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Asia Wind Energy Association

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AWEA WEBINAR SERIES 2020 - TECHNICAL SESSION

Offshore Wind in Asia: Early Technical Assessments and Installation Implications

SPEAKERS:

ZAHIDUR RAHMAN
Senior Consultant & Jack-up Rig Specialist
Longitude London

HAKIM MOUSLIM
Director
Innosea (LOC Renewables)

RICCARDO FELICI
Senior Consultant
Longitude (LOC Renewables)

TUESDAY, 6 OCTOBER 2020 - 3 PM SGT

Asia Wind Energy Association

The Asia Wind Energy Association was established in December 2016 to become the leading trade association for the wind energy sector in Asia Pacific.

The association acts as the regional platform for all wind power industry stakeholders to collectively promote the best interests of the wind power sector.

The Asia Wind Energy Association is supported by a wide variety of stakeholders from the offshore and onshore wind industry.

Information

www.asiawind.org

@asiawindenergy

Asia Wind Energy Association

(65) 6679 6071

membership@asiawind.org

Asia Wind Energy Association

CapitaGreen - Level 24
138 Market Street, Singapore 048946

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Introduction

Riccardo Felici

Senior Consultant
Longitude Singapore (LOC Renewables)

Riccardo is a Naval Architect specialised in cable installations. He has gained considerable offshore renewables energy experience while working with Longitude since 2015. He has extensive knowledge and experience of designing, analysing and surveying a range of fixed and floating offshore structures including mobile offshore jack-up units, semi-submersibles and barges. In addition to performing numerous installation assessments he has been involved in the conversion and new built design cable lay vessels. Most recently, Riccardo has applied his specialist knowledge to manage the engineering scope for the installation of cable interconnectors in the Asia Pacific region supporting installation contractors and developers from Longitude's Singapore office.

Hakim Mouslim

Director
Innosea Nantes

Hakim is an offshore engineer with significant experience in the management of offshore projects. As head of INNOSEA, Hakim has managed INNOSEA's team for the execution of more than 120 reference projects in offshore wind (floating and fixed), wave & tidal to date. He has large engineering and project management experience in offshore wind projects. Hakim has been also involved in site development, contractual management in the offshore industry including the construction of the SEM-REV offshore wind test site in France. Hakim also acts as expert in expert committees (IEC/ BSI for marine renewables).

Zahidur Rahman

Senior Consultant
Longitude London(LOC Renewables)

Zahidur is a Chartered Engineer, Member of the Royal Institution of Naval Architects (RINA), and Naval Architect. He is a highly experience engineering consultant specialising in location approvals of Jack-ups for the Offshore Wind and Oil & Gas sectors, comprising their Site Specific Assessments when elevated and Punch-through Survivability analysis during installation. His recent experience also includes Seismic capability analysis for Jack-ups on location and Spudcan impact analysis when going on location. Zahidur has presented Training Courses related to Jack-up assessments & operations to audiences comprising International Jack-up Barge owners & operators. He has also given technical presentations of papers at City University Jack-up Conference (2015) and RINA Wind Farm Support Vessels conference (2017). Zahidur has also worked extensively with Floating Structures including Dry Transport engineering and Mooring analysis concept and detailed design for FPSOs, Vessels and Jack-ups

Early Technical Assessments and Installation Implications

Risk mitigation through early studies aimed at improving OWF yield and optimising installation

Hosts: Hakim Mouslim, Riccardo Felici & Zahidur Rahman

6th October 2020, 03:00PM SGT

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The premier marine and engineering consulting firm since 1979, in oil & gas, renewable energy and shipping sectors

- Trusted advisor driving **energy transition** in offshore sectors
- World-class **expertise** in engineering & marine disciplines
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Marine Warranty Surveys
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INNOSEA An LOC Company

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Pre-FEED and FEED Design
Foundation Package Management
Design Software Supply
Research and Development
Cable Design

Technical experts with multidisciplinary backgrounds with a focus on renewable energy projects

JLA An LOC Company

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Survey Services

Marine consulting and survey services for offshore construction, drilling and production operation

LOC Data

Branding created to focus on digital services

LOC Renewables

Branding created to focus on renewable markets

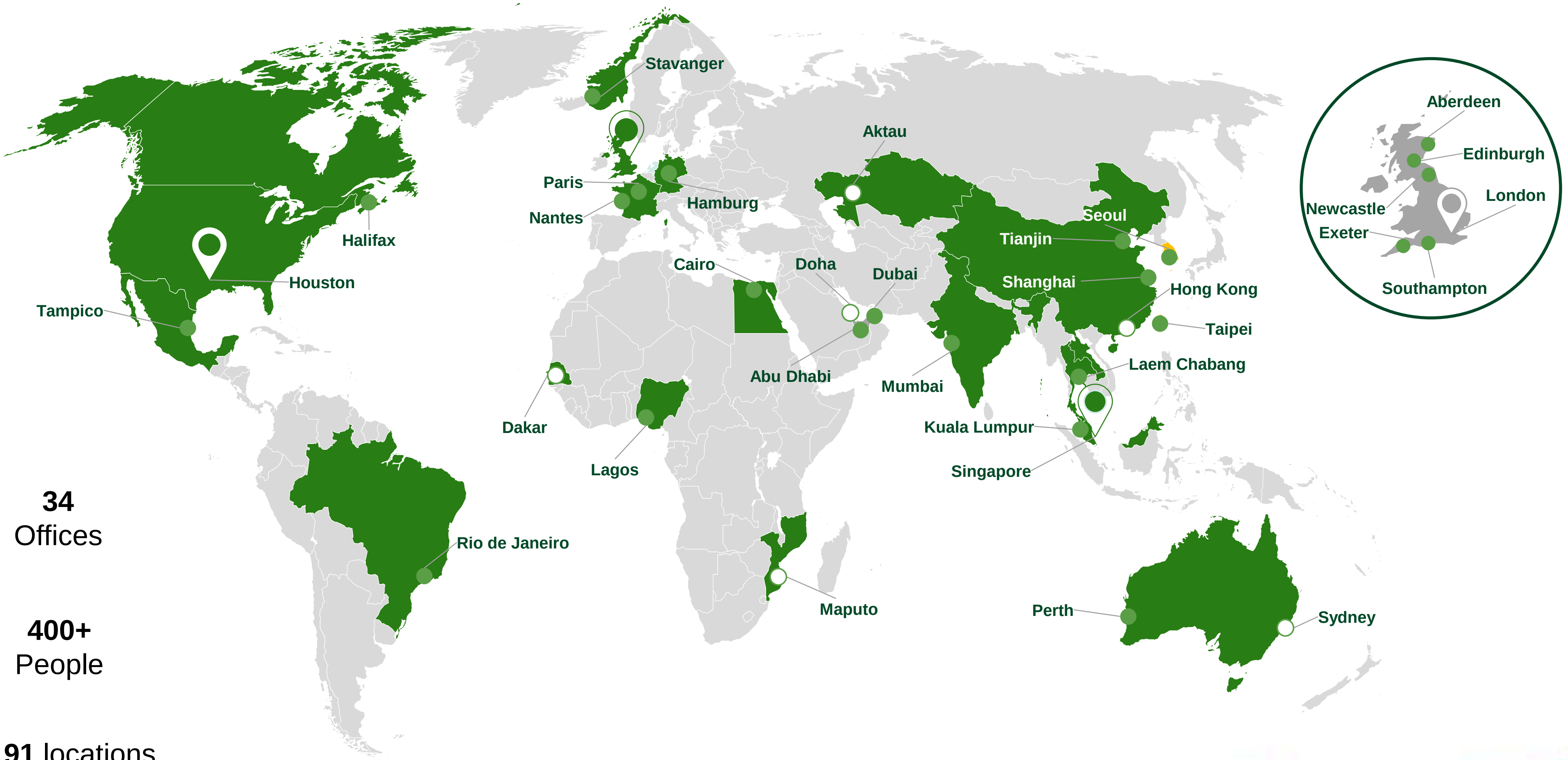
Leading Offshore Change.

Key:

Regional hub

Office

Project office



34
Offices

400+
People

191 locations
55 countries

Agenda

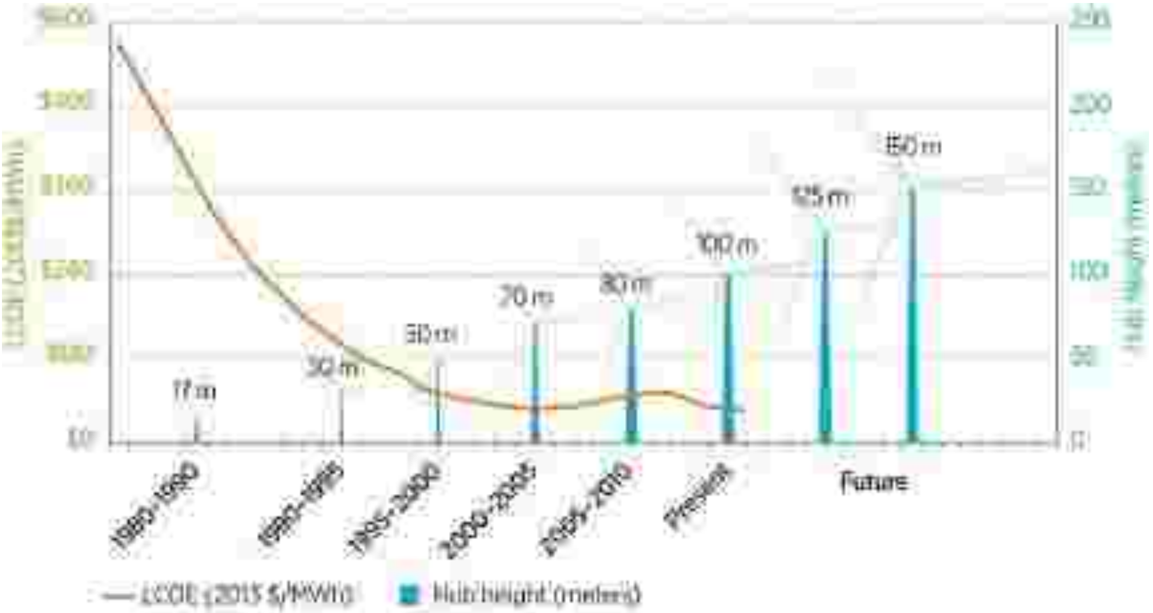
- Background
- Offshore Wind Farm design in APAC
- Cable Installation in typhoon areas
- Jack-up Operations in earthquake regions
- Conclusions
- Q&A

Background - On the horizon

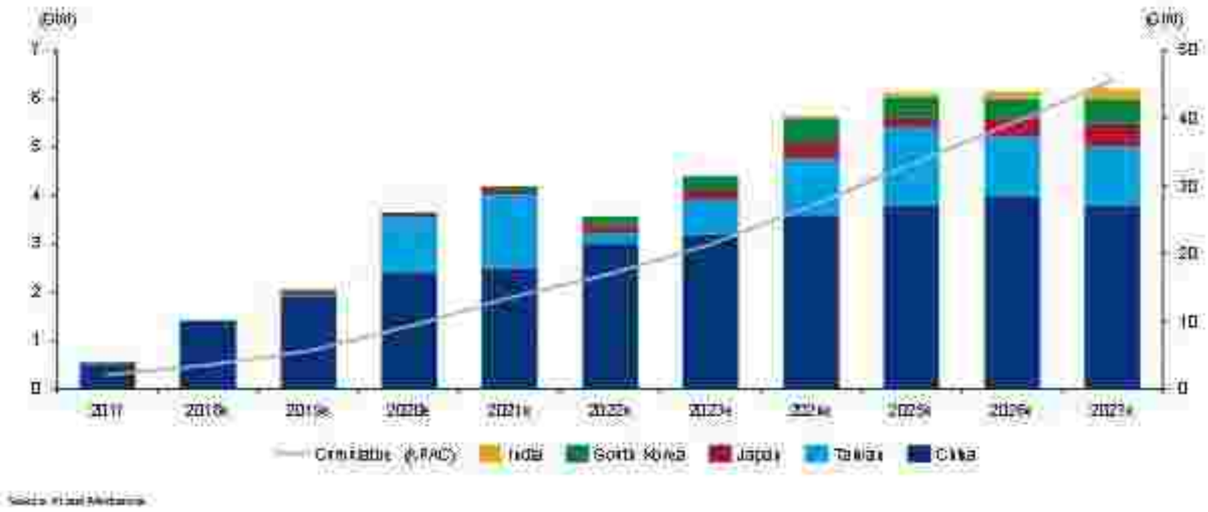
APAC OWF Projects – Where do we start?

