Hydrodynamic Effects to the Motion of an Remotely Operated Vehicle When Launched through the Water Surface in Waves

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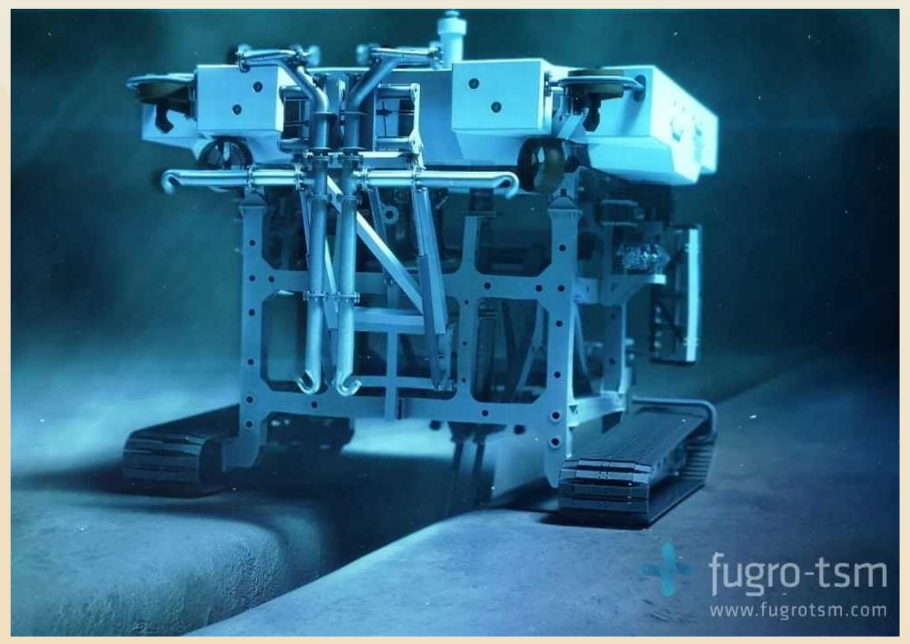
Introduction

Remotely operated vehicles (ROV) are essential tools used in the development and exploration of seabed resources. This includes mining seabed minerals, servicing offshore hydrocarbon production facilities and surveying the subsea environment. ROVs are useful for any underwater environment that is beyond human reach.

Accurate design of ROV's handling systems is very essential to achieving safe deployment and recovery process and also in minimising the likely occurrence of failure modes like slacking and snatching of the umbilical or tether as the occurrence any of these failures could result in a total loss of the ROV. The design of this handling system relies on the use of appropriate hydrodynamic coefficients.

Current methodologies for the prediction of these hydrodynamic coefficients are based on the assumptions that water condition is ideal, which is not reality. To obtain applicable coefficients, proper evaluation of hydrodynamic response of a ROV in practical conditions is needed.



Aims

- ❖ Better understand the motion characteristics as the ROV passes through the splash zone and is affected by waves
- ❖ Acquire hydrodynamic values for numerical modelling
- ❖ Predict the hydrodynamic coefficients the ROV experiences during its launch and recovery process in realistic conditions

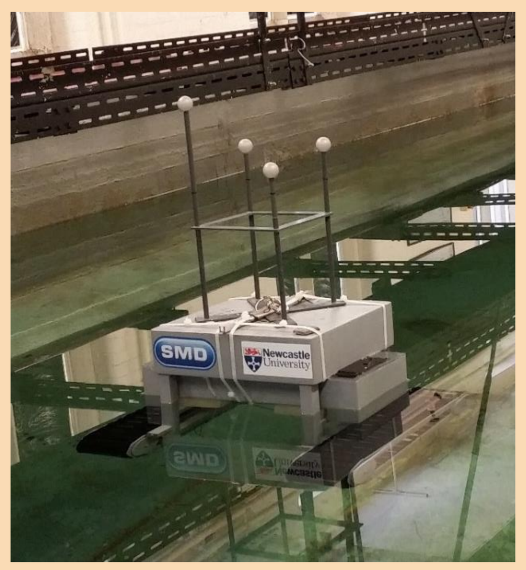
Method

- ❖ Heave decay tests were conducted on both ROV model and box model for several submerged depths
- ❖ Required hydrodynamic coefficients were calculated by equations:

$$A = \frac{T_n^2}{4\pi^2} C - M \ (kg)$$

$$B = \frac{1}{\pi} \ln\left(\frac{S_0}{S_2}\right) \sqrt{C(M + A)} \quad (N/(m/s))$$

- ❖ Data analysis of the predicted experimental responses



ROV model (scale ratio of 1:12)

