awatea

The Business of Marine Energy

Oceania Room | Te Papa Tongarewa | Wellington

WET-NZ Progress Towards Commercialisation: 2004-2011

AWATEA Conference 2011

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Phase 1: 2004-2008

- **4 year government funded programme to**
  - explore WEC concepts
  - investigate the resource in New Zealand
  - Create IP
  - Attract industry investment
- **Start from scratch**
  - No background WEC research capability or expertise in NZ
  - Limited model testing capacity
  - Limited funding and resources
  - Blind optimism?
- **Patents**
  - New Zealand: submitted Nov 06
  - PCT: submitted Nov 07

Phase 2: 2008-2014

- **Further 6 year FRST programme to develop the WET-NZ technology to pre-commercial level**
  - Improved understanding of the energy extraction and conversion processes
  - Characterise and extrapolate performance
  - Device design, scale up
- **MEDF funding**
  - Technology demonstration at ocean scale in real seas
  - Assess impacts, projected COE
  - Engage industry partners and attract investment
- **US DoE programme to demonstrate TRL 5/6 status**
  - Following initial testing, a second upgraded half scale device will be constructed and deployed off Newport, Oregon
  - Led by North West Energy Innovations, Oregon, USA.

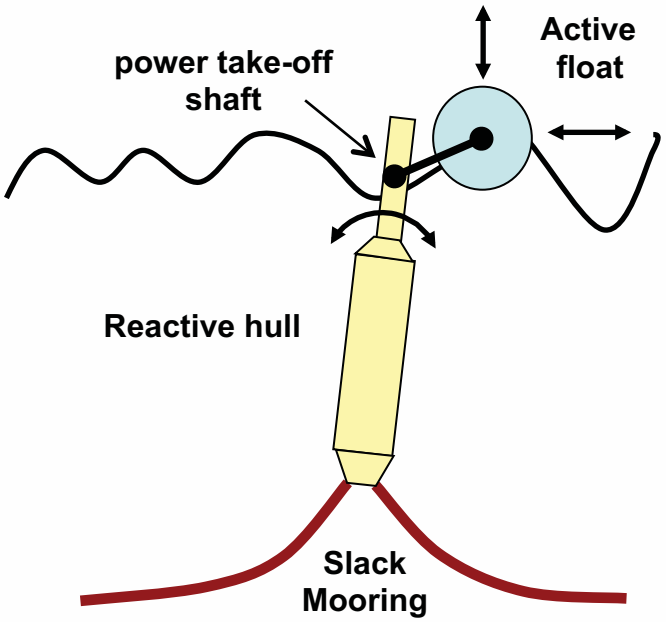
WET-NZ Concept

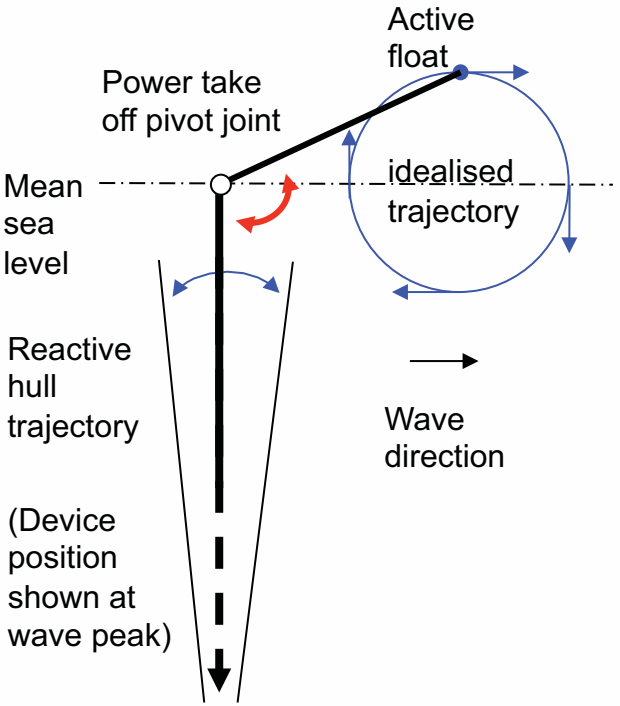
- **Engineering perspective**
  - PTO must be conventional (initially at least)
  - It must eschew inherent survivability principles
  - It must be “materials efficient” – all surfaces actively involved in energy transfer
  - Direct drive / active loading

- **Hydrodynamic principles**
  - “Multi-mode” operation
  - Broad-band
  - Self reacting
  - 30m+ water depth to avoid wave attenuation
  - Etc.

