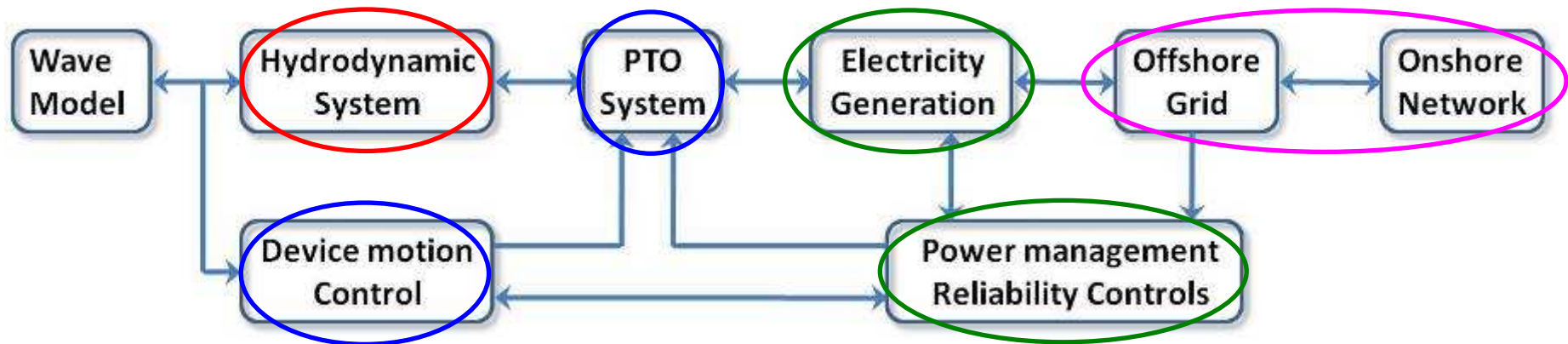




# An Automatic, Time-Domain, Hydrodynamic, WEC Array Model

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# The Wave-To-Wire Model

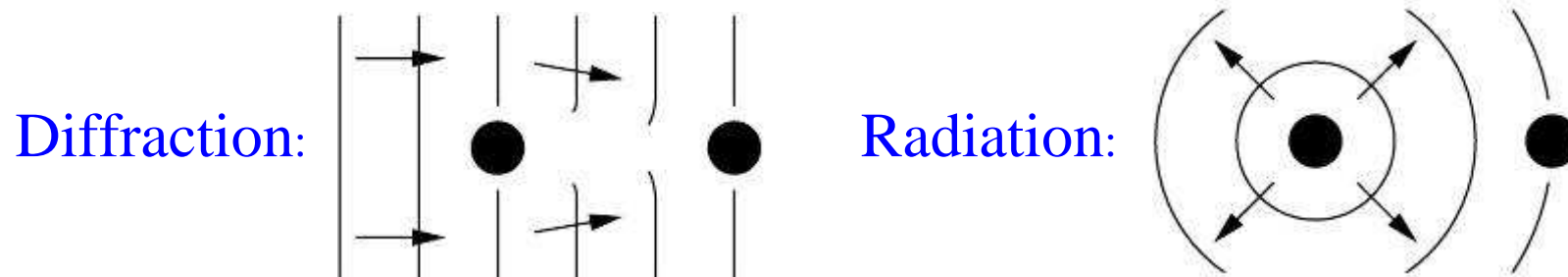


- SuperGen Marine researchers are working on various aspects of this model.
- This presentation is about the **hydrodynamic model**.
- Dr Matt Stables will talk about the **PTO and control**.
- Dr Markus Mueller will talk about **generator aspects**.
- A poster outside discusses **network integration** (Anup Nambiar).

# Hydrodynamic Array Model



- An accurate numerical model must:
  - Simulate the wave induced motion of wave energy converters in an array.
  - Also take account of all the hydrodynamic interactions between the devices (*i.e.* both wave diffraction and radiation).

