Placing Albany on the map of the world's leading renewable energy cities

Knowledge transfer in ocean engineering

Prof. C. Gaudin

The University of Western Australia

SUT Evening Technical Meeting

10/10/2018

Question

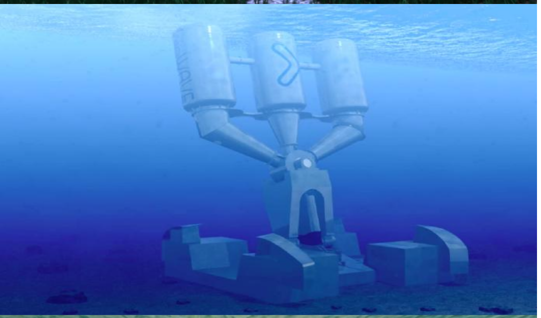
What can the offshore renewable industry learn from the oil&gas industry?

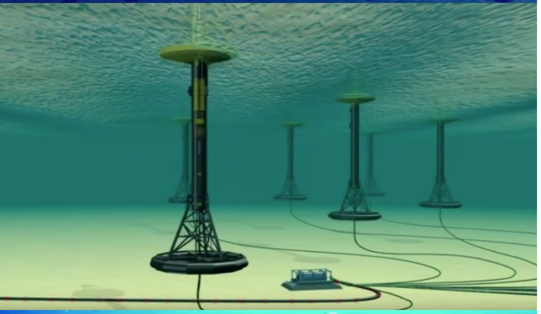
Question

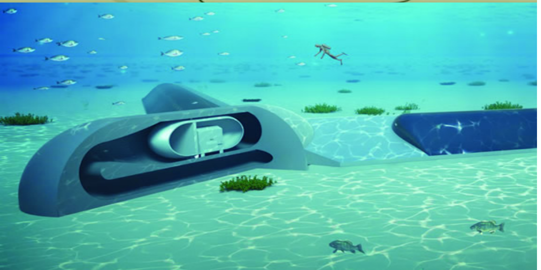
What can the oil&gas industry offshore learn from the renewable industry?

The Wave Energy Research Centre

THE UNIVERSITY OF WESTERN AUSTRALIA







Wave Energy Research Center

$3.75M State government funding

$1M UWA matching fund + >$6M in-kind contribution)

Perth and Albany based

20+ Academics

10+ PhD students

Wave flume, geotechnical centrifuge, Pawsey

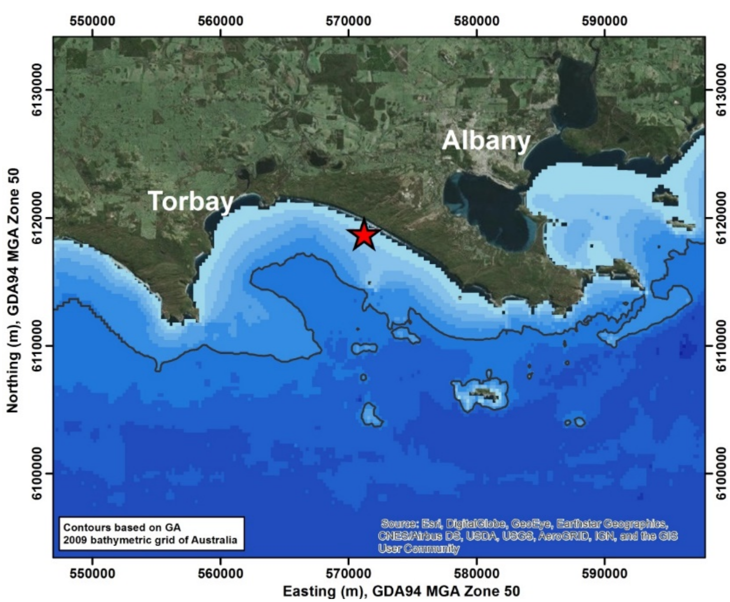
The site

World class wave resources

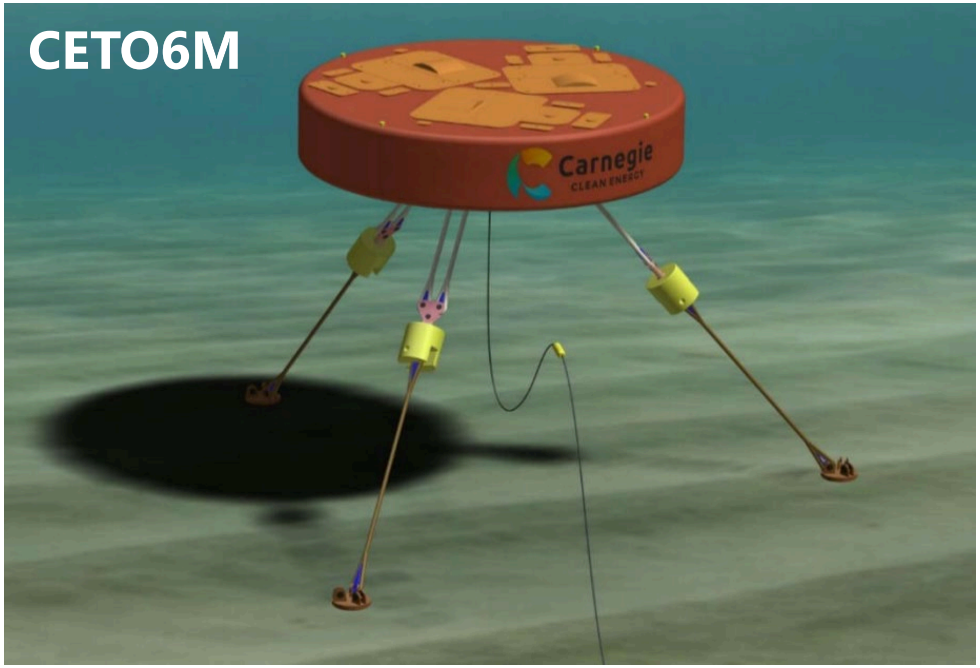
- 40 kW/m
- T_p = 12 s
- 2.9 m < H_s < 4.5 m
- Low H_{max}/H_s ratio
- Small tidal range < 1m

