Performance Enhancement of Sloped Buoy Wave Energy Converters through Numerical Optimisation

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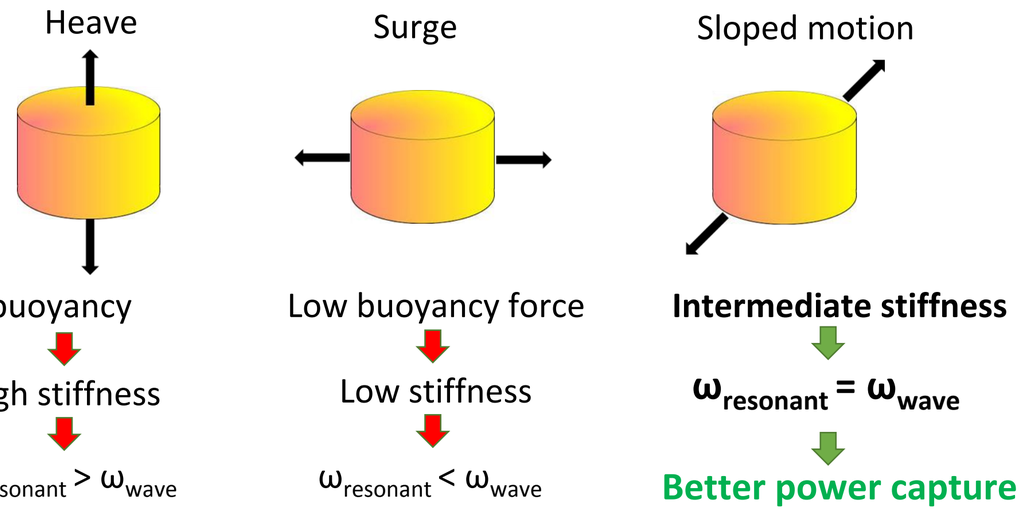
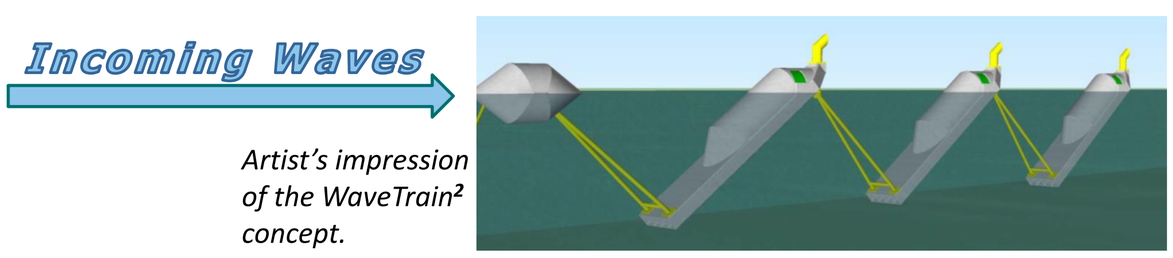
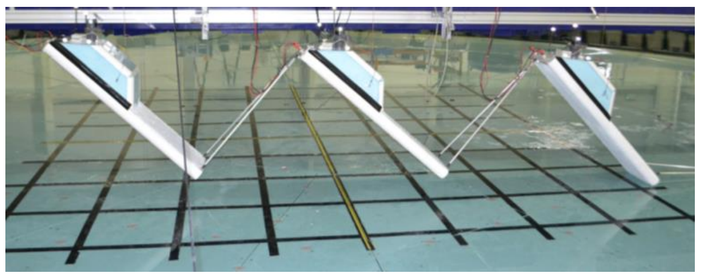
Motivation

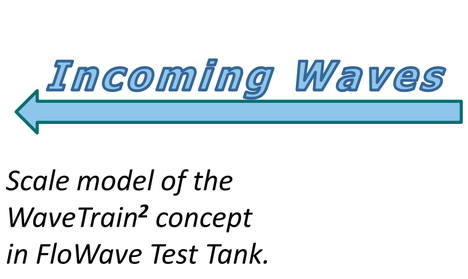


- Previous testing of freely-floating sloped buoys demonstrated that the predicted large power absorption bandwidth tended to collapse in practice, due to excessive pitching about the inclined plane.
- This concept aims to constrain such pitching and retain the wide bandwidth, by connecting multiple sloped modules in series via mechanical struts and rotational joints.
- An **oscillating water column** in each module facilitates power capture.



