Water Research Laboratory | School of Civil & Environmental Engineering

Performance and Operational Safety of Floating Pontoons

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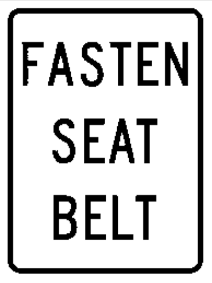
PERSPECTIVE



- Boeing 737 = 0.2g at take off

- Severe turbulence in plane = 0.6g (up and down)

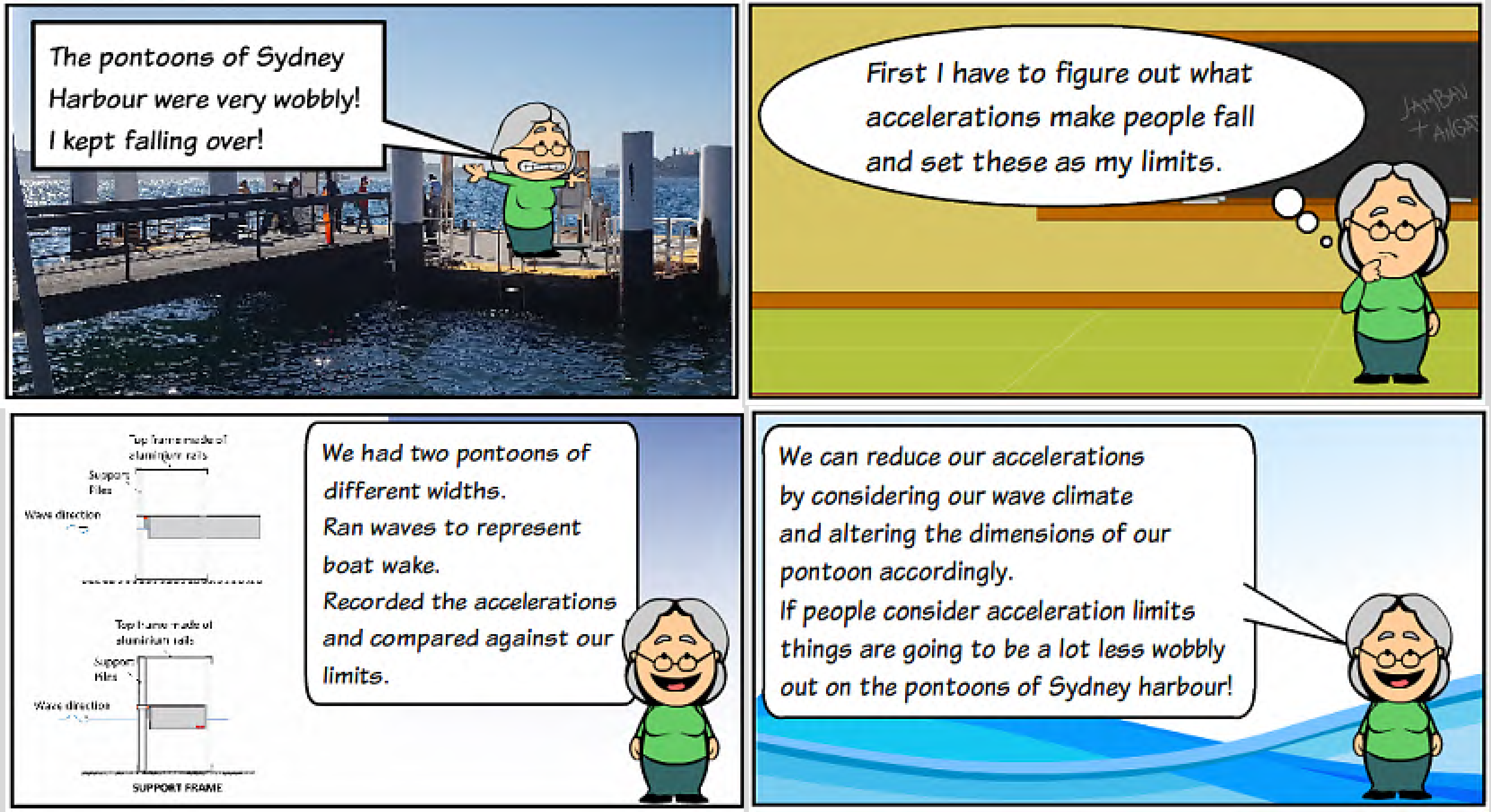
- Rounding a corner in a car = 0.6g (side to side)

FLOATING PONTOON

- A platform supported by pontoons (airtight hollow structures designed to provide buoyancy). Usually joined to shore with a gangway. Held in place by piles or anchored cables.

- Provides a point of access and egress to vessels.

- Today discussing piled box floating pontoon.



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BACKGROUND

- Floating pontoons move as a result of wave actions – ***Dynamic Motions***

- For a person standing on a floating pontoon, these dynamic motions can cause ***Postural Instability***

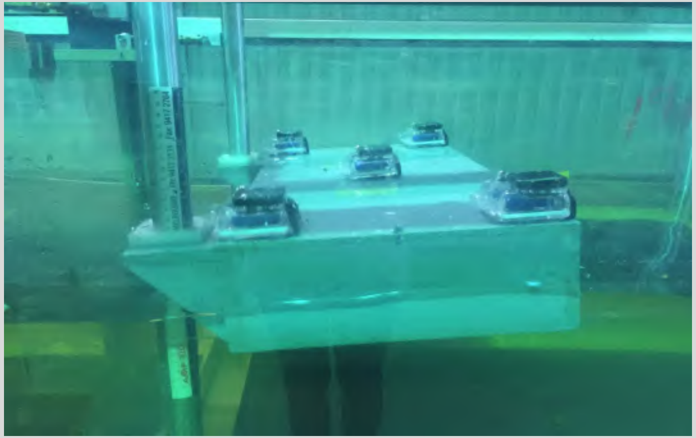
- ***Dynamic motions*** and associated ***Postural Instability*** currently not covered in floating pontoon design codes/standards