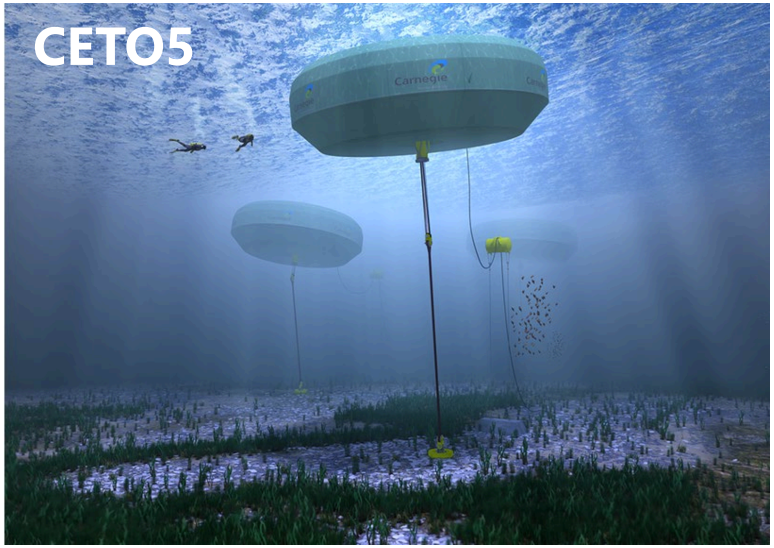
Social and political drive

- Development of remote communities
- Albany 100% renewable by 2026
- Existing 35 MW wind farm



Albany Wave Energy Project (AWEP)





- Deployed by Carnegie Clean Energy
- 1.5 MW point absorber
- Follows on CETO5 PWEP
- Enabling pre-commercial CETO array
- Develop permanent common user infrastructures

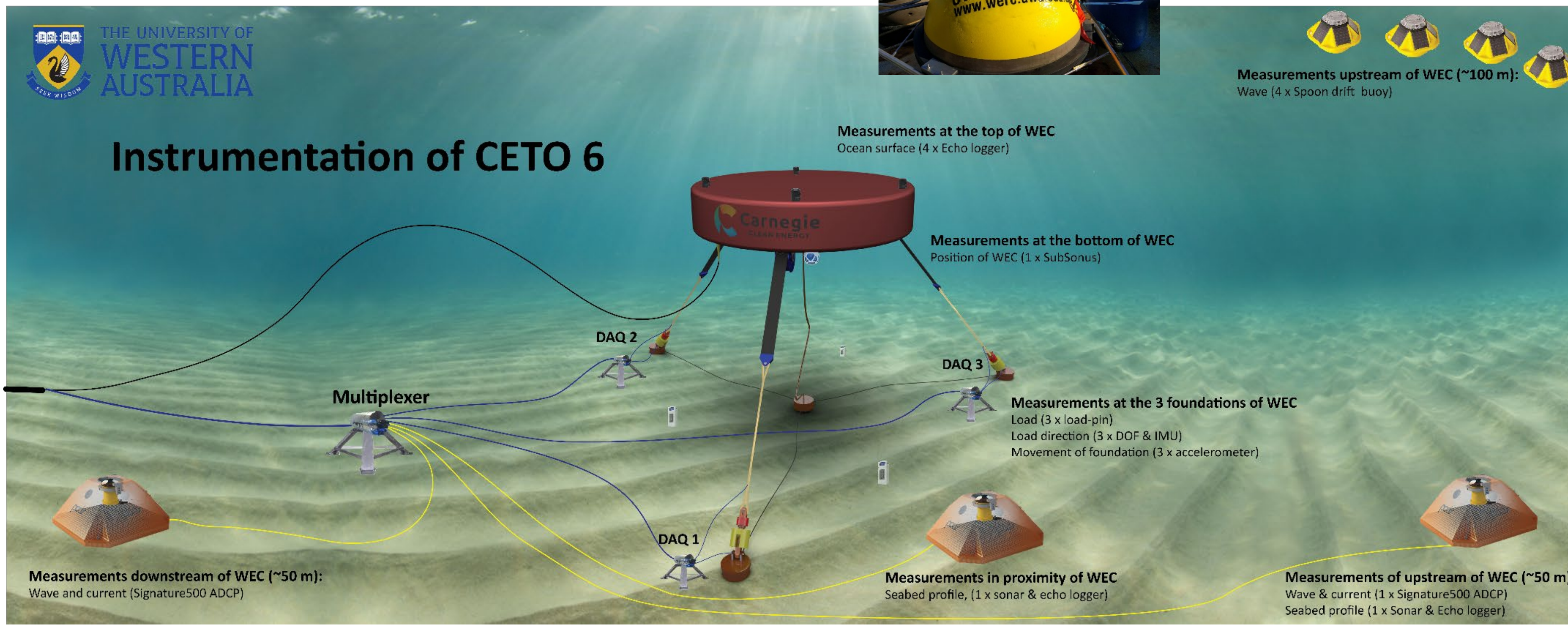
WERC Research activities

THE UNIVERSITY OF WESTERN AUSTRALIA

- **Wave modelling**
    - Resource assessment, including modal conditions as well as extremes
    - Wave-device interaction
    - Down stream (coastal) impacts
- **Hydrodynamics**
    - Device-device interaction
    - Device stability
    - Optimisation and active control
    - Extreme response and survivability
- **Foundation engineering**
    - Performance under “exotic” loading (dynamic, multidirectional, …)
    - New design paradigms (survivability, reliability)

