WHEN TRUST MATTERS

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Remote Technology for Offshore Wind Inspection and Maintenance Project Review

BSEE

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DNV Offshore Wind North America

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01 – INTRODUCTION OF PROJECT TEAM

Project Contract

Customer: BSEE

Order No. 140E0121P0021

Solicitation No. 140E0121Q0038

Contract Award: $162,745

Period of Performance: Aug 2022 – Aug 2023

CO: Stephanie Brock

COR: Nathan Good

Project Team

PROJECT SPONSOR

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PM Team

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Project Manager
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02 – INTRODUCTION TO THE RIT STUDY

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Objective and Scope of Remote Technology Review

Provide a guide to the current state of RT for maintenance of OSW facilities

- Above and below water line
- Applications for remote monitoring, inspection, maintenance, testing and repair
- Identify commercially available technologies
- Determine the types of remote activities that can be conducted remotely
- Develop a register of critical components
- Identify current and future remote technologies
- Identify best practices for documenting the results

DNV's Process/Approach

- Drew on internal experts from oil & gas, maritime, onshore and offshore wind
- Performed web-based searches for literature, publications, news articles, and marketing materials relevant to RT
- Conducted interviews, surveys, and internet research of a wide range of remote technology companies
- Developed a Register for each task where all task-specific information was logged and organized.
- Applied DNV's standards, recommended practices, and guidelines related to remote inspection for offshore wind

- Selected a representative technology to "spotlight" for each Register that provides both a summary of that technology and why it was included in the report, and highlights where in the accompanying **Remote Technology Register** workbook to find further details. The intention of the Spotlights is to serve as an aid to navigating the workbook

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03 – PROJECT OVERVIEW

Remote Technology aspects explored in this study

Register #	Description
	Research, determine, document, and present…
1	different remote monitoring **methods** (e.g., visual, ultrasonic, thermographic, vibration, audible)
2	different types of commercially available **Remote Inspection Technologies** (RITs) (e.g., Unmanned Aerial Vehicles (UAVs), Remotely Operated Underwater Vehicles (ROVs), and Robotic Crawlers)
3	a list of **critical components** of an offshore wind turbine and electrical service platform that can be inspected, tested, calibrated and/or repaired remotely using commercially available technology
4	international offshore wind developer **remote inspection programs**
5	optimal **remote inspection intervals** in conjunction with staffed inspections
6	current U.S. and international **industry standards, practices, guidelines** that can be met by employing RITs above and below the water line
7	how remote systems could perform **maintenance, testing, repairs and component replacements**. This could be limited to replacing small parts, cleaning, lubrication etc.
8	the different types of **remote systems under development** and present what duties they are planned to conduct (inspections, testing, maintenance, repair, etc.), both above and below water line
9	best practices for **documenting the results** of the remote inspections, maintenance, testing, and repair

