016	23.02.2016
[redacted]	[redacted]	653.75	17	Generator General overhaul	14.01.2016	23.02.2016
[redacted]	[redacted]	667.01	17	Generator General overhaul	21.01.2016	23.02.2016
[redacted]	[redacted]	703.90	62	Pipes/Valves etc. inspection	06.11.2014	03.11.2014
[redacted]	[redacted]	501.60	324	Crank Shaft Deflection	25.02.2019	13.11.2018
[redacted]	[redacted]	601.60	90	Crankshaft Deflection	21.08.2019	13.11.2018
[redacted]	[redacted]	634.51	215	Propeller Blades Surface Inspection	30.09.2019	16.11.2017
[redacted]	[redacted]	351.01.01	23	Pump Running Condition Check	17.01.2017	10.01.2017
[redacted]	[redacted]	351.01.01	28	Visual Inspection	18.06.2016	18.06.2016
[redacted]	[redacted]	351.01.12	2	Pump Test against closed valves	01.12.2015	03.12.2015
[redacted]	[redacted]	404.01	211	Control of oil level gr. tank	28.05.2014	28.05.2014
[redacted]	[redacted]	651	93	Air Filters/V-belts Check	23.02.2017	01.02.2017
[redacted]	[redacted]	651.03	30	Clean the after cooler	05.04.2014	05.04.2014
[redacted]	[redacted]	652	93	Air Filters/V-belts Check	20.02.2017	01.02.2017
[redacted]	[redacted]	652.75	43	Visual Insp./func. test	21.10.2016	21.09.2016
[redacted]	[redacted]	653	93	Air Filters/V-belts Check	25.02.2017	01.02.2017
[redacted]	[redacted]	653.75	43	Visual Insp./func. test	21.09.2016	21.09.2016
[redacted]	[redacted]	702.01.02	10	Clean steamer suction pump	02.02.2015	02.02.2015
[redacted]	[redacted]	703.03.01	175	Check pump while running	33.04.2016	25.03.2016
[redacted]	[redacted]	703.62	26	Pump Main Overhaul	30.04.2016	06.04.2016
[redacted]	[redacted]	721.90	955	Test of Emergency cooling from Afterpeak	10.04.2016	10.04.2016
[redacted]	[redacted]	722.01.02	36	Clean/Insp. FW cooler	29.05.2014	29.05.2014
[redacted]	[redacted]	755.90	75	Pipe System Inspection	25.03.2016	25.03.2016
Total						

21 DNV © 05 MAY 2022 DNV

21

10
09 May 2022




CBM
Condition-based maintenance

Predictive (preventive) maintenance for machines and equipment


Monitoring, diagnostics and prognostics by an approved service supplier (CBM)

