



## 6 Degrees-of Freedom Towed Buoy Dynamic Assessment

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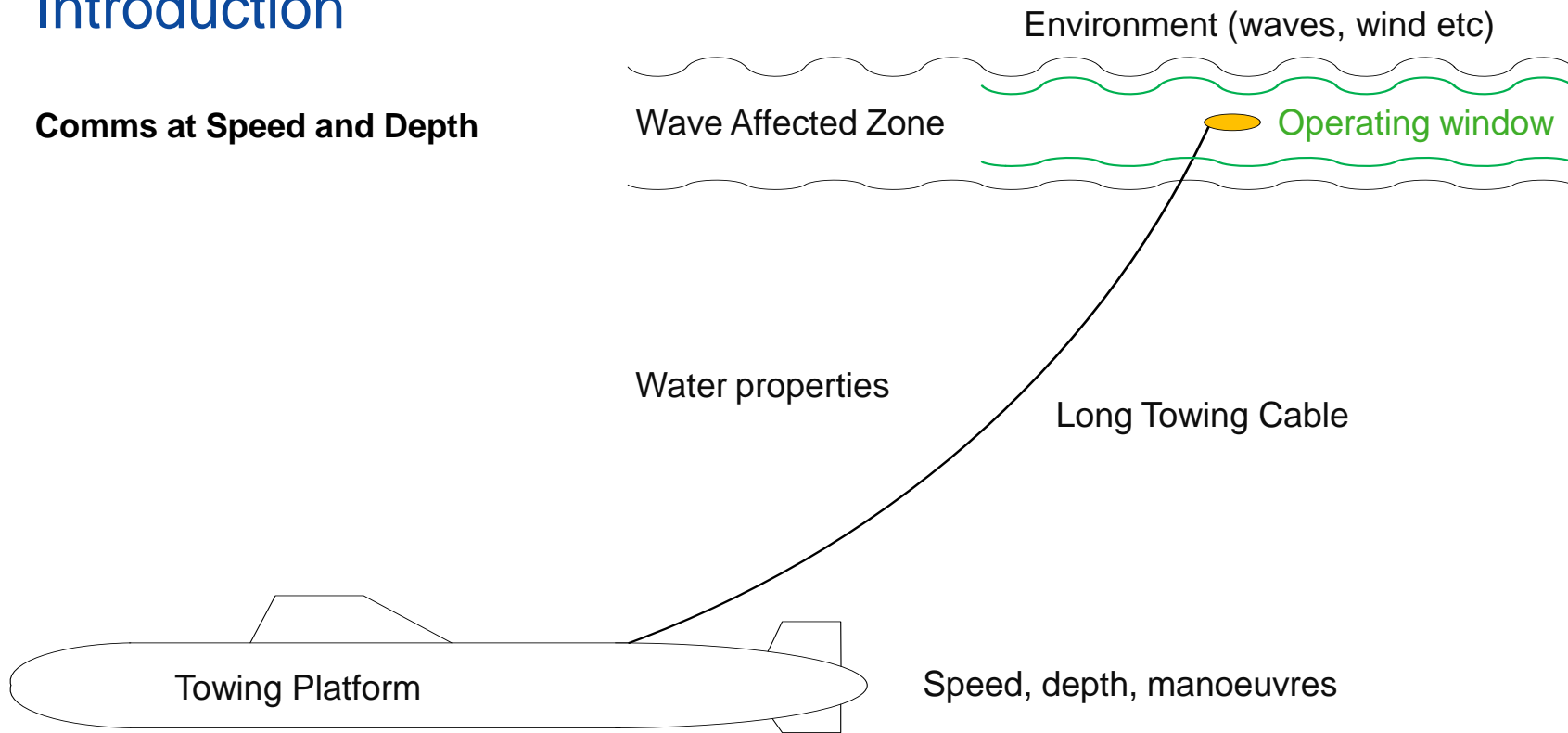
# Introduction