FLOATING PONTOON DESIGN

- Minimal design codes available
  - British Standard/NSW Maritime
  - Review existing test results for similar structures
  - Model testing
  - Select design based on performance criteria and cost

FLOATING PONTOON MOTIONS

- Performance influenced by:
  - Structure - Width, draft and mass
  - Hull – Shape/perforations
  - Mooring system
  - Water depth
  - Wave period



HUMAN RESPONSE TO MOTION

Age
Size
Fitness
Expectation
Experience
Standing

PERSON

+

Magnitude
Frequency
Axis

MOTION

=

Postural
Stability

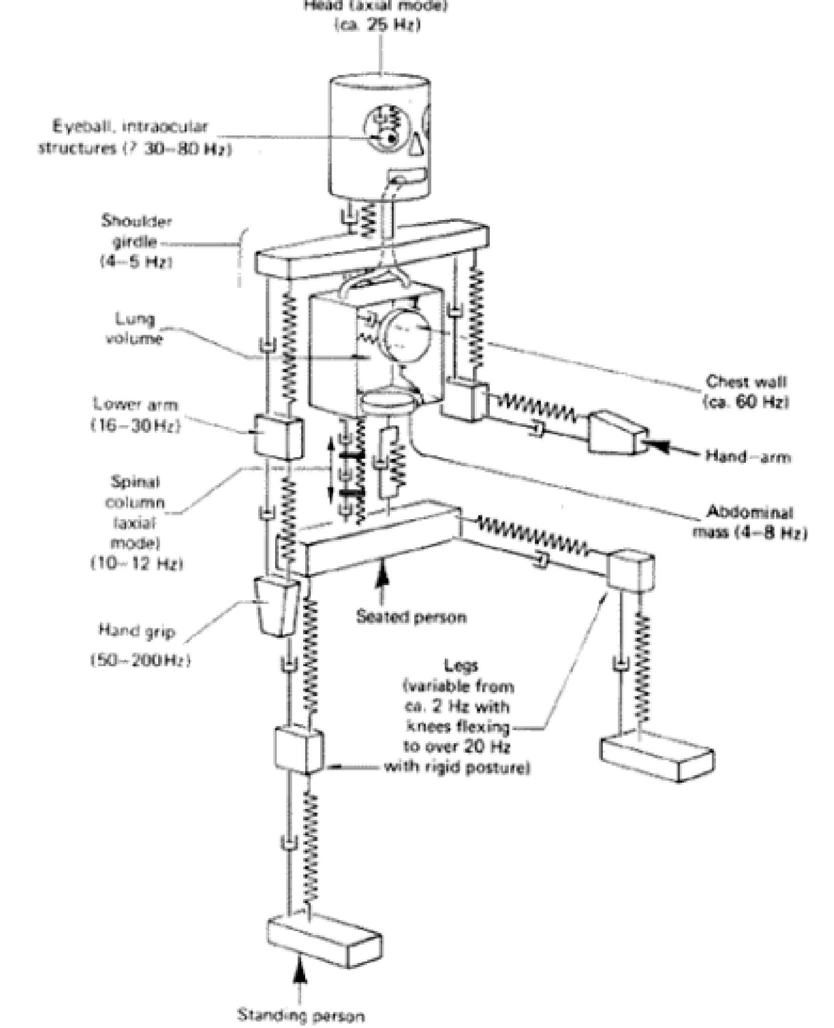
'Postural stability is the ability to maintain the body's centre of gravity over the base support during quiet standing and movement.'
(Hageman et al. 1995)

POSTURAL STABILITY - STANDARDS

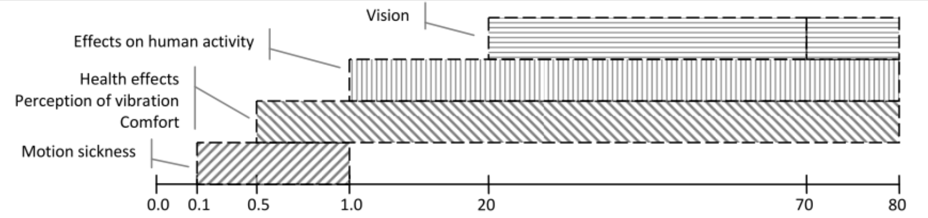
- Some standards are available comparative to floating pontoons including:
  - Vessels
  - Floating Bridges
  - Trains
  - Vibration effect

- No standards specific to motions of floating pontoons and postural stability

ABS Doc. No. 102: 2001
ABS Doc. No. 103: 2001
ASTM F1166-07
BS 6841:1987
BS 14253:2003
ISO 2631-1:1997
ISO 2631-4:1997
ISO 2631-5:1997
ISO 6954:2000
MIL-STD-1472F:1999
NATO STANAG 4154:2000
Graham (1990)
NSW Maritime 2005



Symptoms	Frequency
General feeling of discomfort	4-9
Head symptoms	13-20
Lower jaw symptoms	6-8
Influence on speech	13-20
"Lump in the throat"	12-16
Chest pains	5-7
Abdominal pains	4-10
Urge to urinate	10-18
Increased muscle tone	13-20
Influence on breathing movements	4-8
Muscle contractions	4-9



SOURCE: P.Matsangas 'Presentation - Human Performance Standards for Ship Motion Acknowledgments'

FIELD MEASUREMENTS

- Three operational floating pontoons located around Sydney Harbour
  - Balmain East
  - Man-O-War Steps
  - Walsh Bay