Maintenance performed according to condition

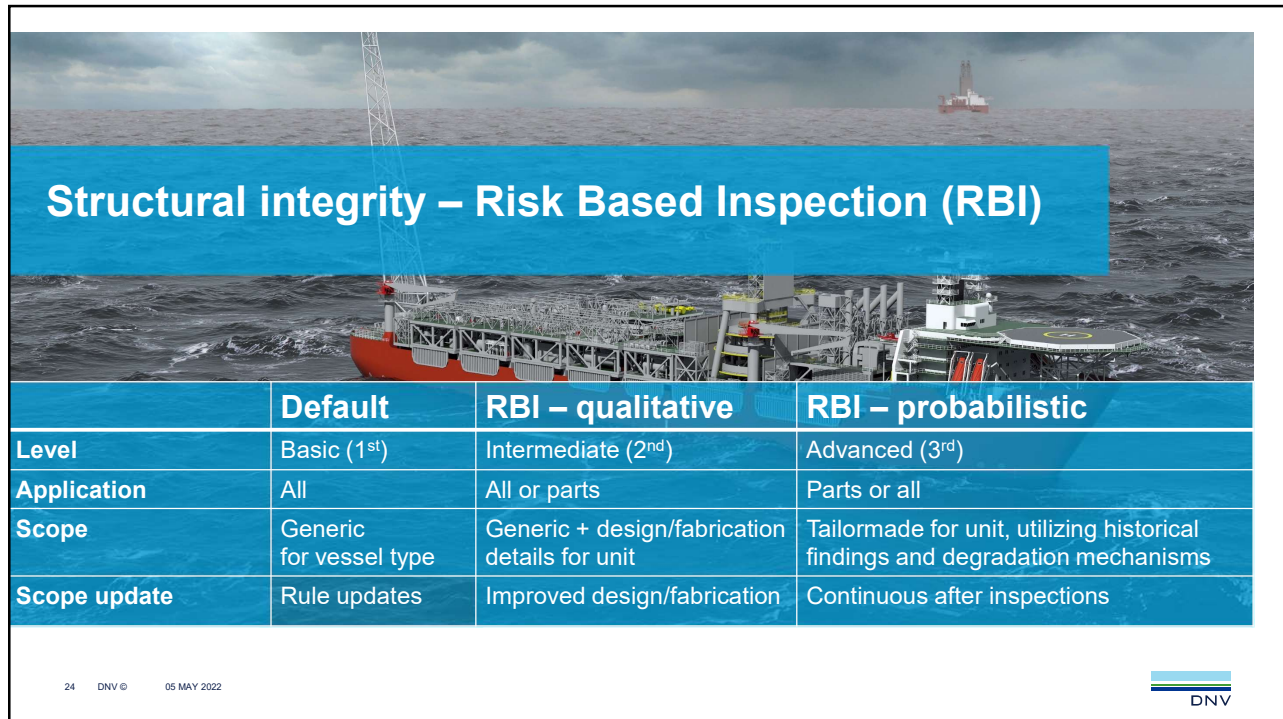
22 DNV © 05 MAY 2022 

22

Reduced cost in operation
Structural items


23 DNV © 05 MAY 2022 

23

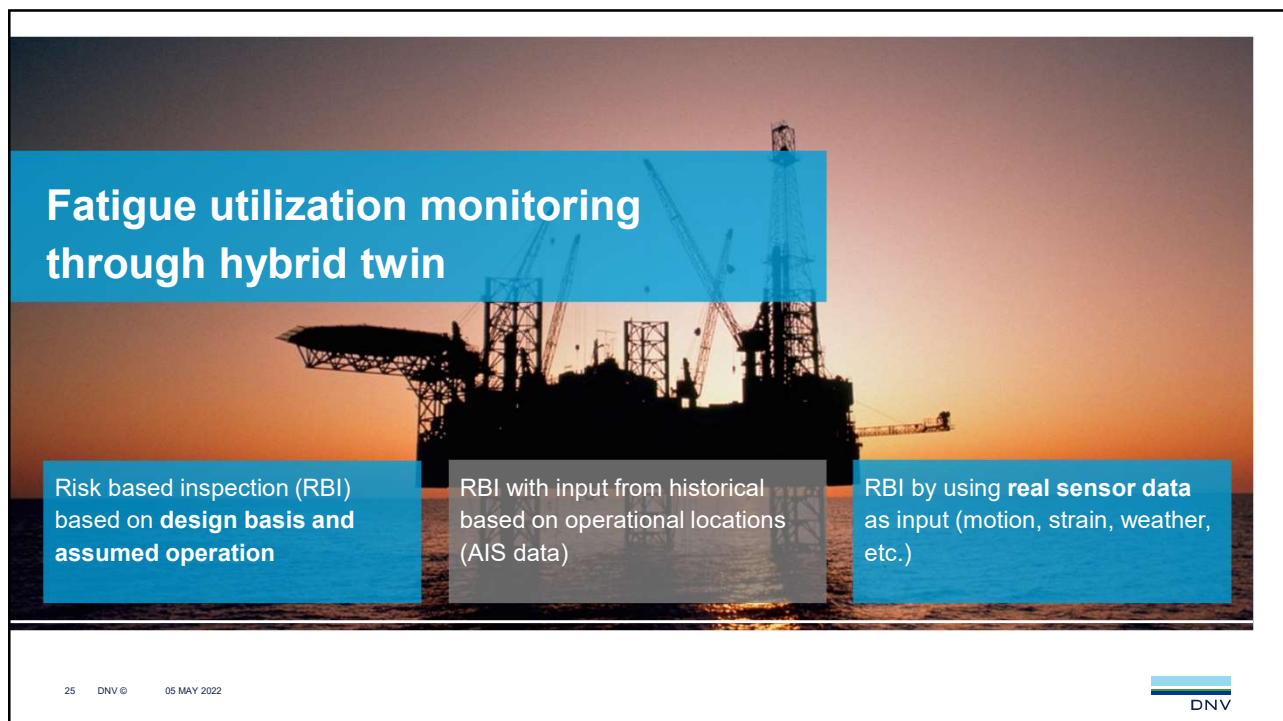


Structural integrity – Risk Based Inspection (RBI)

	Default	RBI – qualitative	RBI – probabilistic
Level	Basic (1 st)	Intermediate (2 nd)	Advanced (3 rd)
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

24 DNV © 05 MAY 2022 

24




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.)

