

Use of Cryogenic Buoyancy Systems for Controlled Removal of Heavy Objects From the Seabed

R. Nicholls-Lee – rnl@soton.ac.uk - School of Engineering Sciences
Prof. R.A Shenoi, Dr S.R. Turnock, Dr M. Tan and Dr P.C. McDonald

Motivation & Aim

- Numerous methods of lifting and lowering objects from the seabed have been developed throughout the history of ocean engineering and exploration. Initially, these methods were in practice for the purpose of marine salvage.
- New methods for marine salvage and decommissioning of structures in the open sea are continually being sought in order to improve control and lower operational costs.
- This project involves working with a consortium of companies led by Deep Sea Recovery, DSR, to investigate the concept design of a lightweight cryogenic marine heavy lift buoyancy system.
- The objective is to be able to lift or lower large displacement objects under full remote control.
- The opening stages of the project work include the development of a system that will operate to a depth of 350m. As part of the design process for such an arrangement, numerical simulation of the complete system has been undertaken in order to develop mechanical, cryogenic and process control systems.
- The system is lightweight, and makes use of cryogenics (liquid nitrogen) to provide a large lift capacity at deep depths.
- It is to operate efficiently, effectively and reliably in the aggressive subsea environment and is able to withstand temperatures between 77K and 323K.



Figure 1

Prototype Testing

- Open shallow water tests are planned using a skid arrangement, Figure 4, on which two caissons can be mounted.
- The two caisson system provides the opportunity to test the control system with one caisson acting as the lead vessel and the second the slave.
- The skid has been designed such that access to the caissons is easy, with a platform in the centre. The drip tray contains and LIN spillage that may occur when filling or emptying the device and therefore protecting the ground/deck from LIN runoff.
- There is the potential to increase/decrease the mass of the skid by adding/removing concrete blocks thus enabling extensive testing of the system.