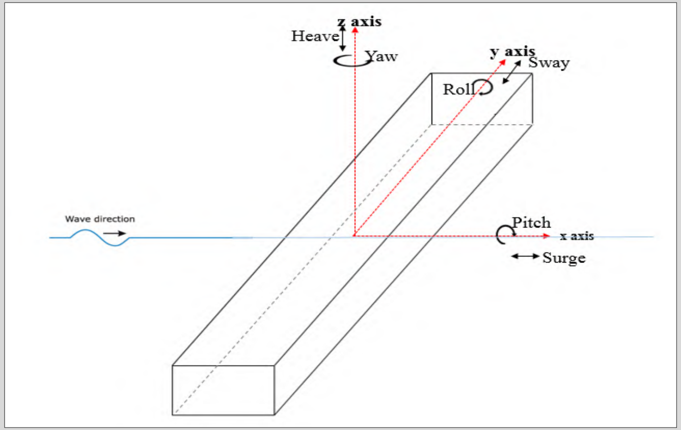
- Wave climate - boat wake

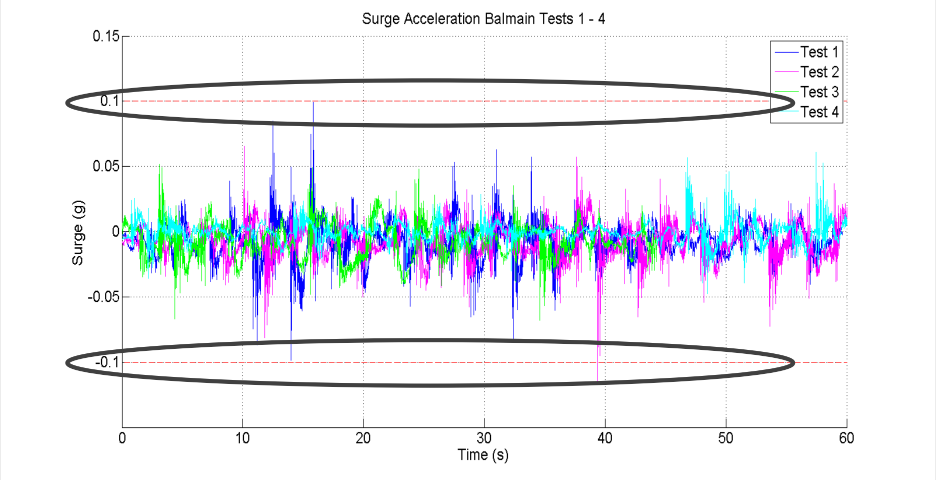
- Accelerations recorded using Inertial Measurement Units (IMU)

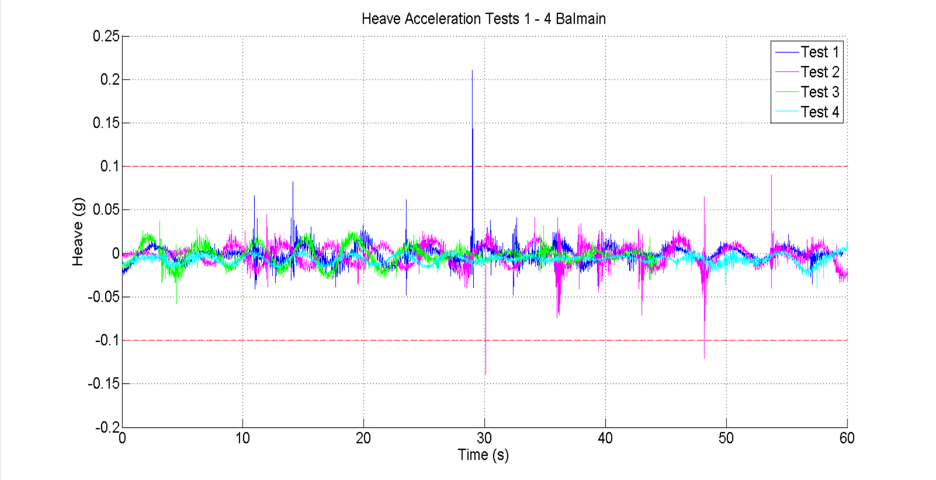
Motivated the lab work

FIELD TESTING ACCELERATIONS

- Showing results for Balmain East (new structure)
  - Peak Acceleration
    - Surge acceleration (x axis) – max 0.12g
    - Heave acceleration (z axis) – max 0.21g







FIELD TESTING ACCELERATIONS

- Root Mean Square (RMS) Acceleration
  - RMS Acceleration

	SML	Balmain	Walsh Bay	Man O War
Vertical	0.02g	**0.02**	**0.02**	**0.04**
Lateral	0.03g	0.02	**0.03**	**0.05**

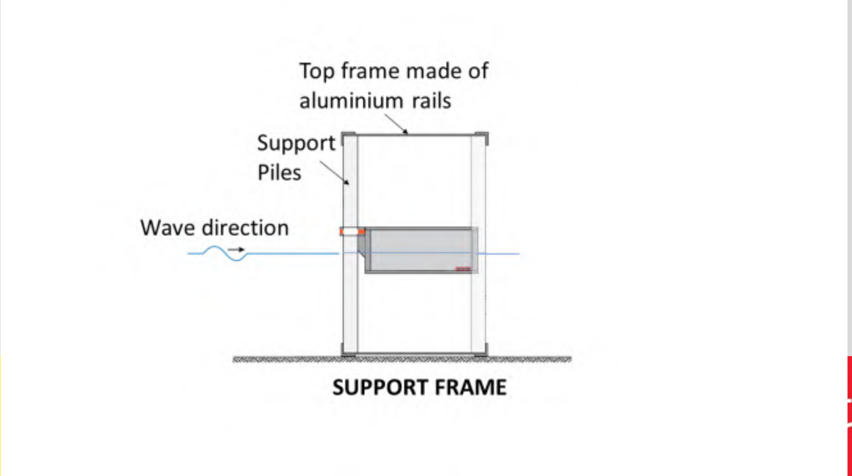
Very mild wave climate on day of testing – no wind