Development in the OW industry has seen drastically reduced LCoE over time in more developed markets.

APAC market is predicted to grow year on year.



APAC offshore wind power outlook, 2017-2027e

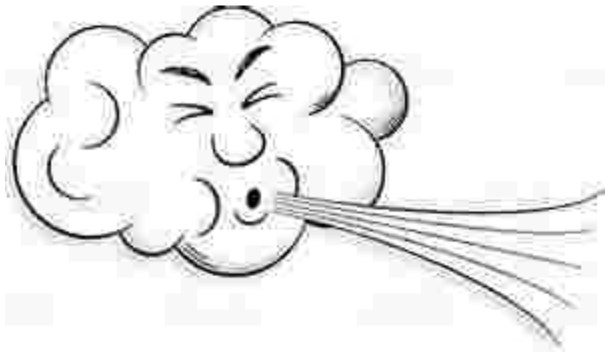


Can we have the same reduced LCoE in APAC region on day one?

What are the local challenges?

Operating Environment

Normally….



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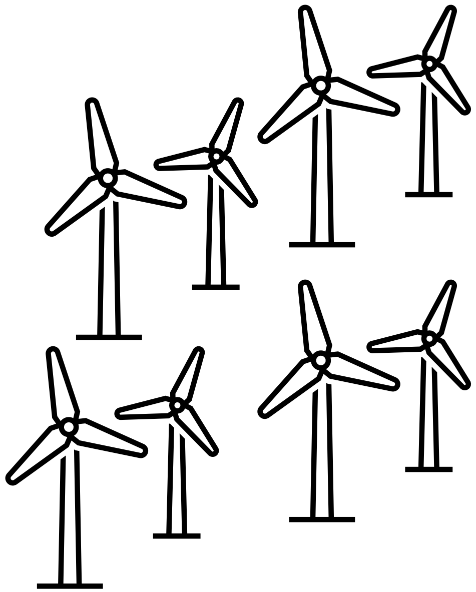

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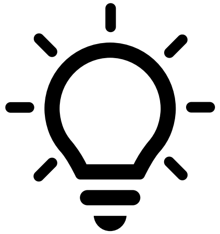
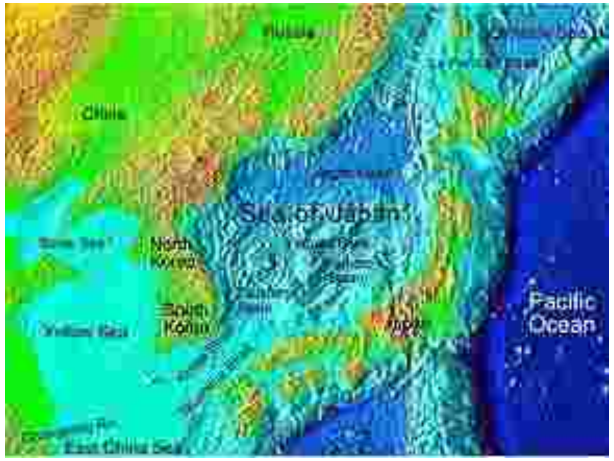
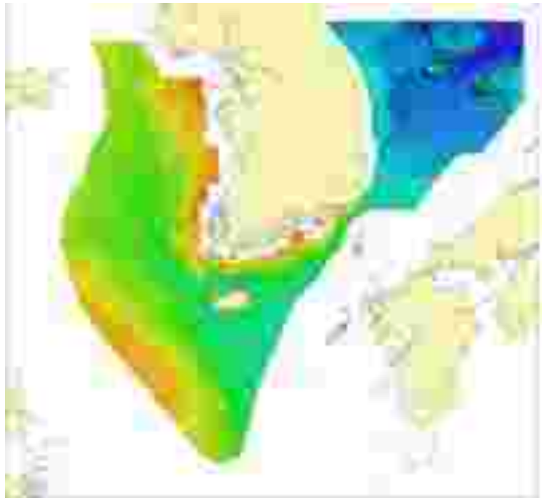


BUT......

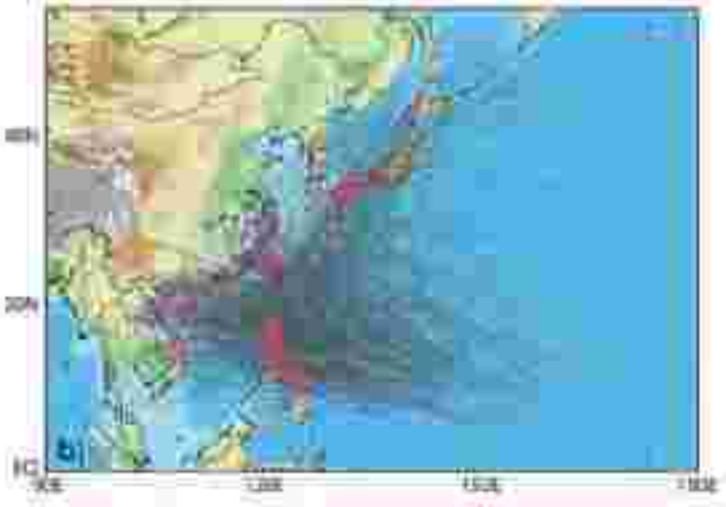
APAC OWF Technical Challenges

What about water depth?

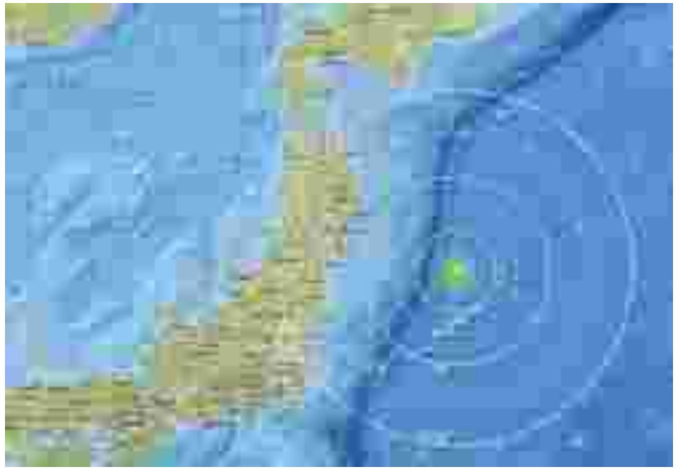




What about typhoons?



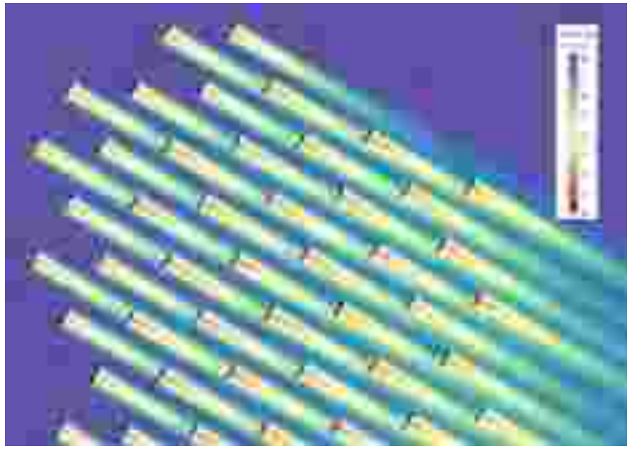
What about earthquakes?



Offshore Wind Farm Design in APAC

Concept Design – Maximising your site

- Wind farm concept design aim is to achieve minimum levelised cost of energy (LCoE)
- It is a multi-variable design optimisation problem which requires a broad view over many technologies:
  - Influence of turbine on support structure design
  - Energy yield assessment
  - Design of electrical infrastructure
  - Installation methods
  - Operations and maintenance
  - Etc.



- **APAC region** presents deep water sites especially in South Korea and Japan
- **Floating Wind** is becoming ever more pivotal to the industry due to the seabed morphology.
- What are the challenges and risks mitigations ?

Floating Wind – Complex problems

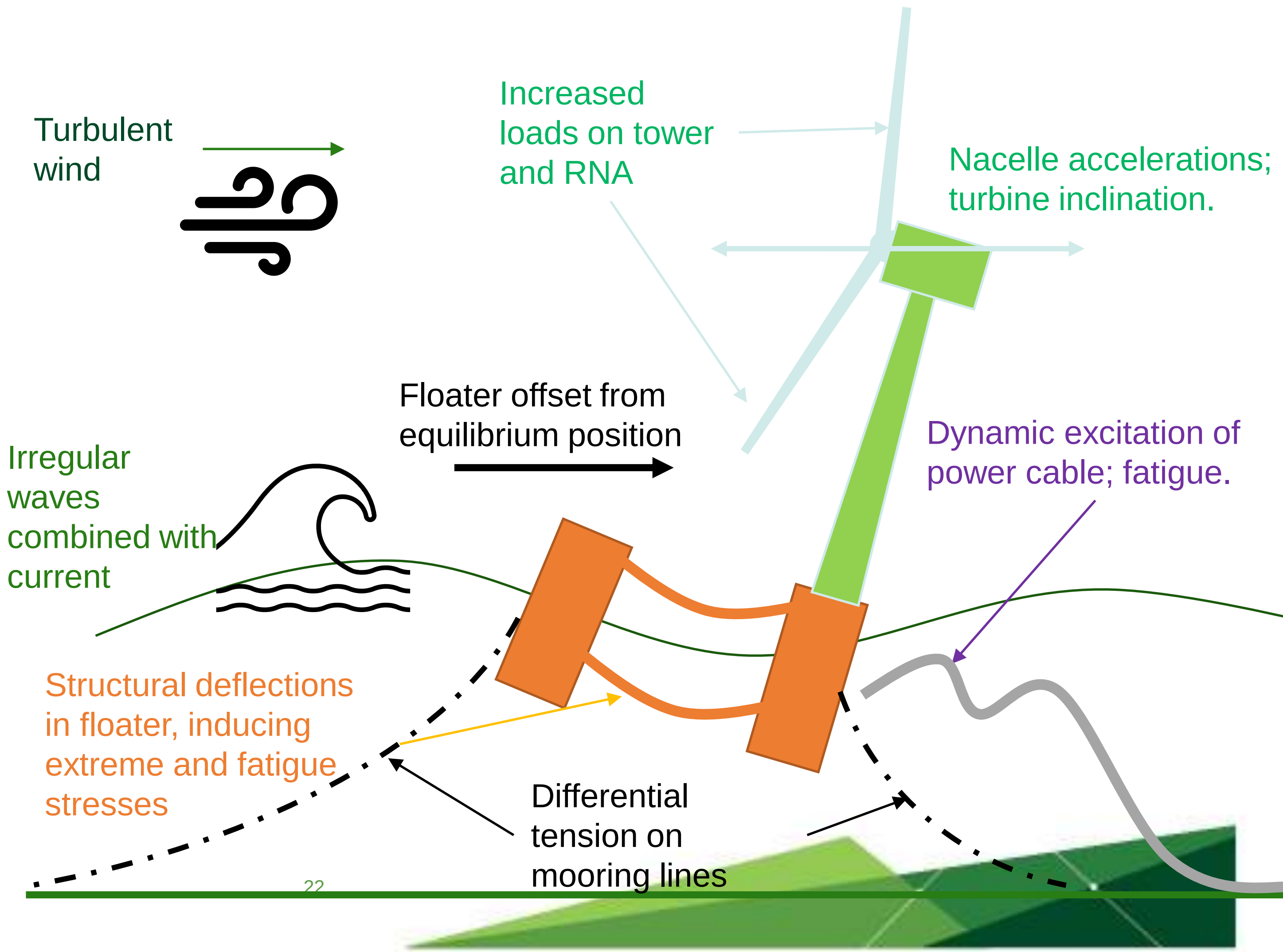
- **Simplified illustration**: illustration is in 2D, assuming wind and waves are co-aligned
- **Complexity**:
  - even in 2D, many phenomena interact: waves, wind, structural dynamics, control, mooring lines and cable dynamics.