Results & Discussions

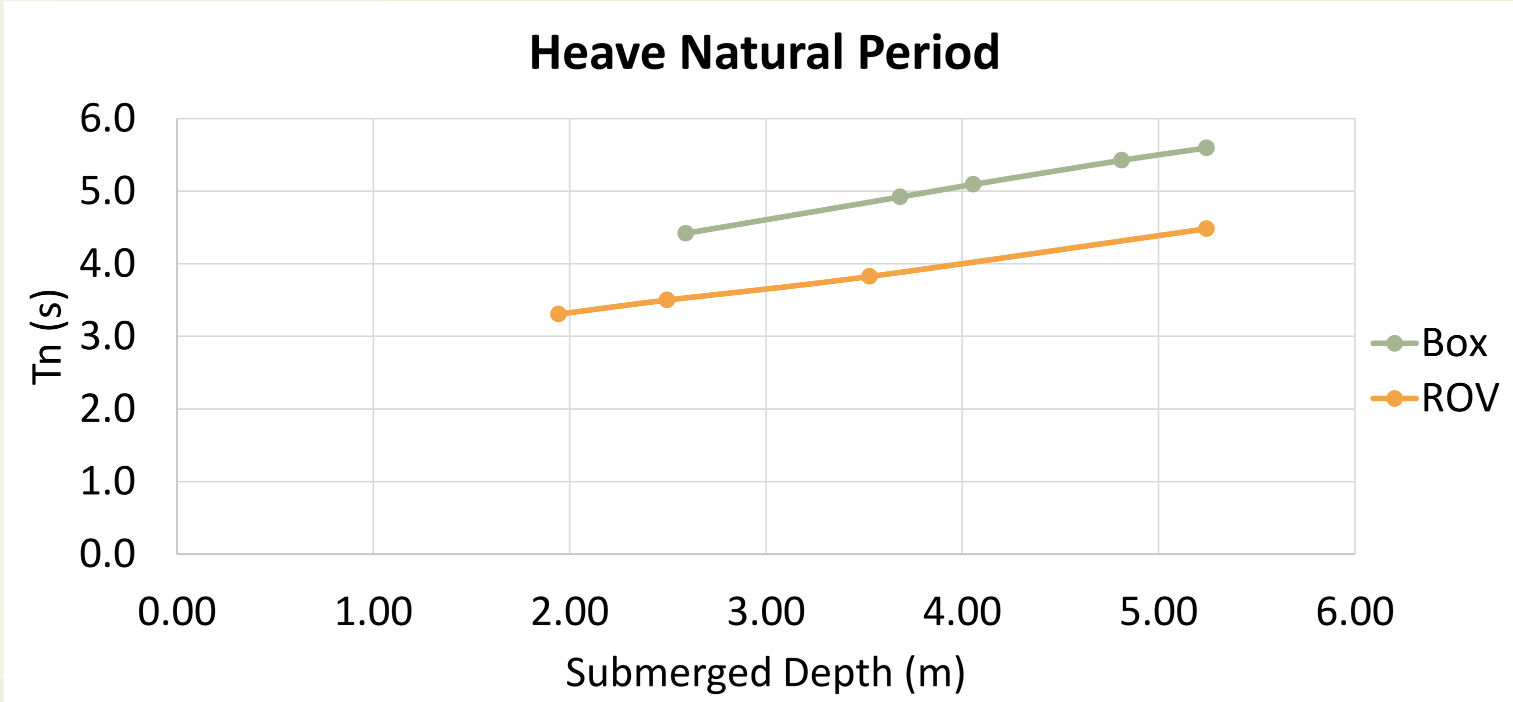


Figure 1

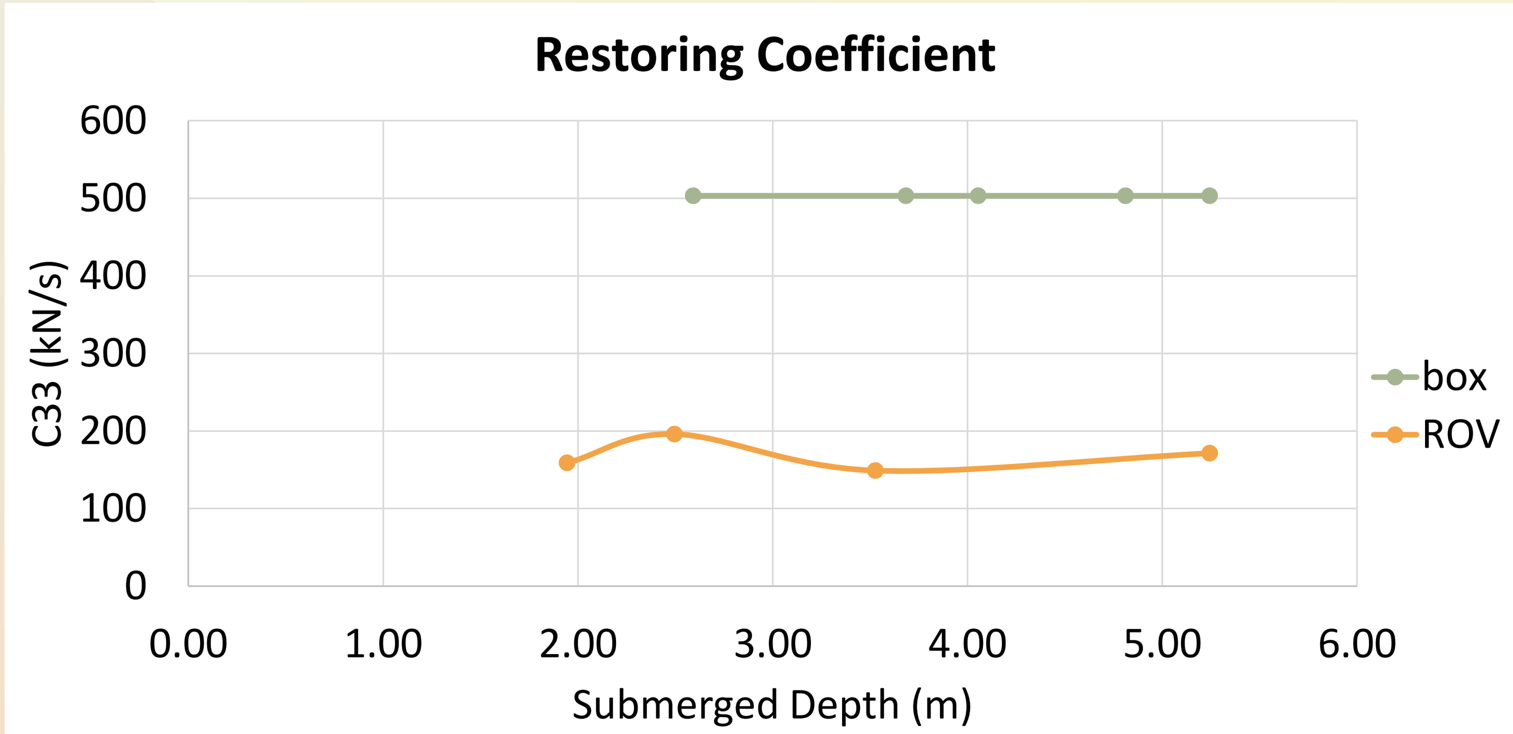


Figure 2

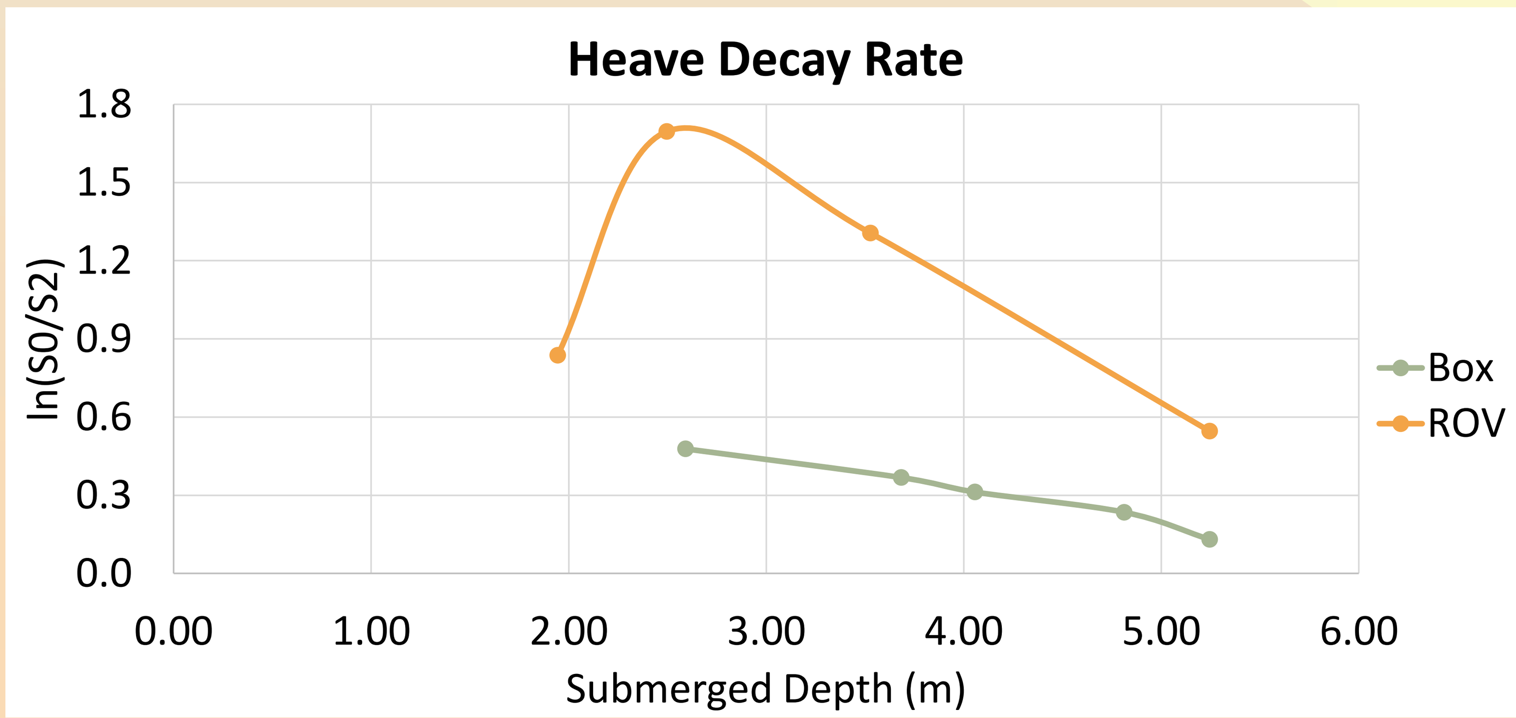


Figure 3

Acknowledgements

- ❖ Many Thanks to Newcastle University Research Scholarship and Soil Machine Dynamics (SMD) LTD for the funding
- ❖ Many Thanks to Dr. Simon Benson and Dr. Musa Bashir for the guidance and advices
- ❖ Many Thanks to all technicians in the Marine Technology Laboratory for the supports

- ❖ Figure 1 is a comparison of the heave decay rate between the box model and ROV. Different water plane area results in a significant change in the decay rate over the range of depths tested.
- ❖ Less water plane area results in less restoring coefficient (Figure 2), which makes larger decay rate. This results in a nonlinear relationship between depth and decay rate.