WET-NZ Concept

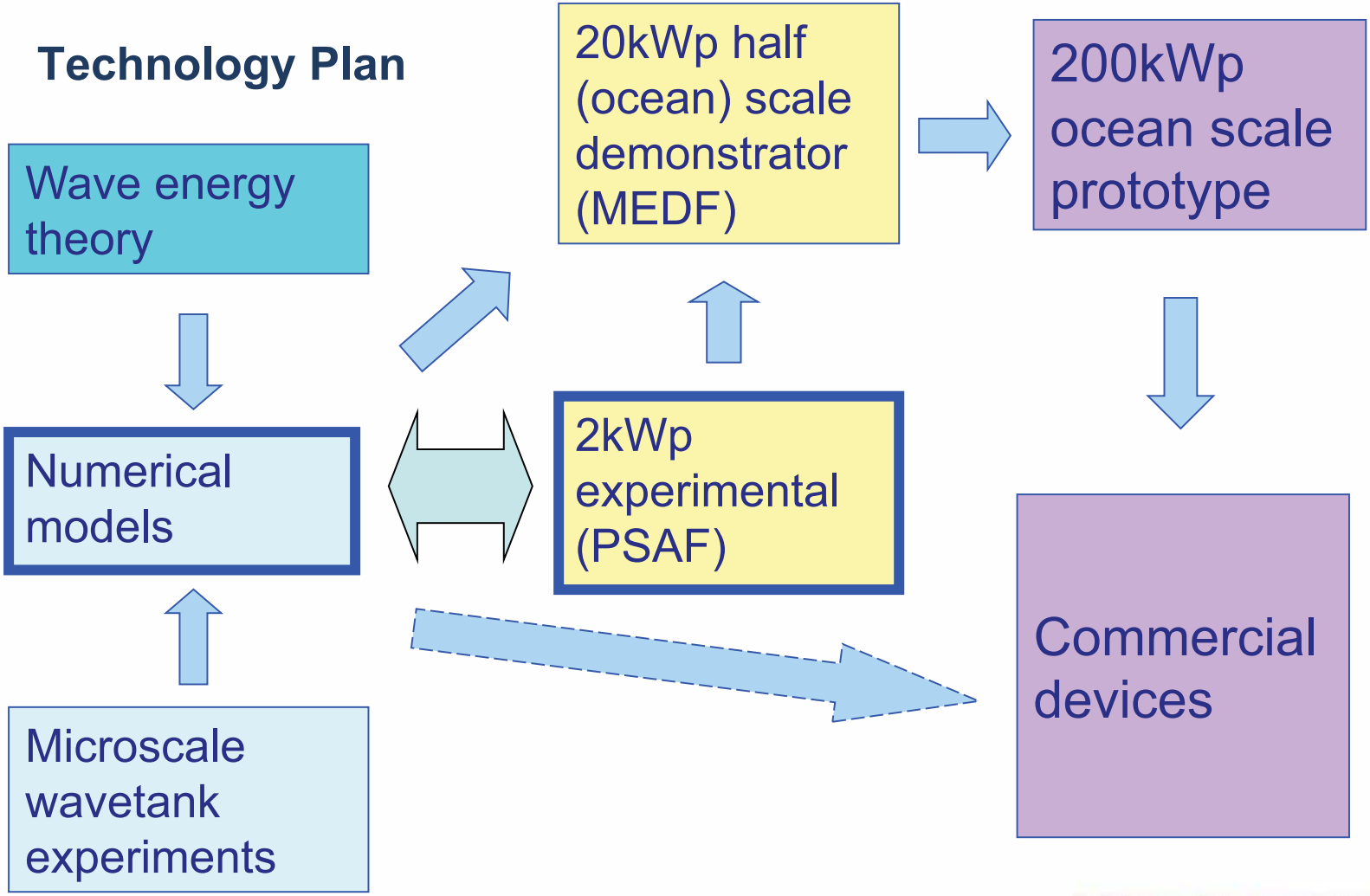
- **Multimode interaction**





WET-NZ Programme Overview

- **Technology Plan**



Scale : 1/100 to 1/1

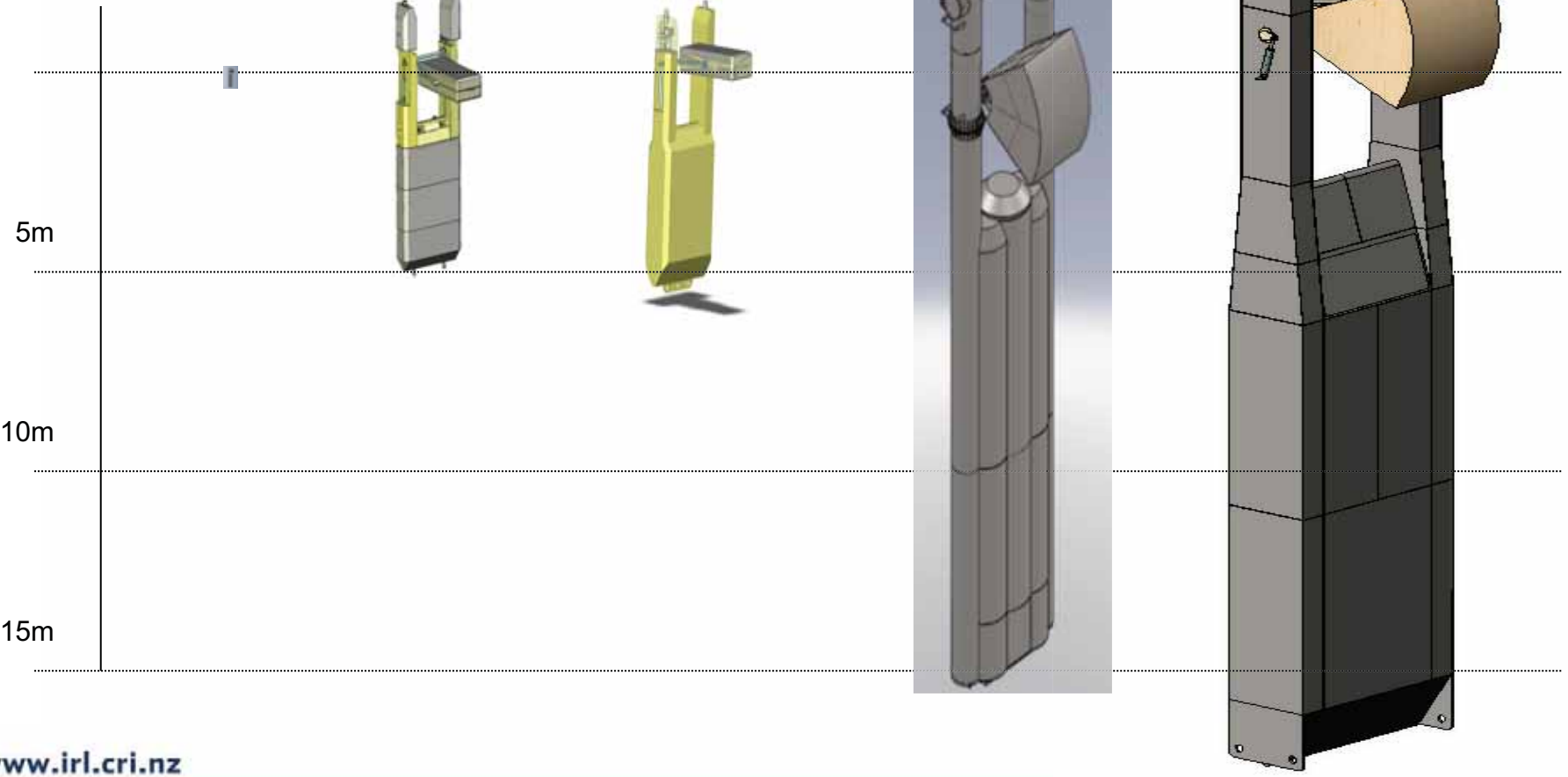
2004 1/100
Wave Tank
Model 0.1W

2006 1/5
Experimental
~1kWp,Tp<3s

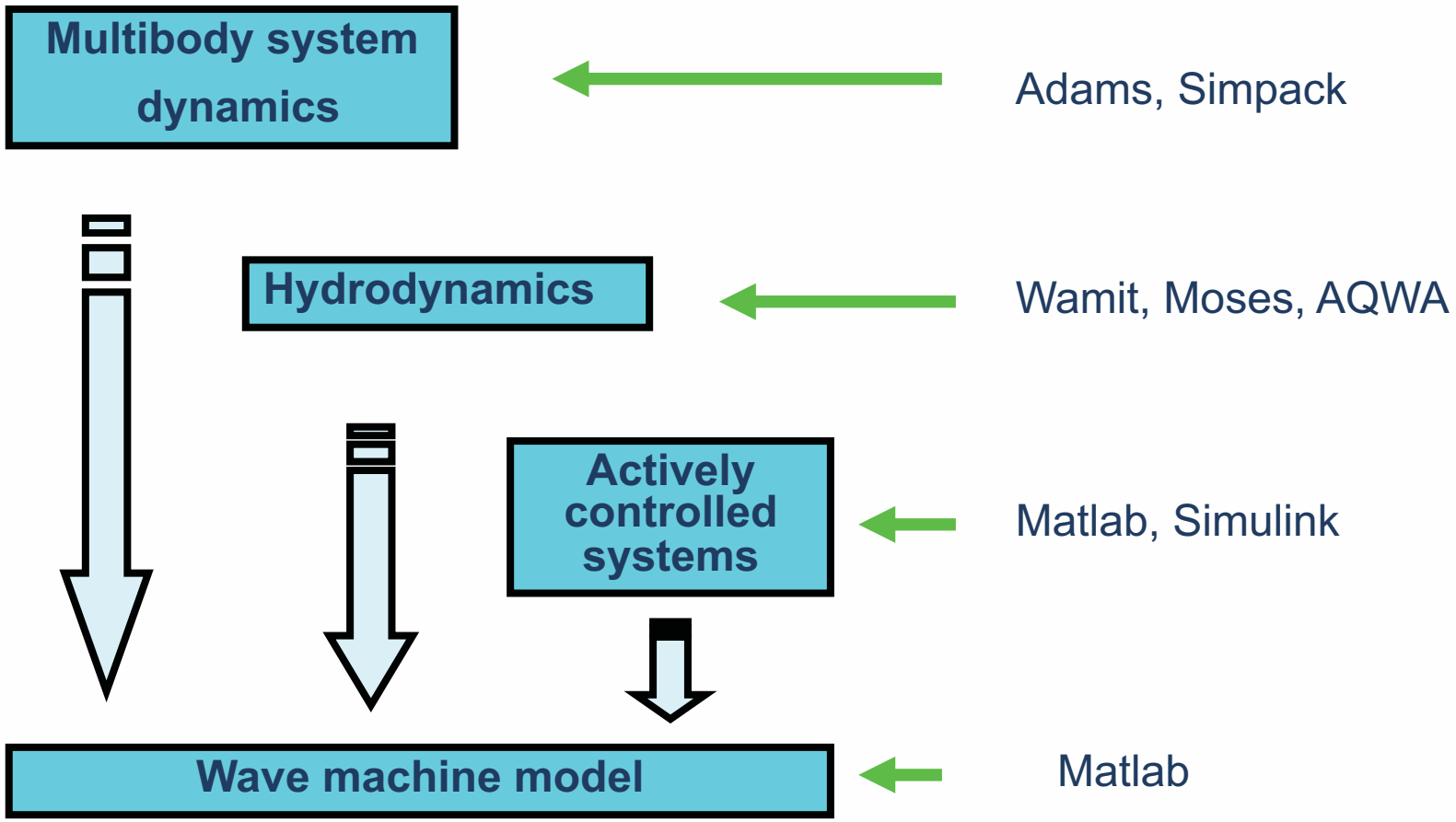
2008 1/4
Upgraded
Experimental
2kW, Tp<3s

2011 1/2