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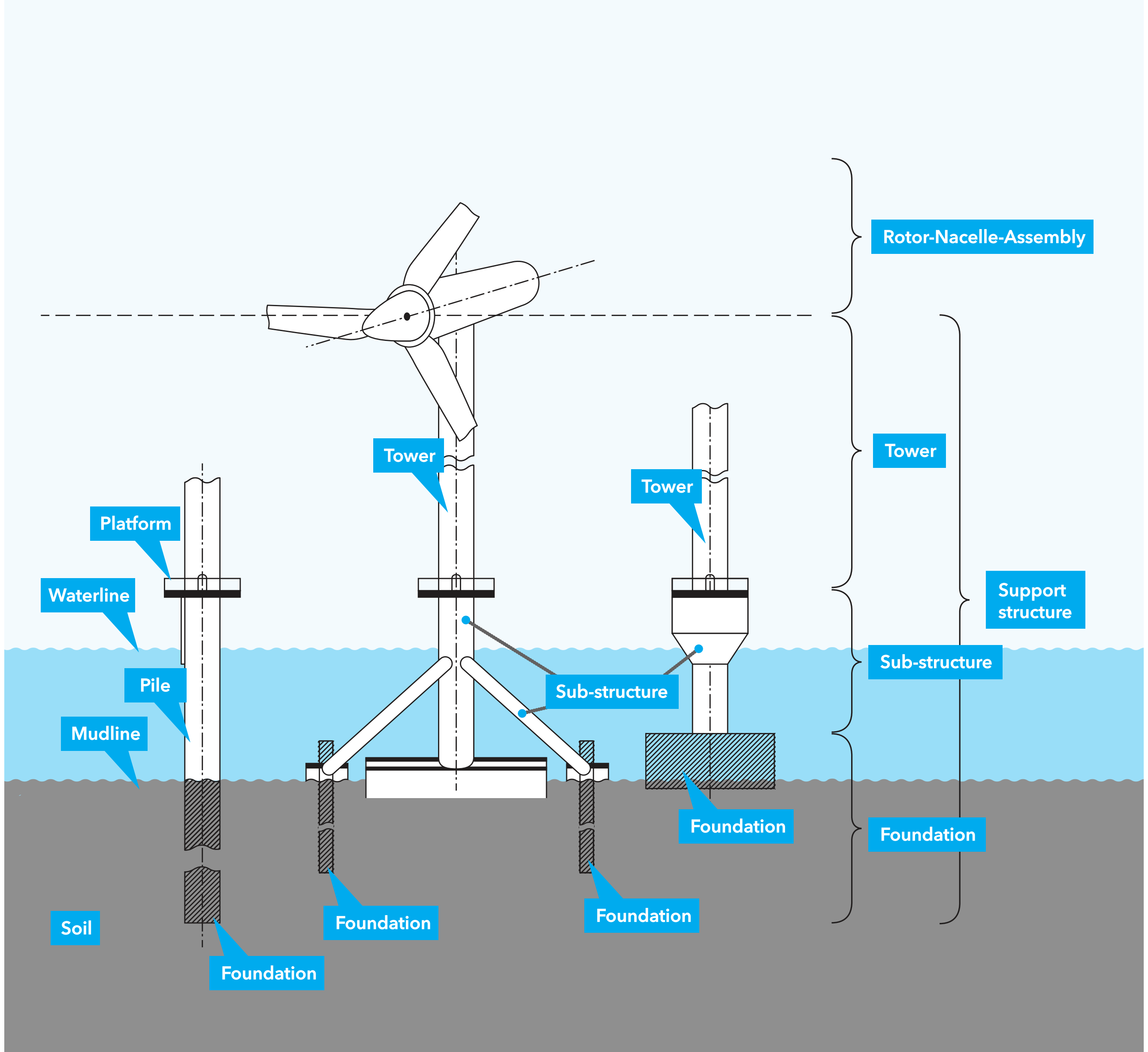
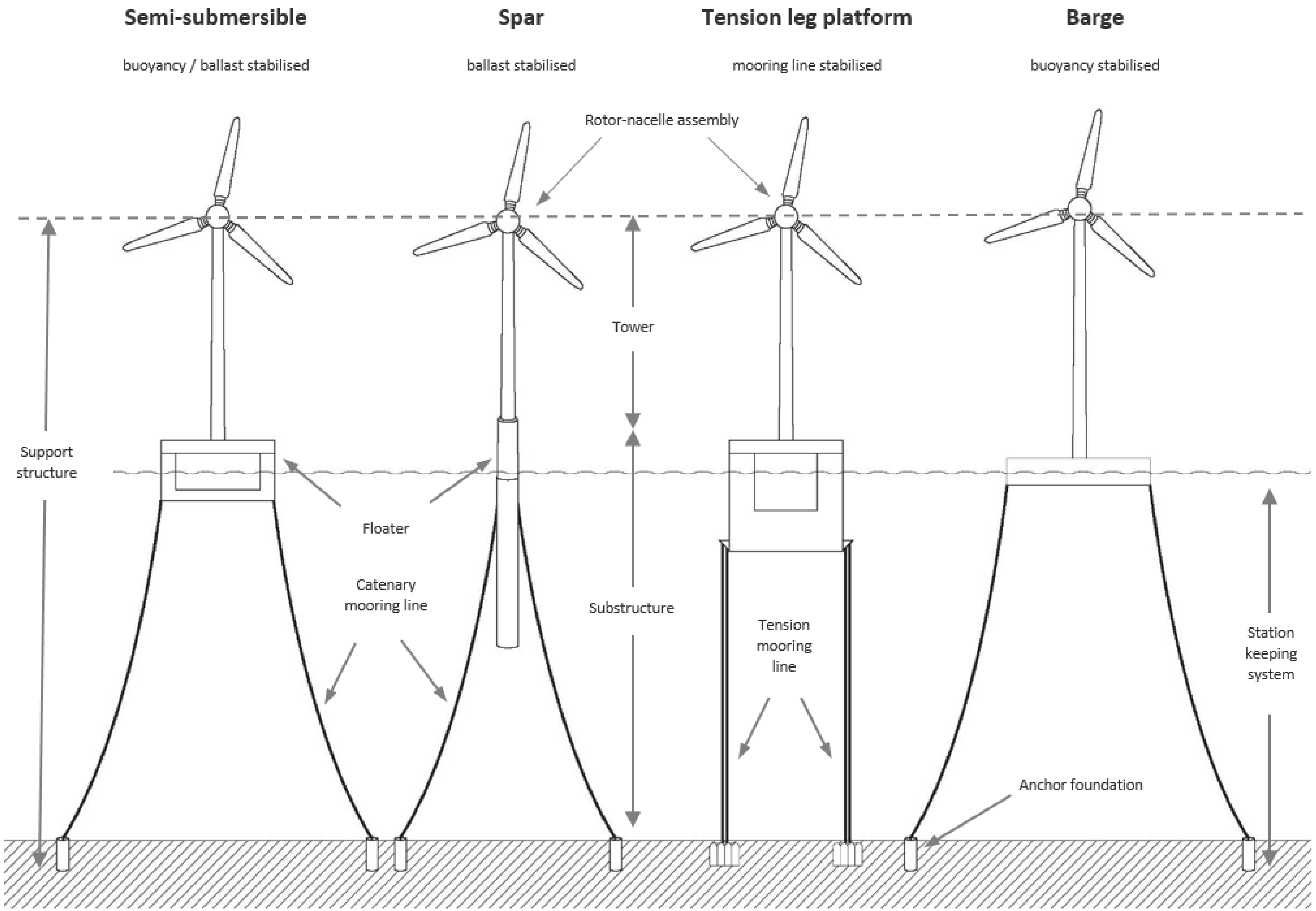
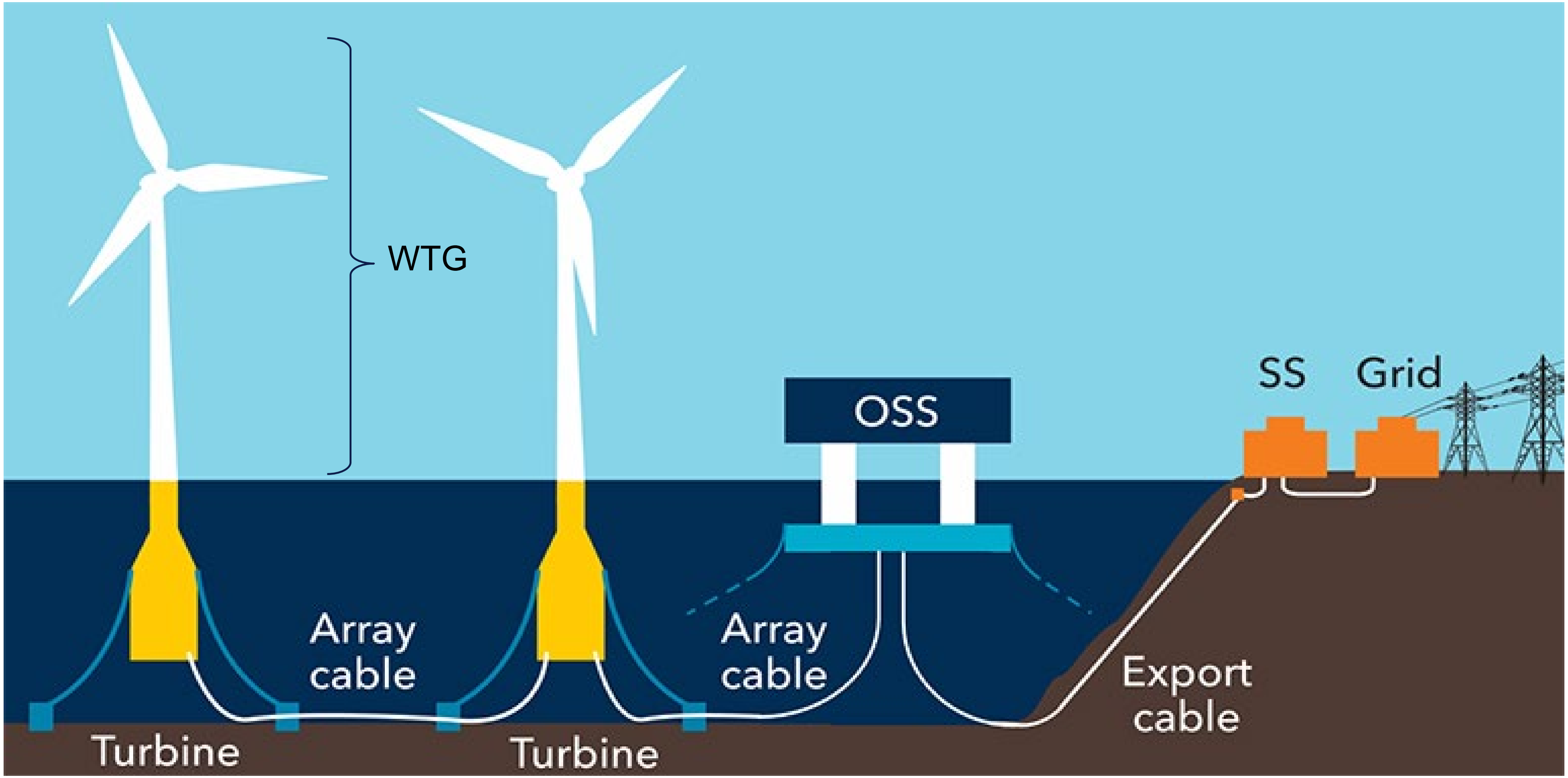
Components of fixed-bottom wind turbine systems



