Scientific and technical challenges of the SEATURNS wave energy converter

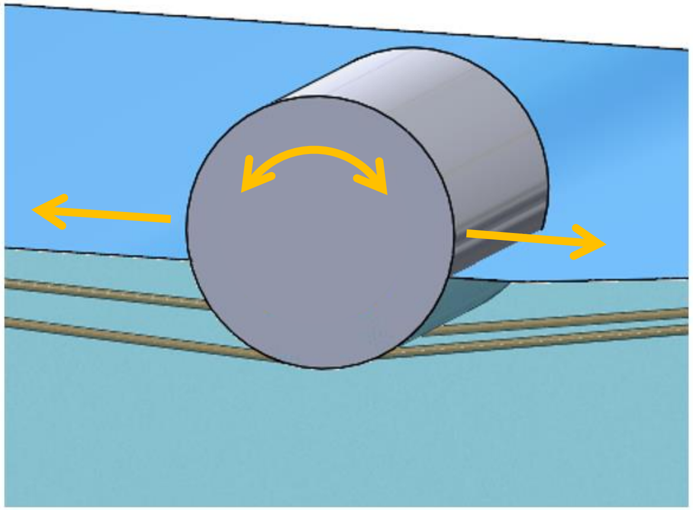
Gabriel CANTEINS

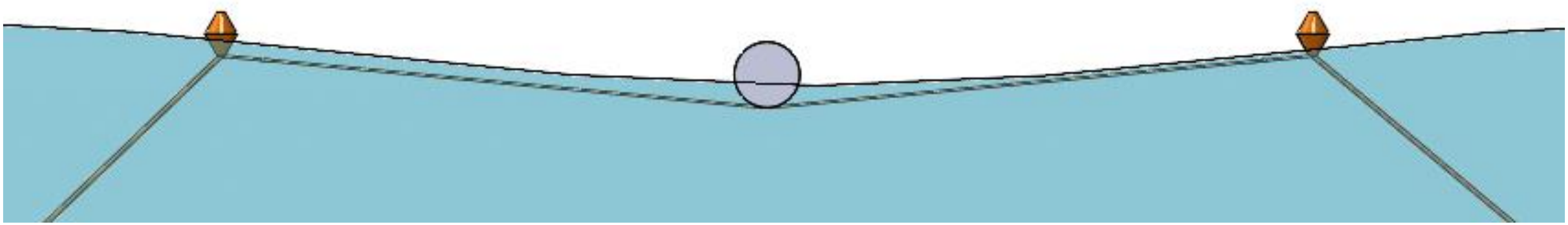
Project Manager

Video presentation

Innovative anchoring system – The yoyo principle

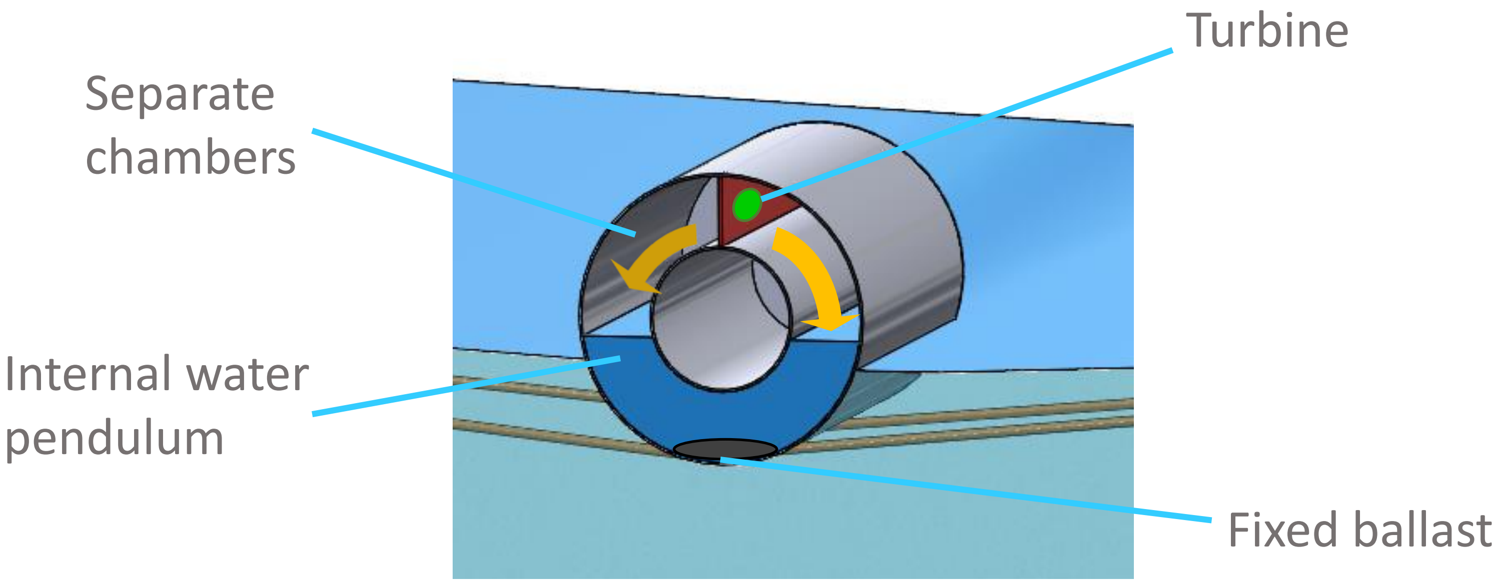
A patented solution (No. FR 3 073 013, "Dispositif houlomoteur flottant")