Demonstrator
20kWp, Tp<8s

201? 1/1
Commercial
200kWp, Tp<12s

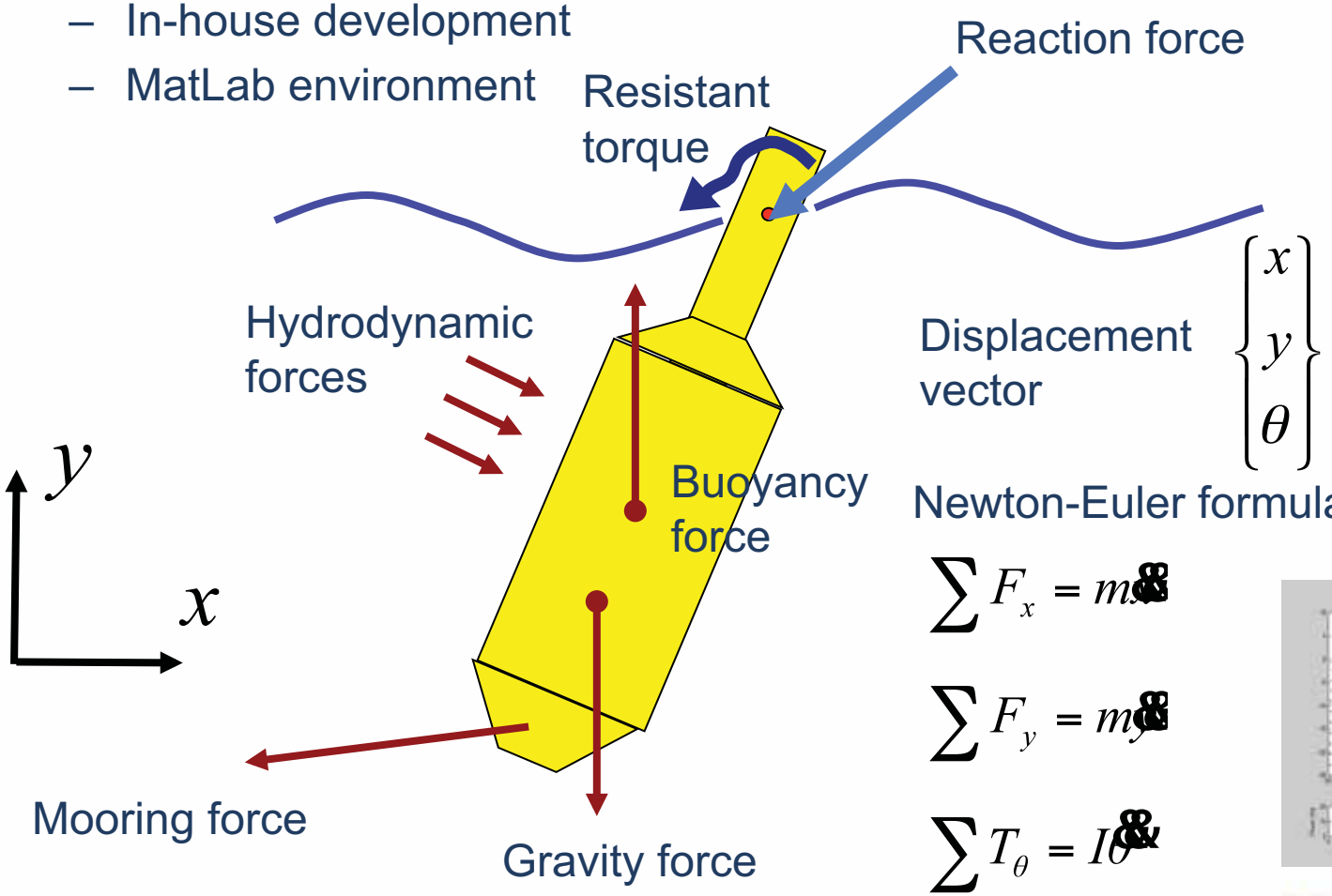


Numerical Models: 1/100 to 1/1



Numerical Models: 1/100 to 1/1

- **Rigid body dynamics**
  - In-house development
  - MatLab environment



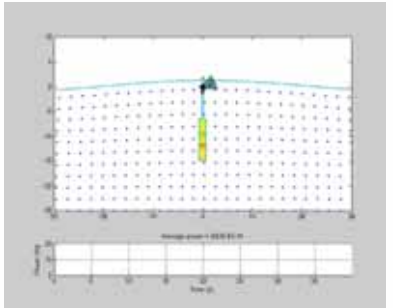
Displacement vector $\begin{Bmatrix} x \\ y \\ \theta \end{Bmatrix}$