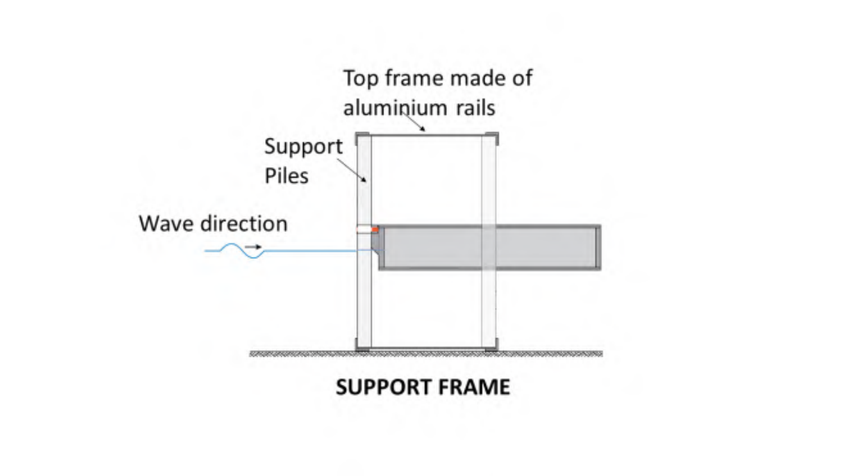
EXPERIMENTAL STUDY

- Undertaken two different rounds of testing - 0.6m and 1.2m flume

- Two floating pontoons differing width/beam – 2.83m and 5.63m prototype

- Altered draft



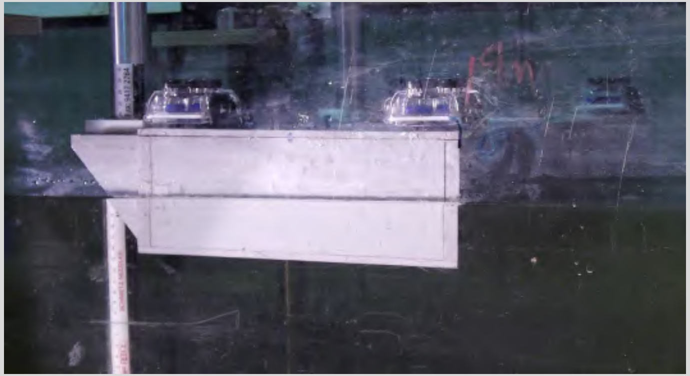


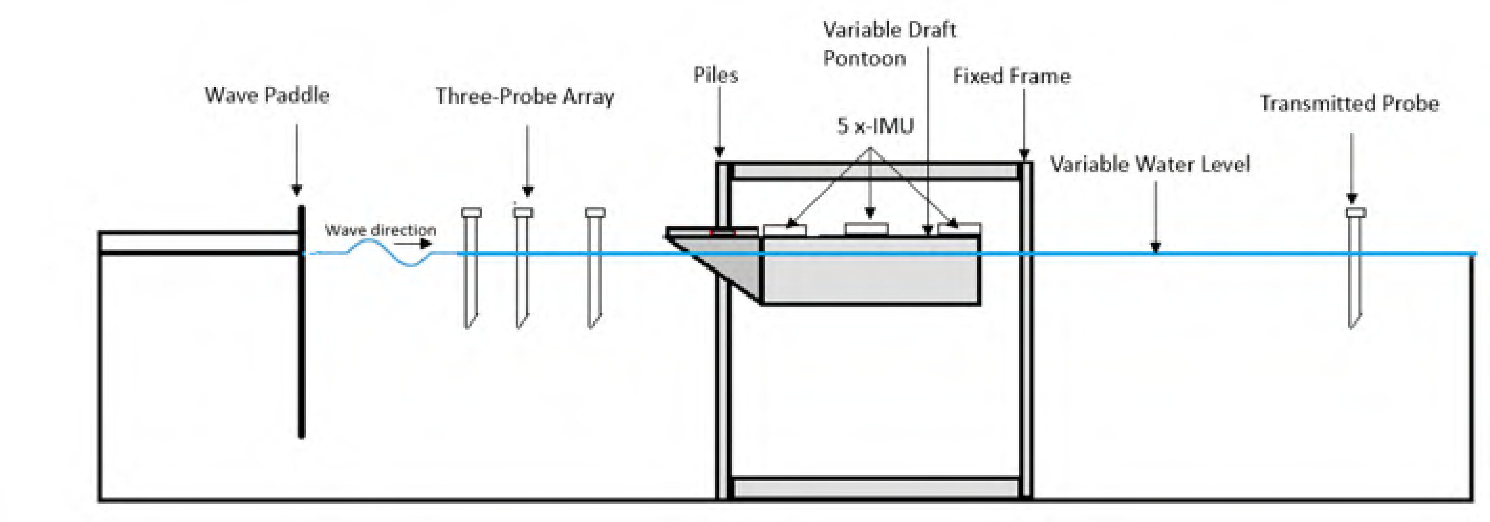
EXPERIMENTAL STUDY

- Wave periods 2 – 7s prototype
- Wave height 330mm prototype

BOAT WAKE

- Three probe array
- Tested each wave period 3 times and recorded accelerations
- Scale – 1:10