- ❖ Figure 3 illustrates the natural period for the two tested body. The linear relationships suggests that the natural period of tested body only depends on the submerged depth.
- ❖ Results of relevant hydrodynamic values are presented in Table 1 & 2. The damping value is shown to vary markedly over the range of submerged depths tested. The relationship with submerged depth follows a similar trend to the decay rate.

Box model

	Heave Decay Rate	Heave Natural Period	mass	Restoring Coefficient	Added Mass	Damping value
Subm. Depth (m)	ln(S0/S2)	Tn (s)	M (t)	C33 (kN/m)	A33 (t)	B33 (kN/(m/s))
2.592	0.478	4.420	132.985	503.310	116.053	53.860
3.684	0.368	4.921	189.010	503.310	119.757	46.160
4.056	0.312	5.094	208.096	503.310	122.776	40.549
4.812	0.235	5.426	246.883	503.310	128.483	32.475
5.244	0.130	5.598	269.047	503.310	130.443	18.594

Table 1

ROV

	Heave Decay Rate	Heave Natural Period	mass	Restoring Coefficient	Added Mass	Damping value
Subm. Depth (m)	ln(S0/S2)	Tn (s)	M (t)	C33 (kN/m)	A33 (t)	B33 (kN/(m/s))
1.944	0.837	3.307	19.181	158.986	24.870	22.300
2.496	1.608	3.501	19.181	196.053	41.672	55.900
3.528	1.306	3.826	19.554	149.096	35.735	37.734
5.244	0.546	4.484	41.645	171.470	45.679	21.250

Table 2

Conclusions

- ❖ Damping value changes significantly as the ROV emerges through the water surface
- ❖ Damping must be carefully controlled in a numerical simulation
- ❖ Use of single damping value in numerical simulation will result in inaccuracy

References

- ❖ M. Bashir, S. Benson, A. Murphy, M. Menon, R. Eastwood, D. Cunny, and M. Zwanenberg, 'Hydrodynamic Characteristics of ROVs During Deployment Through Wave-Affected Zone'
- ❖ Eng Y.-H., Lau M.-W., and Chin C.-S., 'Added Mass Computation for Control of an Open-Frame Remotely-Operated Vehicle: Application Using WAMIT and MATLAB'