Integrated Loads Assesment

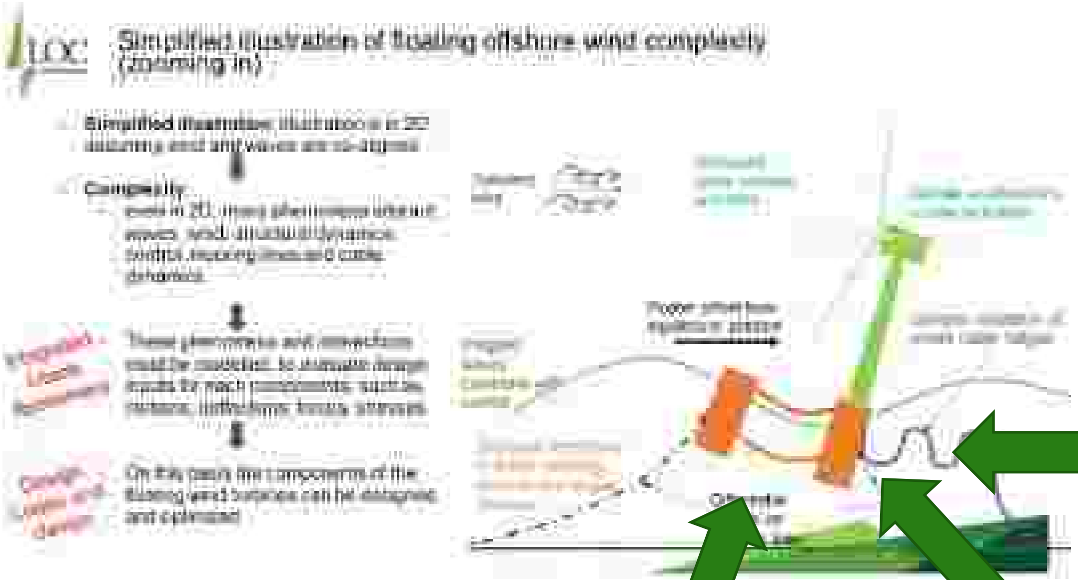
- These phenomena and interactions must be modelled, to evaluate design inputs for each components, such as motions, deflections, forces, stresses.

Design Loads and design

- On this basis the components of the floating wind turbines can be designed and optimized



Floating Wind – Construction, Installation & Maintenance



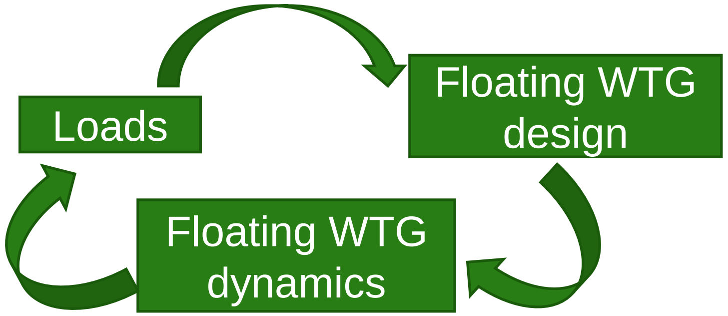
Logistics, fabrication: impose constraints on draft/LOA of floater, site selection

Offshore installation, towing: impose constraints on ballast compartments

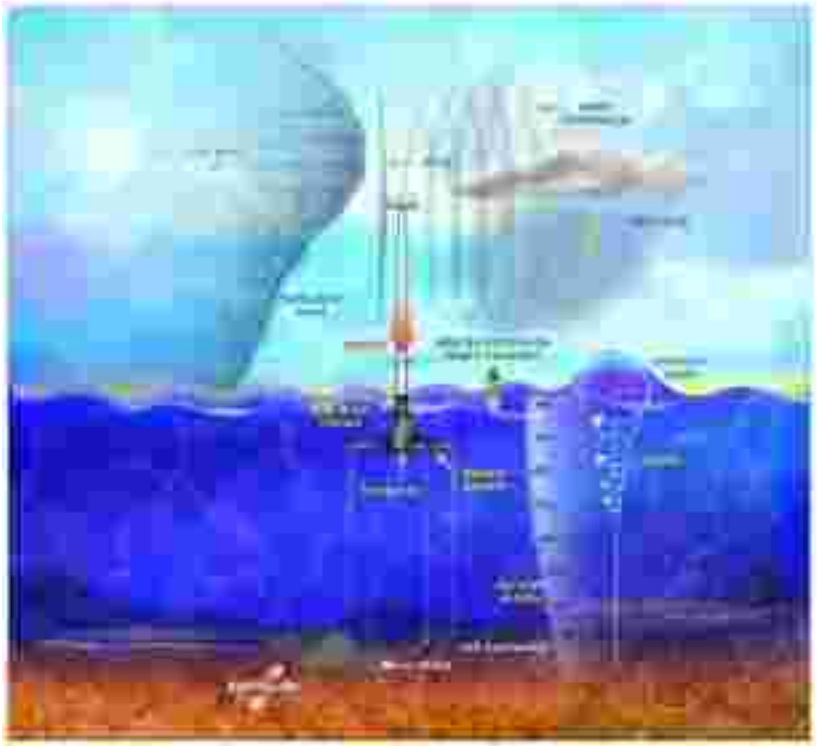
Maintenance: imposes specific mooring/cables disconnection systems and/or severe motions restrictions

Integrated Load Assessment

- Aim: assessing the “behavior” of the floating wind turbines by numerical modelling:
  - Motions
  - Deflections
  - Loads
- Challenges:
  - Iterative process:



  - Multiple software solutions, none being “the established one”
  - Computational burden (20 000+ time domain simulation per loop).
  - Need of detailed inputs from WTG supplier
  - Need of robust inputs for hydrodynamic. Tank testing needed.



Source: NREL, Jonkman, J. , Dynamics Modeling and Loads Analysis of an Offshore Floating Wind Turbine
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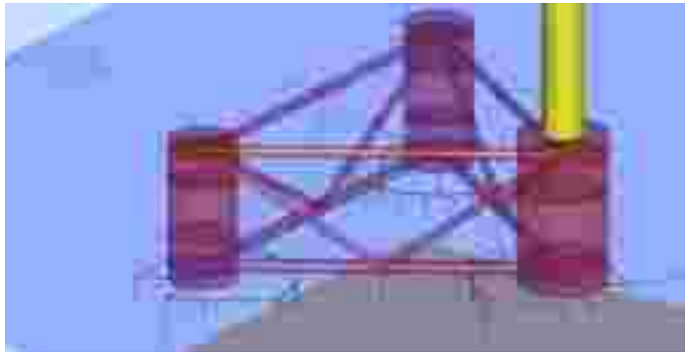
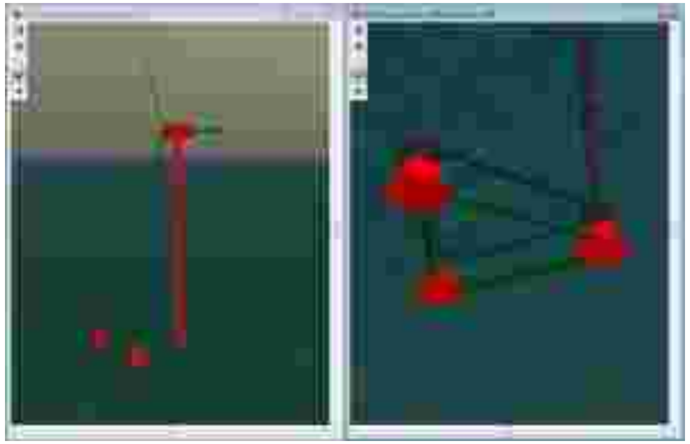
Integrated Loads Assessment – software tools

- Approach 1: “hydrodynamics + moorings” into legacy aeroelastic software
  - Advantage: based on robust aeroelastic solutions
  - Disadvantage: limited modelling capabilities for hydro and moorings.
  - DNVL GL Bladed: used by INNOSEA
    - WTG data can be encrypted by WTG suppliers
    - Recognized and used by a number of WTG suppliers.
  - NREL FAST + hydrodyn: used by INNOSEA
    - Open source tool: implementation of specific features; HPC computing easy.



- Approach 2: software tools coupling
  - Advantage : enables WTG supplier to run ILA (without need of sharing WTG data)
  - FAST + Orcaflex: used by INNOSEA
  - Siemens BhawC + Orcaflex: developed by INNOSEA, used by Siemens with INNOSEA support



- Approach 3: “aeroelastics” into offshore engineering software
  - Deeplines Wind, Orcaflex (new), Wood Group Flexcom
  - INNOSEA is able to use these solutions. Experience in code-to-code comparison against these. No request from client yet.
  - Question: will WTG suppliers make the effort to generate WTG dataset for these new tools?

Local structural analysis

- Each WTG component must be structurally checked *vs* design loads found by Integrated Loads Assessment.
- Specific challenge: from global behavior to local structural check:

“Integrated Loads Assessment” model

“Simplified” structural assumptions (ex: beams elements)

Many loads cases (20 000 simulations)

Selection of design loads

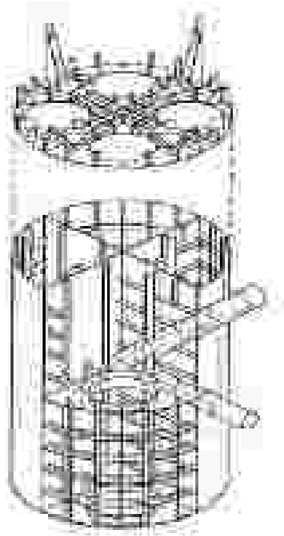
“Accurate” structural model

Structural assessment / code check

This step depends on:
- Structural arrangement/structural parts “Simplifications” of the global model
- Limit State: FLS, ULS, SLS

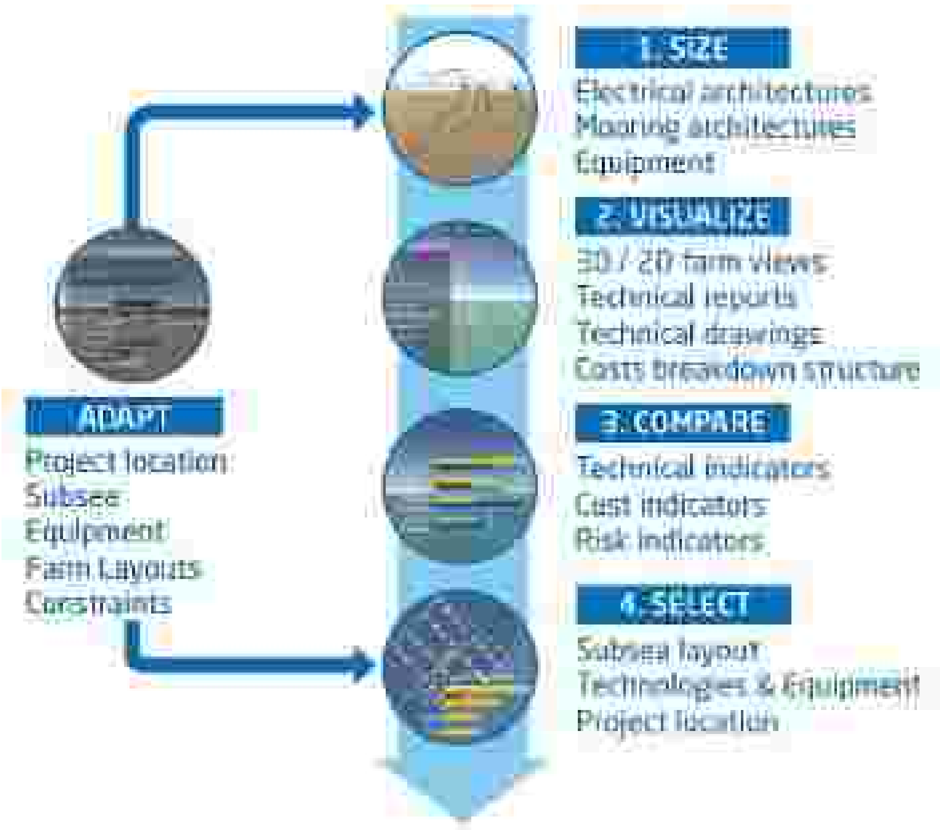
Integrated Loads Assessment by itself is insufficient to prove floater design robustness

Floater designer’s expertise (related to specific floater solution)



Concept Design OWF

Bespoke software to asses the layouts and their impact on the project



OUTPUTS

Set of eligible subsea architectures and performances

- Mooring Architectures
- Optimized Electrical Networks
- Pre design of Umbilicals' shape
- Selection of Anchors and Cables
- Performances assessment (KPI)

OWF Design – Early assessments and risk mitigation

What are the risks?