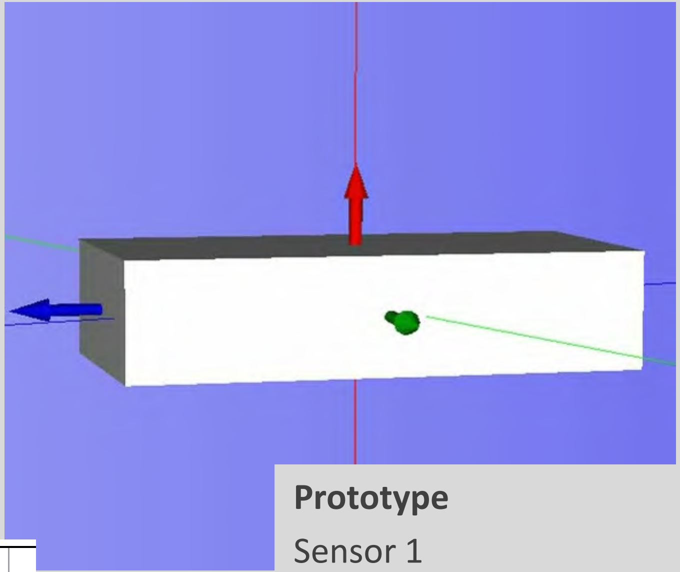


EXPERIMENTAL STUDY

- Accelerations/angles recorded using 5 x Inertial Measurement Units (IMU)