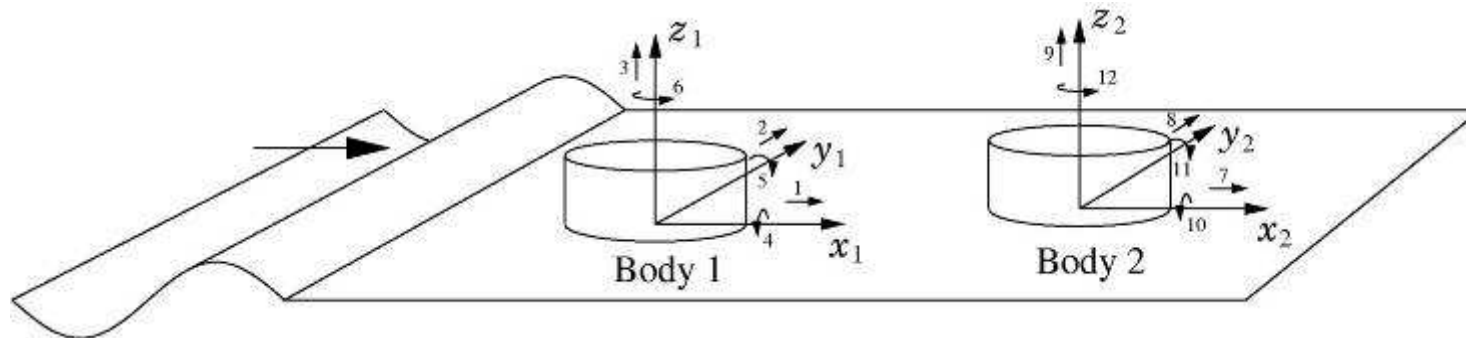


- That is, each converter feels the disturbance to the sea created by the other converters.

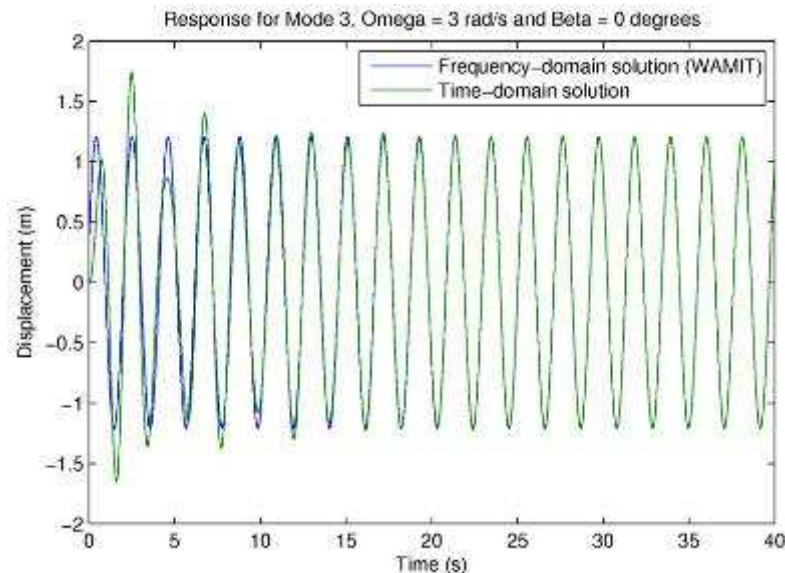
# Frequency-Domain v Time-Domain



- The commercial code WAMIT<sup>®</sup> can simulate converter arrays:



- But WAMIT<sup>®</sup> is frequency-domain (it gives the “steady-state” response to sinusoidal incoming waves).



- *i.e.* WAMIT<sup>®</sup> will not simulate transients.
- It is not suitable for:
  - The wave-to-wire model.
  - Nonlinear control.
  - Nonlinear mooring forces, PTO forces *etc.*
- Need a **Time-Domain** model.

# Time-Domain Array Model



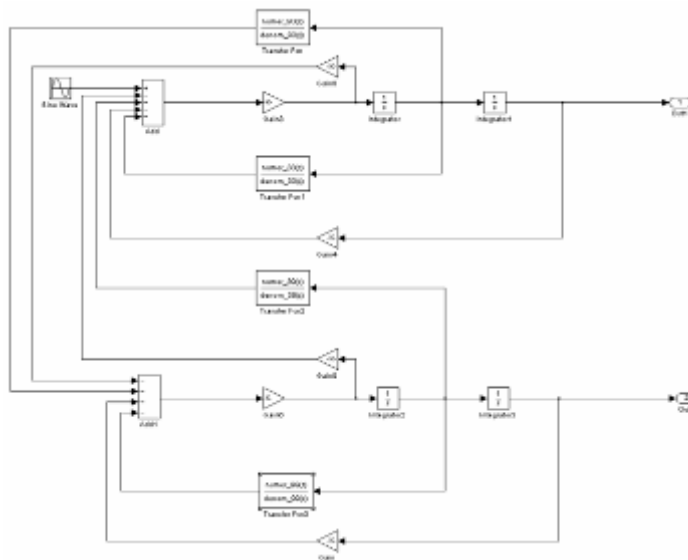
- A new *automatic, time-domain*, hydrodynamic, converter array model has been developed using *state-space* techniques.
- It works from WAMIT<sup>®</sup> data.
- It models any number, shape and configuration of devices in an array, with each moving in up to 6 degrees of freedom.
- It is fast (not a computationally demanding CFD solver) but captures all the essential physics.
- It operates within the loop-time of the control algorithms as required for wave-to-wire modelling.