## **6 Degrees-of Freedom Towed Buoy Dynamic Assessment**

- **Introduction of the system**
- **Purpose of developing this capability**
- **Challenges**
- **Simulation**
- **Key Performance Indicators**
- **Conclusion**

# Introduction

## Comms at Speed and Depth



# Purpose

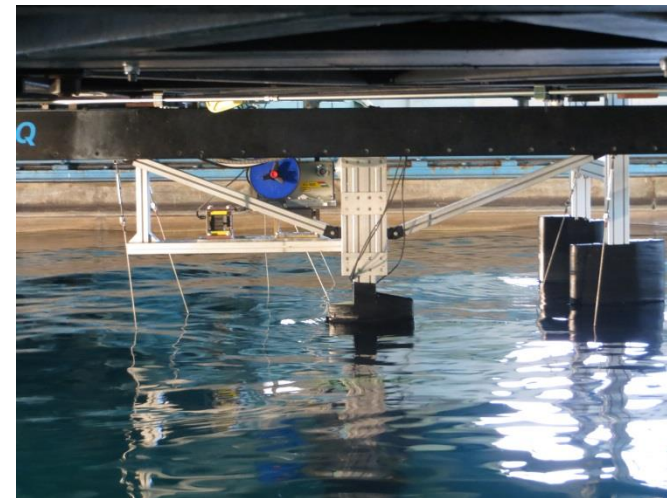
**Provide confidence across a number of areas:**

- **Assess simulation performance against test data**
  - Validation activities
- **Assess performance impact of design changes**
  - Developmental tool - improve design & performance
- **Assess performance across wide range of operating scenarios**
  - Time and availability of platforms make this very challenging to achieve with testing
  - Define operating envelope – interpolate between measured points of data
  - De-risking tool – increase likelihood of full scale trials being successful

# Challenges

## Scale

- **Underway towed systems are very large**
  - Towed body to towing platform spans hundreds of meters
- No test facilities large enough to accommodate full scale testing
- Requires towing platform
  - Often actual platform due to lack of suitable research platforms
- High risk going from the drawing board to full scale tests



Tank Testing

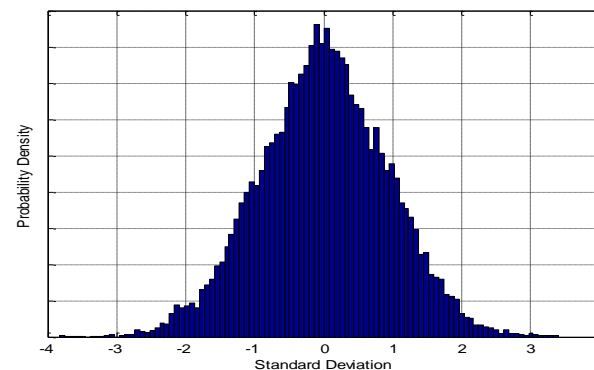
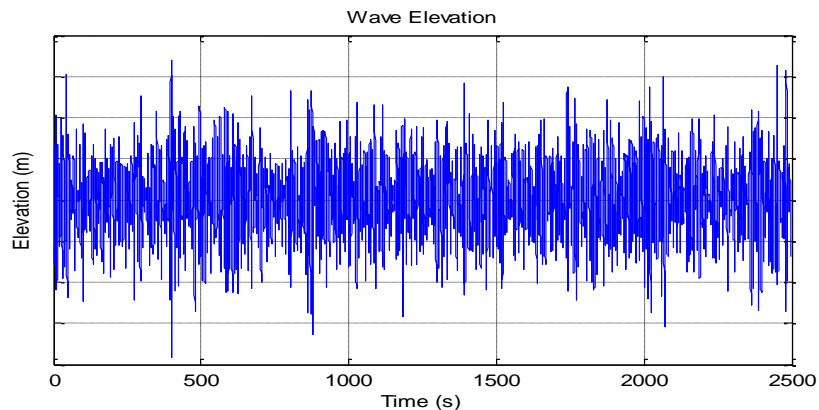
## Hydrodynamic scaling

- **Different for turbulent transition (Reynolds Number  $R_e$ ) and wave making resistance (Froude Number  $F_r$ )**
  - Not possible to scale for both simultaneously
  - Scale based on  $F_r$  and add leading edge trips to artificially trigger turbulent transition at lower Reynolds Numbers.

