# Moving forward with physical modeling

Kevin L. Bertram, Kristopher A. H. Innanen and Joe Wong

## ABSTRACT

For many years now CREWES has used a physical modeling facility to acquire scaled-down repeatable 2D and 3D marine seismic data. This system is capable of producing seismic industry standard SEGY files that can easily be used by processing software. This is an invaluable tool for conducting experiments in house with various interface modules.

Piezopin transducers are used for both sources and receivers. New transducers have been developed that produce S-waves, but these are larger in size and are contact transducers that require physical contact with the model. CREWES is interested in using this technology to carry out more experiment.

There is also an interest in creating newer more complicated models. The idea of using 3D printing technology is being looked at. This will require testing with new materials for contrast results of interfaces.

## INTRODUCTION

CREWES has been successfully using a robotic physical modeling system to conduct scaled down marine surveys (Wong, et. al. 2016), Figure 1. This provides data essential to student and staff research. This is a constantly improving system as new technologies become available.

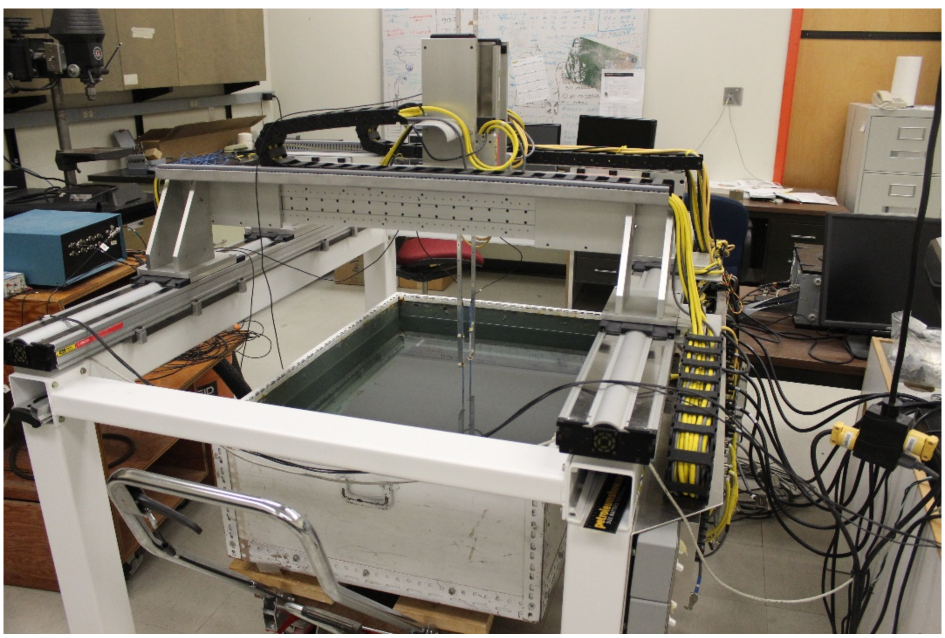

FIG. 1. The physical modelling system.

Typically models, Figure 2, are created and placed into an open top water tight box or tank. This tank is then filled with distilled water (available from a tap in many University of Calgary labs). This water needs to be as deep as possible as seismic reflections from the surface are fairly strong on the acquired date.