Artist's impression of the WaveTrain² concept.





Scale model of the WaveTrain² concept in FloWave Test Tank.

Frequency Domain Model

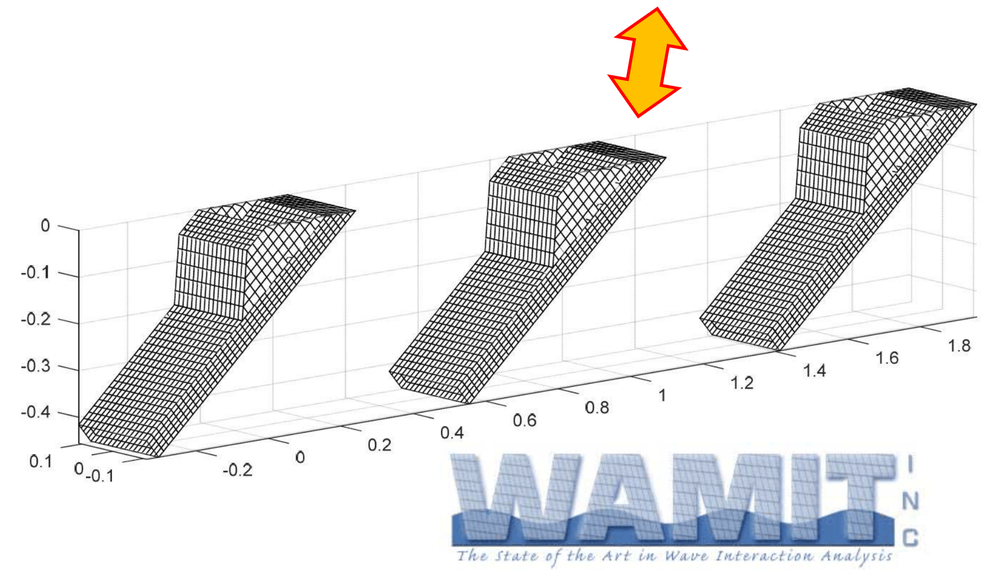
- **Generalised modes** of motion enable efficient modelling of the *hinges* and *water columns*, without the need for post-processing.

'N' degrees of freedom

Solve for device motions

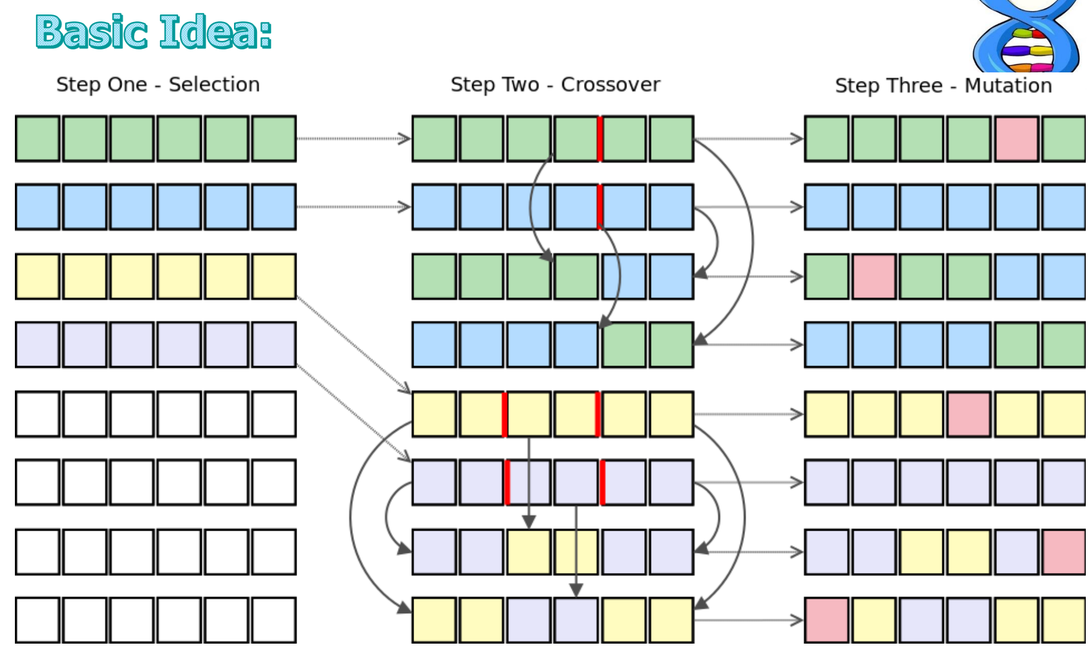
$$\sum_{j=1}^{N}\left[-\omega^2\left(M_{ij}+A_{ij}\right)+i\omega B_{ij}+C_{ij}\right]\xi_i = X_i$$