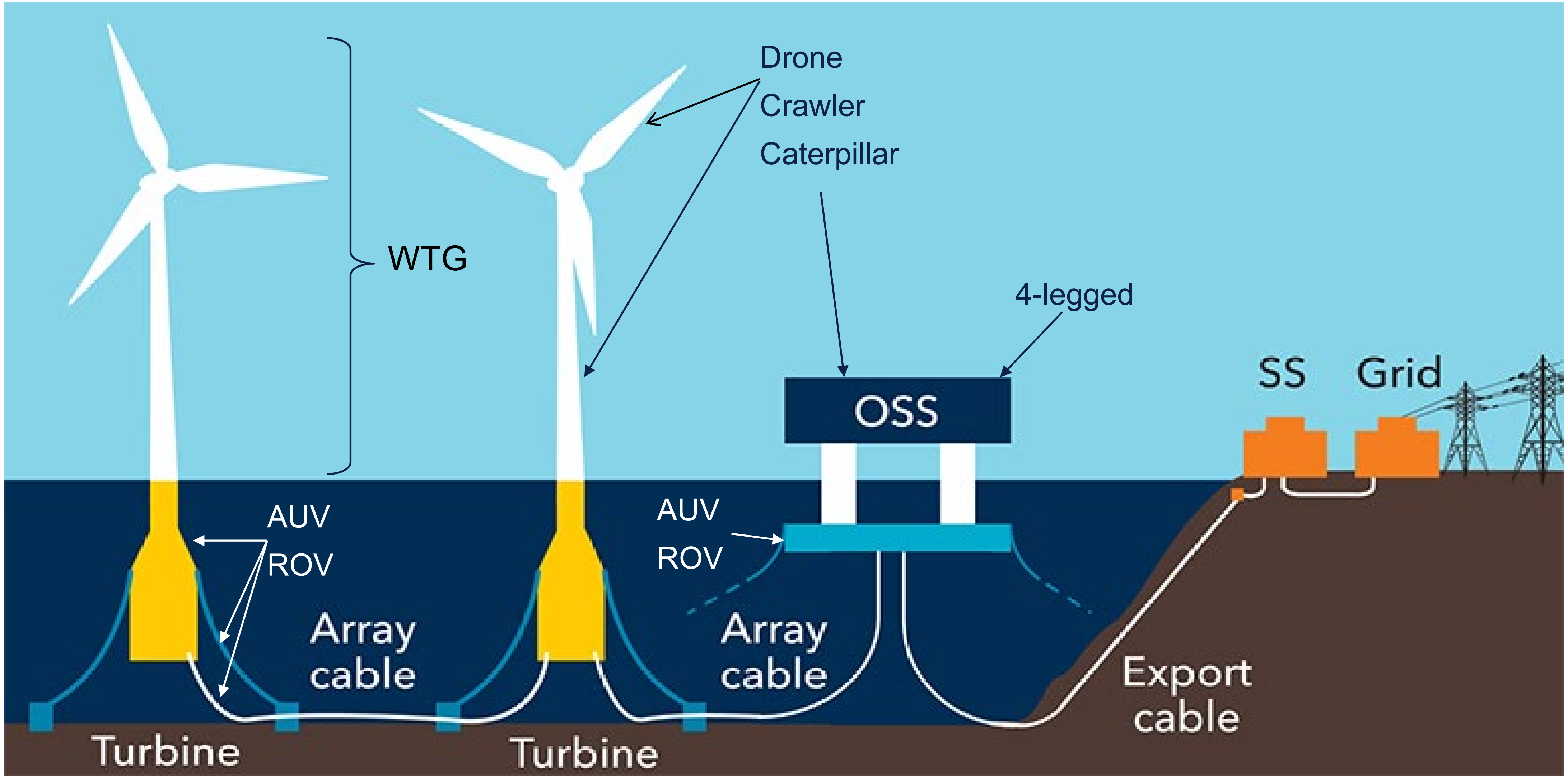
Components of floating wind turbine systems