- Sensors connected via Bluetooth to laptop

- Accelerometers measured heave, surge, sway and angles of motion



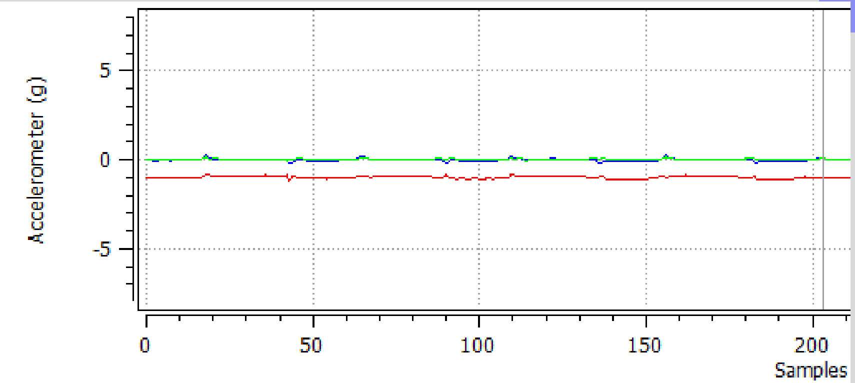
Prototype

Sensor 1

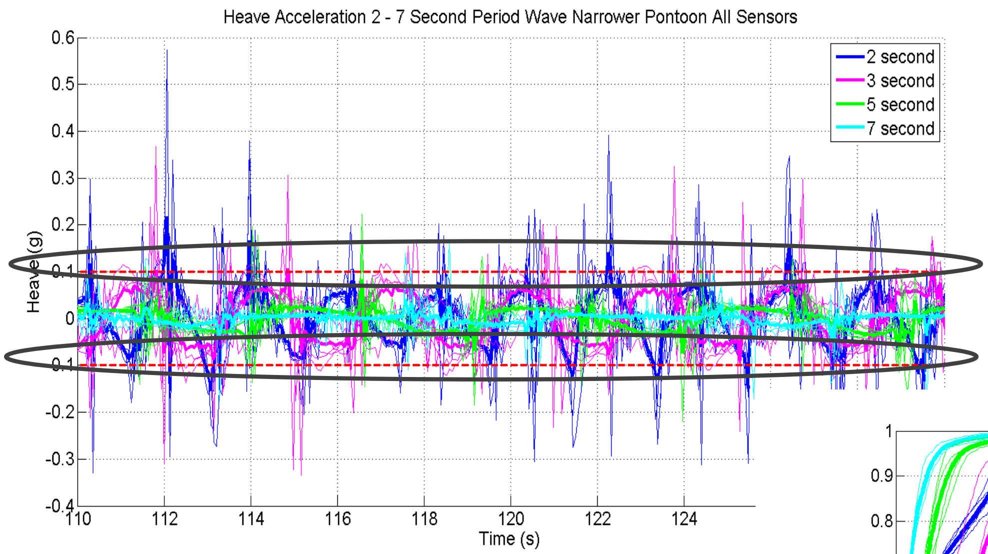
2830mm Width

2s Period

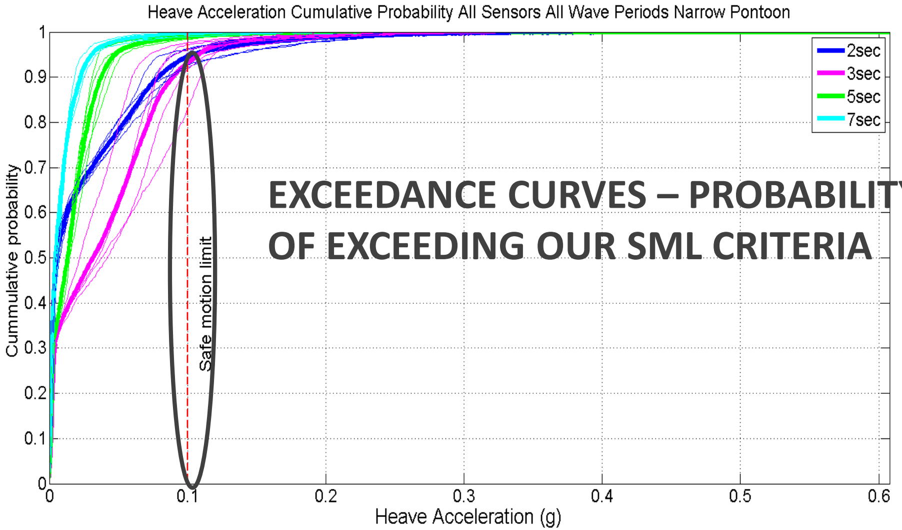
300mm Wave Height



PEAK ACCELERATIONS – NARROW PONTOON

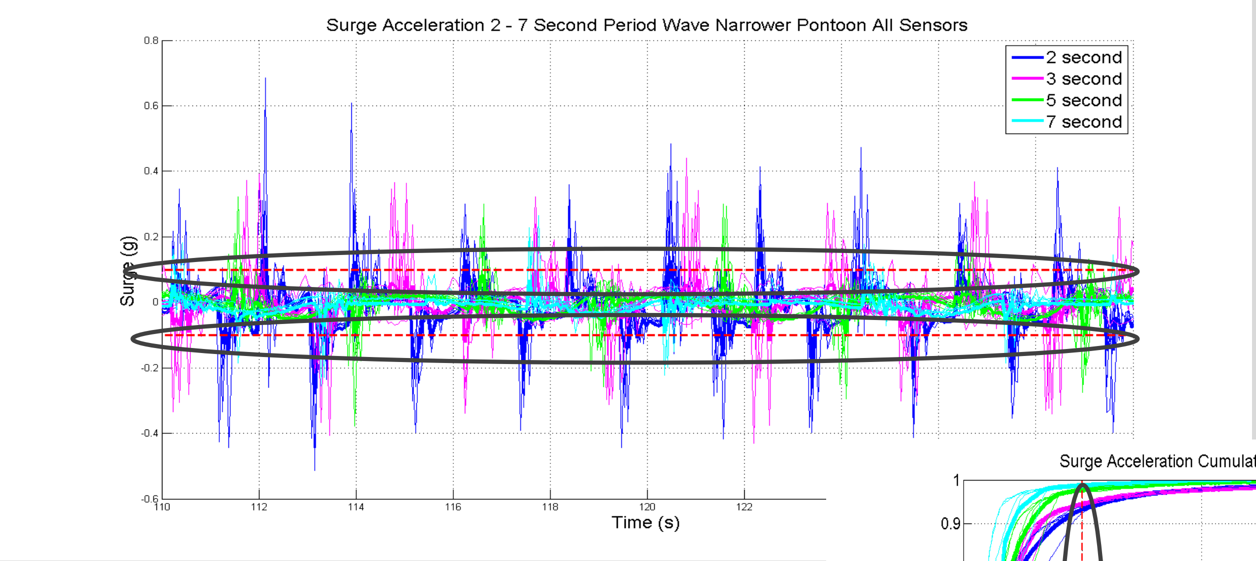


- Heave (z-axis) - Three second period wave highest probability of exceeding SML heave (7%)