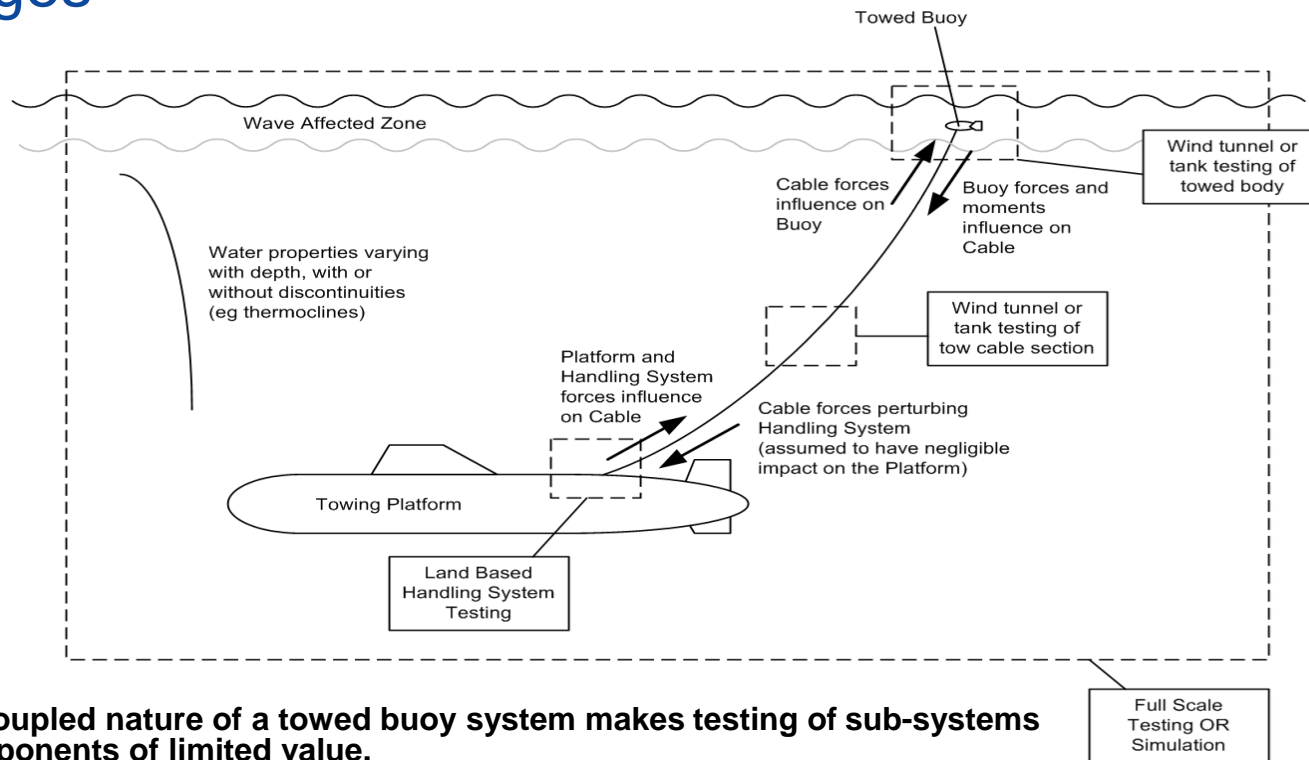
# Challenges

## Operating Environment

- **Wind and waves by nature are chaotic and turbulent**
  - Repeatable experiments cannot be achieved
  - Sea states are characterised in statistical terms i.e. significant wave height, period..
  - Statistical methods of analysing performance becomes necessary