OSW Project Components



Remote Technology Applications



List of Companies

#	Company	Application
1	4Subsea	Below water
2	ABJ	Above water, service provider
3	Aerodyne Measure	Above water, service provider
4	ANYbotics	Above water
5	Apellix	Above water, service provider
6	Applus	Below water
7	BAE Systems	Below water
8	Blade Edge	Above water, service provider
9	Bladebug	Above water
10	Boston Dynamics	Above water
11	CWIND / Global Marine	Below water
12	DJI	Above water, Below water
13	DNV	Above water
14	Drone Base	Above water, service provider
15	ECA Group	Below water
16	Ecosub	Below water
17	EddyFi Technologies	Above water, Below water
18	EM&I	Below water
19	Fraunhofer IWES	Above water
20	General Dynamics	Below water
21	Houston Mechatronics	Below water
22	Hydroid/Huntington Ingalls	Below water
23	Innovate UK	Above water
24	Innovtek	Below water
25	International Submarine Engineering, LTD, (ISE)	Below water
26	ISE	Below water

#	Company	Application
27	Kawasaki Heavy Industries	Below water
28	Konsberg	Below water
29	L3 Harris	Below water
30	MarineSitu	Above water
31	MarynSol	Below water
32	Mitsubishi	Above water
33	Oceaneering International, Inc.	Below water
34	Olis Robotics	Above water
35	ORE Catapult	Below water
36	Perceptual Robotics	Above water
37	Pharos Offshore Group	Below water
38	Precision Hawk	Above water, service provider
39	Rope Robotics	Above water
40	SAAB	Below water
41	Saipem	Below water
42	Sandia National Labs	Above water
43	SIMS Offshore	Below water
44	Sky Specs	Above water, service provider
45	Skyguage Robotics	Above water
46	Skyline Drone	Above water, service provider
47	Subsea7	Below water
48	Superdroid Robots	Above water
49	Teledyne	Below water
50	V2subsea	Below water
51	Vaarst (technology wing of Rovco)	Below water
52	Wind Power Lab	Above water, service provider
53	Xocean	Above water

04 – REMOTE TECHNOLOGY REGISTERS

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1. Remote monitoring methods

- 15 methods investigated

Monitoring Method	Description
Visual Inspection	Visual inspection of external surface to identify surface condition.
Radiographic Inspection	X-rays allow inspection of internal components made of materials through which X-rays can travel.
Ultrasonic Inspection	Ultrasonic waves transmitted into materials to detect internal flaws or characterize external surfaces as well as internal areas in metallic and non-metallic (e.g., composite) components.
Thermographic Inspection	A nonintrusive, usually non-contact inspection technique that involves measuring temperature. Can be used to get a point measurement or provide a contour map showing temperature variations over an area.
Infrared Thermography	A specific type of thermographic inspection that measures temperature differences to within 0.05 ° C. Provides a contour map showing temperature variations over an area, where thermal signatures may be caused by friction in structural cracks, or changes in air flow such as boundary layer turbulence over a blade.
Accelerometer	Measures vibrations, detecting specific frequencies related to structures (e.g., natural frequencies) and rotational components (e.g., gear mesh frequencies)
Acoustic Emissions	Measures acoustic signals from an elastic wave (20-1000 kHz) generated by rapid release of energy from within a material. Can be cracking or popping noises due to structural damage, or tonal signals due to air passing over a feature (e.g., on blade surface)
Microwave	Detects changes in dielectric constant of materials
Fiber Optics	Measures strain
Fiber Optics - Optical	Time domain reflectometry is used to identify anomalies in the fiber optic cable (embedded in subsea cable) along its length
Fiber Optics - Thermal	Distributed Temperature Measurement System (DTMS) uses the change in optical signal to determine the temperature of the fiber optic and therefore adjacent conductor/cable
Strain Gauges	Measure state of strain [stress] of a structure using a gauge attached to the structure
Digital Twin	Virtual model (software tool) designed to accurately reflect a physical system. The tool collects and processes various inspection data to represent the state of the components and predict their behavior.
Magnetic Flux Leakage	Magnetic field applied to external post-tensioned tendons, metallic cables, steel structures to detect location and extent of corrosion
Coupon Inspection	Small samples of materials that are exposed to the environment in operating equipment. They are removed at specified intervals and inspected to monitor structural/material integrity.

1. Remote monitoring methods: Spotlight on Ultrasonic Testing/Inspection

Monitoring Method	Ultrasonic Testing (UT)
Description	Ultrasonic waves transmitted into materials to detect internal flaws or characterize external surfaces as well as internal areas in metallic and non-metallic (e.g., composite) components. Different UT techniques include Pulse Echo UT, Phase Array UT, and Air Coupled UT
Typical Equipment	portable ultrasonic inspection probe
Type (external/ embedded)	external
Type of equipment it applies to	Foundations, moorings, cable system, blades, welds on towers and other structures
Examples of identifiable failure modes	Structural damage, degradation and aging, Insulation damage
Advantages (Technical and economic)	1) More accurate than visual inspection. Able to measure thickness. 2) Measurement will quantify the status of failure mode (structural damage), can produce high quality scans of crack/weld issues. 3) Well established Non-destructive inspection method.
Disadvantages / limitations (Technical and economic)	1) Expensive 2) Deployment of equipment involved can be challenging offshore 3) Requires post-processing of data and its interpretation (certified technician) 4) Not suitable for certain materials, odd shapes, small objects and rough materials for sound transmission
Extent of application in offshore wind industry	Underwater or above water inspections of welds and metallic materials of the turbine base can be carried out using ROVs
Applicable AWL, BWL or both?	BOTH
Data Format	UT Scans, measurements
Data processing method	1) Human inspects scans to identify defects, records measurements by hand 2) Machine learning tool inspects scans to identify and log anomalies, then human reviews and verifies logged anomalies