- Layout and Turbine selection not maximising the true site potential
- Incorrect load assessment leading to turbines inefficiency – particularly in floating wind
- Not detailed structural model to asses fatigue states of floaters
- Selection of foundations not considering construction logistics and installation implications
- Delay in installations due to local variables not being considered

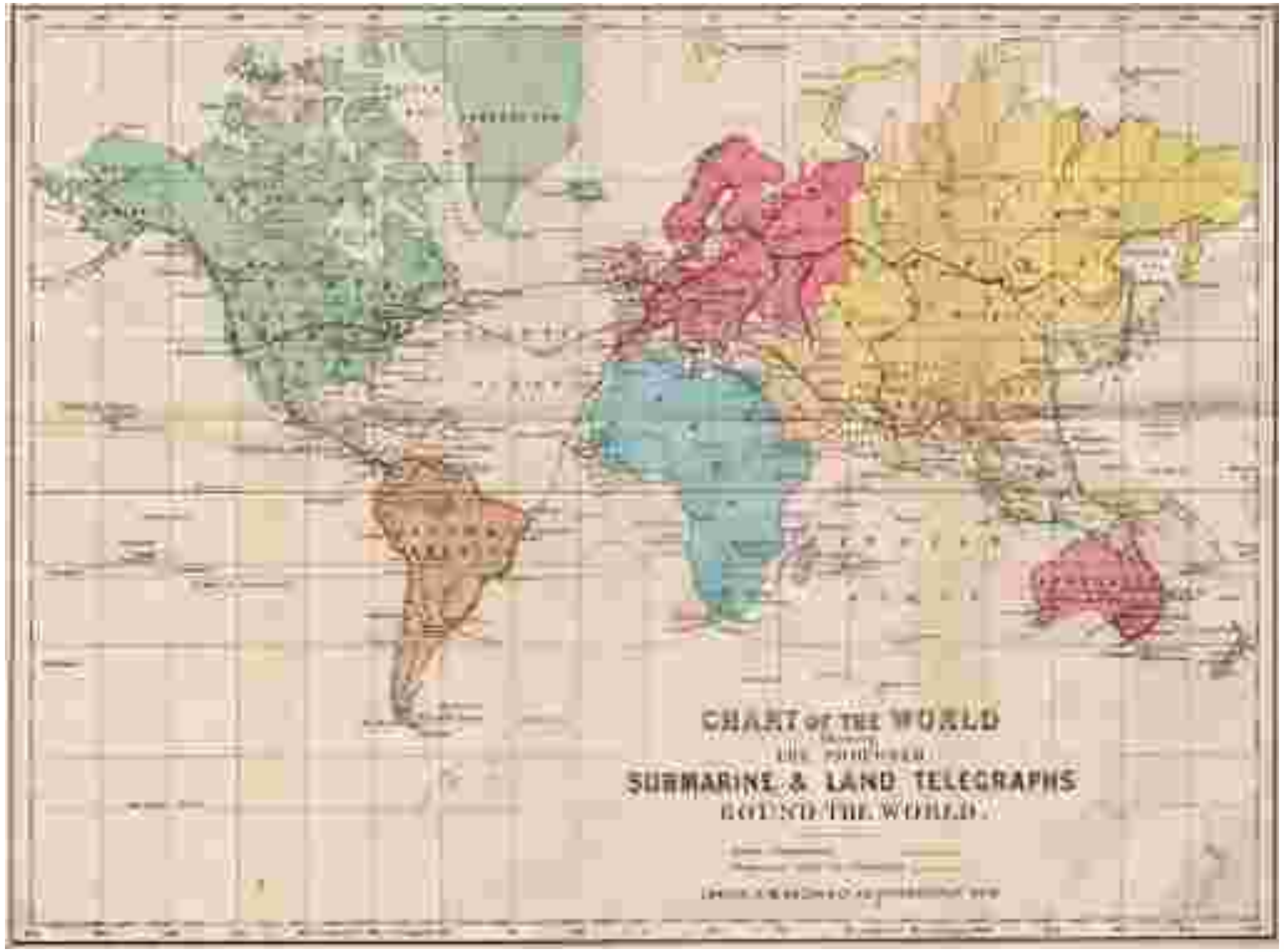
How to mitigate risk?

- Several farms **layout comparisons** including sensitives on turbine sizing and location
- **Coupled dynamic simulations** for global load assessments supported by **experience**
- Local structural check to ***assess fatigue life*** based on global loads
- **Construction and installation assessments** for the selected site based on supply chain and availability

Cable Installations in typhoon areas

Cables installations

- Cable ships have been laying cables for over a century



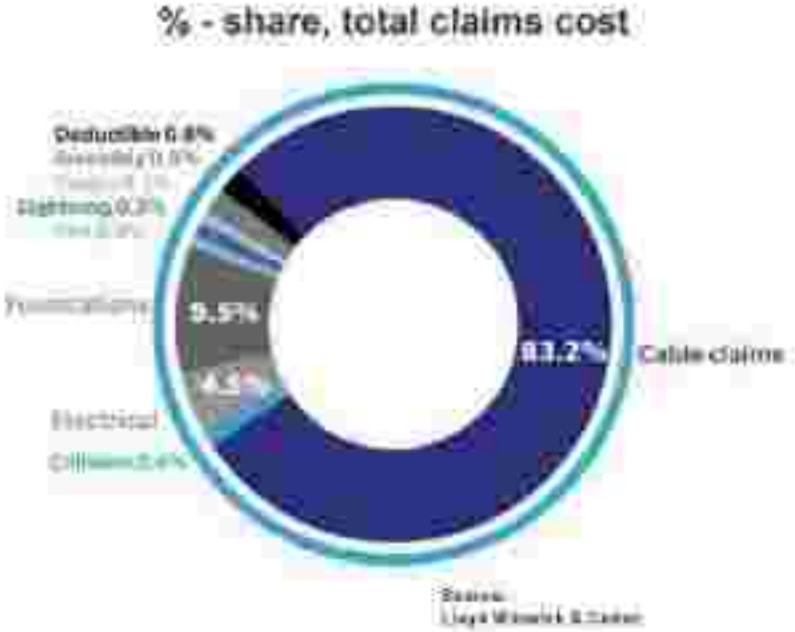
- Static cable catenary checks were used to ensure the cable safety

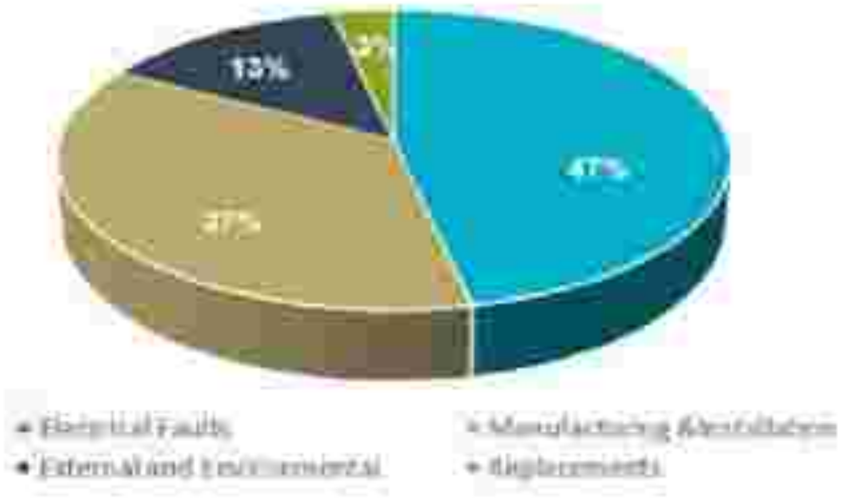
Cables installations in recent years

- Cable installation techniques have improved over hundreds of km of cable laid
- More sophisticated cables – especially for floating wind
- Analytical skills have been increased substantially to model the cable behaviour
- Highly specialised vessels being developed

HV cables installations in recent years

However cables today are still responsible for about 80% of the insurance claims with a good part of these failures being related to installation



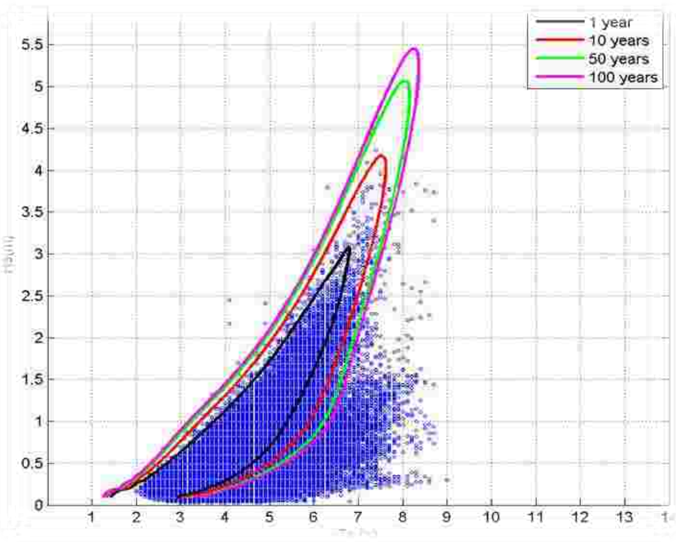


WHY…

Source: https://s3-eu-west-1.amazonaws.com/media.newore.catapult/app/uploads/2018/09/17152615/Subsea-Power-Cable-Trends-Othmane-El-Mountassir-and-Charlotte-Strang-Moran-AP-0018.pdf

Cables in OWF

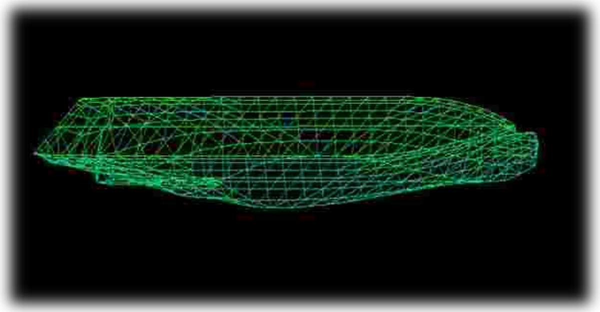
- Increasing number of operations each year due to the growth of OW worldwide
- Ever increasing number of cables to be installed due to increasing in size of each OWF
- The above leading to cables needing to be installed in higher sea states due to limited installation windows