# Time-Domain Array Model

1. Minimal user-input required: only the name of the WAMIT<sup>®</sup> output files.
2. A single Simulink<sup>®</sup> block required for all arrays.

## Previously

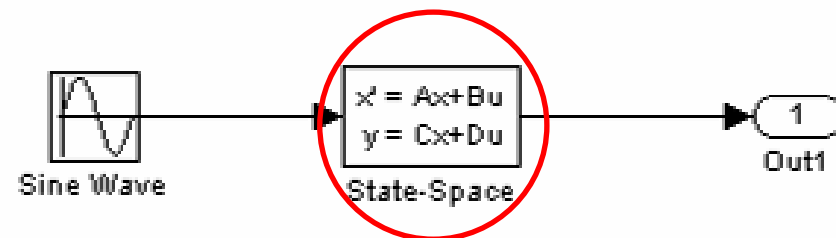
Must construct a different Simulink<sup>®</sup> diagram for each array studied:



A two device array

## Now!!!

1 Simulink<sup>®</sup> block for all WEC arrays:



ANY array

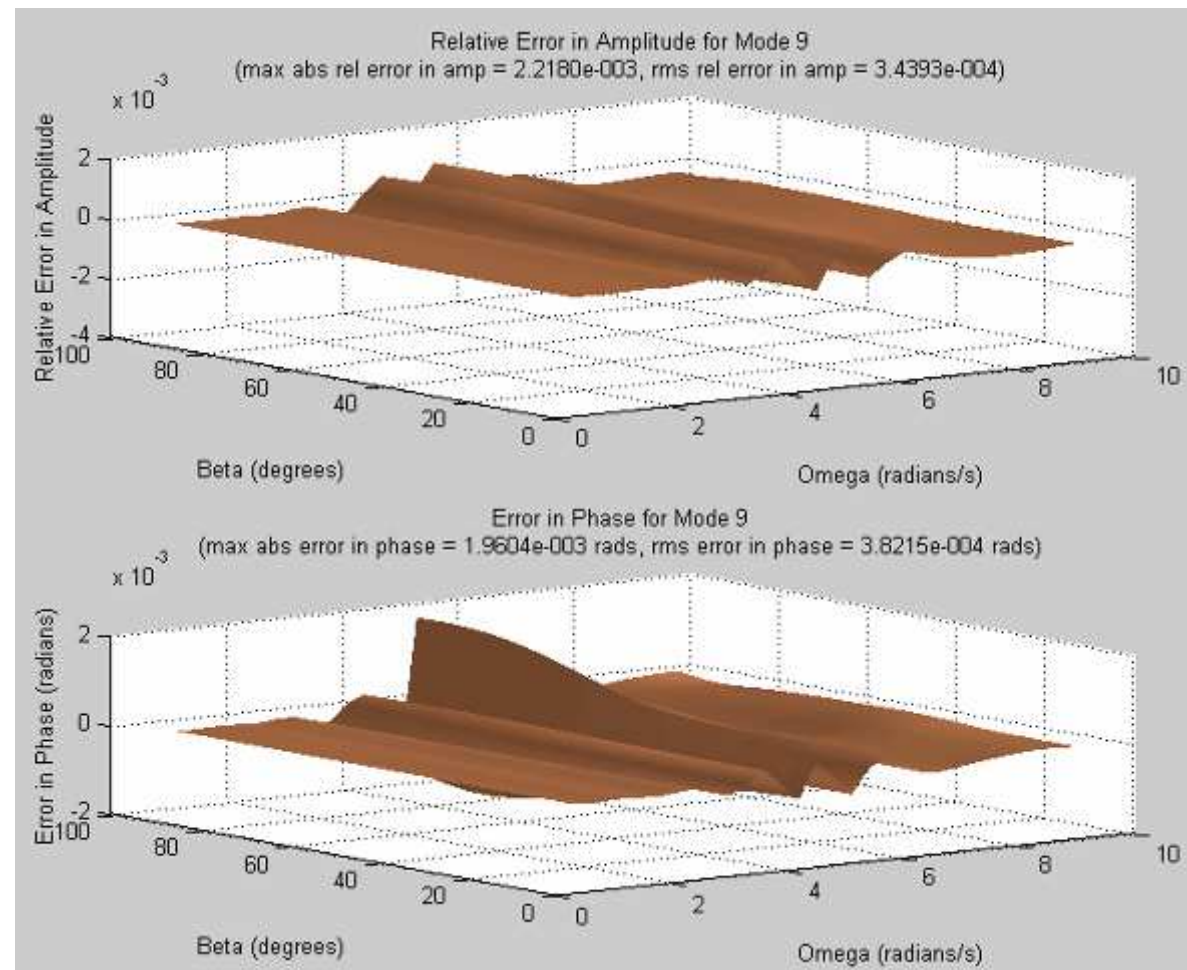
# Steady-state error relative to Freq Domain