2. Remote Inspection Technology

25 RTs capable of more than just inspection

For each RIT…

- Equipment name, type, and manufacturer or service provider
- Number of years the technology has been used for commercial applications and, where applicable, project references
- Technical specifications, including maximum operating water depth, weight, and battery options
- Permanent or removable RIT tools that aid inspection
- Deployment method and location
- Offshore wind structures that may be inspected using the technology
- Capabilities for inspection
- Level of autonomy,
  - 1 = human hand-operated,
  - 2 = human-operated remotely,
  - 3 = fully autonomous, i.e., no human intervention
- Advantages compared to manual inspection
- Risks associated with the technology

2. Remote Inspection Technology

Above water line

Manufacturer	Equipment Name	RIT Type
ANYbotics	ANYmal	4-legged robot
Boston Dynamics	Spot	4-legged robot
Superdroid robots	HD2	caterpillar robot with robotic arm
Mitsubishi	EX ROVR	caterpillar robot with robotic arm
Xocean	USV	Unmanned Surface Vehicle
Bladebug	crawler robot	crawler robot with six independent legs that use suction to maintain connection to the blade surface
DJI	drone and sensors manufacturer	
Rope Robotics	BR8 Robot	Robot hoisted to blade using ropes
EddyFi	Magg crawler robot	Small, tethered robot equipped with rare-earth magnets that attach to steel towers

Service Provider	Equipment Name	RIT Type
SkySpecs	flying drones	Thermal imaging
ABJ	Windvalue	Thermal imaging
Aerodyne Measure		Thermal imaging
Aerodyne	DT^3	Robotic blade care with AI driven defect detection.
Precision hawk	Drone	Thermal imaging
Apellix		UT
Skyline Drone		UT

2. Remote Inspection Technology

Below water line

Manufacturer	Equipment Name	RIT Type
International Submarine Engineering Ltd (ISE)	EXPLORER	AUV
L3Harris Technologies, Inc.	IVER4 580	UUV
L3Harris Technologies, Inc.	IVER4 900	UUV
Kongsberg Maritime	HUGIN (1000, 3000, 4500)	AUV
Kongsberg Maritime	HUGIN Superior	AUV
Oceaneering International, Inc.	Freedom	ROV
Hydroid (a Kongsberg company)	REMUS 100	AUV
Hydroid (a Kongsberg company)	REMUS 600	AUV
Hydroid (a Kongsberg company)	REMUS 6000	AUV
L3Harris Technologies, Inc.	IVER3 EP	AUV
General Dynamics Mission Systems	Bluefin-9	UUV
General Dynamics Mission Systems	Bluefin-12	UUV
ECA Group	A9, A18, A3000	AUV
ECA Group	A9-E	AUV
ECA Group	H2000	ROV
SAAB	Sabertooth	AUV IMR Platform
SAAB	Seaeye Tiger	AUV
4Subsea	SMS Strain Sensor; SMS Guard; SMS Motion; 4Insight (ML data analysis)	sensor
Offshore RE Center (ORE)	iFrog	crawler robot

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3. Critical components for inspection, AWL – Rotor-nacelle assembly

System	Critical components
ABOVE WATER	
Rotor blades	Skin (external). Note blade skin refers to all layers of the composite laminate, and thickness decreases from blade root to tip.
	Skin (internal). Note blade skin refers to all layers of the composite laminate, and thickness decreases from blade root to tip.
	Spar. Structural element (beam or beams) internal to the rotor blade, often made of epoxy-resin infused layers of carbon fiber for high strength and low weight
	Bolts (blade root)
Rotor hub	Cast iron body
Main bearing	Races and rollers
	Cast iron housing
Mainshaft/ Kingpin	Forged or cast body
Generator	Direct-Drive windings and magnets
	Direct-Drive rotor and stator housings carry high torque loads
	Medium-speed windings and magnets
	Bearings
Gear-box	Gears
	Bearings
Generator frame	Main weldment or casting
Bedplate	Cast iron body
Yaw Drive	Yaw motors gearboxes, pinion, bearings, slewrings
Power Electronics	Electrical components

3. Critical components for inspection, BWL – WTG Foundation

System	Critical Components
BELOW WATER	
Foundations	concrete based (GBF)
	steel structure (monopile, transition piece, jacket)
	Bolting
	scour protection material
Floating hull	concrete based structure (e.g., windcrete concrete spar buoy, BW Ideol concrete barge floater)
	Steel structure (e.g., monopile, tension-leg platform (TLP), spar buoy)
Corrosion Protection (CP) System	Anodes
Mooring	polyester
	ultra-high molecular-weight polyethylene (e.g. Dyneema)
	chain
	Anchor piles

4. Remote inspection programs

No.	Inspection type	Remote or Manned? Why?
	ABOVE WATER LINE	
1	Periodic visual inspection of AWL external structural condition	Remote: Drone launched from vessel near turbine: limited drone battery life requires nearby deployment.
2	Periodic visual inspection of external condition of wind turbine blades	Remote: Drone launched from vessel near turbine: limited drone battery life requires nearby deployment
3	Periodic internal blade inspection - visual	Manned + Remote: Onboard inspection system (robot or drone) (including inspector-guided robot or drone)
	BELOW WATER LINE	
4	Periodic inspection of BWL external structural condition	Remote: ROV launched from a special purpose vessel within the wind farm
5	Periodic inspection of BWL internal structural condition	Manned and remote: Combination of divers, technicians, and external or internal UV automated equipment can be used to determine thickness
6	Determine subsea export cable location	Remote: ROV launched from a special purpose vessel within the wind farm
7	Periodic visual inspection of mooring lines and anchors for floating wind foundations	Remote: ROV launched from a special purpose vessel within the wind farm

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4. Remote inspection programs: compliance with 30 CFR 585.824

How does remote inspection support/enhance compliance with 30 CFR 585.824 - How must I conduct self-inspections?	(a) Develop a self-inspection plan specifying:	1) Type, extent, frequency of in-situ inspections of all mooring systems and floating facilities
		2) How corrosion protection is monitored for AWL and BWL structures
	(b) Report annually to BOEM, by Nov 1:	1) List of facilities inspected in preceding 12 months
		2) Type of inspection
		3) summary of the inspection indicating what repairs, if any were needed, and overall structural condition of the facility.