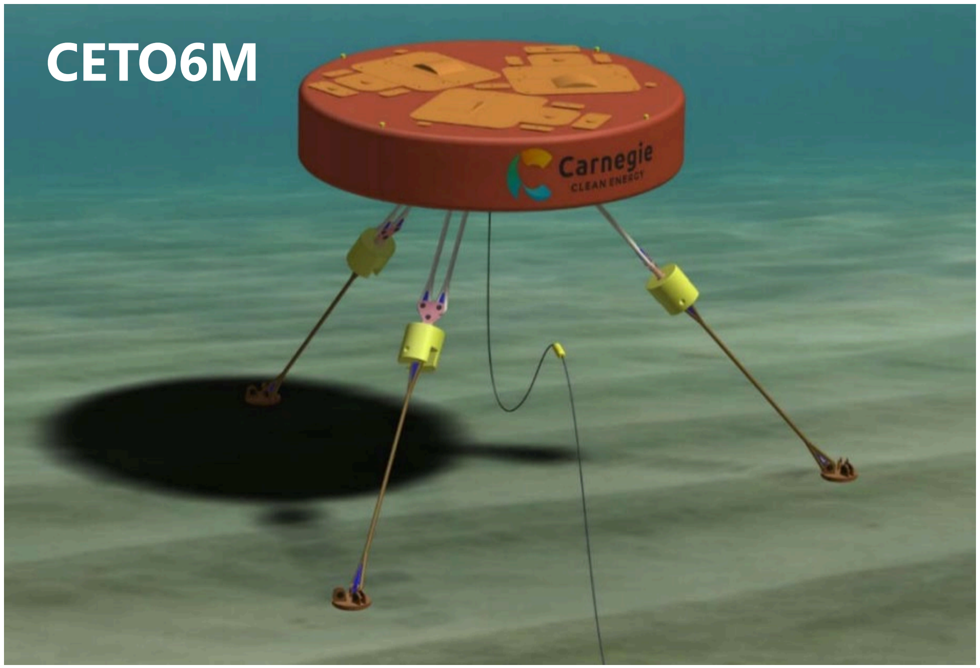
Living laboratory

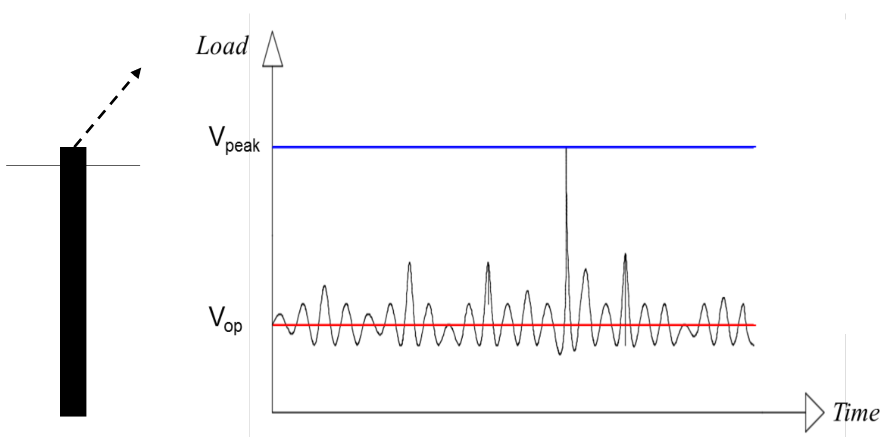
2 AWAC



- Streaming data 24/7 over 12 months
- Made publically available
- Data integrated to IMOS (Integrating Marine Observing System)
- Available for research and teaching purpose

Specificities of point absorbers





- Designed to resonate with waves
- Experience high acceleration
- Foundations serves for station keeping and reaction force
- Experience extreme/snatch loads
- **Power take off** characteristics governs hydrodynamic motion, mooring line loads and power efficiency

- Efficiency driven by active control
- Design driven by survivability

Impact wave farm, wave field

Impact wave farm

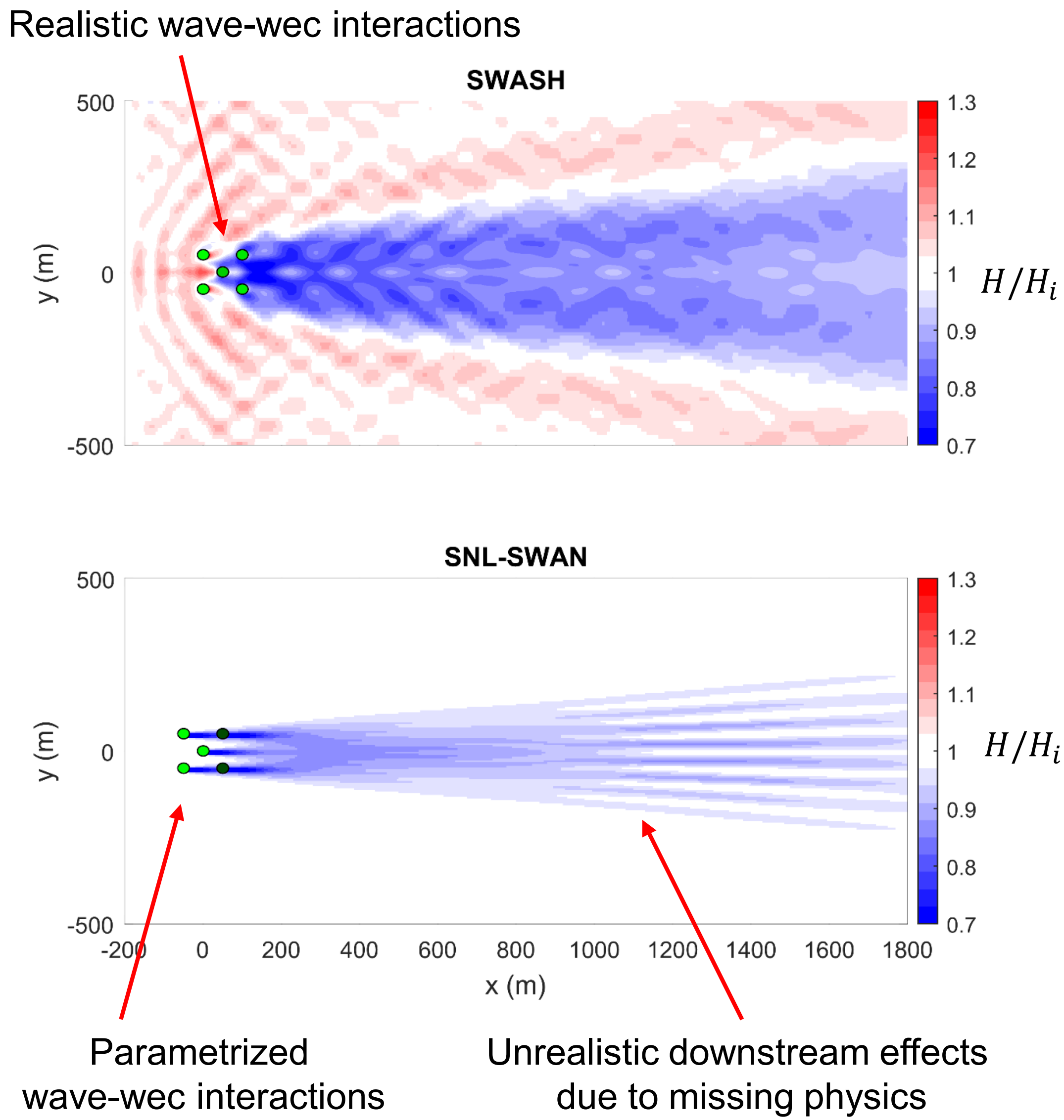
SWASH vs SNL-SWAN

Idealised simulation

- Flat bottom 20m deep
- Irregular waves
- $H = 1$ m, $T_p = 10$ s

Difference wave height between <u>farm</u> (H) and <u>no farm</u> (H_i).