25 DNV © 05 MAY 2022 

25

Towards optimized structure inspections and operability

Sensors System

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

Optimized
Inspection Regime
and operability

Dashboard	Sensor Details	Detailed Analysis	Data Quality
No. of Installed Sensors 56	Data Quality Index 94%	Low Data Quality Sensors (DQ > 80%) 3	Data Quality Over Time 0% over time
Maximum Recorded Value 84.14 (70)	Maximum Recorded Value -36 (50)	Maximum Mean Value 0.031	Maximum Accumulated Fatigue 1.76E-3
Maximum Mean Value -36 (50)	Maximum Fatigue Damage Rate 0.294		

Survey Regime based on condition

26 DNV © 05 MAY 2022 DNV

26

Hybrid Twin – based on sensor input

Design 3D Models and Analysis

Strain Gauges Data

Real time response on hybrid twin

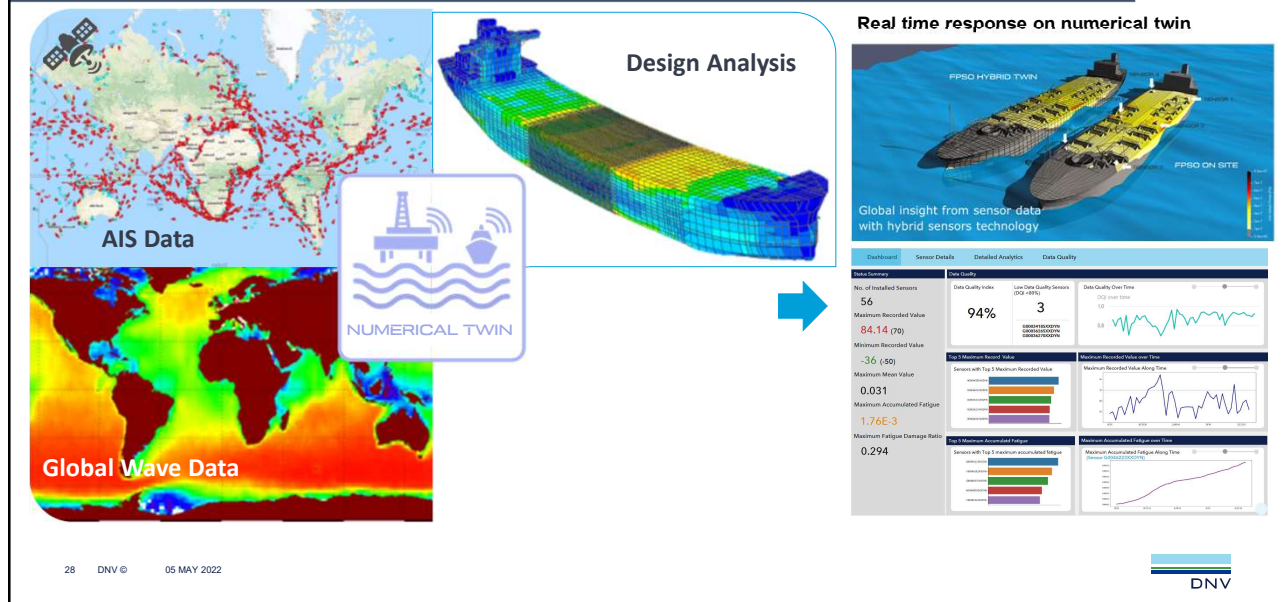
Global insight from sensor data with hybrid sensors technology

Dashboard	Sensor Details	Detailed Analysis	Data Quality
No. of Installed Sensors 56	Data Quality Index 94%	Low Data Quality Sensors (DQ > 80%) 3	Data Quality Over Time 0% over time
Maximum Recorded Value 84.14 (70)	Maximum Recorded Value -36 (50)	Maximum Mean Value 0.031	Maximum Accumulated Fatigue 1.76E-3
Maximum Mean Value -36 (50)	Maximum Fatigue Damage Rate 0.294		

27 DNV © 05 MAY 2022 DNV

27

Numerical Twin – based on wave data input



28

Tank inspection with remote inspection techniques

31

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.