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5. Optimal inspection intervals in conjunction with manned inspections

System	Critical Components	Recommended inspection interval (from Standards/RPs)	RIT activity	Manned activity
ABOVE WATER LINE				
Rotor blades	Skin (external)	regular inspection intervals as specified by the OEM (typically annual)	* Drone flies in pattern along blade exterior, covering the entire blade length, inspects structural integrity of laminates, adhesive joints at leading and trailing edges; * Drone records video of all surfaces plus high resolution still photos of areas of interest.	* Operator required to fly drone. * Operator is located on a vessel near the turbine. * Activity eliminated: - crew transfer from CTV to WTG platform - tower climb - crew rappelling down the length of the blade
	Skin (internal)	regular inspection intervals as specified by the OEM (typically annual)	* Drone flies or crawler moves in pattern along blade interior, covering entire blade length, inspects structural integrity of laminates, adhesive joints inside the blade (e.g., shear web), attached items (lightning protection), corrosion; * Drone records video of all surfaces plus high-resolution still photos of areas of interest	* Operator required to fly drone or crawler. * * Operator transfers from CTV to the WTG, climbs the tower to the nacelle, and enters the hub. * Operator is located in the rotor hub or blade root when flying the drone. * Activity eliminated: - Confined space entry of inspector into blade from hub (reduction of one person as blade entry attendant not needed) - Inspector walking/crawling the length of the blade interior to conduct visual inspection
	Spar (internal)			
	Bolts (blade root)	regular inspection intervals as specified by the OEM (typically annual)	* Drone with camera records HD video of bolt markings to check for slippage; part of the internal blade drone inspection campaign	* Manual spot-check bolt pre-tension for bolt loosening * Activity eliminated: - Time saved by technician not having to check markings on each bolt
Rotor hub	Cast iron body	At least once every 5 years	* None.	* Manual visual inspection as specified by OEM.
Main bearing	Races and rollers	As per OEM recommendation, accounts for CMS	* CMS monitors the main bearings. Sensors include: temperature, acoustic, vibration analysis, wear debris analysis	* Manual inspection of the main bearing required; includes looking for wear, checking for smooth operation (no 'play' in the bearing) * Activities eliminated: - Time saved by relying on CMS system to indicate when inspection is required. * Reduced time per technician inspection

6. Current standards (ST), recommended practices (RP), service specifications (SE), offshore standards (OS), and rules for classification (RU) that can be met by employing RITs.

35 Codes & Standards relating to RIT

Standard ID	Title
ABOVE WATER LINE	
DNV-RP-0175	Icing of wind turbines
DNV-RP-0363	Extreme temperature conditions for wind turbines
DNV-RP-0416	Corrosion protection for wind turbines
DNV-RP-0585	Seismic design of wind power plants
DNV-SE-0190	Project certification of wind power plants
DNV-SE-0439	Certification of condition monitoring
DNV-ST-0126	Support structures for wind turbines
DNV-ST-0145	Offshore Substations
DNV-ST-0361	Machinery for wind turbines
DNV-ST-0376	Rotor blades for wind turbines
DNV-ST-0076	Design of electrical installations for wind turbines
BELOW WATER LINE	
30 CFR 250.919	In-service Inspection Requirements (BOEM)
DNV-ST-0119	Floating Wind Turbine Structures
DNV-RU-OU-0512	Floating offshore wind turbine installations
DNV-RP-E308	Mooring integrity management
DNV-OS-E303	Offshore Fibre Ropes
API RP 2SK	Design and Analysis of Stationkeeping Systems for Floating Structures
API RP 2MIM	Mooring Integrity Management
API RP 2I	In-service Inspection of Mooring Hardware for Floating Structures
API RP 2SM	Recommended Practice for Design Manufacture, Inspection, and Maintenance of Synthetic Fiber Ropes for Offshore Mooring
DNV-ST-0359	Subsea power cables for wind power plants
DNV-RP-F401	Electrical power cables in subsea applications
DNV-RP-B401	Cathodic Protection Design

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6. Current standards (ST), recommended practices (RP), service specifications (SE), offshore standards (OS), and rules for classification (RU) that can be met by employing RITs.

10 Cyber security or related standards

Standard ID	Title
ABOVE WATER LINE	
DATA MANAGEMENT AND SECURITY	
DNV-RU-OU-0512	Floating Offshore Wind Turbine Installations
DNV-RP-0497	Data Quality Assessment Framework
DNV-RP-0496	Cyber security resilience management for ships and mobile offshore units in operation
DNV-RP-A204	Qualification and assurance of digital twins
DNV-RP-0317	Assurance of sensor systems
DNV-RU-OU-0300	Fleet in Service
DNV-RP-0575	Cyber security for power grid protection devices.
DNV-RU-SHIP Pt.6 Ch. 5	Equipment and design features
DNV-ST-0322	Management systems for auto-remote operations
DV-OS-D203	Integrated Software dependent systems (ISDS)

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7. RTs for maintenance, testing, repairs, replacements

25 RTs capable of more than just inspection

For each RIT…

- Name of manufacturer, service provider, or operator of equipment
- Name and type of equipment
- Status of development
- Detailed description of equipment and technical specifications
- Payload tools that support maintenance, testing, repairs, and inspection activities
- Deployment method and location
- Components that may be managed using the equipment
- Details regarding equipment capabilities for maintenance, testing, and repairs
- Level of autonomy:
  - 1 = human hand-operated,
  - 2 = human-operated remotely,
  - 3 = fully autonomous, i.e., no human intervention once deployed
- Level of use for activities related to the wind turbines, both onshore and offshore
- Safety impacts of the use of equipment compared to manned inspection methods
- Benefits, challenges, and risks associated with the use of equipment

8. RTs under development

21 RTs under development; only a sampling

For each RIT…

- Name of manufacturer, service provider, or operator of equipment
- Name and type of equipment
- Status of development
- Detailed description of equipment and technical specifications
- Payload tools that support maintenance, testing, repairs, and inspection activities
- Deployment method and location
- Components that may be managed using the equipment
- Details regarding equipment capabilities for maintenance, testing, and repairs
- Level of autonomy, where
  - 1 = human hand-operated,
  - 2 = human-operated remotely,
  - 3 = fully autonomous, i.e., no human intervention once deployed
- Level of use for activities related to the wind turbines, both onshore and offshore
- Safety impacts of the use of equipment compared to manned inspection methods
- Benefits, challenges, and risks associated with the use of equipment