- Decrease wave height in lee (blue shades)
- Increase wave height (red shades) due to scattering and radiation of waves

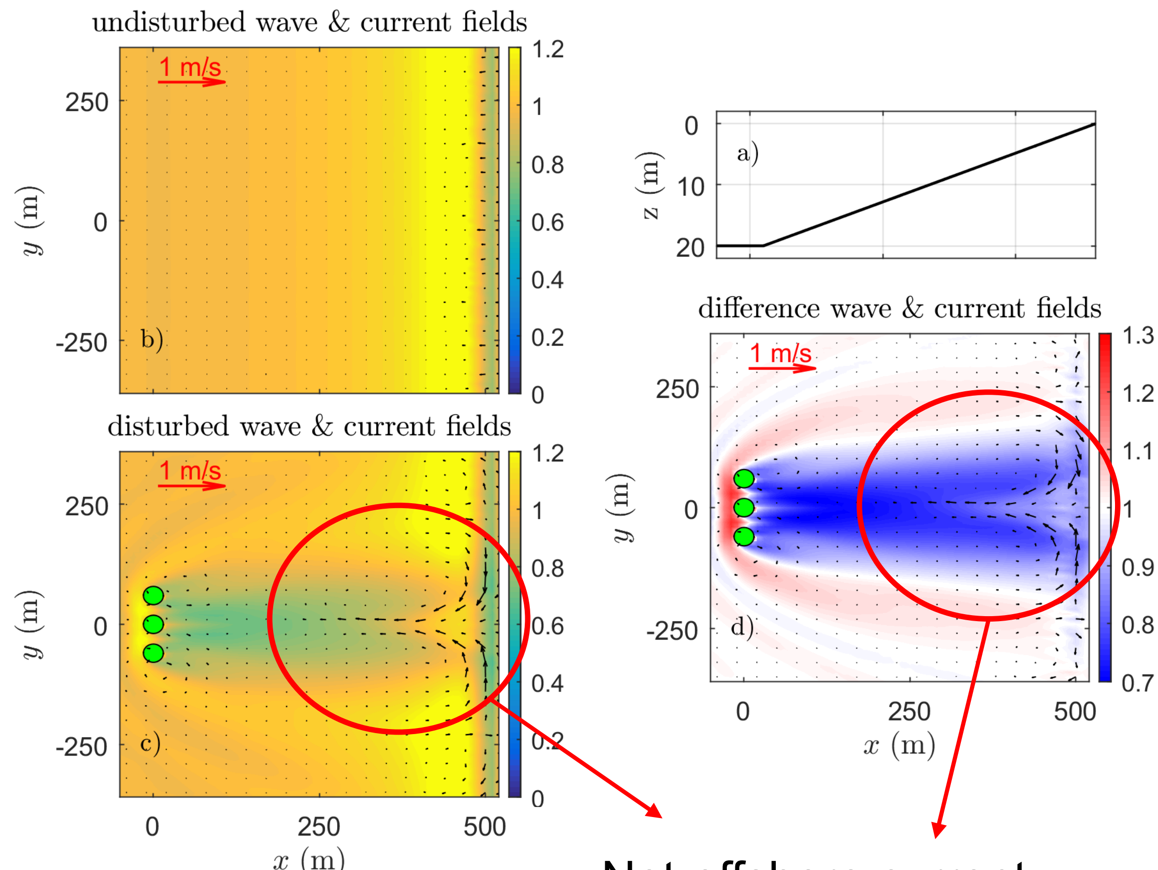


Impact wave farm, wave-induced currents

Impact wave farm
SWASH

Idealised simulation

- Constant slope (1/25)
- Irregular waves
- $H = 1$ m, $T_p = 10$ s



Net-offshore current due to wave farm

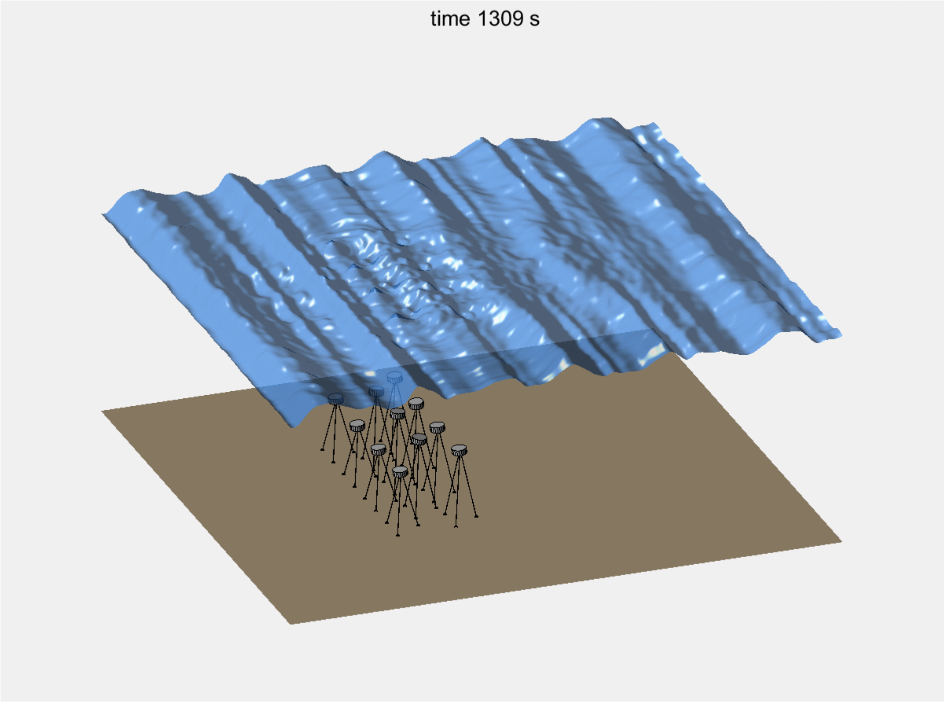
Knowledge transfer

SWASH

Realistically captures wave-WEC interactions and absorption of wave energy by WECs.

Intrinsically accounts for wave-induced currents in the coastal region
→ proxy for coastal impact

State-of-the-art tool to assess coastal impact by WEC farms.



Knowledge transfer
Further development in progress the model to simulate the **wave-induced motions** of **moored ships**

Wave by Wave Prediction

Current wave modelling standard:

- Predict the *probability* of a wave having a given size and period in a given sea state. Model around extremes given these statistics.

Wave by wave prediction:

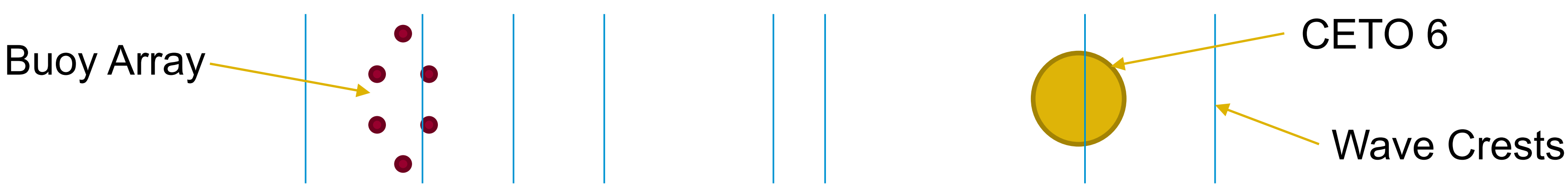
- Exactly determine the oncoming wave ahead of time

Application for WECs:

- Actively control the device's resonance to generate maximum power from each oncoming wave

Albany plan

- Deploy an array of buoys to predict WEC oncoming waves exactly



Wave-by-Wave knowledge transfer

THE UNIVERSITY OF WESTERN AUSTRALIA

Predicting omnidirectional irregular waves in a wave-tank

Results where experimental record (top) is used to predict down-wave and into the future (next three plots)