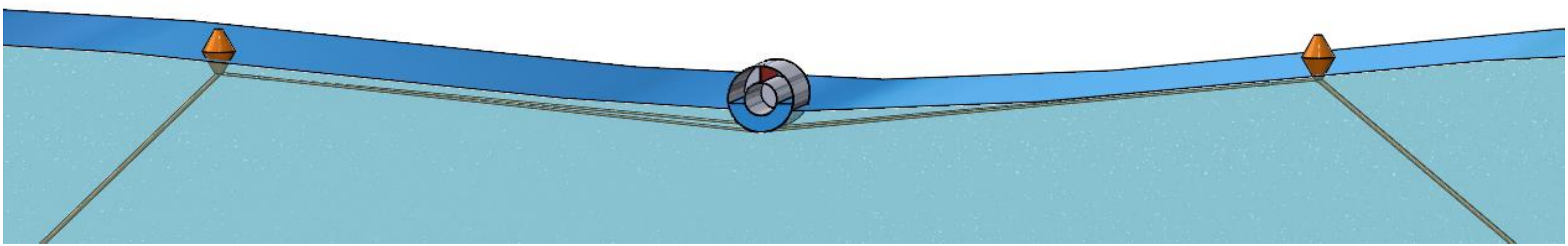




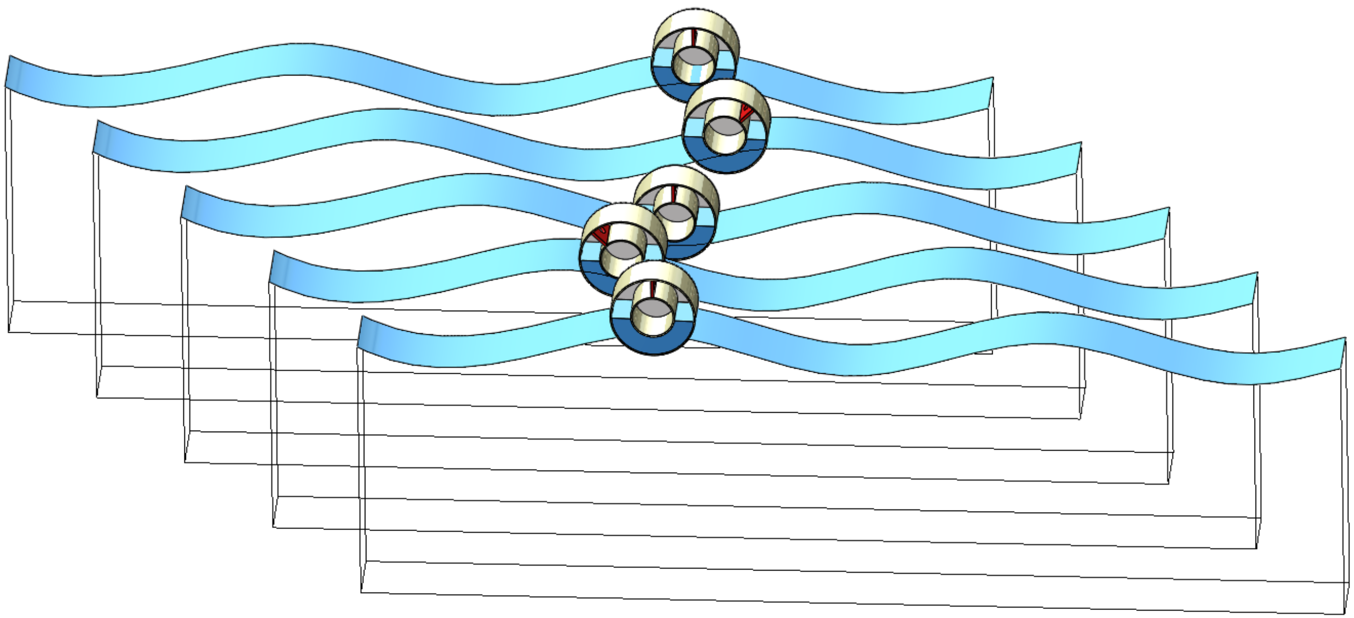
SEATURNS's solution

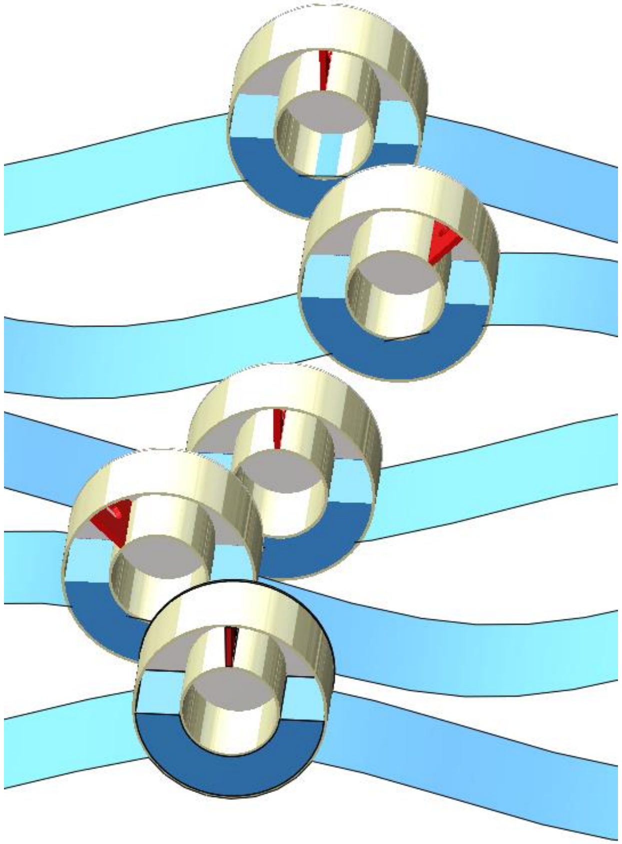
Energy conversion – The oscillating water pendulum principle





Simplicity – Two steel concentric cylinders with caps, sea water and a turbine





SEATURNS's solution

Simplicity, sturdiness, performance

A simple and robust system designed to withstand hostile conditions and reduce maintenance costs.