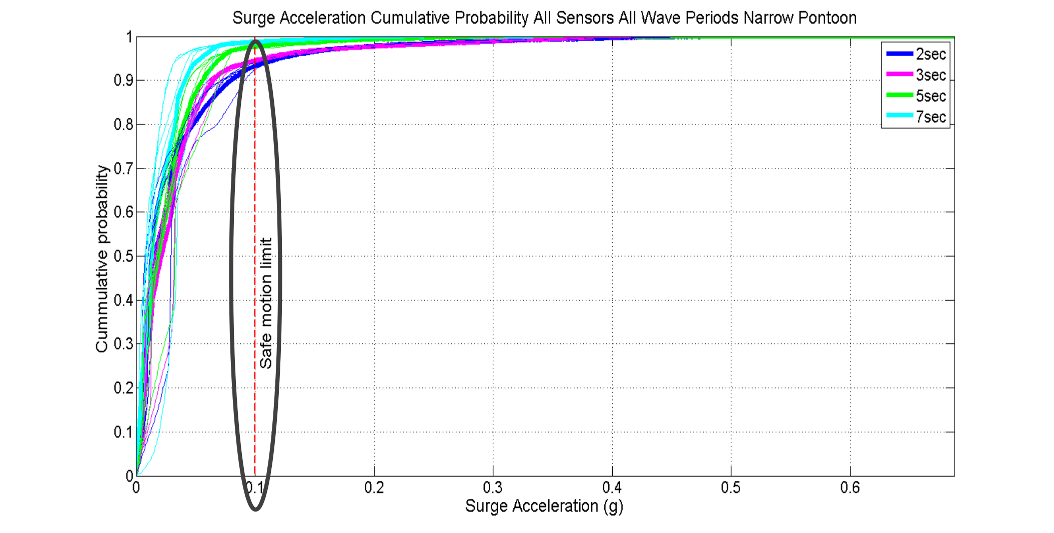


EXCEEDANCE CURVES – PROBABILITY OF EXCEEDING OUR SML CRITERIA

PEAK ACCELERATIONS – NARROW PONTOON

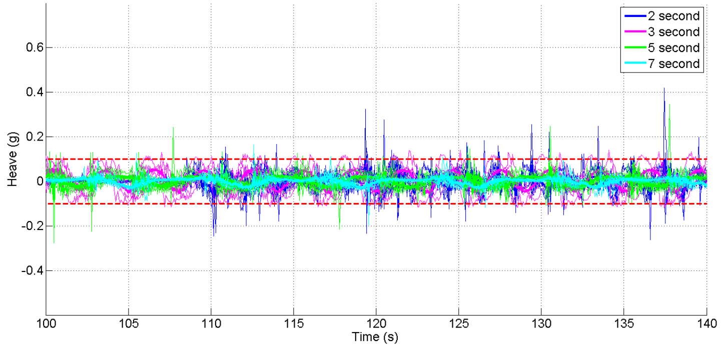


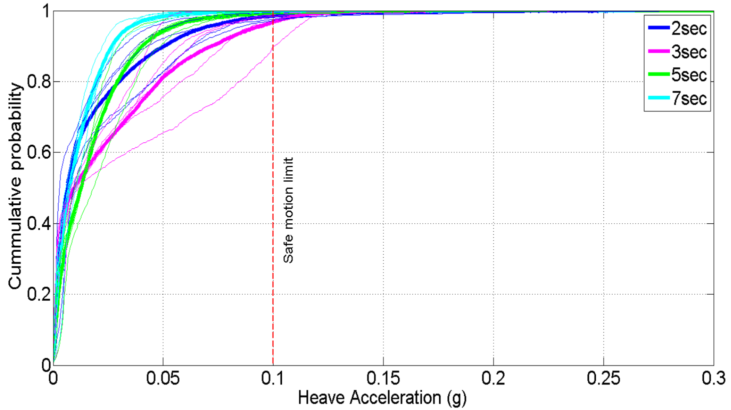
- Surge (x-axis) - Two second period wave highest probability of exceeding SML surge (8%)



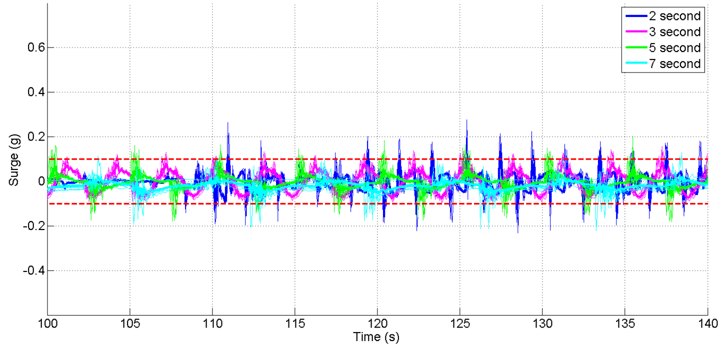
PEAK ACCELERATIONS – WIDE PONTOON

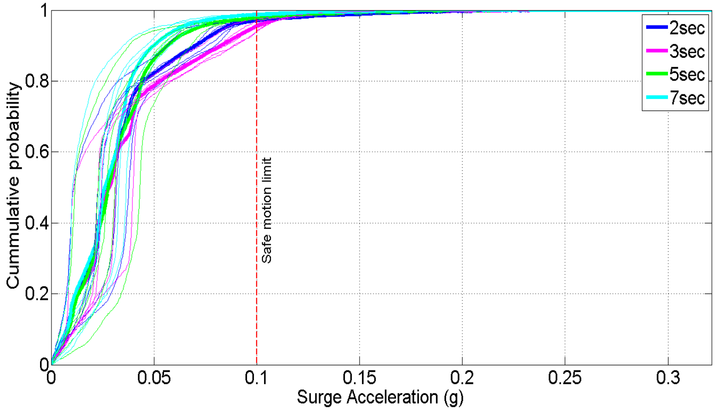
- Heave (z-axis) - Three second period wave highest probability of exceeding SML heave (3%)



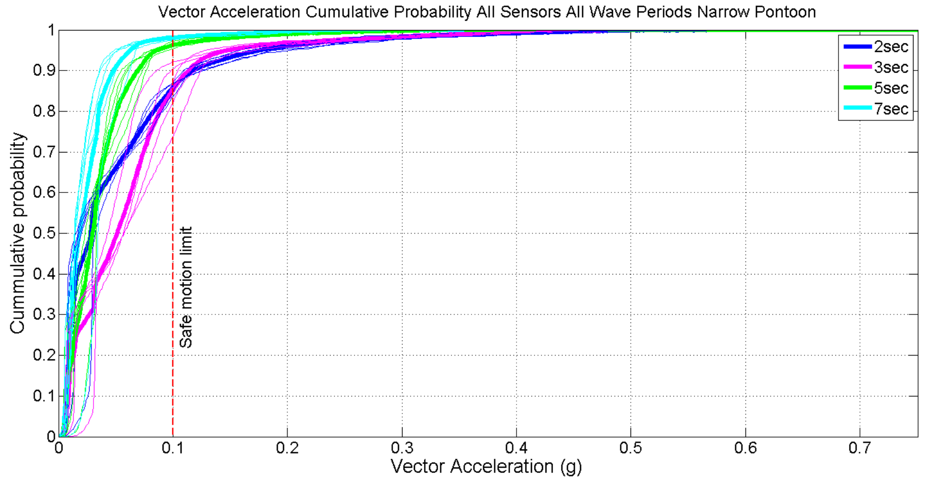


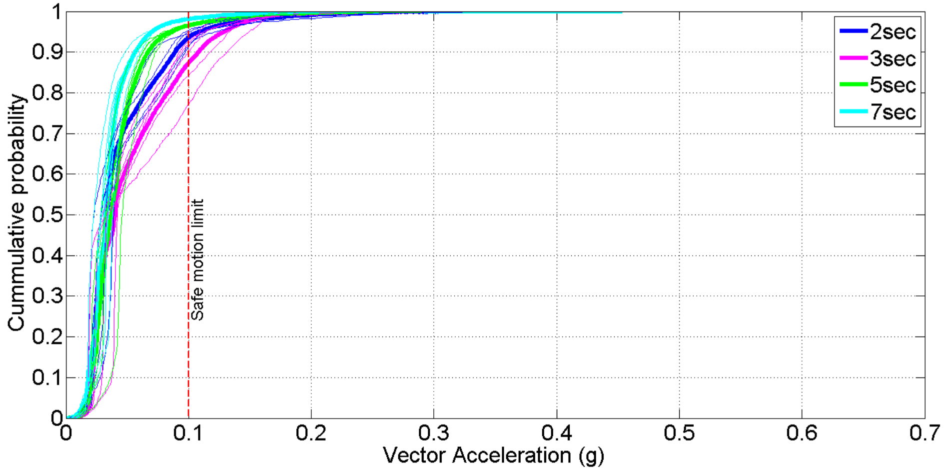
- Surge (x-axis) - Two second period wave highest probability of exceeding SML surge (4%)