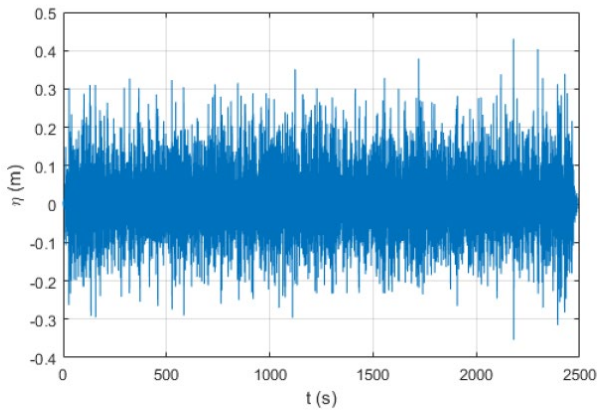
Surface Elevation (m)

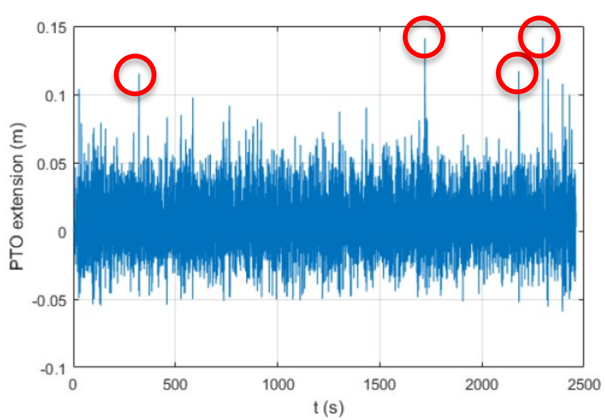
Knowledge transfer

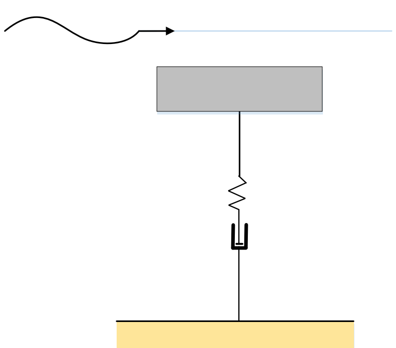
- Forewarning of extreme waves and green water
- Active control strategies to stabilize vessels/structures

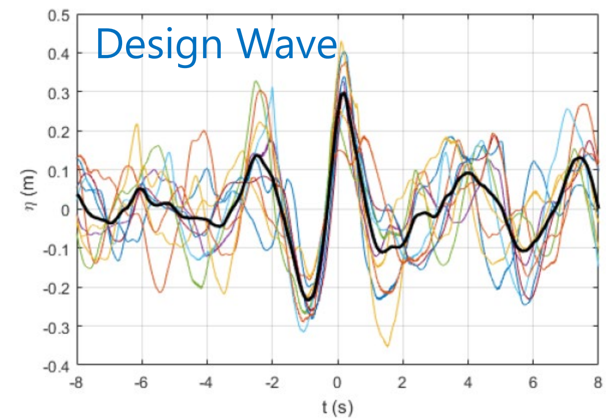
Design waves

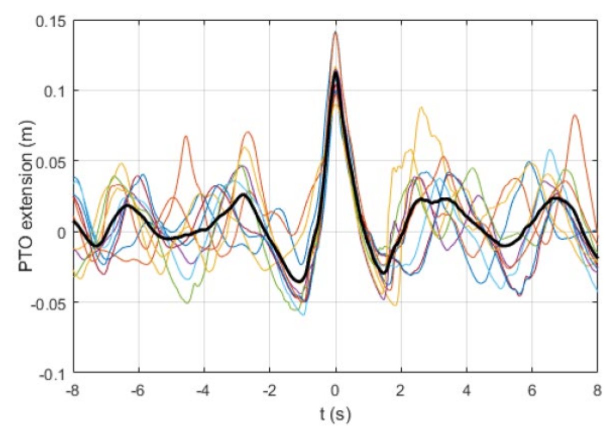
Identifying the short incident wave time-series representing a return period and underlying spectrum that causes a particular response to be MAXIMISED (for the underlying spectrum)