8. Focus on Smart Mooring (emerging technology)

- Manufacturer: DNV
- Name: Smart Mooring Monitoring System
- Type: Software platform
- Status: Pilot testing underway
- Description
  - Turnkey digital solution
  - Replaces existing systems
  - Minimal IT hardware installation
  - More accurate than physical sensors
- Tools: NONE
- Deployment method: IT hardware installed in tower base
- Monitors: FOWT mooring lines
- Capabilities:
  - Mooring line failure detection mode
  - Virtual load sensor mode – monitors mooring line fatigue life
  - Operates in real time
- Safety impact: Early detection of mooring line trouble reduces failures
  - Monitoring likelihood of a mooring line failure
- Benefits: SMM system eliminates need for sensors
- Risks: Position inaccuracy can lead to incorrect tension in the mooring lines

DNV's SMM System

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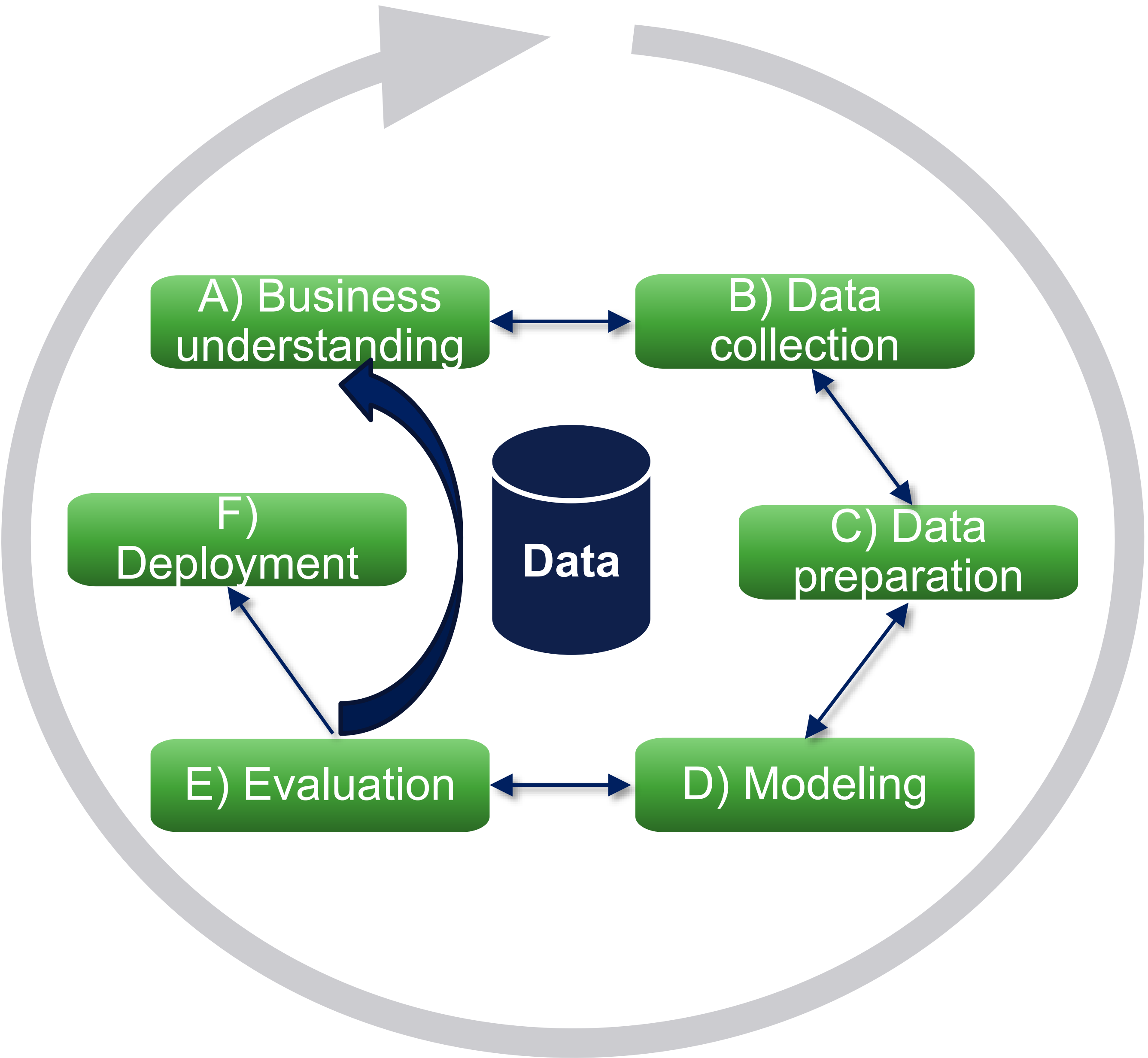
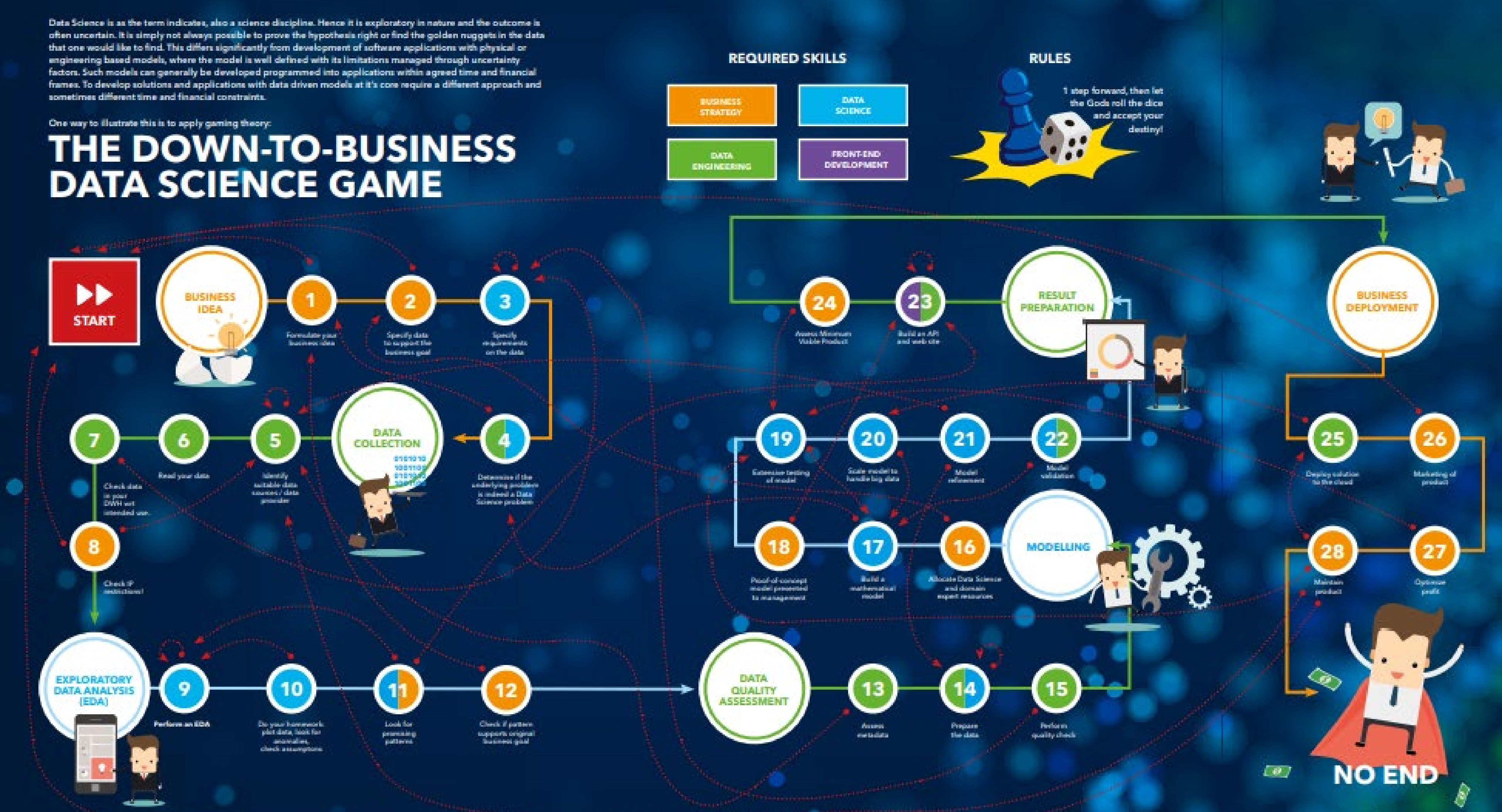
9. RT Documenting – Best Practices