Newton-Euler formulation

$$\sum F_x = m\ddot{x}$$

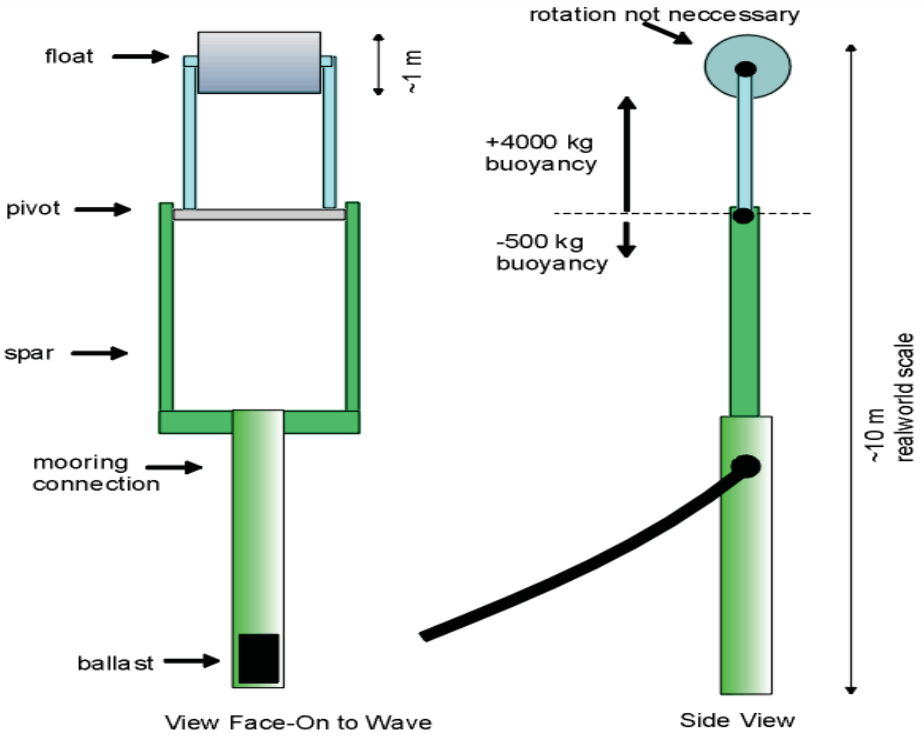
$$\sum F_y = m\ddot{y}$$

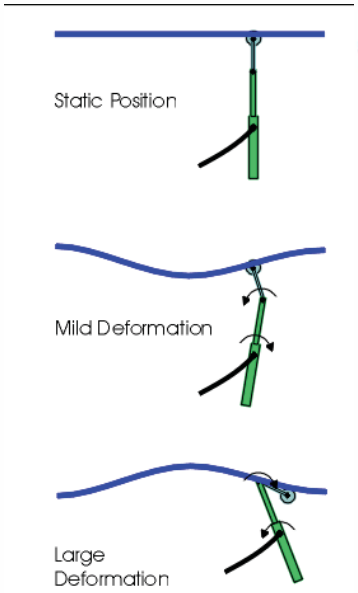
$$\sum T_\theta = I\ddot{\theta}$$



Wave Tank Models: 1/100

- **Initial work at the Auckland University wave tank**
  - "Spar-fork" experimental model (NIWA diagram)
  - Overall length 200mm
  - Dry weight 100gms



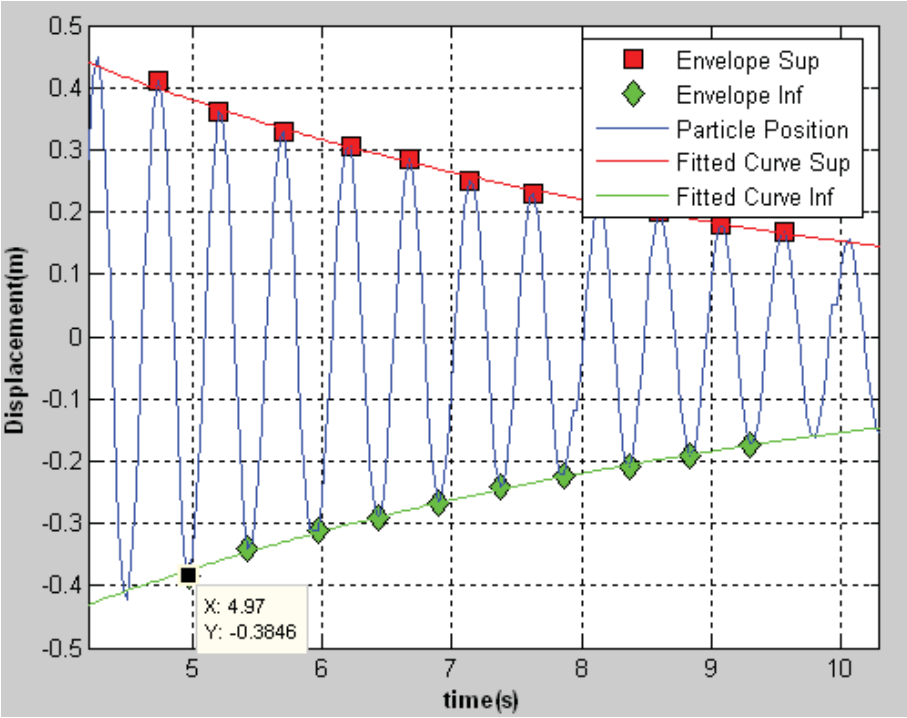


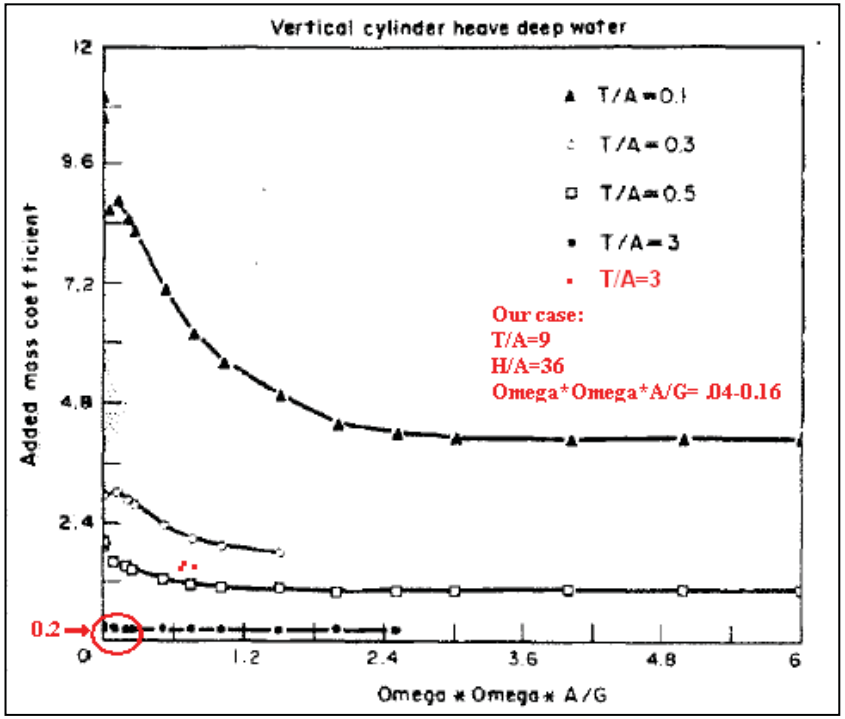
Wave Tank Models: 1/100

- **Later experiments to investigate added mass coefficients**
  - Static tank
  - Basic shapes (hull, float)
  - Different modes (heave, surge, pitch)
  - Video tracking
  - Frequency response and damping measured