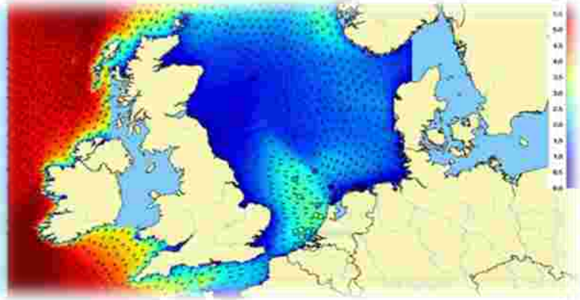


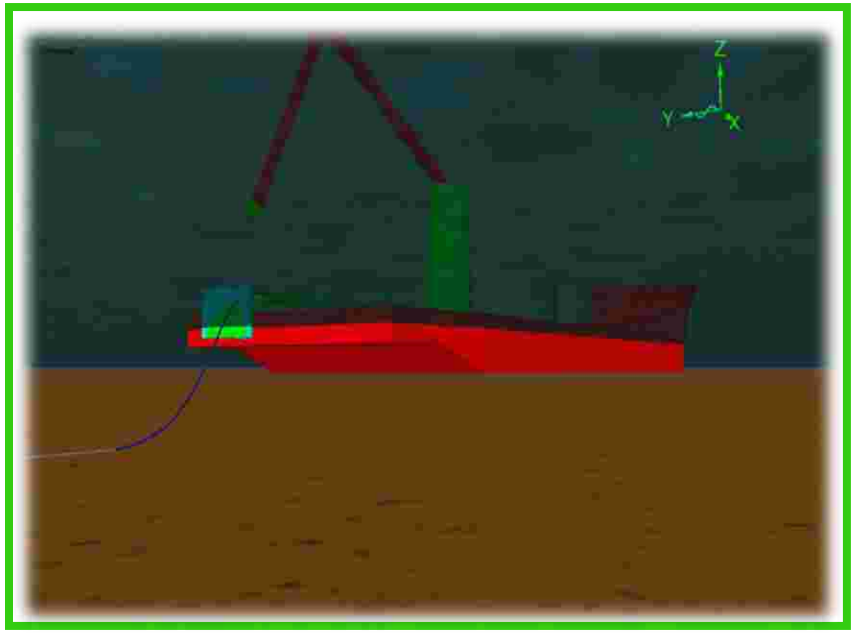
Non-Exceedence - PERCENTAGES												
Months	Point A			Point B			Point C			Point D		
	2.0m<	2.5m<	3.0m<	2.0m<	2.5m<	3.0m<	2.0m<	2.5m<	3.0m<	2.0m<	2.5m<	3.0m<
Jan	11	27	44	18	46	70	5	20	38	2	11	23
Feb	9	25	43	18	45	69	5	22	42	3	14	27
Mar	13	35	55	28	58	80	15	42	65	10	28	48
Apr	30	55	75	46	77	92	36	69	86	28	53	72
May	59	82	91	70	93	98	67	87	94	51	76	89
Jun	72	91	97	75	94	99	85	99	100	81	94	98
Jul	80	94	99	78	97	100	87	99	100	91	99	100
Aug	83	96	99	81	97	100	87	98	99	87	97	99
Sep	65	88	96	74	95	99	73	94	98	67	86	94
Oct	42	68	82	55	83	95	40	73	89	28	52	73
Nov	19	40	61	32	66	84	16	43	67	9	24	43
Dec	12	28	45	22	48	72	8	27	48	4	15	29
Annual	41	61	74	50	75	88	44	64	77	39	54	66

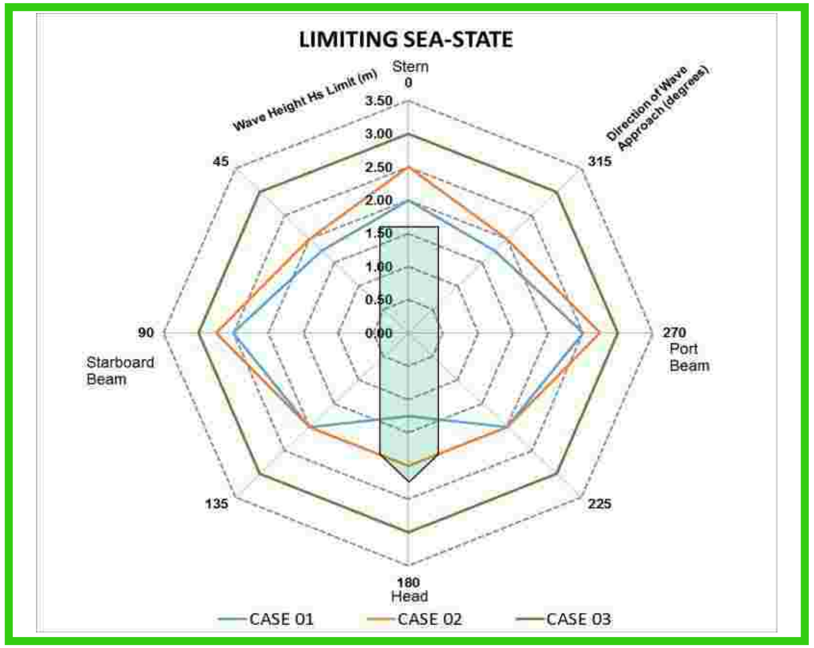
How can we mitigate this risk?

Cable installations assessments



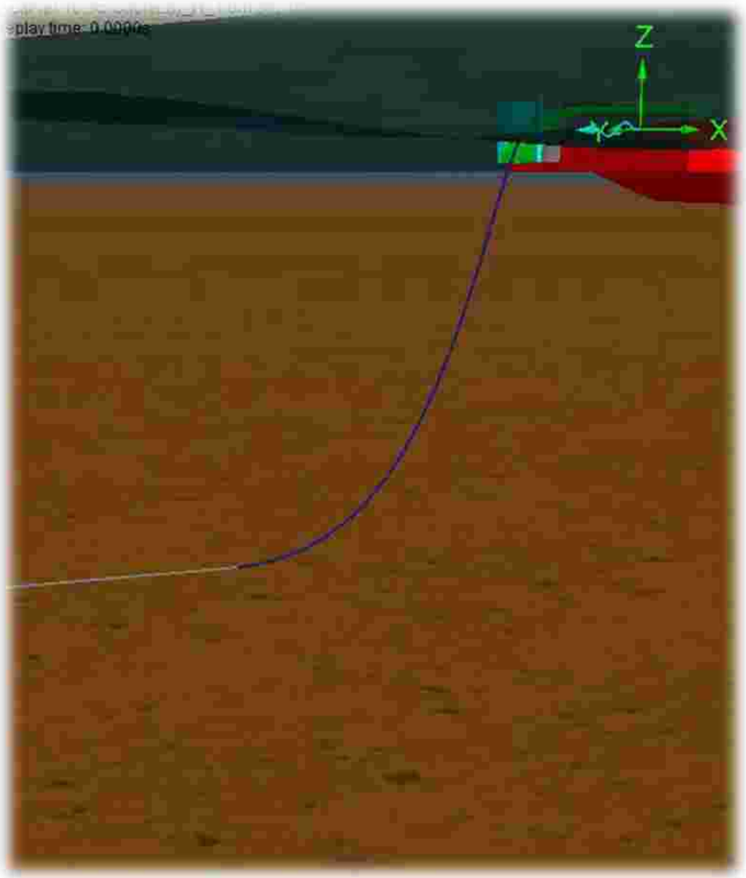


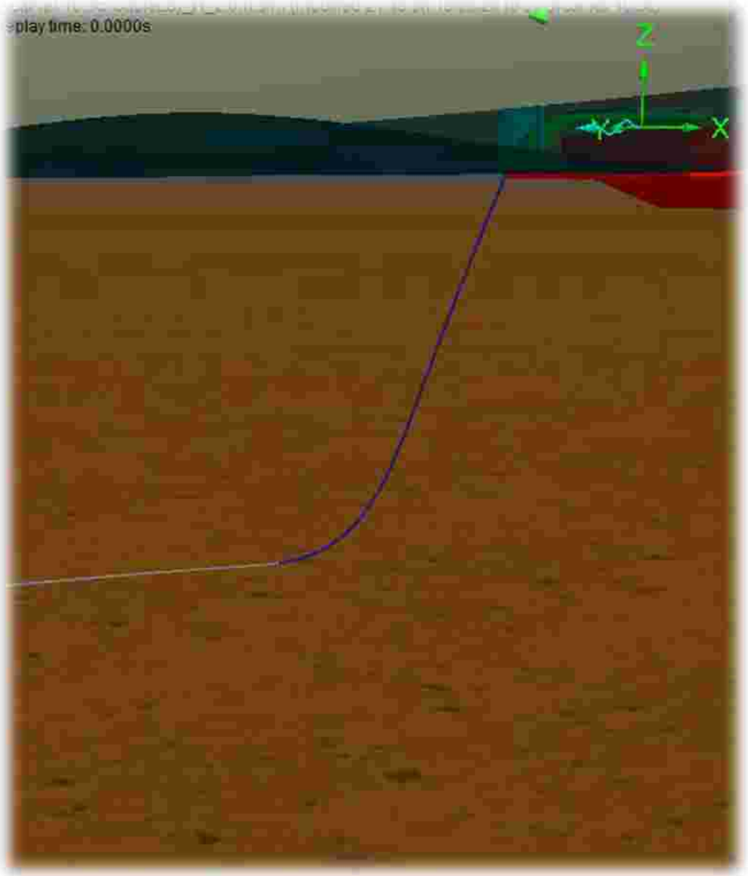


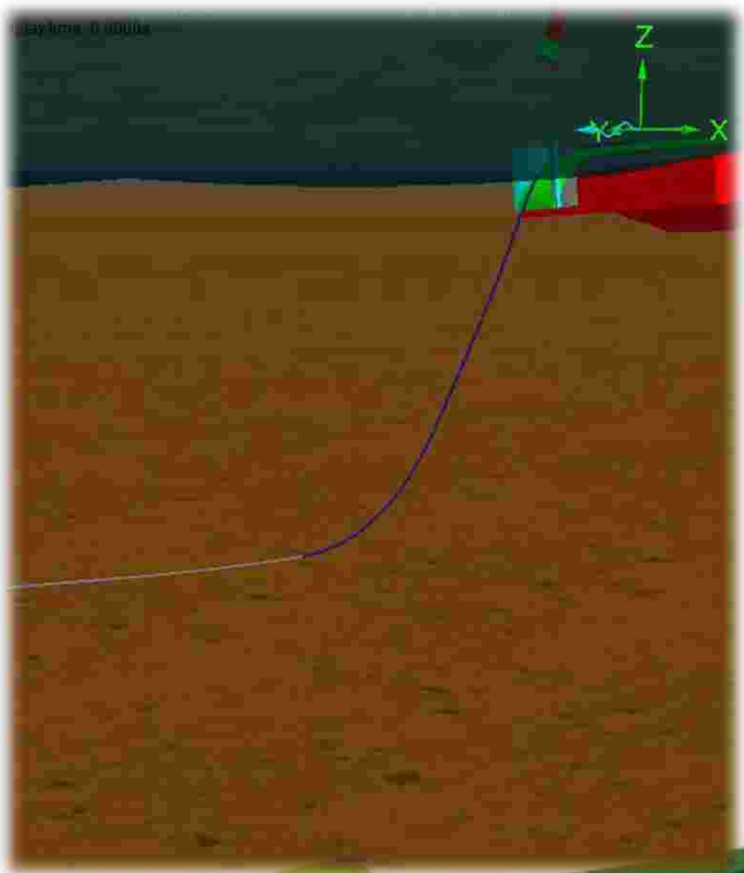


Cable installations assessments

- Full dynamic simulations to ensure cable integrity – Especially for floating WTG