A turbine with multiple applications

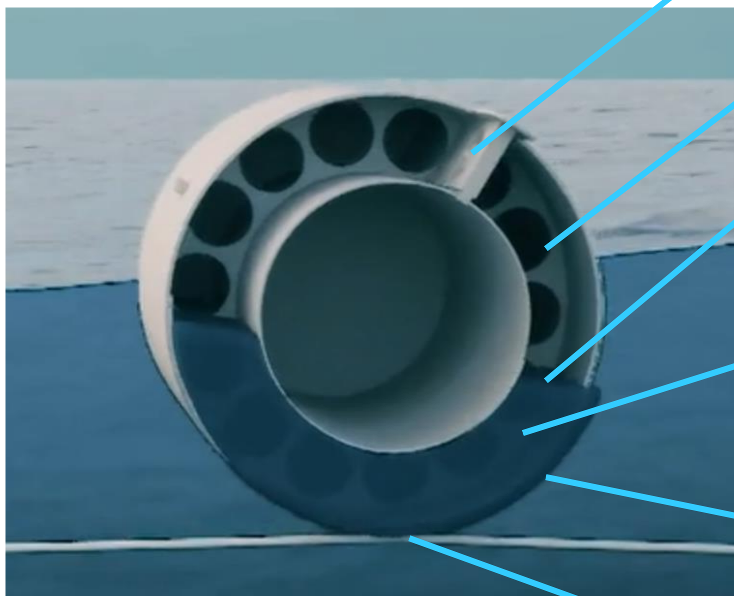
Dimensions: Ø 6 m x L 9 m

Net weight: 22 tonnes

Needs in studies

Key parameters:

- Outer diameter
- Inner diameter
- Ballast weight
- Water pendulum volume
- Turbine diameter
- Type of propeller

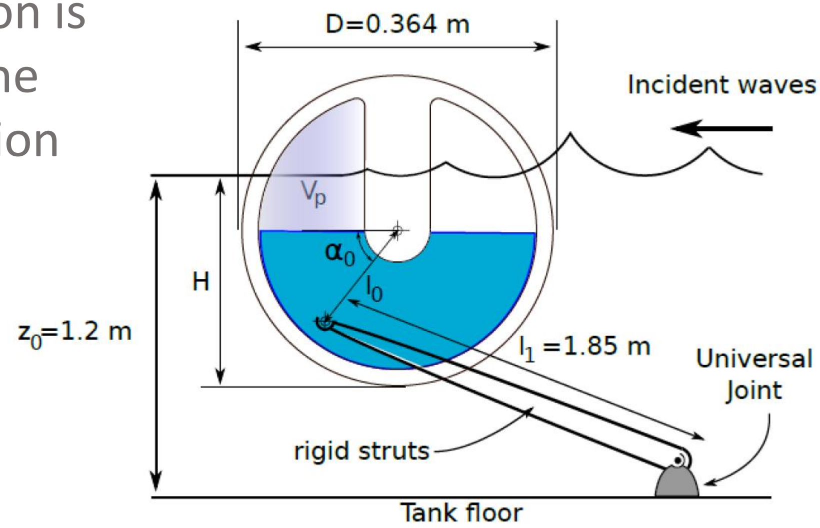


- Two-way air turbine (or other solutions)
- Internal aerodynamics
- Two-phase fluid mechanics (inside)
- Structure – fluid (water) interaction (inside)
- Swell – float interaction (oustide)
- Float and mooring lines behaviour

Preliminary assessment

Main conclusions:

- Demonstration of the viability of the concept and how it works
- Highlighted advantages: innovative anchoring and energy capture optimised for a wide spectrum of swell wavelength
- A preliminary evaluation of energy production is given, based on published performance of the most similar concept of WEC, the "desalination duck" (Edimbourg university)