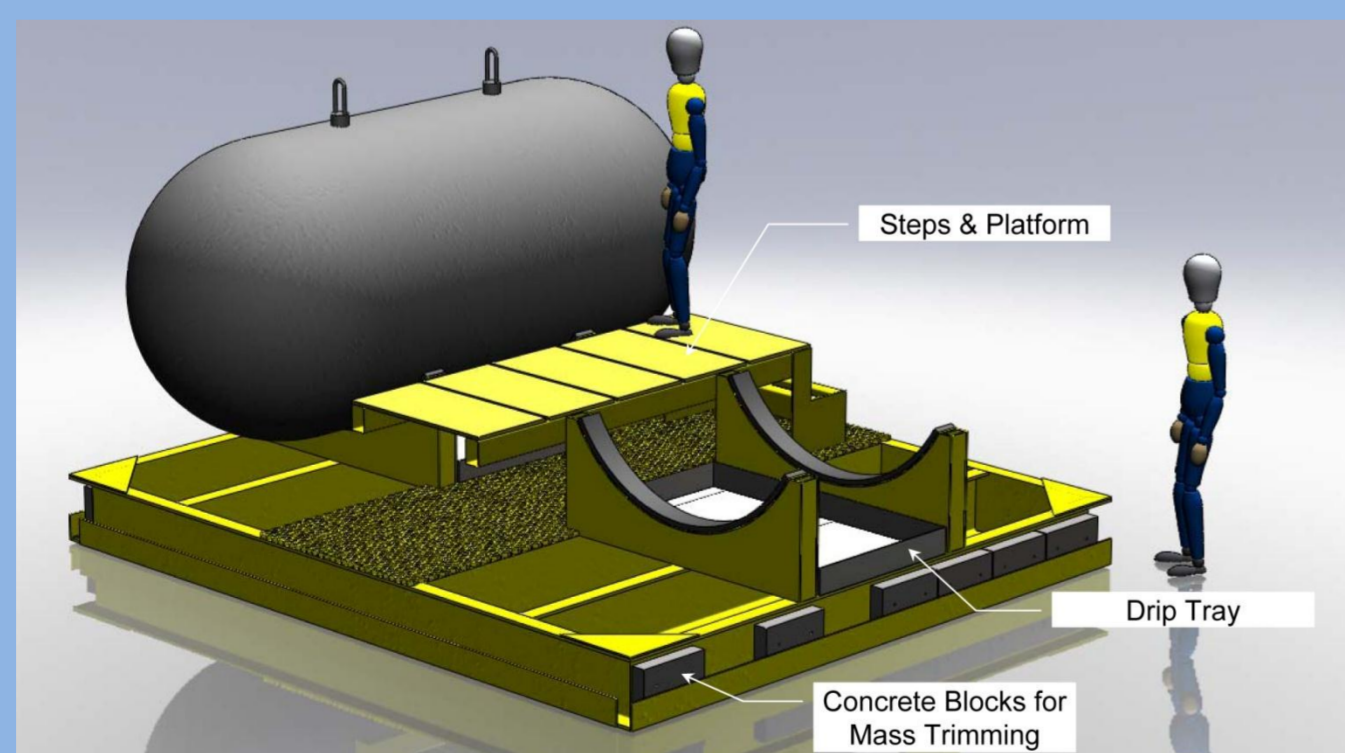


Figure 4

Conclusions

- A concept for a lightweight cryogenic marine heavy lift buoyancy system is under development. This design incorporates a modular structure for ease of transport and improvement. It is initially intended to operate at 350m, with future work taking the concept to deeper depths.
- The design of the cryogenic Dewar has been discussed.
- Information as to the skid arrangement for the prototype tests is given.
- The numerical model of the system is considered, from which the control algorithms will be developed.

Design

The DSR buoyancy system has a modular design such that components can be replaced/upgraded without having to construct an entirely new vessel. The modularity also enables the system to be transported more easily. Figure 2 illustrates a schematic of the DSR buoyancy system

- A. Buoyancy chambers
- B. Main valves
- C. Cryogenic Dewar
- D. Fins
- E. Free flood grilles
- F. Load attachment

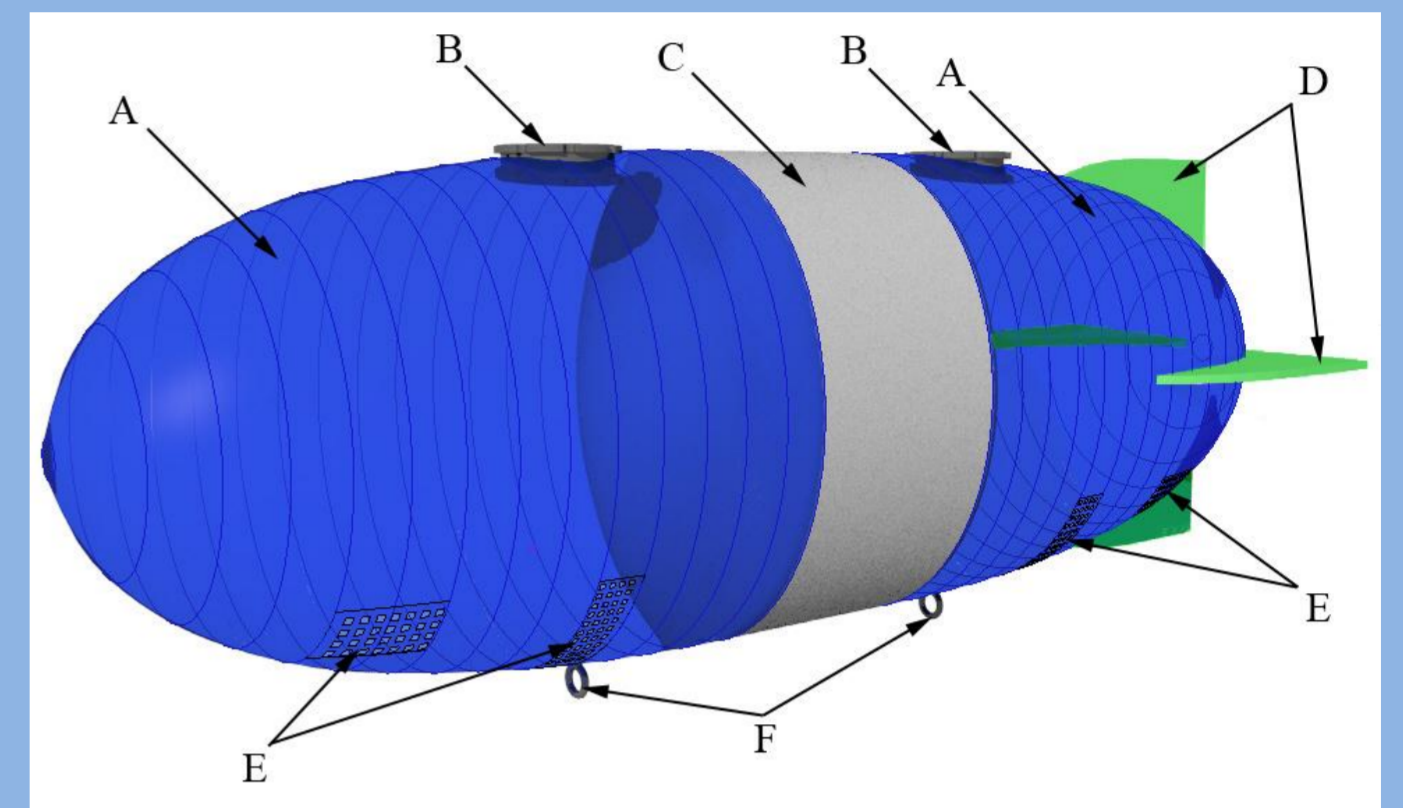


Figure 2

The Dewar

The central part of the device is the cryogenic Dewar and gasification system. The cryogen is heated to produce gas at the ambient temperature and pressure which is then released into the buoyancy chambers. The rate of gasification is also a method of lift control.