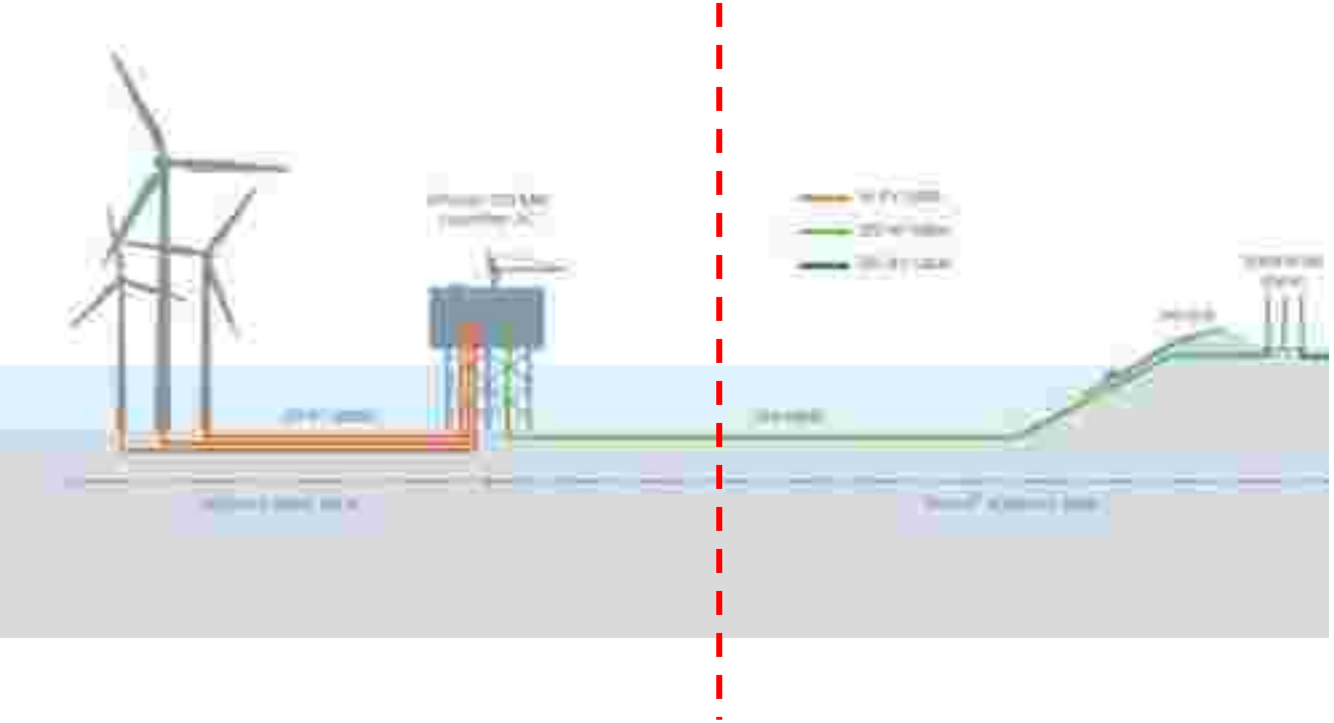


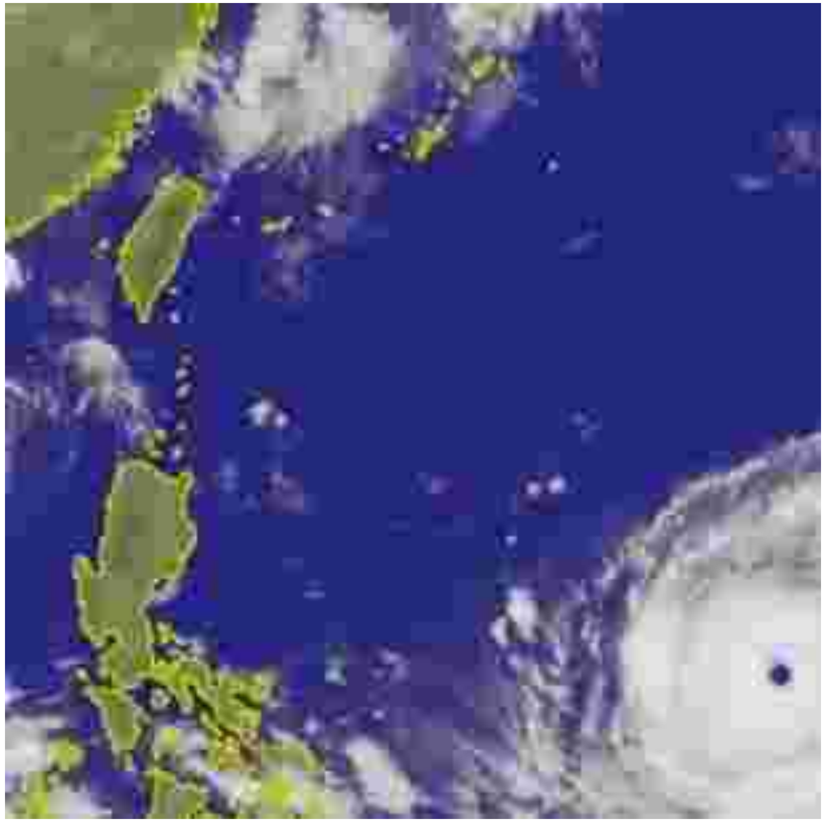




HV Power Cables installations – Typhoons implications

- Large 10 year, 100 year wave heights
- Locally two main areas of concern for in-place analysis
  - Nearshore cable instability if not simultaneously buried
  - High CPS loadings in 100year return events

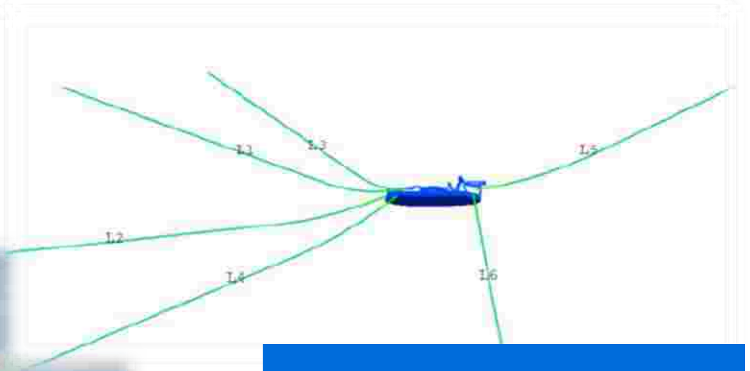




Nearshore Cables installation

Many critical operations take place in the nearshore area:

- Land-fall pull-in operations
- Shallow water skid mooring
- Grounding operation
- Export cable wet storage



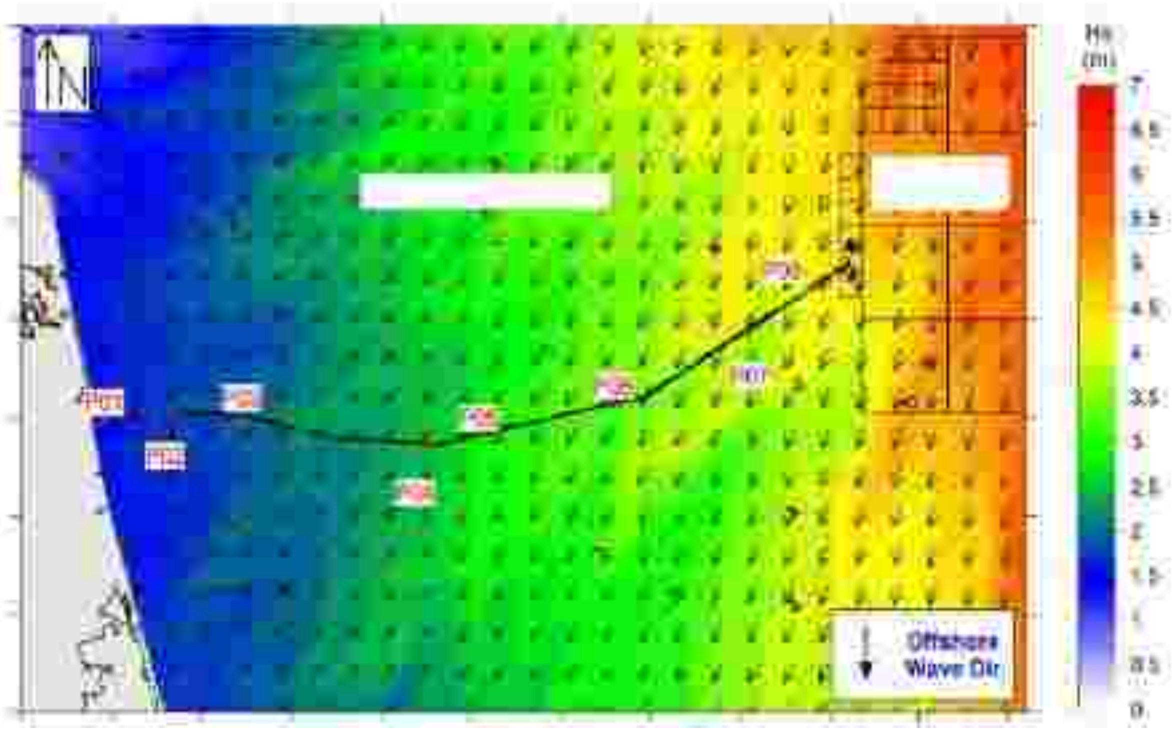
Source: http://www.gpccumbria.co.uk/

HOWEVER

- Met-ocean often not detailed enough on nearshore areas and often applicable only to offshore
- Effects are magnified in a typhoon environment where we see large wave heights for the in place return periods
- Not suitable standards for correctly assessing the cable stability applicable for pipelines

Nearshore Cables installation

- Near shore modelling results in an accurate modelling of the waves' behaviour
- Reduce conservativism and allow for correct wave heights to be considered
- When combined stability assessments based on geotechnical data and cable properties

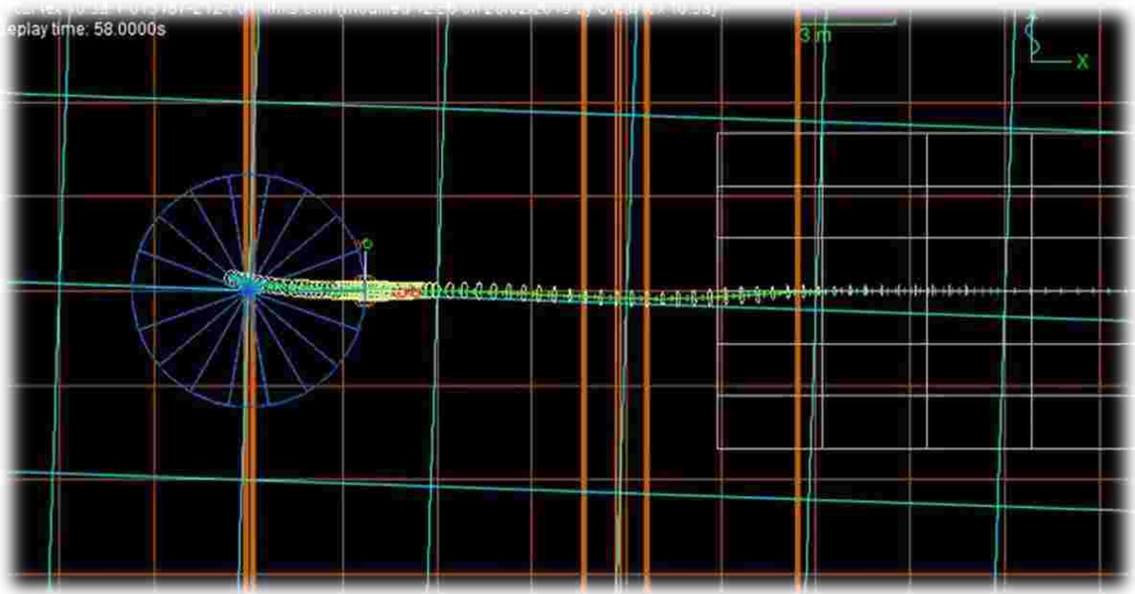


Allows for:

- Improved operations planning for shore pull-in
- Stability assessment for site specific conditions
- Considerations for actual cable embedment and reactions
- Project costs savings for both operations and reduced precautionary measures.

Offshore Cables installation – In place ULS

- Dynamic simulations to predict the cables' behaviour
- Cable Protection System (CPS) loading considered in Ultimate Limit State (ULS)
- Soil resistance to accurately predict motions during extreme events
- Detailed CPS model to study the mechanical properties



Cable Installations - Early assessments and risk mitigation

What are the risks?