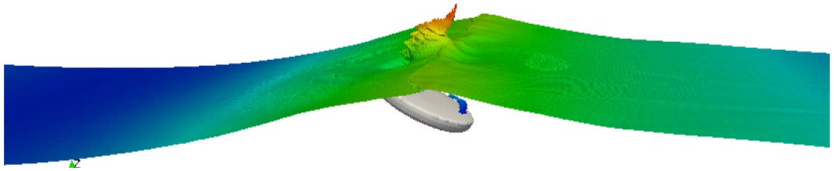


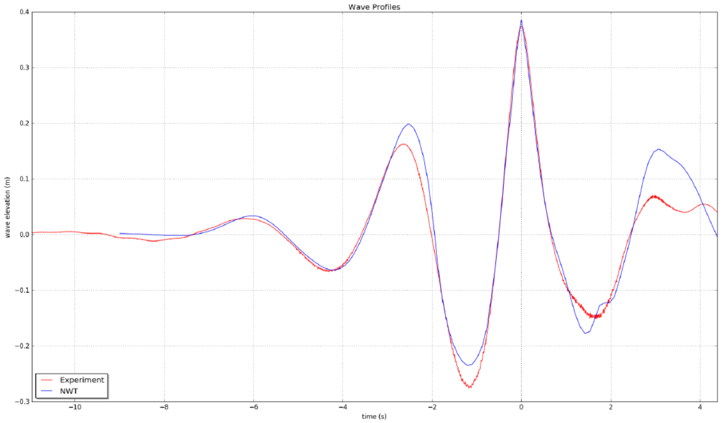


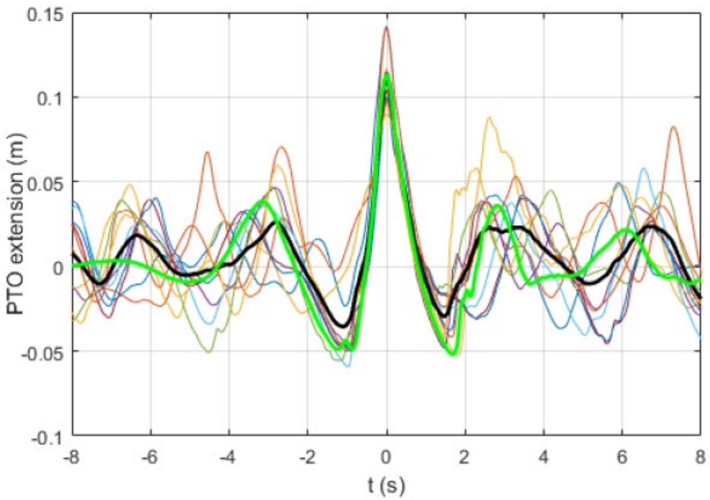




Design waves





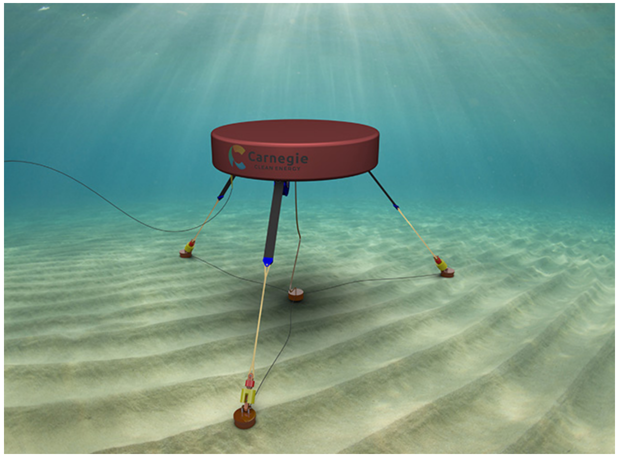


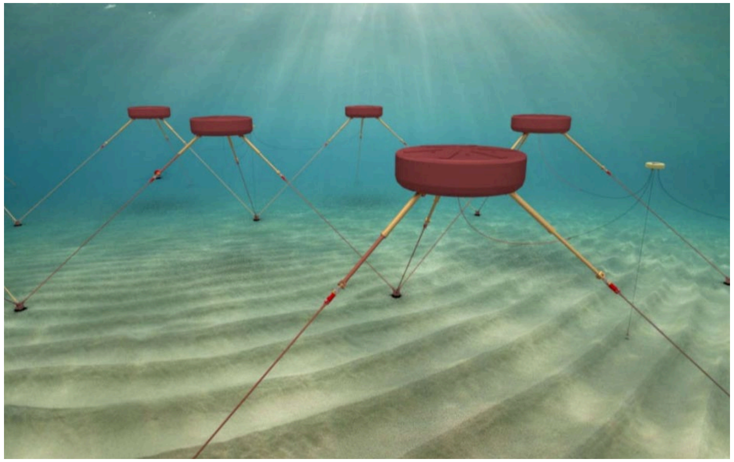
Knowledge transfer

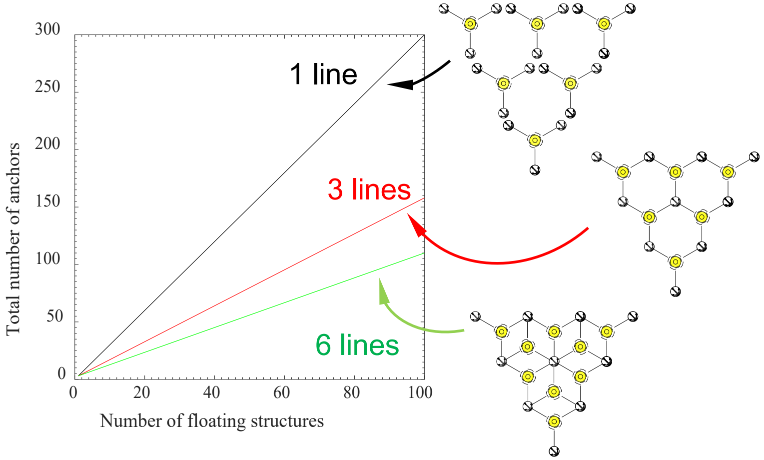
- Applicable for floating oil and gas structures
- Significant time/cost saving in CFD

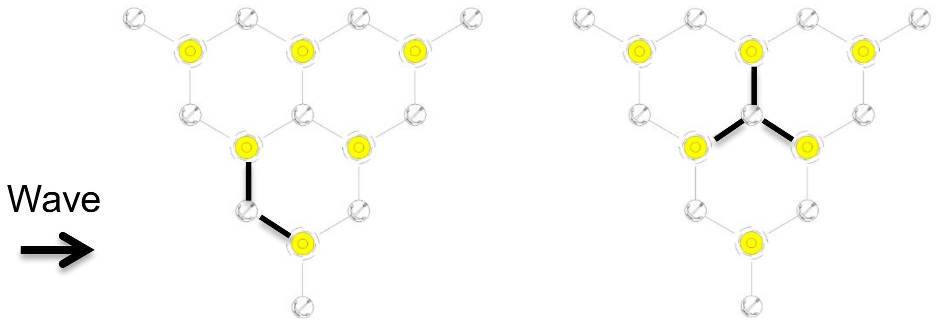
Foundation engineering

- Moving to array of WECS requires innovative anchoring systems
- Foundation sharing promising but challenging to design