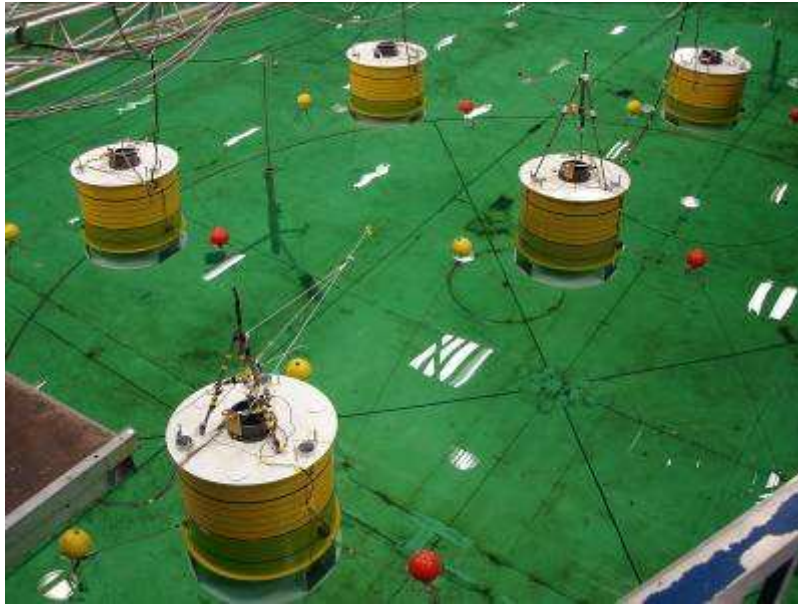
- An automatic post-processing code has been developed to assess the time-domain model.

- These *error* surfaces show the time-domain model is working correctly.

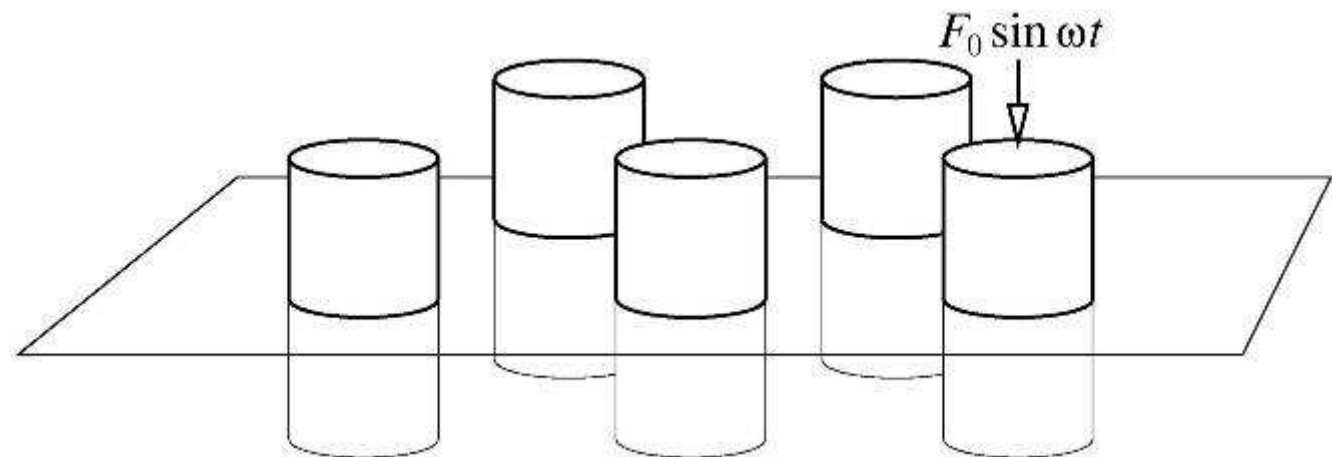
- Notice the small values on the vertical axes.