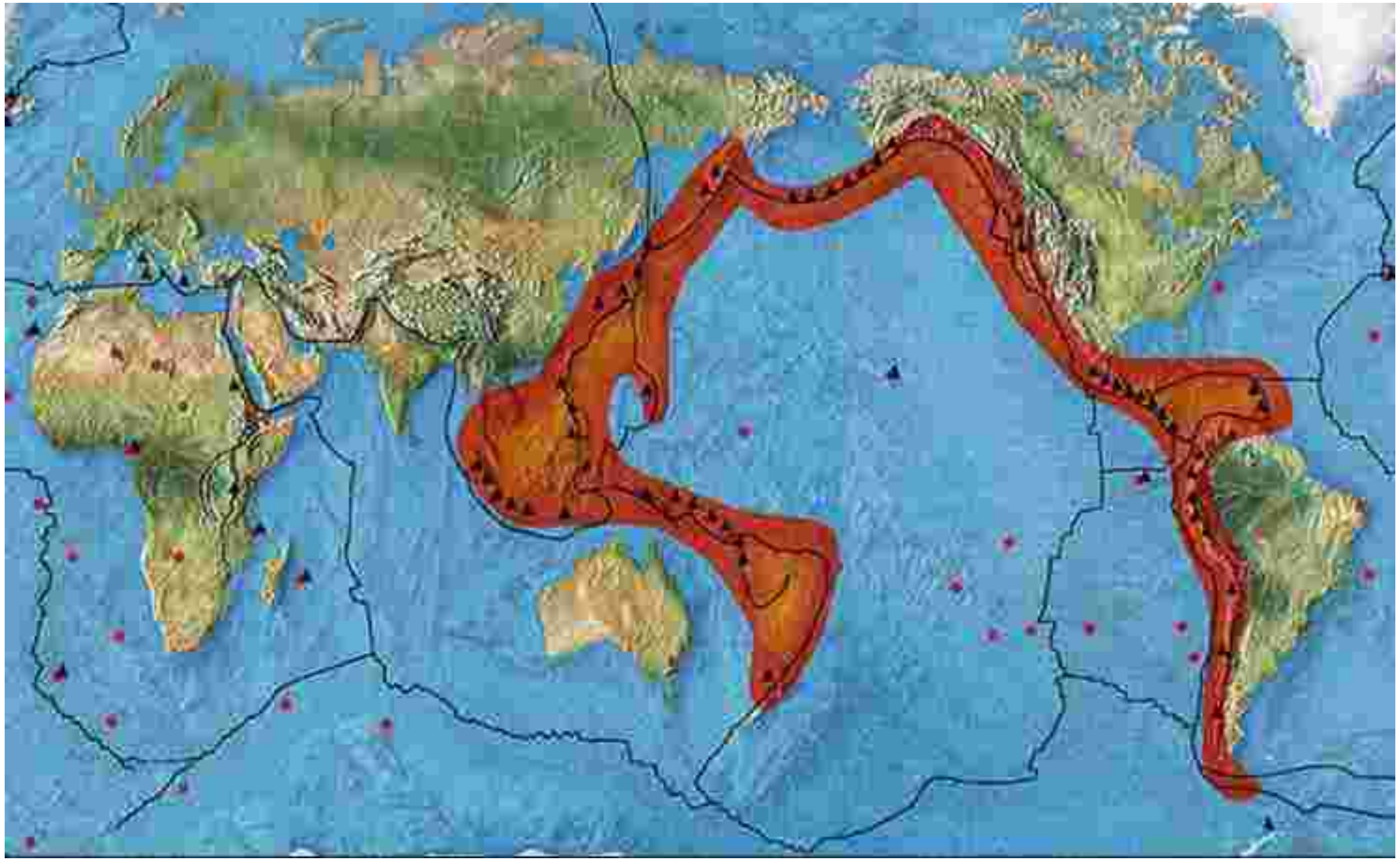
- Damage to cables during installations
- Reduced operability
- Additional expensive unnecessary corrective measures
- Increased costs due to vessel and systems requirements

How to mitigate risk?

- Detailed ***met-ocean analysis of onshore areas*** as well as offshore
- Accurate **soil modelling** to determine cable stability and reactions
- Create accurate ***operation modelling***
- Planning of operations with the aide of **dynamic simulations** to “play-out” several scenarios

Jack-up operations in earthquake regions

The Ring of Fire - Earthquake Prone Areas



- Some of the biggest growth areas for offshore wind farms (OWF) include :
  - Korea
  - Japan
  - Taiwan
  - Philippines
  - Indonesia
- This region is earthquake prone
- Liquefaction caused by seismic activity is one of the biggest risks that developers have to deal with
- LOC have worked with rig owners in assessing and mitigating that liquefaction risk, during jack-up installation, on several OWF

Liquefaction in Earthquake Prone Locations

- **LIQUEFACTION** - a phenomenon whereby a **saturated** or **partially saturated soil** substantially **loses strength** and stiffness in response to an applied stress
- Usually due to earthquake shaking or other sudden changes in stress condition, causing it to **behave like a liquid**
- Loose sands and silts prone to liquefaction
- Biggest Risk is during manned wind turbine installation with vessel in jack-up position

Hotel in Hualien, Taiwan after the 2018 earthquake

Key issues in seismic assessment

What return period earthquake design peak ground accelerations (PGAs) should be applied to assess the integrity of the jack-up on location?

What return period earthquake design accelerations should be applied to assess the integrity of the lifting operations?

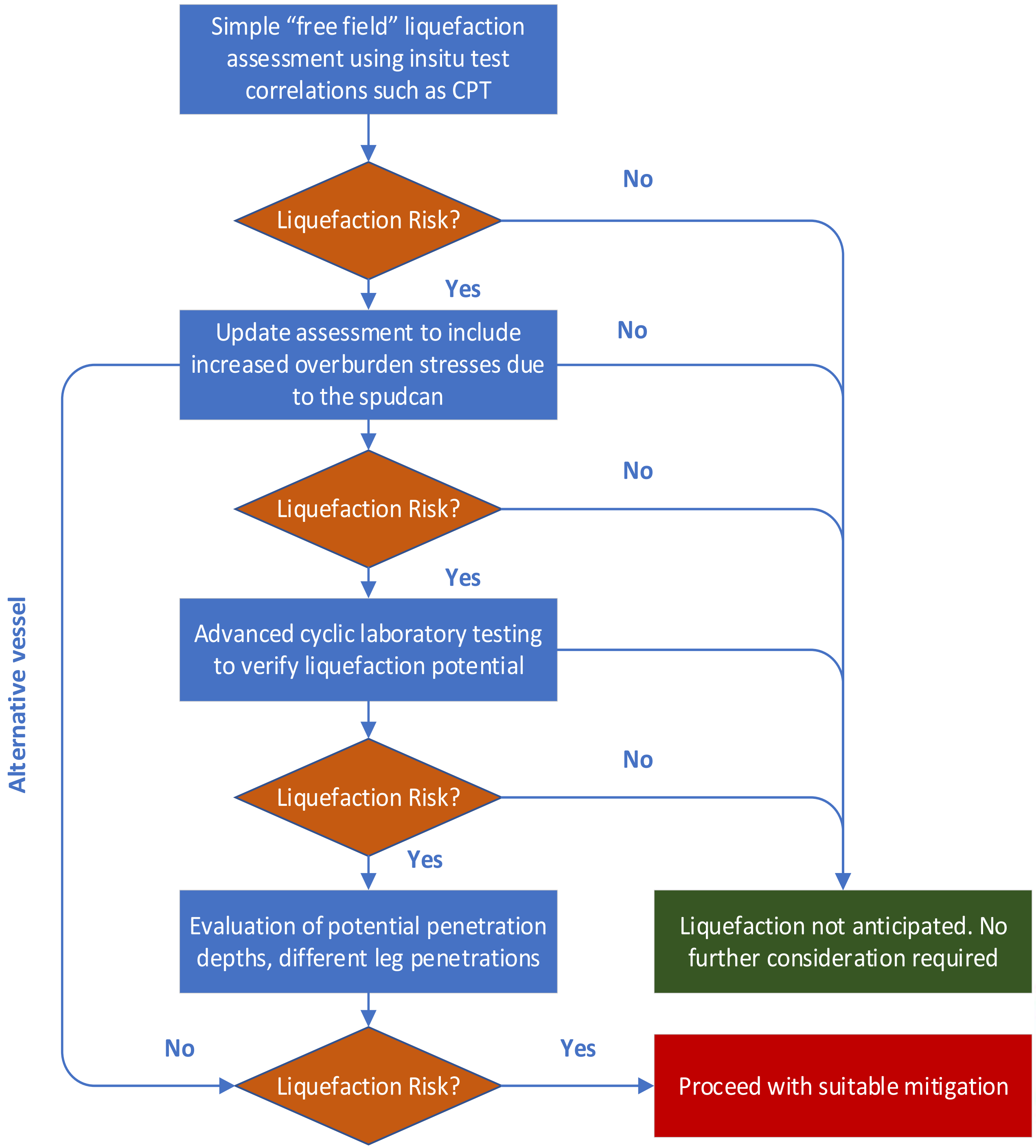
If such PGA are applied would that lead to failure of the soil due to liquefaction for free field?

Site Specific Seismic Hazard Assessment

- Offshore Windfarm construction in Asia has been growing especially in Taiwan
- Taiwanese building regulations require that when earthquake loads are to be assessed for overall design integrity, 475-year return conditions are applied
- Derive a site specific seismic hazard curve.
- This will require stringent statistical analysis of offshore earthquakes and the resulting ground acceleration. This curve which should plot the annual probability of exceedance vs ground acceleration would enable the assessor to identify the relevant return period acceleration that should be used in design

Liquefaction Assessment

- LOC have carried out a number of seismic and liquefaction assessments for jack-up operations on OWF in Asia
- LOC have developed their own workflow for liquefaction as presented in this flowchart to the right

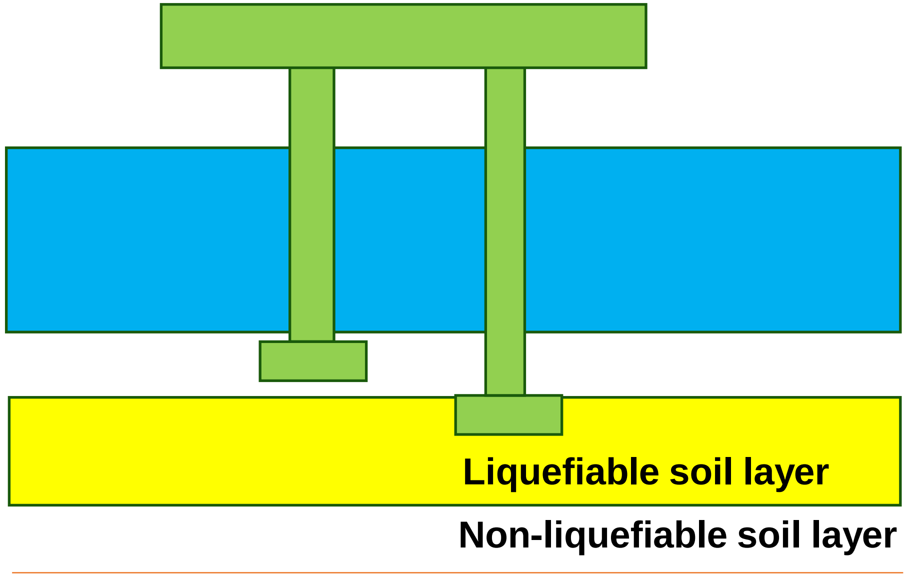


Jack-up Seismic Assessment: Dealing with liquefaction risk

- Jack-ups are sometimes founded in soils that are at risk of liquefaction in response to Seismic Ground Accelerations
- From an assessment perspective for Marine Warranty this can be addressed in 2 ways:

  - **Consequence-based approach –** Perform an assessment of the jack-up experiencing a soil liquefaction event and demonstrate that the jack-up would not experience damage

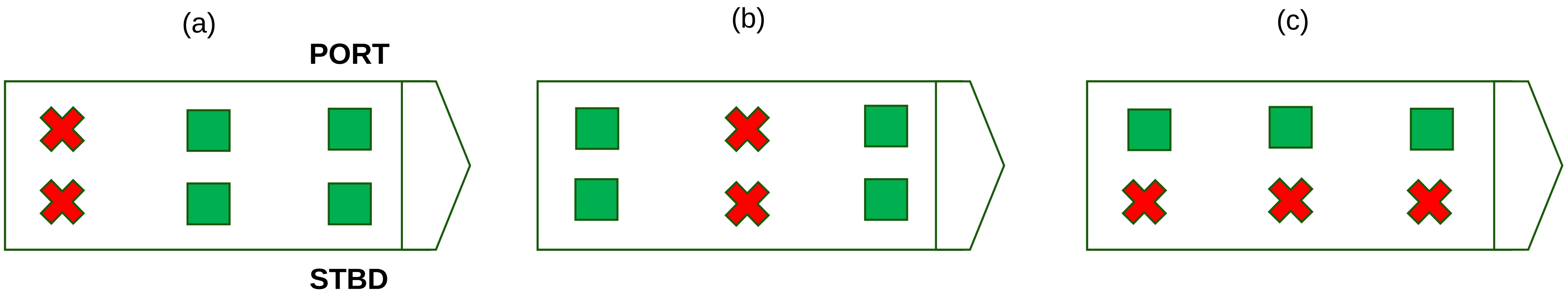
  - **Risk-based approach –** Quantify the risk of soil liquefaction occurring and demonstrate it is sufficiently low to be acceptable to Vessel owner, MWS and Underwriter