PEAK ACCELERATIONS – VECTOR





- Vector acceleration – combined effect, accounts for acceleration occurring each axis
- Narrow Pontoon – Three second period vector acceleration probability of exceeding SML (15%)
- Wide Pontoon – Three second period vector acceleration probability of exceeding SML (13%)

- **Results have shown that increasing beam → maximum magnitude of acceleration is reduced.**
- **Wider pontoon overall lower probability of exceeding SML when compared with narrower pontoon.**

RMS ACCELERATIONS

Generally wider pontoon behaves better in regards to RMS acceleration. Lower for all scenarios except 3 and 5 second period in surge

- Narrow Pontoon – RMS average of all five sensors

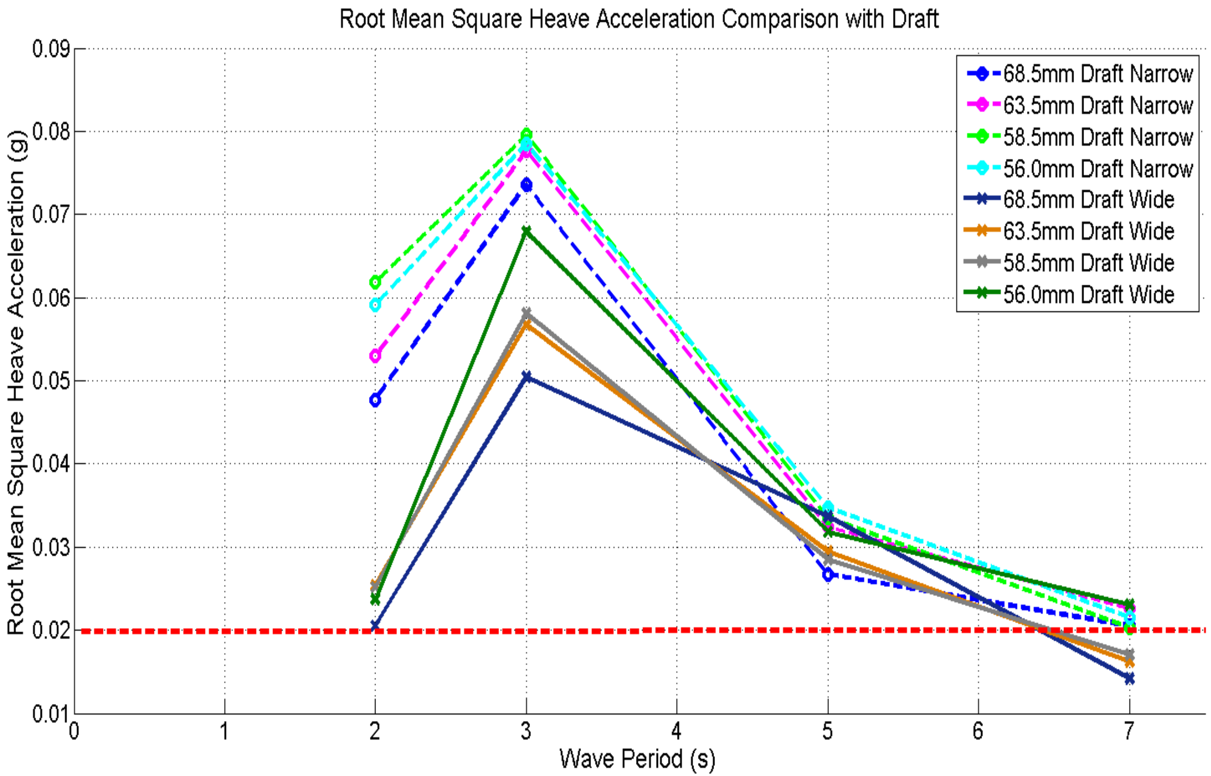
Root Mean Square (RMS) Acceleration	Limiting Acceleration Criteria (RMS) (g)	Wave Period (s)			
		2	3	5	7
a_x surge	0.03	**0.091**	**0.052**	**0.041**	**0.037**
a_y sway	0.03	0.027	0.020	0.020	0.012
a_z heave	0.02	**0.055**	**0.060**	**0.034**	**0.022**

Increased mass and beam to wavelength ratio increases average acceleration in surge and heave however they don't exceed Peak SML

- Wide Pontoon – RMS average of all five sensors

Root Mean Square (RMS) Acceleration	Limiting Acceleration Criteria (RMS) (g)	Wave Period (s)			
		2	3	5	7
a_x surge	0.03	**0.054**	**0.069**	**0.060**	**0.035**
a_y sway	0.03	0.019	0.018	0.011	0.011
a_z heave	0.02	**0.033**	**0.042**	**0.028**	0.018

DRAFT TESTING



- RMS of all five sensors
- Wide pontoon generally lower RMS than narrow.
- Effect of draft is strongest at T=2 seconds
- 2, 3 and 5 second period exceed SML

RESULTS

- Field testing → floating pontoon design concerns
- Lab testing → peak accelerations more than six times 0.1g limit
- Altering dimensions → reduce peak accelerations
- Mild wave climate → **300mm prototype wave height**
- <u>Comfort and safety of users jeopardised</u>

CONCLUSION

- At present dynamic analysis <u>NOT</u> mandated
- Limited useful standards relating to floating pontoons and dynamic motions
- Motions are outside what is perceived as comfortable/safe
- Tool is needed for engineers to asses dynamic motions