Figure 3a shows the two part carbon outer casing enclosing the steel lined, fibreglass wrapped inner container. The probably failure mode of the Dewar is illustrated in Figure 3b. A safety factor of 5 for both the inner and outer containers has been chosen in line with ASME Section X Class 1 design of pressure vessels.

Testing of composite samples has been carried out at room temperature and at cryogenic temperatures. The initial Cryogenic temperature testing is shown in Figure 3c. The grips in this arrangement seized up at -165°C, therefore little useful data was procured. The assembly shown in Figure 3d was designed and is under construction for full immersion (in LIN) testing of specimens. The samples are pinned at either end removing the problem in the previous testing. This arrangement means that testing can be carried out at -196°C.

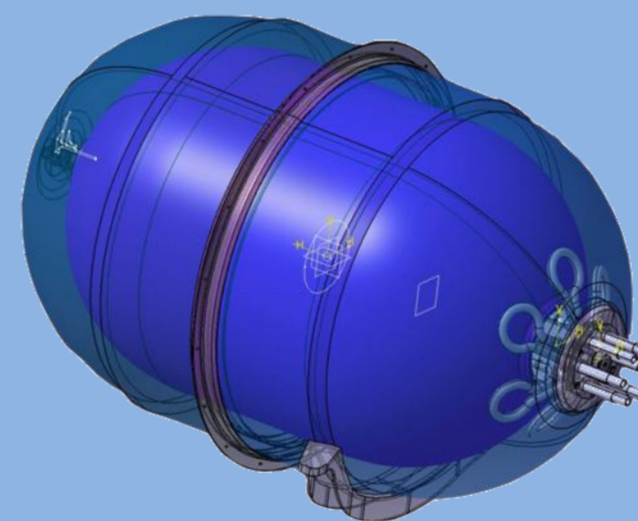


Figure 3a

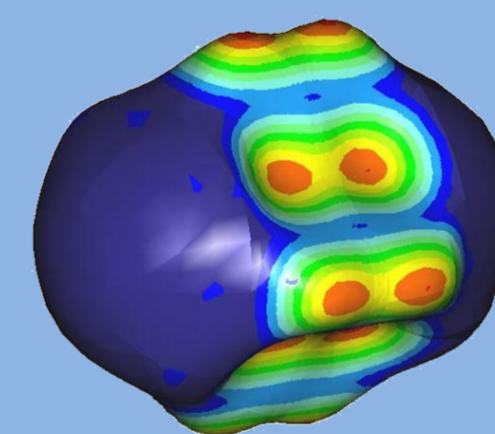


Figure 3b



Figure 3c

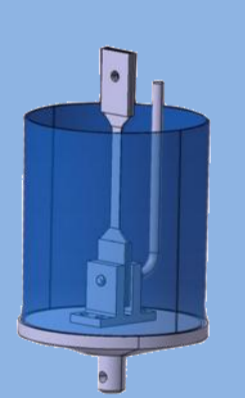


Figure 3d

Numerical Simulation

The operation of the DSR buoyancy system is being modelled numerically in MATLAB Simulink. This is to simulate the processes involved and analyse component parts and sizes prior to build. The control algorithms governing the full scale prototype will be developed from the model.