Source: https://www.youtube.com/watch?v=afBqD8Hm2Ak

Jack-up Seismic Assessment: Dealing with liquefaction risk

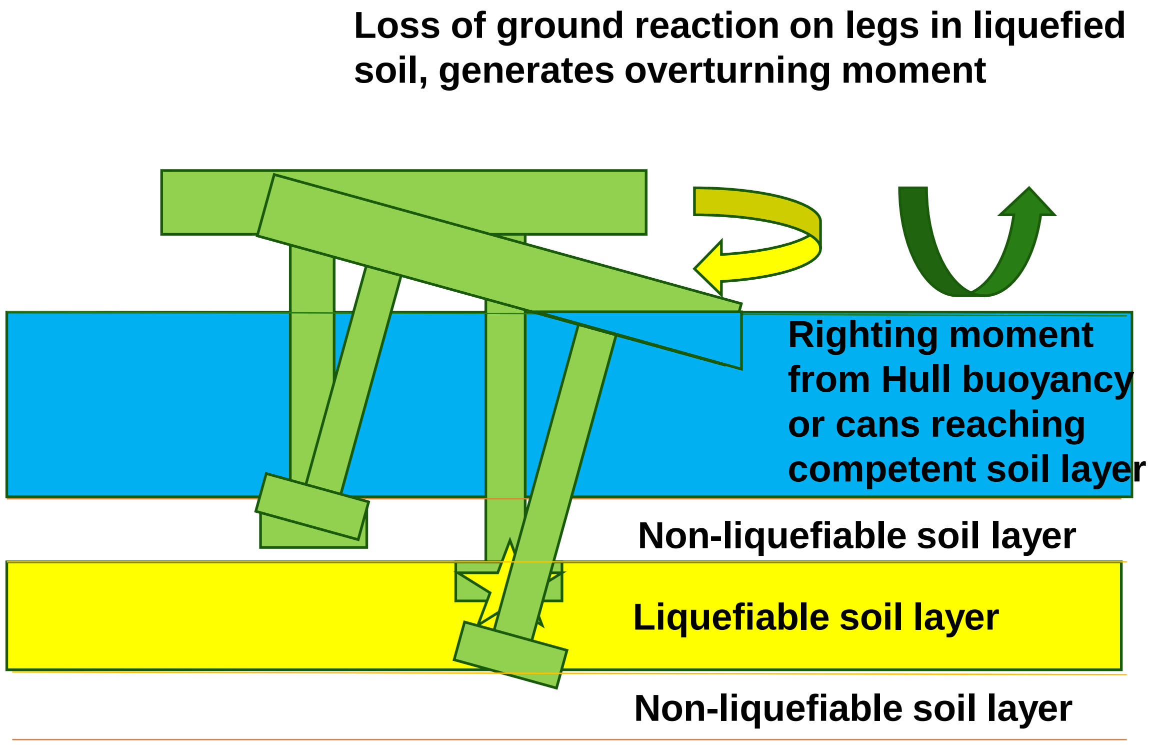
- **Consequence-based approach:**
  - Perform an engineering analysis where liquefaction is modelled as a sudden loss of seabed support on ≥ 1 legs
  - E.g. for a 6-leg unit this may take one of the following forms (✖ denotes a leg where liquefaction has occurred):



  - Option (c) might be considered most onerous as it would result in a loss of stability of the vessel which would start to tilt towards Starboard side
  - Options (a) & (b) may still over-utilise the leg and holding system due to load redistribution from 6 legs to 4-legs and resulting hull sag

Jack-up Seismic Assessment: Dealing with liquefaction risk

- **Consequence-based approach:**
  - Option (c) may be considered similar to a Punch-through event
  - Jack-up will start to rotate about the port-side legs at the spudcans
  - Not reaching equilibrium until either:
    1) Liquefied legs reach a layer of competent soil <u>OR</u>
    2) Hull is subject to additional righting moment e.g. from Hull buoyancy
  - For Option (1) can estimate additional penetration due to liquefaction
  - If you rely on Option (2) it is necessary for the jack-up to be operating with the hull ("Semi-Jacked") either at small airgap or positive draught. This will generally not be possible if the jack-up is installing WTG equipment (Towers, Nacelles and Turbine blades)



Jack-up Seismic Assessment: Dealing with liquefaction risk

- **Risk-based approach:**
  - An alternative is to adopt this approach where the risk of liquefaction event is quantified to a level which is considered ‘As Low As Reasonably Practical’ (ALARP) and acceptable to the designated Marine Warranty Surveyor (MWS), underwriter and other stakeholders
  - This will be an outcome from a formal HAZID/HAZOP assessment
  - Further detailed study on the probability of the liquefaction event occurring, identification of possible mitigation measures and their impact may be required to satisfy the vessel owner, the MWS and underwriter that the risk is ALARP

Jack-up Seismic Assessment: Dealing with liquefaction risk

- **Risk-based approach:**
- Risk assessment focusses on the potential for catastrophic rig failure which depends on whether soil/ structure failure due to earthquake occurs and the vessel is elevated
- Analysis can be considered in terms of three key elements:
  - **Frequency –** likelihood of soil/ structure failure due to earthquake event at each turbine site
  - **Severity –** the probability of rig collapse due to above-mentioned event occurring, while the rig is on location
  - **Exposure –** probability of rig being elevated on location when soil/ structure failure due to earthquake occurs

Jack-up Seismic Assessment: Dealing with liquefaction risk

- **Risk-based approach:**
- Risk of rig failure is considered acceptable if within an ‘As Low As Reasonably Practicable’ (ALARP) region
- The ALARP principle has been widely used in oil & gas and other industries, accounting for practicality of risk reduction measures
- ALARP criterion should be project specific
- Intolerable limit for rig failure in this example taken as 10^{-3} per year

Jack-up Installations - Early assessments and risk mitigation

What are the risks?

- Jack-up punch trough due to liquefaction during earthquake.
- Damage to jack-up, foundations and equipment.

How to mitigate risk?

- Assessing the correct return periods for design earthquake accelerations for the integrity of jack-up
- Free-field and “Under-spudcan” liquefaction RA to identify whether the risk requires mitigation
- Ground pre-treatment to eliminate liquefaction
- Consequences of soil liquefaction on a Jack-up can be severe and can be treated in two ways (not mutually exclusive):
  - **Consequence-based approach**: Perform an assessment of the jack-up experiencing soil liquefaction and demonstrate that it would not experience damage
  - **Risk-based approach**: Quantify the risk of soil liquefaction occurring and demonstrate it is sufficiently low to be acceptable to the vessel owner, MWS and underwriter

Conclusions

How can we help?

- Multidisciplinary team covering a wide range of capabilities from conceptual design through to installation (naval architecture, structural engineering, metocean, coastal engineering, geoscience, etc.) of both ***floating and fixed assets***
- Understanding of ***APAC OWF specific challenges*** and market complexity
- ***Long track record*** with experience in over 130 Offshore Wind Projects
- Overview assessments of OWF layouts, foundation concepts, logistical and installation operations

We would love to hear from you!

RICCARDO FELICI

Senior Consultant

Longitude Singapore

: +65 9017 0706

: r.felici@longitude-engineering.com

HAKIM MOUSLIM

Director

Innosea Nantes

: hakim.mouslim@innosea.fr

ZAHIDUR RAHMAN

Senior Consultant

Longitude London

: +44 7855 066 870

: z.rahman@longitude-engineering.com

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LOC
LONGITUDE An LOC Company
INNOSEA An LOC Company

Riccardo Felici
LOC Renewables / Longitude
r.felici@longitude-engineering.com
www.loc-group.com


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Offshore Wind in Asia: Early Technical Assessments and Installation Implications
TUESDAY, 6 OCTOBER 2020 - 3 PM SGT

Q&A Session

Question 1

How different are the wind farm designs in Taiwan and Japan?

Question 2
Is there a lot of additional costs to make cable installations typhoon proof?

Question 3

Are existing vessels from Europe suitable for installation in typhoon regions?

Question 4

What factors are assessed in determining monopile or jacket foundation for fixed structure offshore wind turbines?

Question 5

Would you see a preference for a specific floater design, i.e. spar, semi or TLP?

Question 6

What is the estimated cost for offshore sea cable for 500kV line per km basis?

Question 7

What is the range of typical footprint for a floating wind array?

Question 8

Does the early assessment include wake effect? How to evaluate wake effect and find the optimized design (e.g. numbers, distance and location of turbines)?

Question 9

What are the key differences between offshore wind cable installation and cable/umbilical/flexible installation for oil and gas projects?

Question 10

Is there a significant difference in leg penetration and air gap for jack ups in the APAC region (e.g. Taiwan), and could you quantify a typical value?

Question 11

Are there any insights from the EU sector with respect to how many WTG's and general capacities (~8MW or more) would be covered under one spread for a typical water depth range?

Question 12

Is there sufficient time to lower the jack up if a seismic event is detected? If so, is there value in monitoring vibration?

Question 13

In Japan, several typhoons could be occurred during the construction phase. Due to mitigate waiting fee of Jack-up vessel by down time of typhoon, can you consider to use derivative method or insurance?

Question 14

Specifically for liquefaction assessments taking into consideration of using jack-ups during installation phases, are you seeing such technical requests coming in from installation contractors for additional assessments to be carried out? i.e. the Formosa1 projects in Taiwan as an example.

Question 15

What in your opinion should developers and EPC companies focus in APAC during development and construction?


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Closing

Information

Asia Wind Energy Association

www.asiawind.org

@asiawindenergy

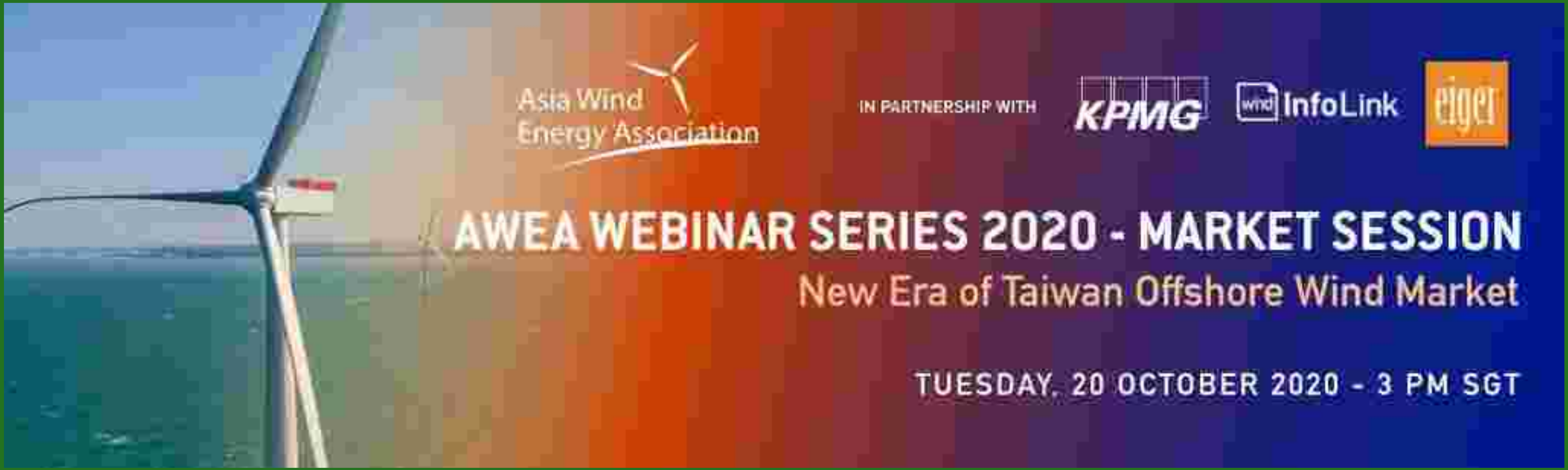
Asia Wind Energy Association

(65) 6679 6071

membership@asiawind.org

CapitaGreen - Level 24
138 Market Street, Singapore 048946

Upcoming Webinar

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Thank You!