Wave Tank Models: 1/100

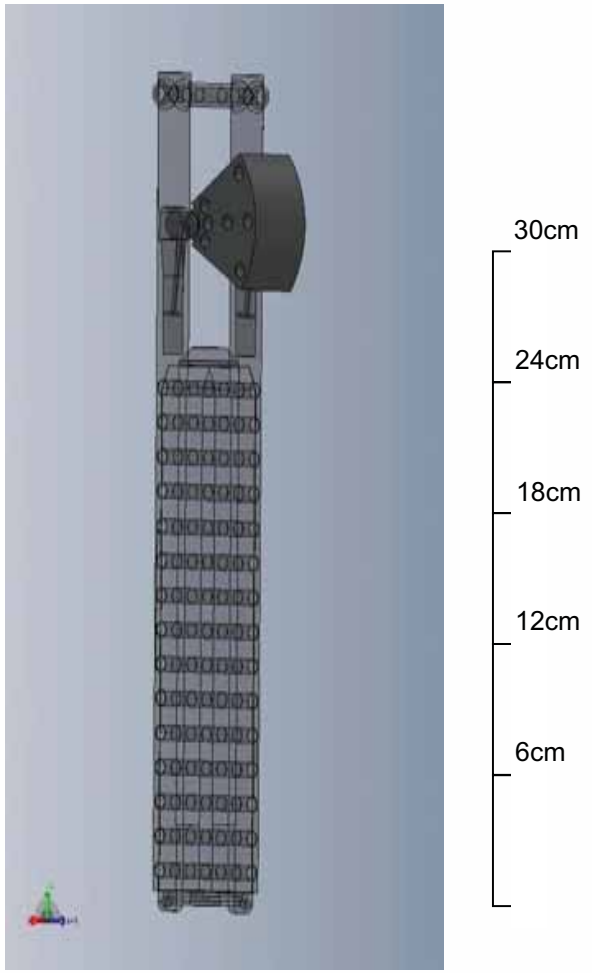
- **Added mass coefficients**
  - Wave making in a static tank
  - Damped oscillatory decay used to obtain added mass coefficients
  - Cross-coupling
  - Relevant coefficients could not be found in the literature





Wave Tank Models: 1/100

- **Further test series planned**
  - Consistent damping
  - Video analysis
  - Examine relationship between motion/ power transfer and relative masses/COG/ COB/MI
- **3D printed model**
  - ABS honeycomb : SG~ 0.40
  - Brass slugs to adjust mass distribution



Engineering Models: 1/5

- **Purpose**
  - Prove and develop design concepts at a “real-world” scale
  - Obtain scaled model parameters to compare with computer model results
  - Develop and test practical PTO concepts
  - PR to attract further investment
- **Scale: transportable on a trailer/truck**
  - ~1kWp (sufficient to measure at a scalable level)
  - Produce useful data in local short-fetch waves (~ 3-6 sec period)
  - Adjustable loading and monitoring accessible from boat/shore
  - Temporary deployment at a near-shore location
- **Two steps**
  - Goalpost structure (~1/5 scale)
  - PSAF device (~1/4 scale)

Engineering Models: 1/5

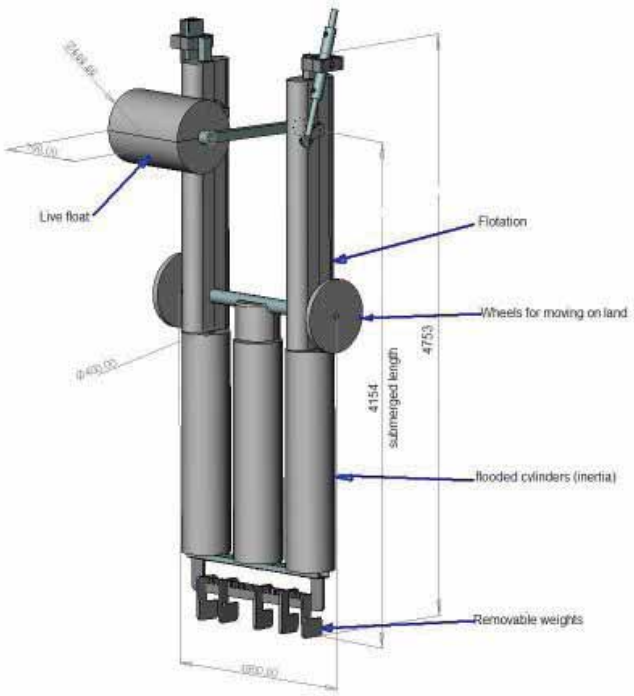
- **"Goalpost" 1/5th Scale Structure**
  - First structure built at a proof of concept scale to test the theory
  - "Goalpost" skeleton spar hull with plastic body parts, water ballast entrapped in drainage pipes
  - 1 tonne dry weight (3 t wet)
  - cylindrical polystyrene float with ~200kg added buoyancy
  - Estimated to respond in up to ~ 3 sec local fetch waves

"Make-do" Test Facilities

- Floatation/damping response tests in the Christchurch public dive pool
- Developed for limited testing in Lyttleton Harbour and surrounds
- Power absorption tests Oct-Dec 06
  - Attempts made to measure power absorption
  - Moored for several weeks before breaking up in a storm

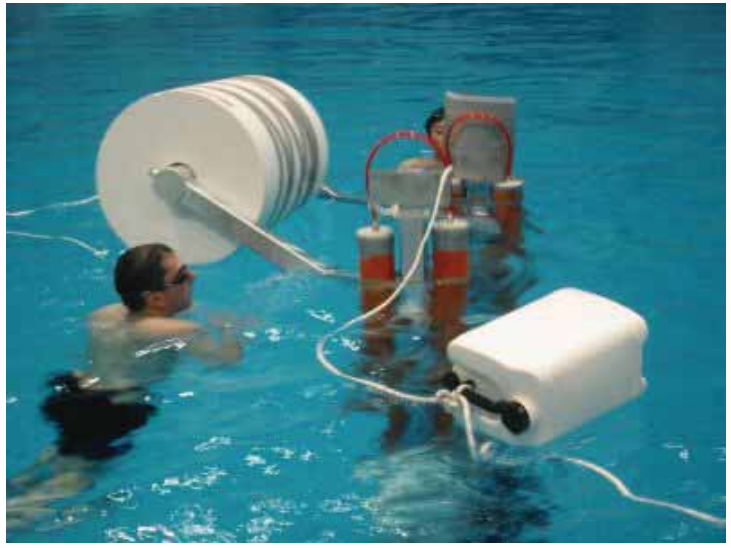
Engineering Models – 1/5

- **Goalpost dive pool deployment June 2006**
  - Simple construction
  - Pipes and polystyrene