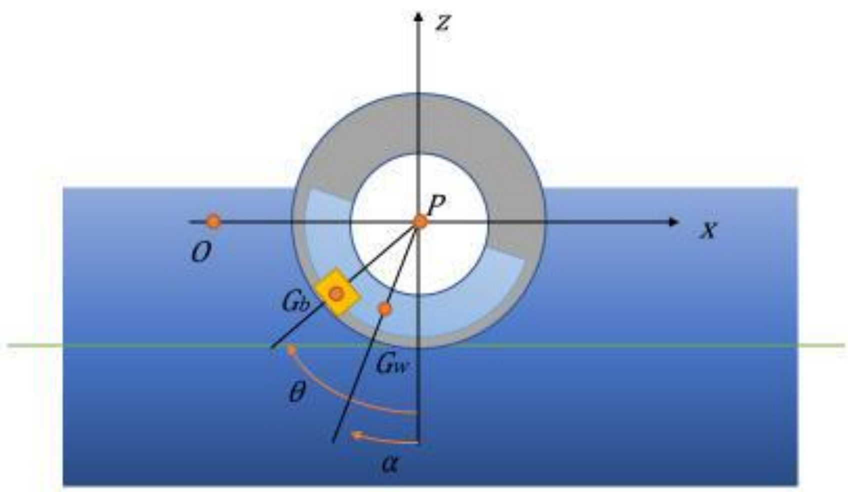


Tank tests

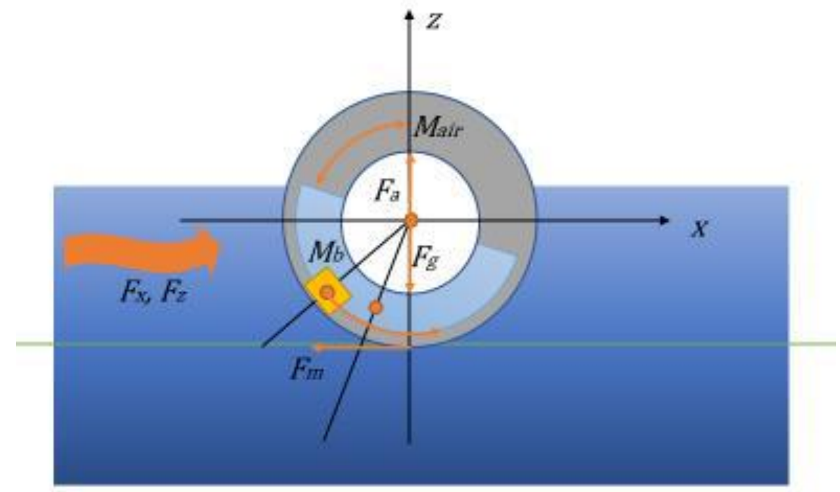
Main conclusions:

- Demonstration of the system's ability to absorb a significant part of the swell's incident energy and convert it into pneumatic power
- Energy capture assured for a wide spectrum of swell wavelength, including the longest swells, even with a small system

Model



Parameters



Forces acting on the system

Main hypothesis:

- 2D resolution, side effects considered in the calculation of hydrodynamic efforts
- Internal water pendulum = rigid volume
- Air pressure calculated with ideal gas laws
- 1st order linearisation of dynamics equations to fit to the linear theory of swell – structure interaction

Solving

System of equations: $\{-\omega^2(\mathbb{M}+\mathbb{M}_A) - i\omega(\mathbb{B}+\mathbb{B}_H) + (\mathbb{K}+\mathbb{K}_H)\}\vec{A}e^{i\omega t} = \overrightarrow{F_e}$

$\mathbb{M}$, $\mathbb{B}$, $\mathbb{K}$: mass, damping and stiffness matrices

$\mathbb{M}_A$, $\mathbb{B}_H$, $\mathbb{K}_H$: added mass, hydrodynamic damping and hydrostatic stiffness matrices

$\overrightarrow{F_e}$: external forces

$\vec{A}e^{i\omega t} = [z, \theta, \alpha, p_1, p_2, F_{mx}]^T$: degrees of freedom (harmonic form)

Hydrodynamic loads computed with InWave (INNOSEA and École Centrale de Nantes)

Results and perspetives

Main results:

- Feasibility of an analytical model
- Results similar to thoses of tank tests (École Centrale de Nantes, 2017)
- Parametric study conducted to specify the float dimensions
- Performance optimisation with variation of the water pendulum volume

Perspectives:

- Take into acount viscous losses and turbulence
- Integrate the swell's 2nd order termes
- Use a more precise turbine model

Further studies

Further studies are needed to:

- Optimize the dimensions of the system to increase performance at all wavelengths. This includes a study of the factors influencing the different natural frequencies of the system.
- Study the anchoring concept of the machine, in particular its stability in directional waves and its resistance in extreme conditions.
- Define the characteristics of a potential pneumatic turbine and check that it is available.