Figure 5a – the overall DSR system in Simulink

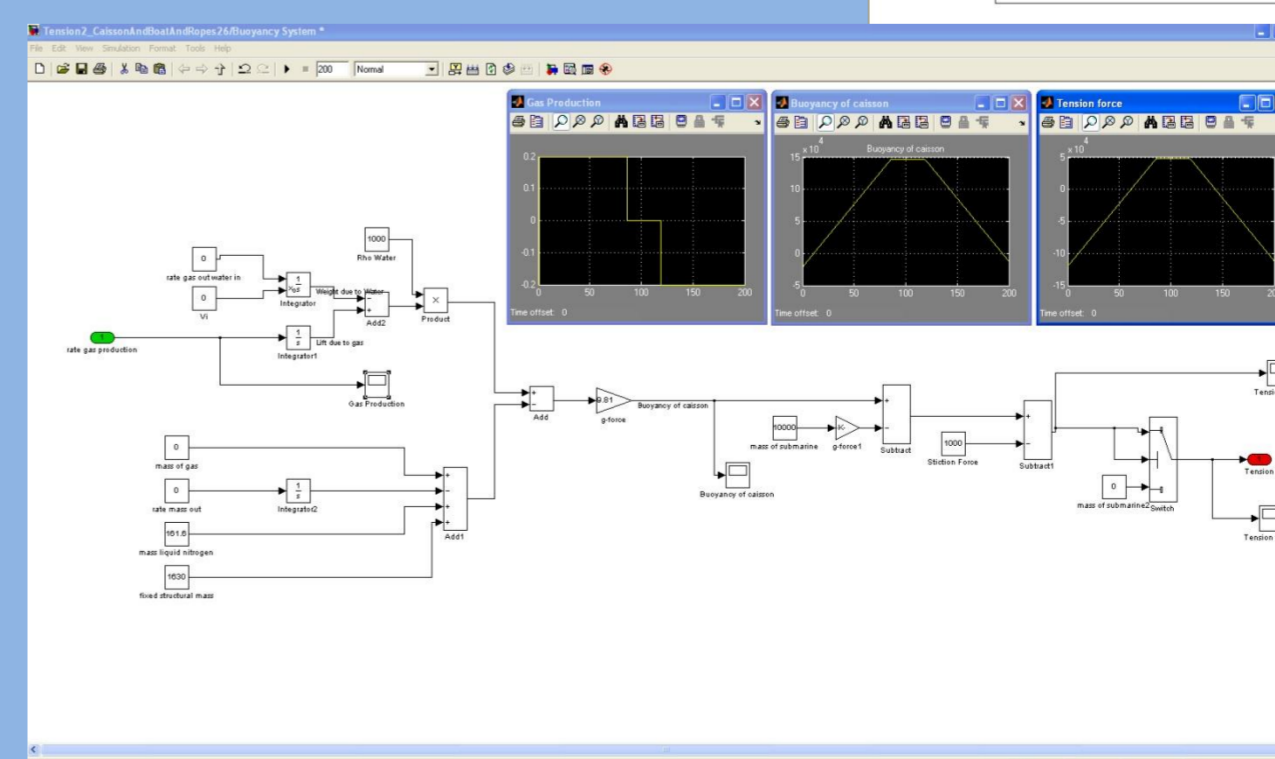
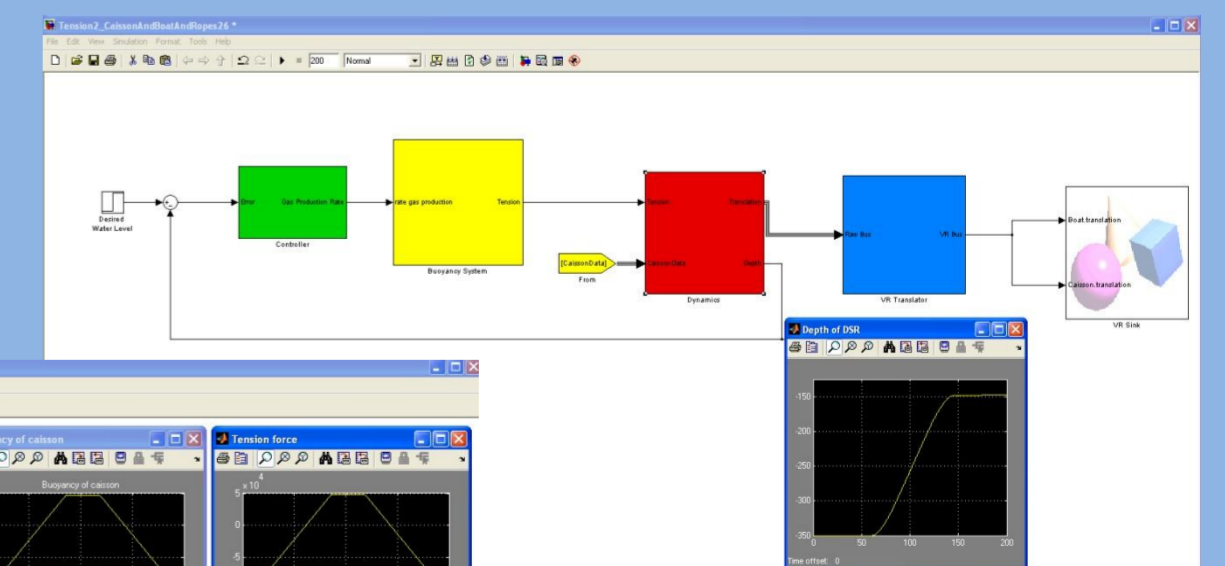


Figure 5b – the buoyancy system in Simulink