Engineering Models – 1/5

- **Goalpost dive pool deployment June 2006**
  - Overnight testing at the local swimming stadium dive pool
  - Observe basic unloaded motion
    - Gather basic data for computer modelling
    - mass/resonant frequencies
    - heave and pitch



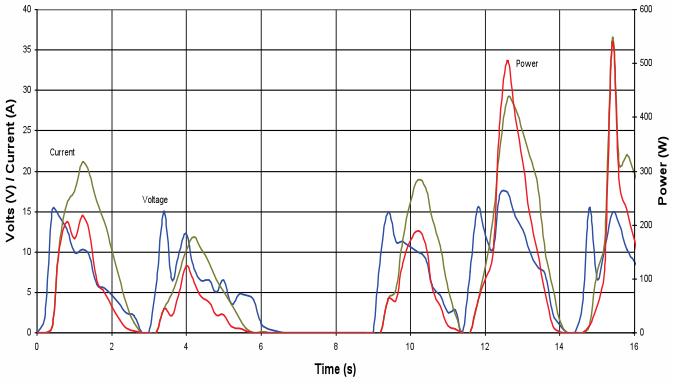
Engineering Models: 1/5

- **Goalpost ocean deployment**
  - First steps into the ocean with Goalpost structure
  - Hydraulic cylinder with throttle valve damping valve added
  - 3D acceleration and hydraulic pressure logged
  - Day testing carried out in Lyttelton Harbor
  - Initial results looked promising

Engineering Models: 1/5

- Foam was clad in galvanised iron sheeting
- trapped water volume increased to slow down the heave response
- Sufficient durability for sheltered near-shore mooring (or so we thought)
- PTO and electrical load installed
- Further sensors added including power monitoring
- GPRS datalogger communication
- Some instrumentation and logistic issues but overall very promising results

Experimental Data from Pegasus Bay



Engineering Models: 1/5

- **Publicity stuff**
  - Lyttelton Harbour
  - Wellington Harbour - World Environment Day (5 June 2008)

- **A job well done**
  - RIP Goalpost device…


CLIMATE CHANGE

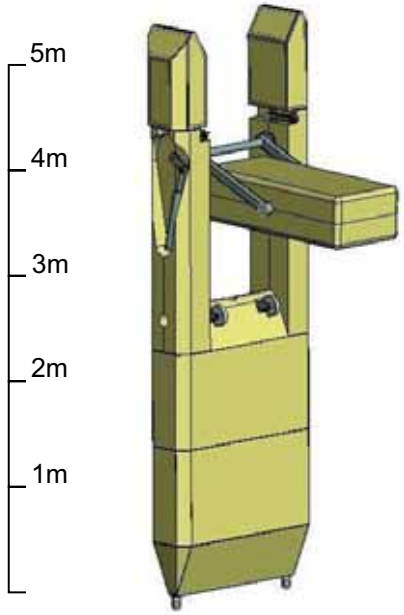
Greens launch campaign

Photo-shoot with Jeanette Fitsimmons - then leader of the Green Party

"It did not die in vain"

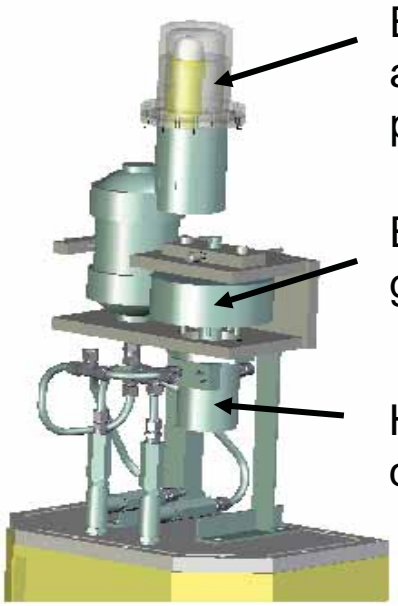
Engineering Models: 1/4

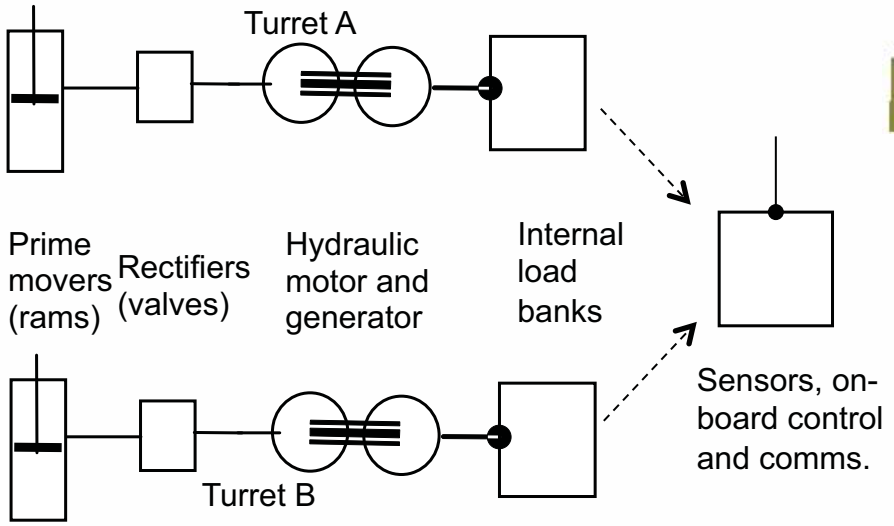
- **PSAF ¼ scale experimental device**
  - Developed from the Goalpost design
  - Increased reactive spar mass and volume
  - Physical strengthening and structural changes
  - Aluminium hull 1050kg dry weight, slight positive buoyancy
  - Float 400kg buoyancy, differing shapes and weights



Engineering Models: 1/4

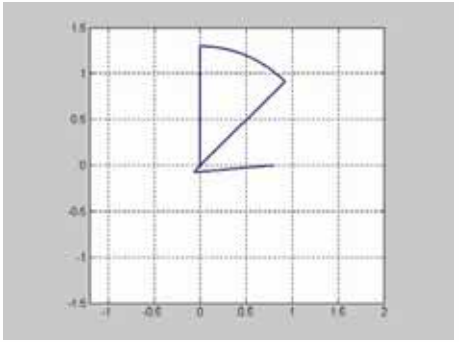
- **PSAF ¼ scale experimental device**
  - Dual PTO
  - 1kWp per side