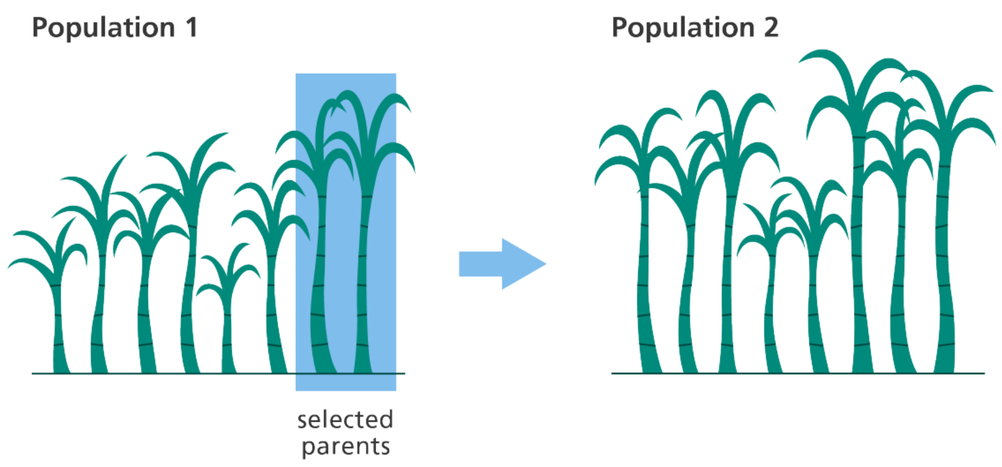
**Hydrodynamic (/static) coefficients*



Genetic Algorithm

Basic Idea:





Implementation:

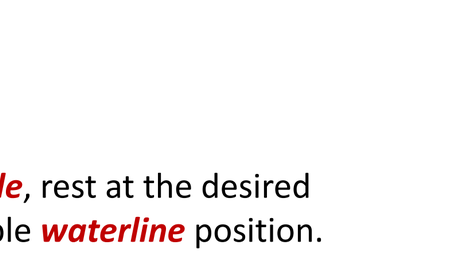
- Each device must be ***statically stable***, rest at the desired ***inclination angle***, and have a suitable ***waterline*** position.
  - ⇒ Custom algorithm ensures the full set of nonlinear constraints are satisfied.
- Objective function uses hydrodynamic data from WAMIT.

Model Assumptions:

- Only **in-plane** device motions are significant.
- The **hydrodynamic interactions of the struts** are negligible compared to those of the modules.
- **Linear** wave theory applies.
- Power take-off behaviour can be modelled using a linear **damping coefficient** applied to a 'massless lid' on top of each water column.

Selection Pressures:

- High extracted **POWER** favoured
- Low **MASS** or device **WIDTH** favoured
- Low **JOINT FORCES** favoured



H_s (m) \ T_{02} (s)	5.0	7.0	9.0	11.0	13.0	15.0	17.0	19.0
0.25	0	0	0	0	0	0	0	0
0.75	149	219	79	18	0	0	0	0
1.50	858	2865	1445	508	79	9	0	0
2.50	0	745	561	324	158	35	0	0
3.50	0	88	263	61	53	35	9	0
4.50	0	0	105	35	9	9	9	0
5.50	0	0	9	26	0	0	0	0
6.50	0	0	0	0	0	0	0	0