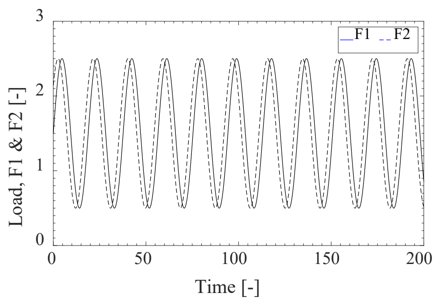


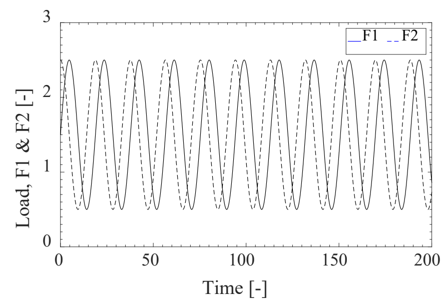


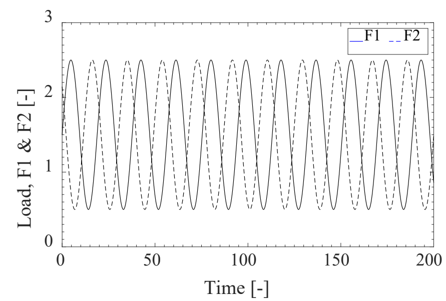


Multidirectional loading

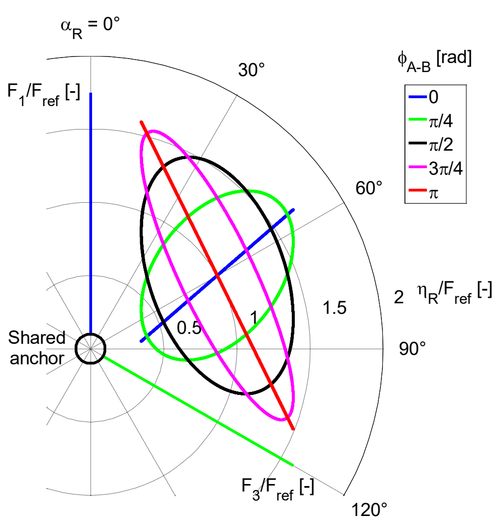
Load regime characterisation



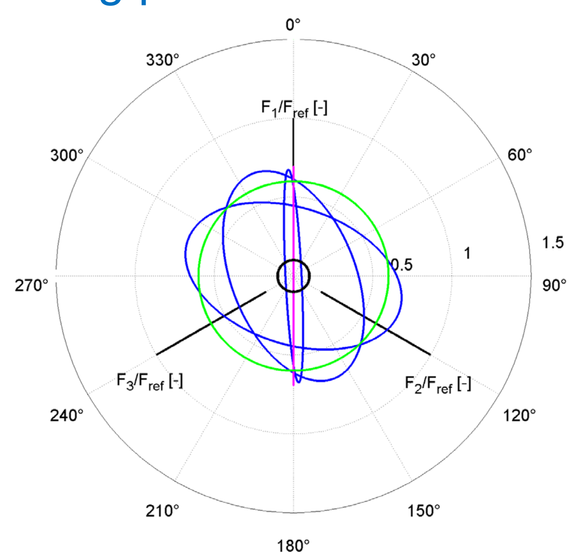




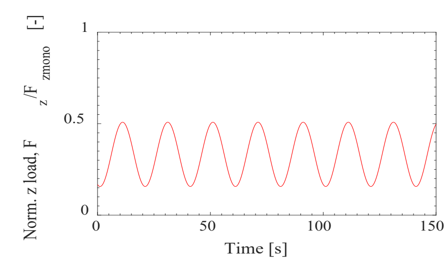
Increasing phase difference

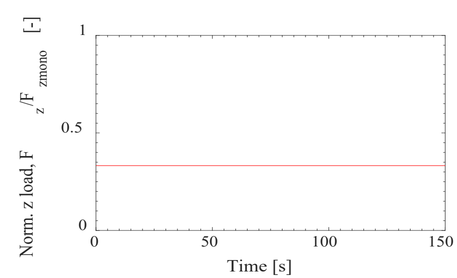


2 mooring lines



3 mooring lines

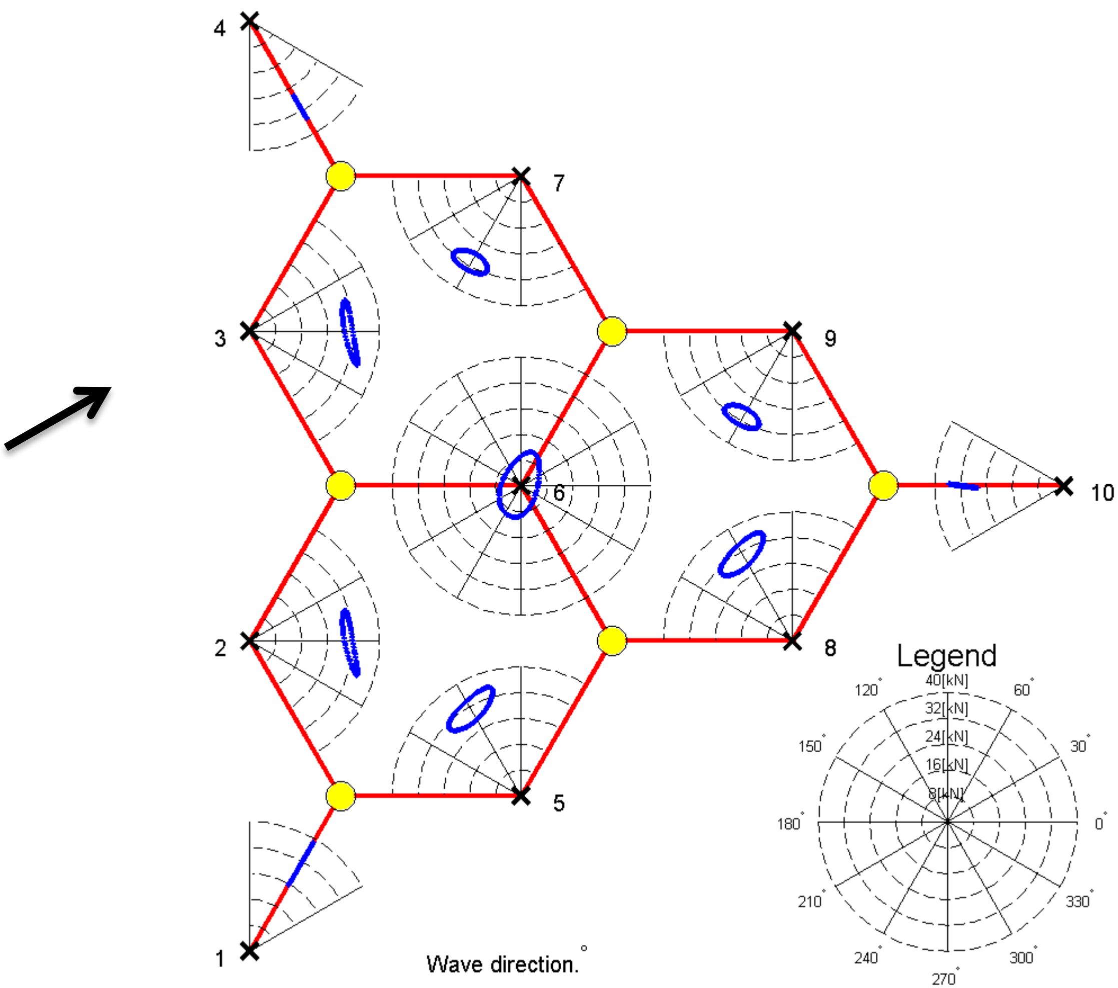




Multidirectional loading

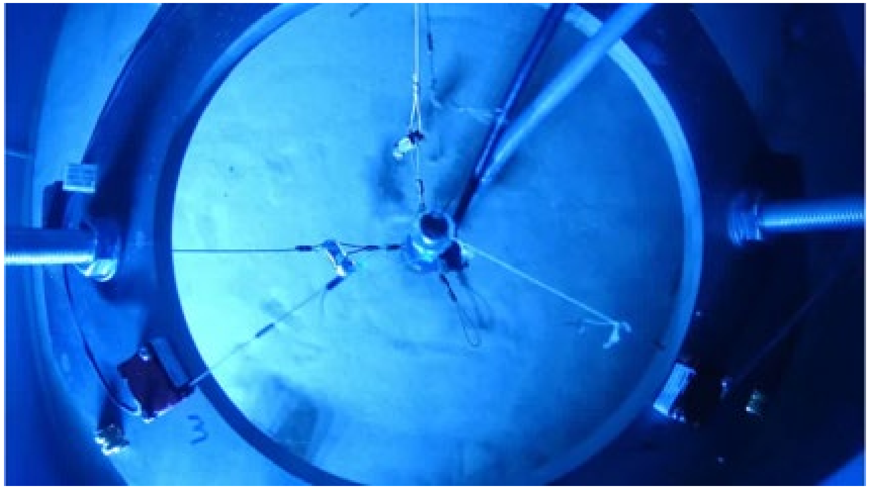
Load regime characterisation

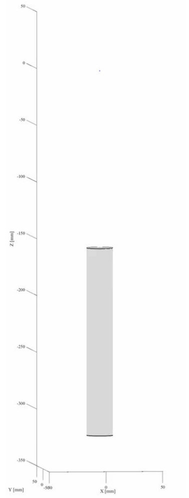
Wave

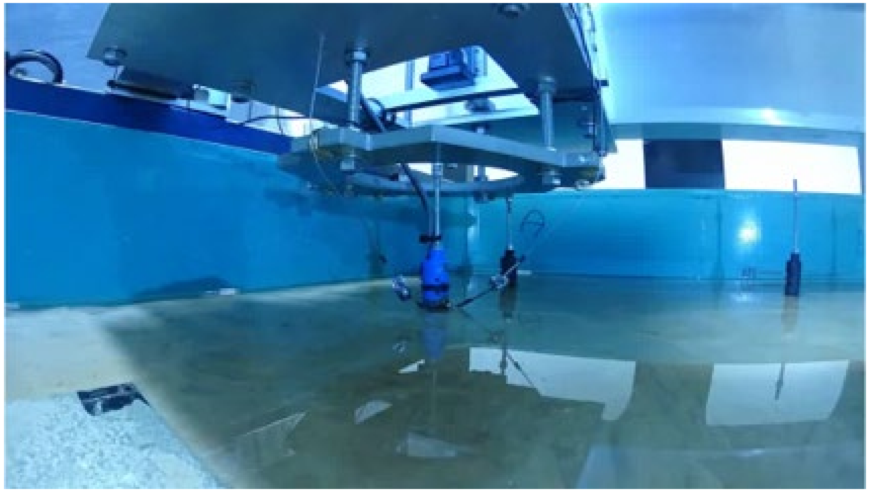


Multidirectional loading

Investigated via centrifuge testing

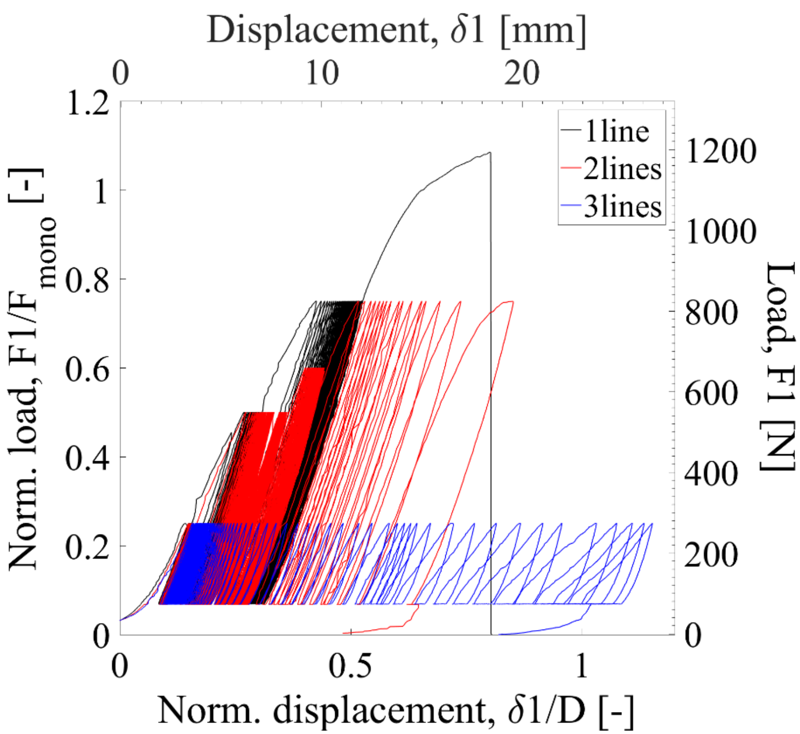


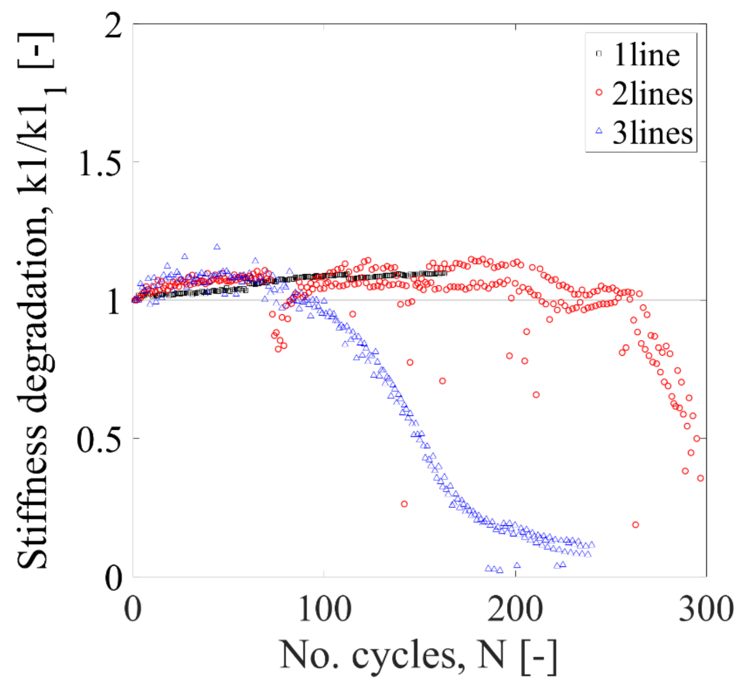




Foundation engineering knowledge transfer

- Foundation performance highly depend on load history
- Significant stiffness change between 1, 2 and 3 mooring lines





Knowledge transfer

- Development of models that capture volume change in 3D
- Cost mitigation measures

Conclusions

New multidisciplinary research centre in Albany

- Research activities in oceanography, hydrodynamics and foundation engineering
- Support activities to AWEP
- Benefit the whole marine renewable energy industry
- Benefit the local ocean community
- Significant learnings to be re-engineered for the offshore oil and gas industry

Acknowledgements

Oceanography

- Prof. Ryan Lowe
- Dr Jeff Hansen
- Dr Dirk Rinjsdorp
- Dr Mark Buckley

Hydrodynamics

- A/Prof. Scott Draper
- Dr Hugh Wolgamot
- Dr David Skene
- Dr Jana Orszaghova

Geotechnics

- Prof. Phil Watson
- Dr Henning Morh
- Manuel Herduin