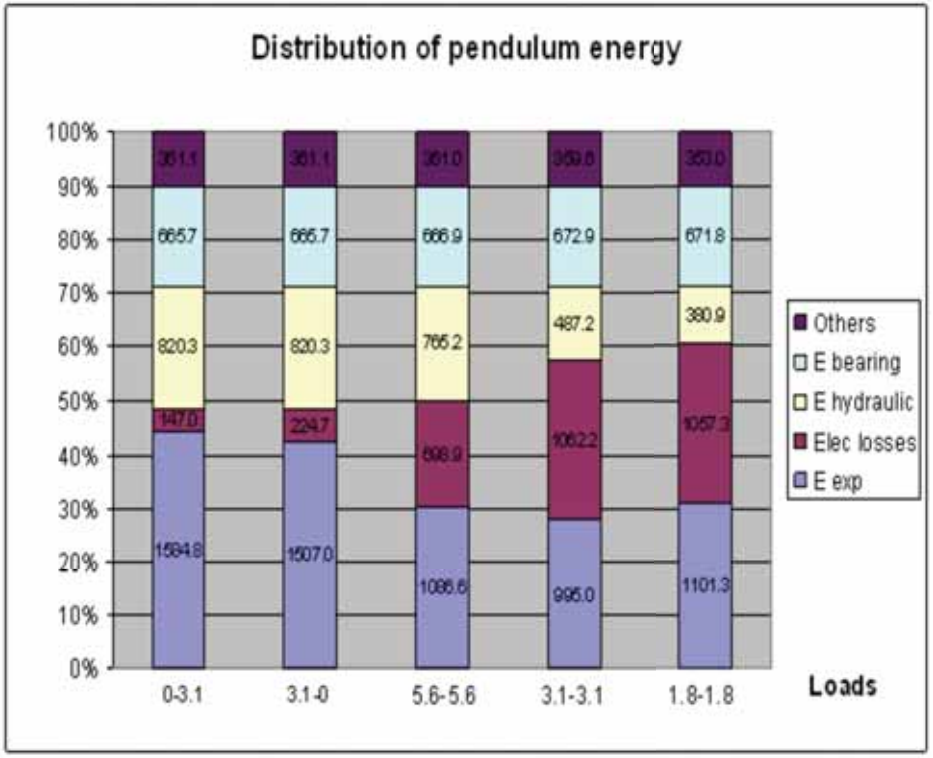




Engineering Models: 1/4

- **PSAF ¼ scale experimental device**
  - Test the performance of PTO technology
  - Detailed analysis of power train efficiencies – numerical modelling
  - Durability and FMIA





Engineering Models: 1/4

- **Repaint**
  - Bureaucracy catch up
    - Isolated hazard gazetted
  - Segment float fitted,1m radius

Engineering Models: 1/4

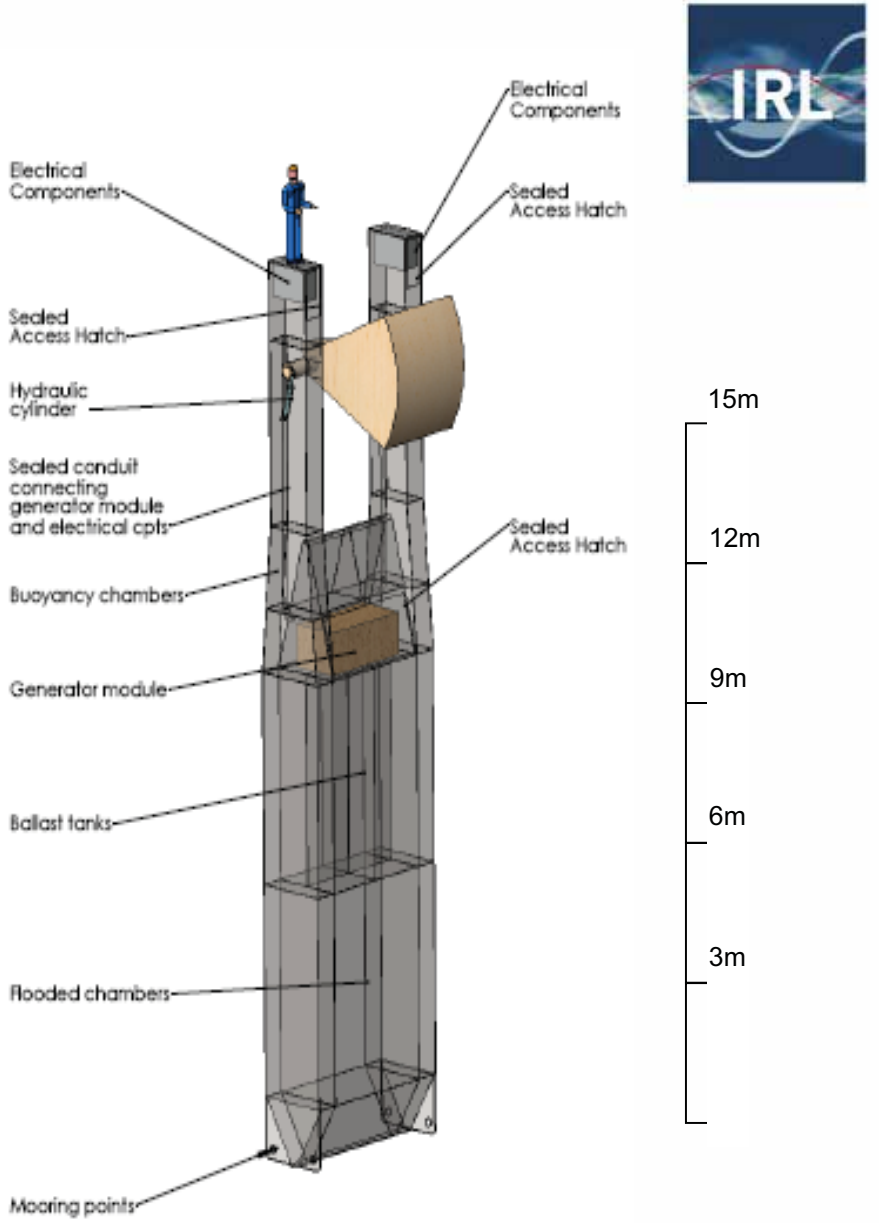
- **Shore based observation**
  - Data collection ongoing
    - Behaviour under different conditions
    - Durability and FMIA

- **Semi-permanent mooring**
  - Taylors Mistake bay

Engineering Models: 1/4

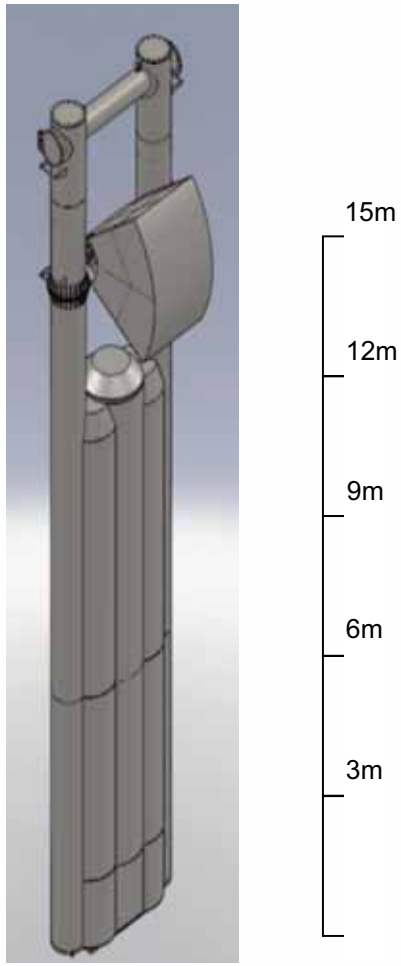
Scale Up: 1/2

- **MEDF Device - conceptual design**
  - Over 100,000 simulations
- **Reactive hull**
  - 15 m draft
  - 50 tonnes wet
  - Still not big enough to respond to ocean-swells
- **Active float**
  - 2 m arm length x 1.8m wide
  - 4 tonnes
  - 2.5m, 8sec waves
  - 20kW peak power capacity
- **Industry engineering expertise used**