32 DNV © 05 MAY 2022

32

REDHUS – digitally assisted survey

Inspection planning by surveyor

Automated drone flight according to 3D modelling and inspection plan

Automated video analysis using AI algorithms

Decision-making by surveyor, guided by visualization of findings

Certificate / report issued

Further inspection required

DNV © 05 MAY 2022

33

Crack detection – Drone inspection



34

Defect detection algorithms – Crack & Corrosion



35

Deformation detection

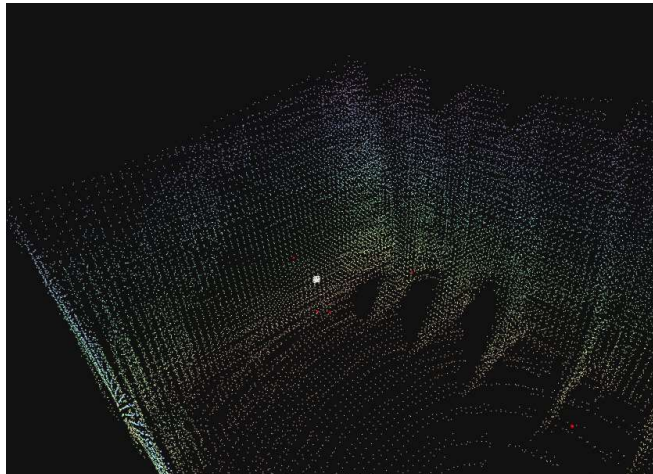


37 DNV © 05 MAY 2022



37

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

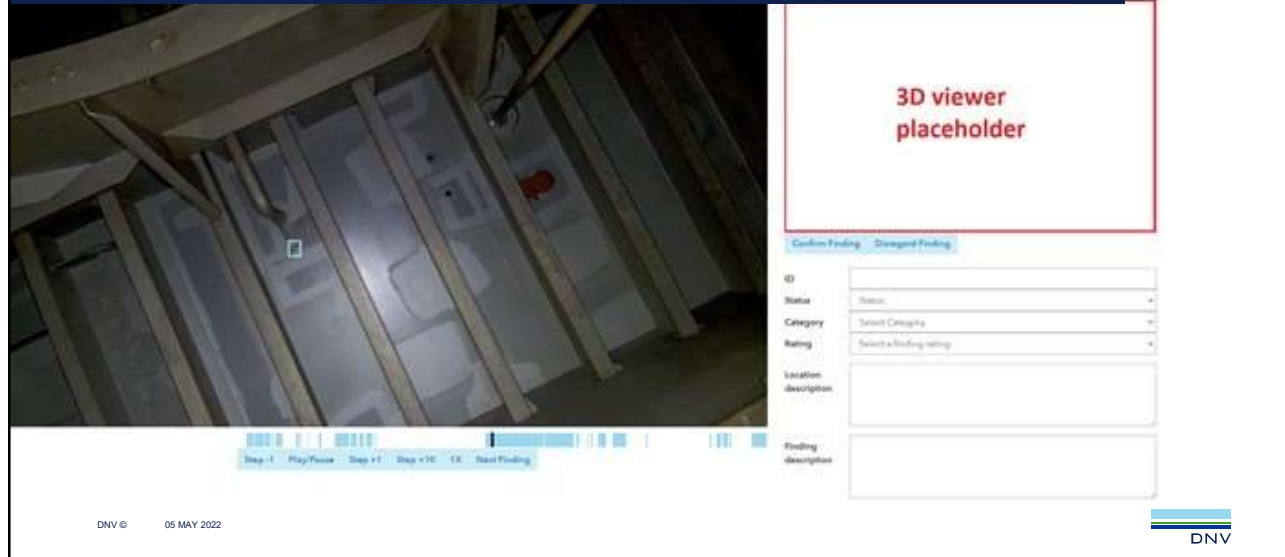


DNV © 05 MAY 2022



38

Video inspection tool – independent verification of the AI



3D viewer placeholder

Confirm Finding | Divergent Finding

ID:

Status:

Category:


Rating:

Location description:

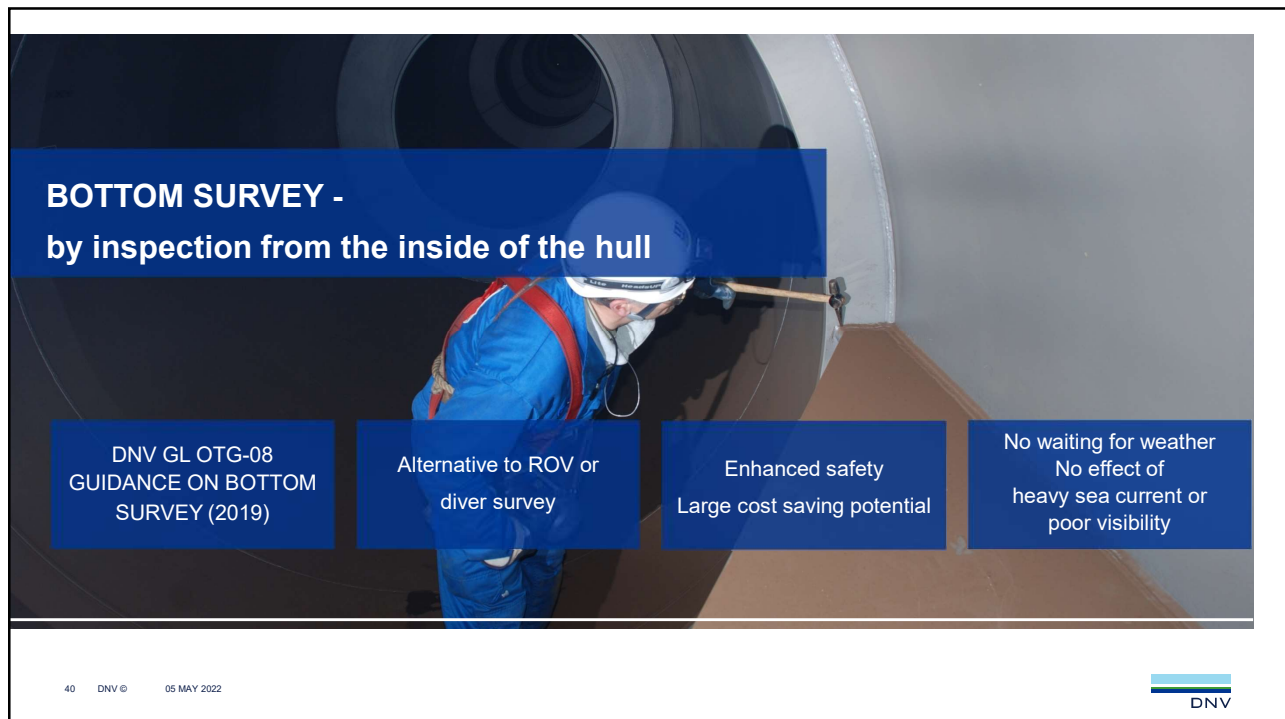
Finding description:

Step -1 | Play/Pause | Step +1 | Step x10 | CE | Next Finding

DNV © 05 MAY 2022




39



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

40 DNV © 05 MAY 2022



40

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 poor visibility or harsh environments
- Significant cost saving potential

DNV·GL

Offshore Technical Guidance

DNVGL-OTG-08 Edition March 2019

— Guidance on Bottom Survey



DNV-CG-0608

DNV

41
DNV © 05 MAY 2022

41

Reduced cost in operation

Mooring systems

44
DNV © 05 MAY 2022

DNV


44

POSMOOR integrity management

Logging usage and operational parameters to determine utilization and condition

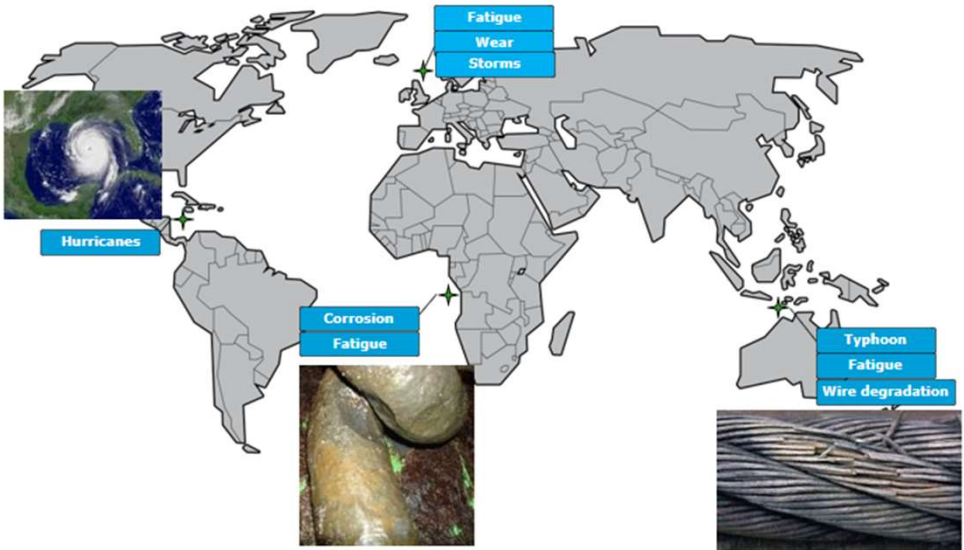
Reduced cost due to inspection and line change out based on usage and condition