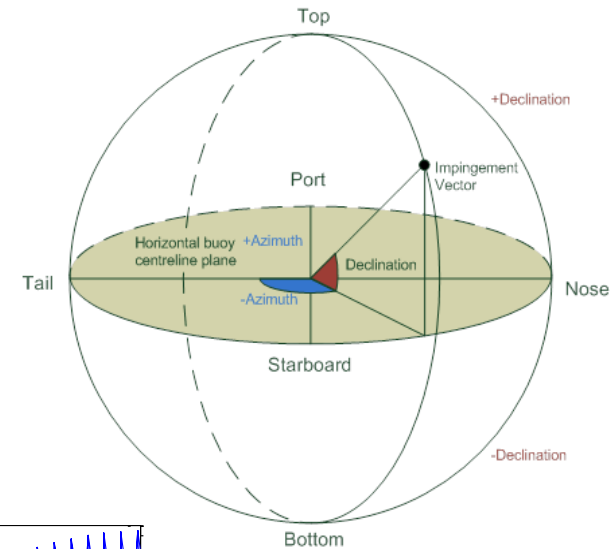
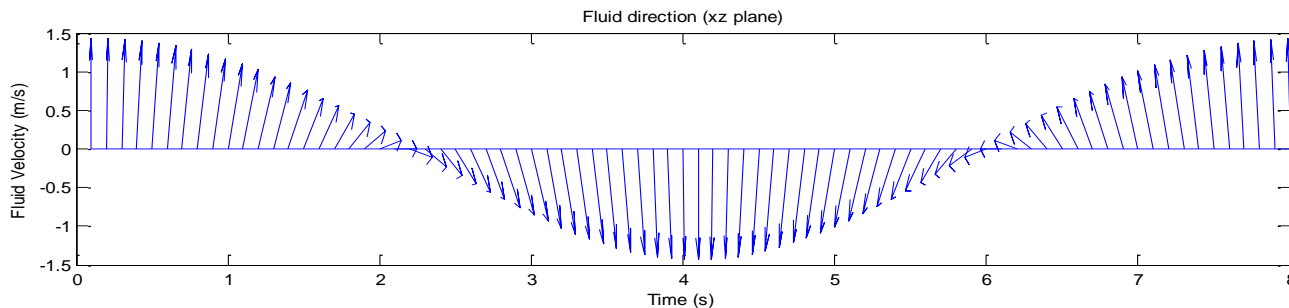
# Challenges