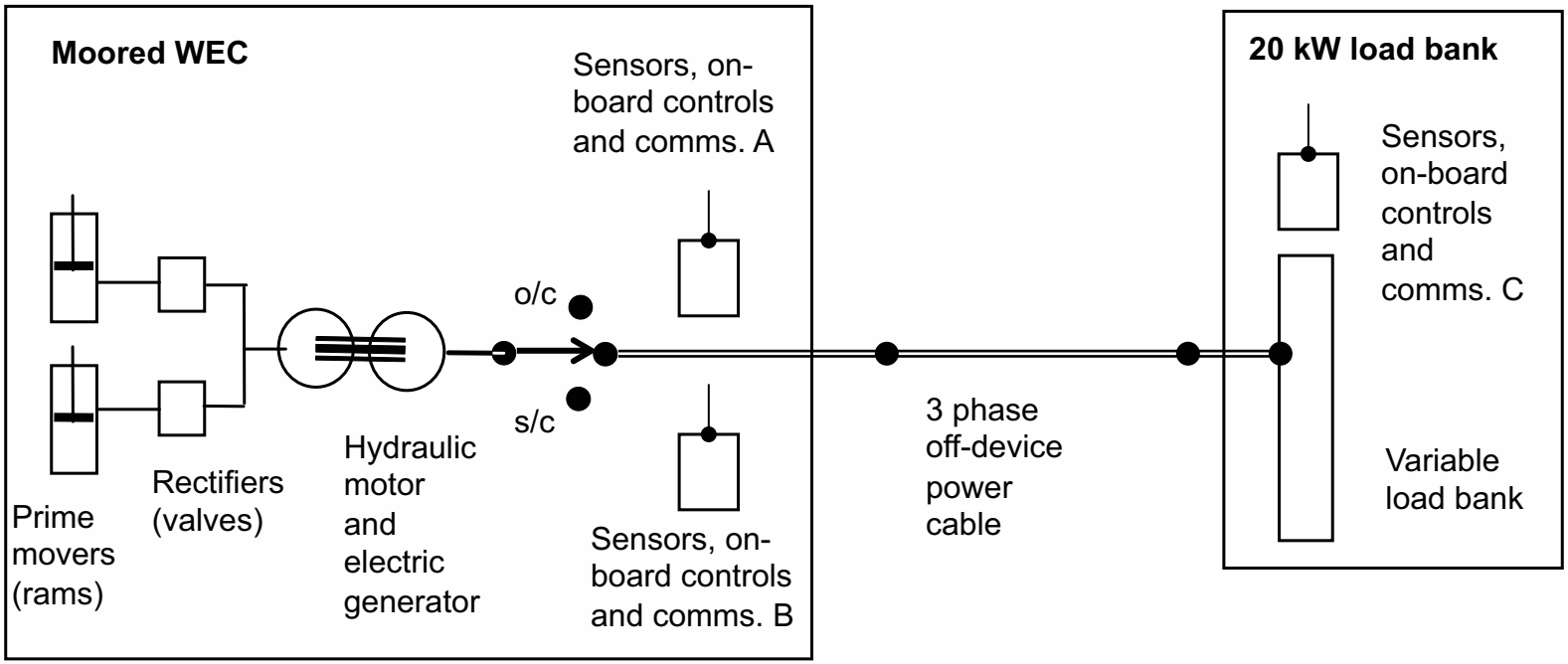
Scale Up: 1/2

- **MEDF Device - purpose**
  - Test a refined design at a pre-commercial ocean-wave scale (>8sec periods)
  - Cost of energy estimations
  - Deploy for 2 yrs+ to demonstrate survivability
  - Attract commercial investment
- **The design**
  - Pipe based structure for strength
  - All PTO systems moved to a top section of the hull



Scale Up: 1/2

- **MEDF Device PTO**
  - cable to a separate 20kW load bank (buoy/vessel/on-shore)
  - Active load experiments planned



Scale Up: 1/2

- **Fabrication progress**
  - Hull
  - constructed with 500mm, 800mm and 1500mm diameter steel pipes

Scale Up: 1/2

- **Fabrication progress**
  - Float and PowerPod
  - Loadbuoy

Power Pod

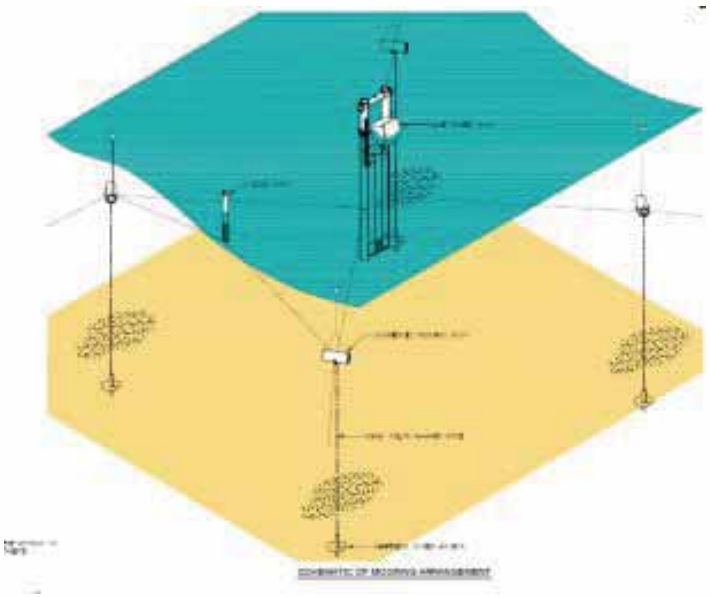
Float

Loadbuoy

Scale Up: 1/2

- **Deployment**
  - Initial test site Akaroa Heads
  - then Moa Pt, Wellington

The Akaroa Heads site



Mooring plan is screw anchor based

Future

USA – Oregon

Future

- Ongoing development and maturing of the design
- Secure further IP
- Deploy at least one full scale device
- Commercialisation vehicle
- Wave farm development

Challenges

- **Device level**
  - Cost of energy
    - Improve numerical models and performance prediction
    - Better understanding of the design tradeoffs
    - More efficient drive train options
  - Ocean scale device testing
    - Survivability
    - Active loading control
- **Installation level**
  - Cost of Energy
    - Mooring of arrays of WECs
    - Electrical interface and shore connections, power quality and delivery
  - Environmental issues

Wave Energy Technology - NZ

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