Reduced cost due to maintenance and testing based on condition

45 DNV © 05 MAY 2022


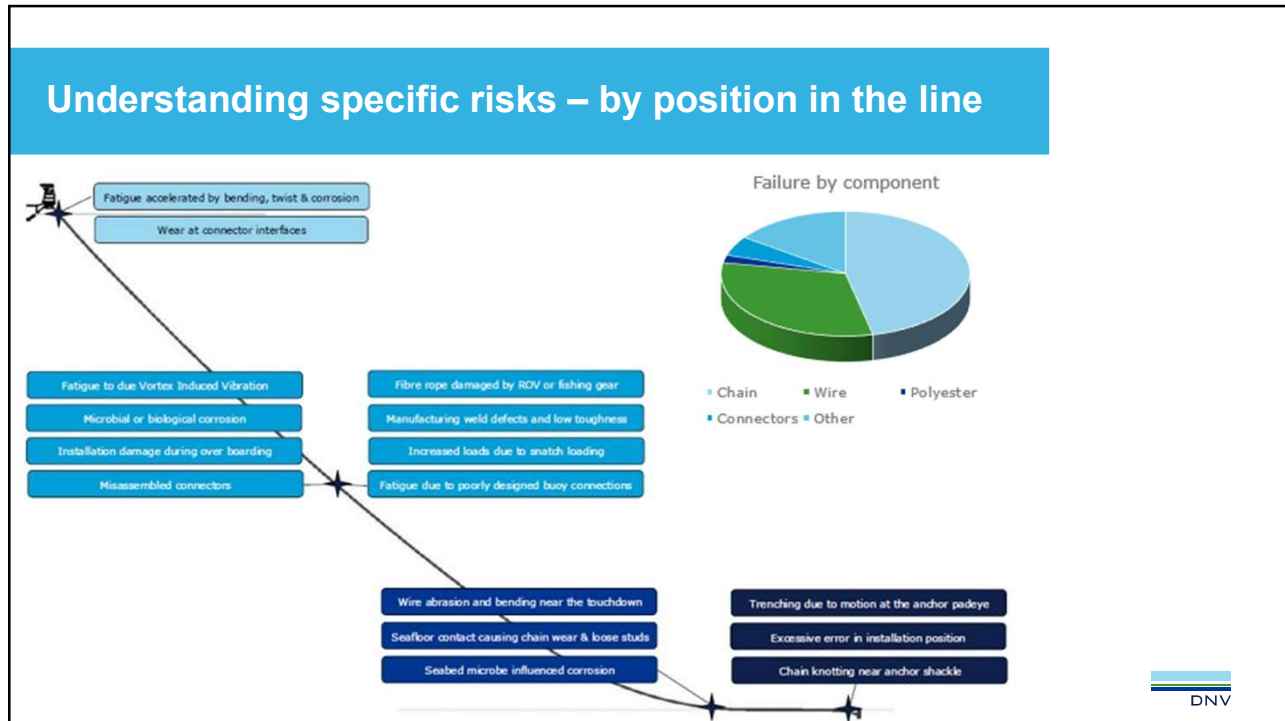
45

Understanding specific risks – by location