Step	Description
	Data Science approach
	Data Science work process
A	Business understanding
B	Data collection/acquisition
C	Data storage/security
	Data handling
	Data processing
	Data cleaning
	Data quality/resolution
D	Machine learning in RIT
	Deep Learning
	Big Data
E	Data-driven modeling/evaluation
F	Data reporting
	Predictive Maintenance



Cross-industry standard process (CRISP) for Data Science

[Data science and machine learning in an industrial context (dnv.com)]



05 – SUMMARY OF RESULTS

Summary of Results

- Potential economic benefits of RT.

  Above water line

  - Qualitative assessment of potential economic benefits of RT
  - Drone service providers report operational cost savings of 35% to 80% for blade inspection, cleaning, and LPS testing
  - Cost savings of up to 50% in defect marking and categorization

  Below water line

  - Preventive maintenance by UUV's can catch early-stage defects, reducing major failures of subsea equipment
  - ND inspection reduces the need for technicians to access difficult locations, reducing costs and allowing reduced inspection frequency
  - Advanced monitoring technology can improve data quality and repeatability, catching details missed by manual monitoring
  - RT can operate in harsher conditions (weather, waves), expanding the weather window

  Economic benefits of RT will reduce the overall cost of offshore wind maintenance and LCOE.

Summary of Results

- Gaps in regulatory framework for RT.
  - RT can be employed to meet standards for inspection (Register 6), either fully remote or in conjunction with human activity.
  - Regulatory framework of RT is evolving; varies for different technologies

  Drones (UAS):
  - Europe (EASA) applies the highest safety standards achieved in manned aviation to UAS as well.
  - US (FAA): small UAS (< 50 lb) must register with the FAA and pilot must hold a certificate with a small UAS rating
  - FAA has no rules for UAS > 55 lb, representing a gap and potential limitation for OSW maintenance

  Robots and robotic crawlers
  - Use of robots is increasing, with significant innovation in progress
  - Move toward standardization could result in lower costs, but little incentive for OEMs or developers to pioneer solutions
  - A more favorable regulatory framework (e.g., performance-based) could help close the standardization gap, benefiting the industry.

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Summary of Results

- Gaps in regulatory framework for RT.

  UUVs

  - UUV traffic is increasing as OSW projects are constructed and become operational
  - Global UUV market will hit $5 billion by end of 2022!
  - Rules governing ships don’t fit UUVs. Regulatory gaps include:
  - No consensus whether a UUV is a vessel
  - COLREGs that govern vessels do not fit the UUV use case (no human on board)
  - USCG vessel registration does not explicitly apply to ROVs.
  - Jones Act needs to be clarified when it comes to UUV

- Risk-based inspection framework using RIT.
  - RT such as drones, crawlers, ROVs and AUVs can facilitate predictive maintenance and risk-based inspection (RBI) by conducting visual inspections as needed
  - RT reduces the need for divers (below waterline) and climbers (above water line)
  - Digital twins support RBI

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06 – CONCLUSIONS

Conclusions

- RT landscape is evolving rapidly
- Drone technology mature, commercial
- Very few RT systems are fully autonomous
- UUV technology mature, robust
- RT potential to greatly reduce costs, improve safety
- OSW standards, rules, guidelines can be met using RT
- Gaps in the regulatory framework for RT

07 – Q&A

Thank you

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