**The highly coupled nature of a towed buoy system makes testing of sub-systems and components of limited value.**

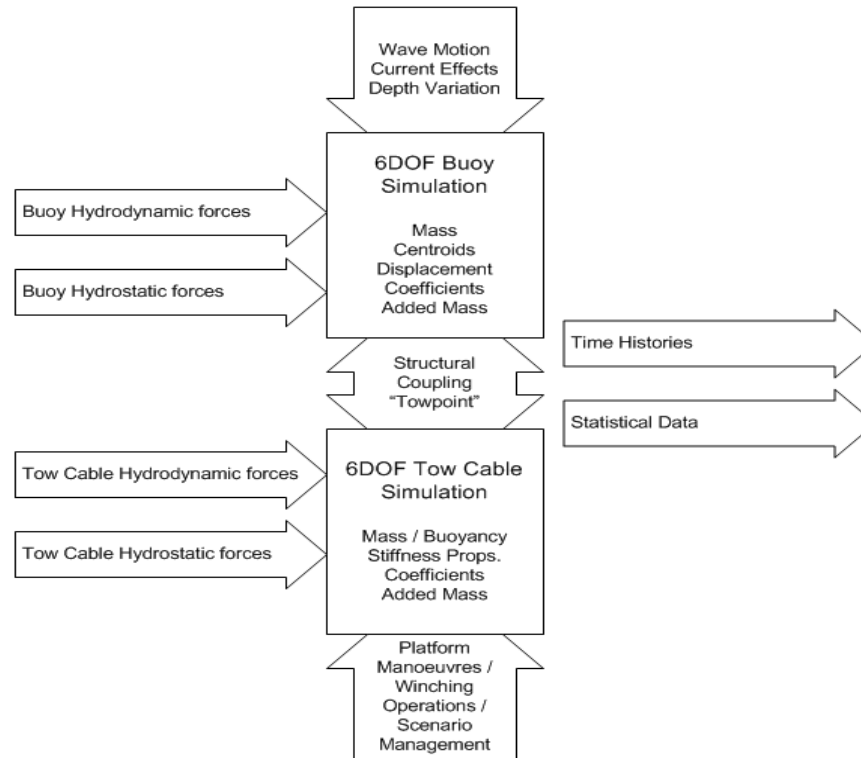
# Challenges

- **Simulation in the wave affected zone:**
  - Full 6 degree of freedom buoy dynamics required for complex shape
  - Hydrodynamic coefficients required for all impingement angles
  - Hydrodynamic scaling challenges





# Simulation



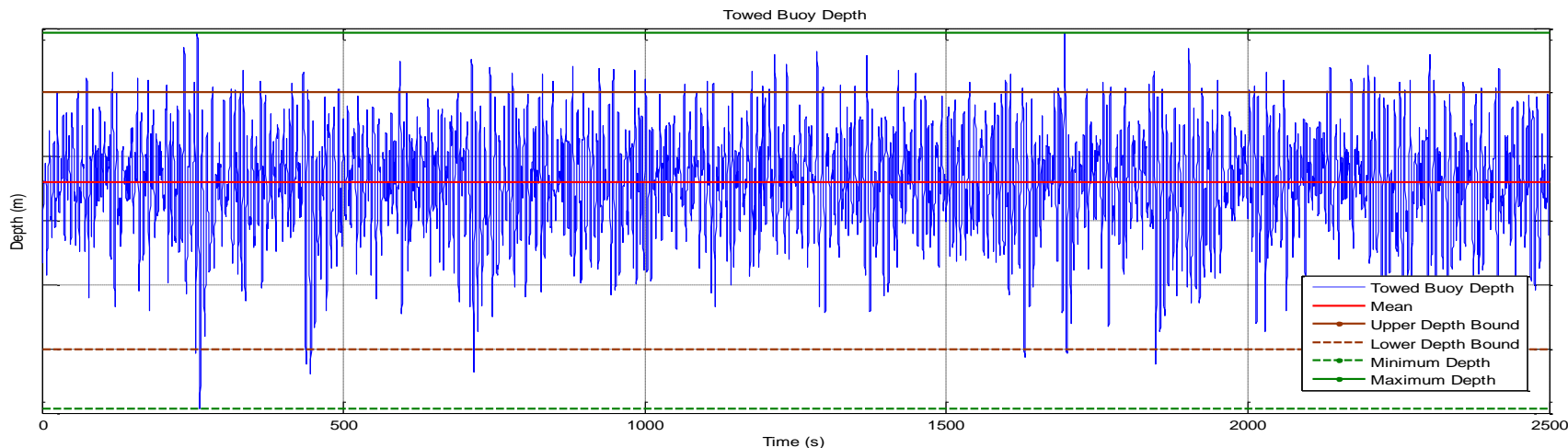
# Key Performance Indicators

## Monitor KPIs: Availability

- Antenna depth
- Antenna orientation

## Results:

- Availability (%)
- Min, max, mean, standard deviation



Operating Window

# Key Performance Indicators

## Assessment of KPI across operating scenarios

- Identify operating scenarios where performance improvements required
- Quantify performance of design changes
- Performance prediction for end user

Note: Random data used to demonstrate visualisation

Speed (kts)	Depth (m)	Sea State b						Sea State b						Sea State b					
		Heading						Heading						Heading					
		z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z	z
x	y																		
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# Conclusion

## **Challenges facing development of submarine towed buoy systems have been discussed**

- Full scale testing is expensive and logistically difficult
- Scaling effects and highly coupled natured limits value of small scale/sub element testing
- Operating environment is chaotic and not easily replicated in a controlled test
- Statistical validation

## **Simulation is an enormously valuable tool**

- Design and development
- Cost and risk reduction
- Predicting operating envelope
- Reducing development timescales
- Maximising chance of success for full scale testing

# **babcock<sup>TM</sup>**