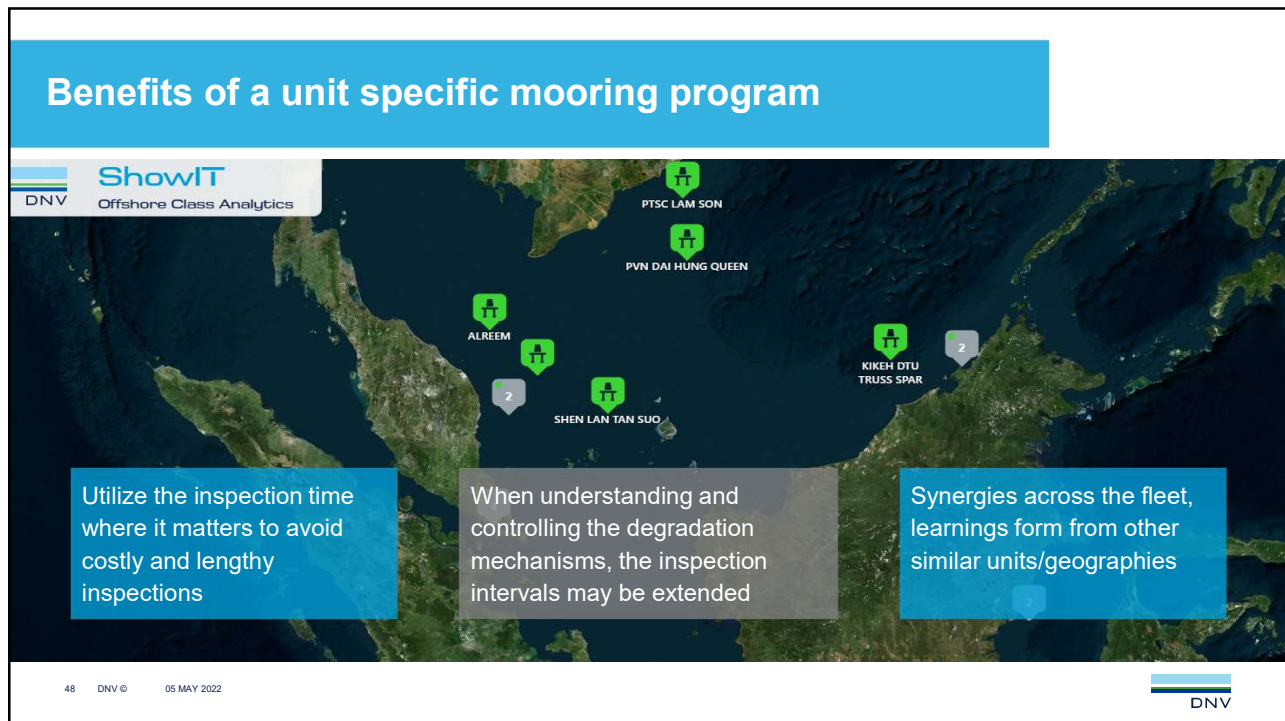




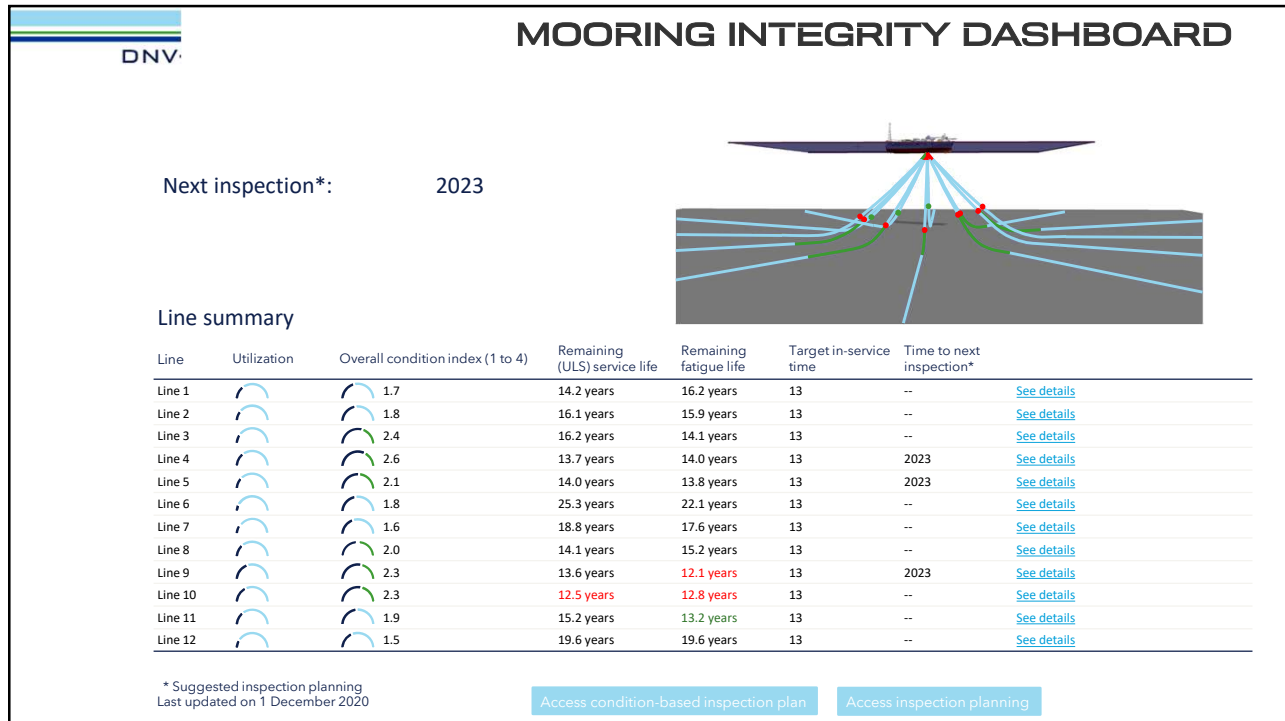
46



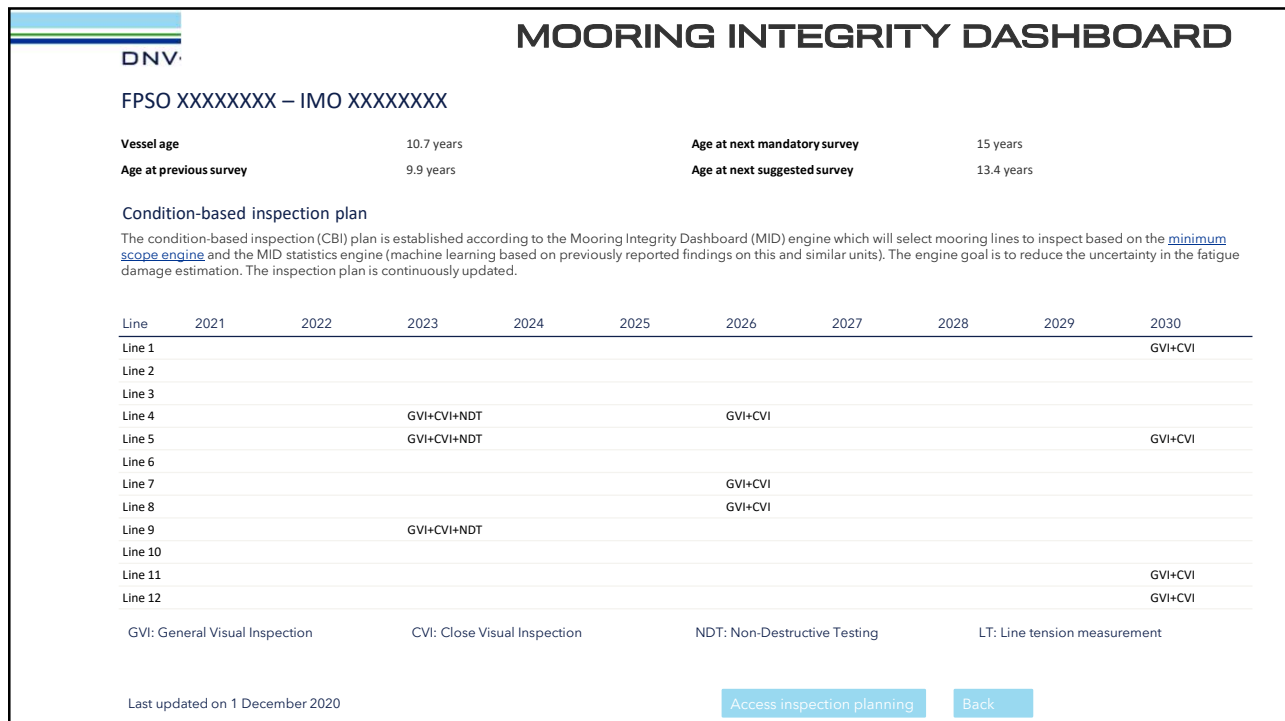
47



48



50



51

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




53 DNV © 05 MAY 2022



53


WHEN TRUST MATTERS

Smart class initiatives

Truls.Richardsen@dnv.com

www.dnv.com

54 DNV © 05 MAY 2022



54