# Example: The Trondheim Five

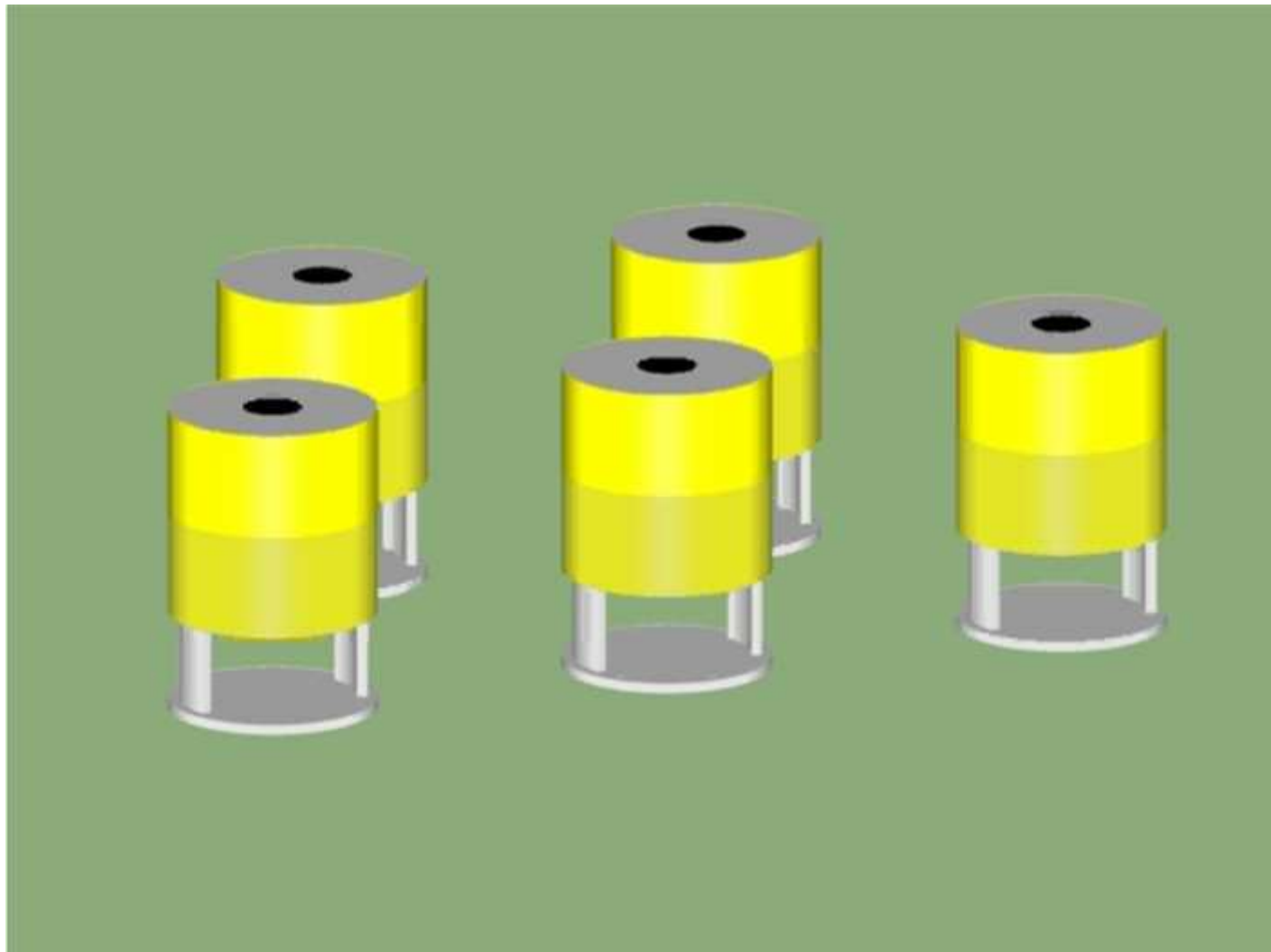


- As an example, we have simulated the absolute and relative motion of the five Trondheim buoys:





# Animation of the Trondheim Five





## Conclusions and Further Work

- We have developed a new, accurate, automatic, state-space, time-domain, hydrodynamic array model.
- It is fast (operating with the loop time of the control algorithms), while still capturing the essential physics.

Further work includes:

- Exploration of the influence of geometry, spacing and body forms on array performance
- Inclusion of non-linear PTO forces, mooring forces *etc.*
- Tank validation of predicted response
- Incorporation of the hydrodynamic model into the larger wave-to-wire model.



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