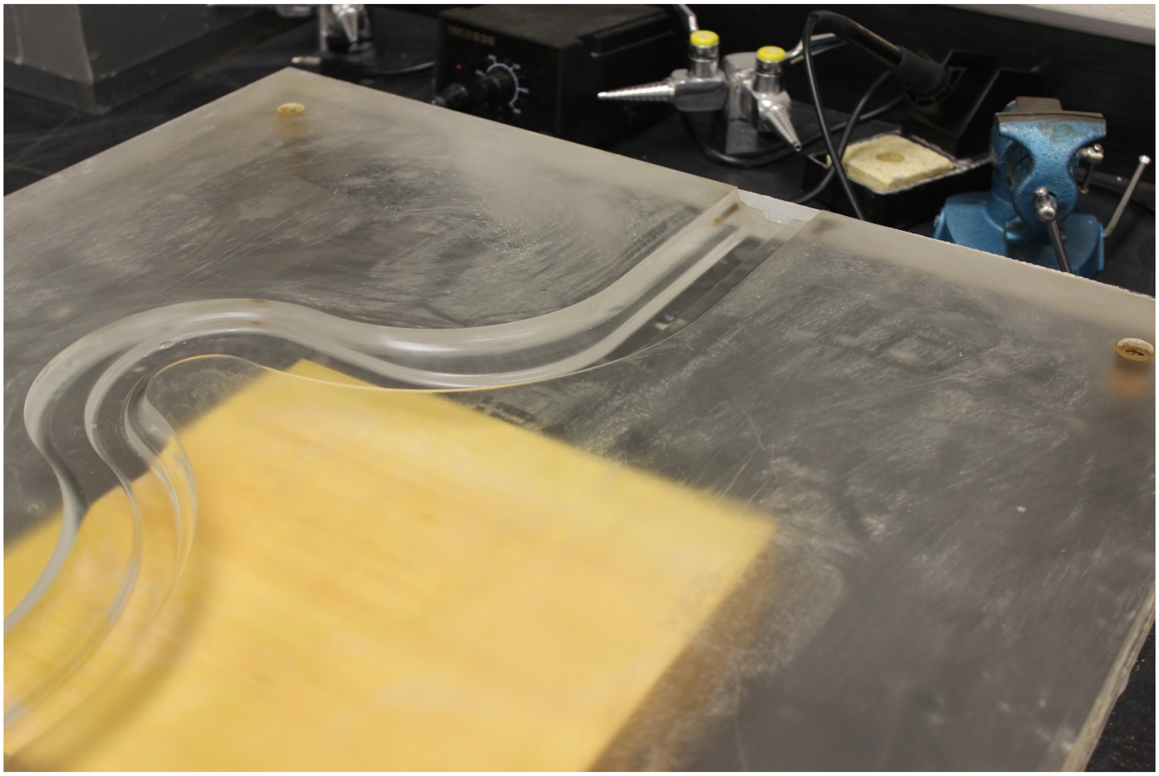

FIG. 2. The channel model.

The model is then slid under the modelling system which consists of two robotic "arms" that have transducers attached to them. A survey is set up using software in the attached computer and the robot carries the survey out automatically. Some surveys are quick and only take a few hours, while longer and more intense surveys can take several days.

## NEW MODELS

Moving forward there is a desire to create new models. Although previous models, such as the channel model, Figure BLAH, are still in use there is a desire to work with other interfaces. Models have previously been created by taking two materials cut to fit together and glued. This works fine, but tends to be limited to simple designs.

There has been some discussion of trying to create more sophisticated models using newer construction techniques. The first obvious technique that need to be explored is Computer Numerical Control (CNC) construction. This would allow for a piece of material to be cut to a pre-designed three dimensional shape. This shape could then be placed in the physical modelling machine and have a survey done over with it simulating the marine floor. Alternatively another material that can be poured on top of this model and then harden could be used to create another interface.

The second obvious technique for creating new models would be to 3D print them. This offers its own set of challenges. Cost effective 3D printing is usually limited to plastic material, although it is possible to 3D print metal now. Again, these models could be place in the physical modeling tank to simulate objects at the bottom of a marine survey or have another material poured over it and hardened.

In order to determine if such model making would work some testing needs to be done to determine the seismic velocities of the materials to be used. It needs to be determined if the difference in seismic velocities between 3D printed plastics and whatever resin is used to encase it is different enough to yield suitable results in processing. It may be possible to 3D print a model and then pour the resin interface and then use another chemical to dissolve the plastic and fill it with another material. This won't be known until the proper testing is done.

## HARDWARE UPGRADES

The first easy upgrade that needs to be looked at is the surface reflection on the data. This can be dealt with by constructing a tank that has higher sides and therefor holds more water. The goal here isn't to eliminate the reflection, but rather to have it appear later in the seismic record. Ideally it would be nice to have this reflection appear at a consistent time on every record. This requires an extra level of control as the water level cannot change between surveys.

One of the challenges with keeping the water level constant is the evaporation of the water in the tank. Usually surveys are done quickly enough that it isn't much of an issue, but it does have the potential to change certain aspects of the data over a longer survey or if a survey were to be repeated. A simple system of a couple of buckets, a pump and some hose should be enough to prevent this issue. The buckets would need to be set up with one above the other. The top bucket will have three hoses connected to it. The first one will have oneend placed in the modelling tank. The second one will be connected at a certain height on the side of the bucket. This height will be what determine the tank's water level. The other end of this hose will be connected to the lower bucket. The final hose will be connected from the lower bucket to the top bucket through a small pump. This way any water above the top level of the tank will be sent to the lower bucket, which will have extra water in it. The pump will put this extra water in the upper bucket. This should keep the level of the water consistent so long as the pump is on and there is extra water in the lower bucket.

Recently the physical modelling system was upgraded with an eight channel receiver that allowed for the ability to record eight channels worth of data at once, Figure 3. So far this setup has only been used in an eight channel 2D line configuration. One of the future upgrades being discussed is a further increase of channels to perform surveys quicker and with different 3D receiver patterns.

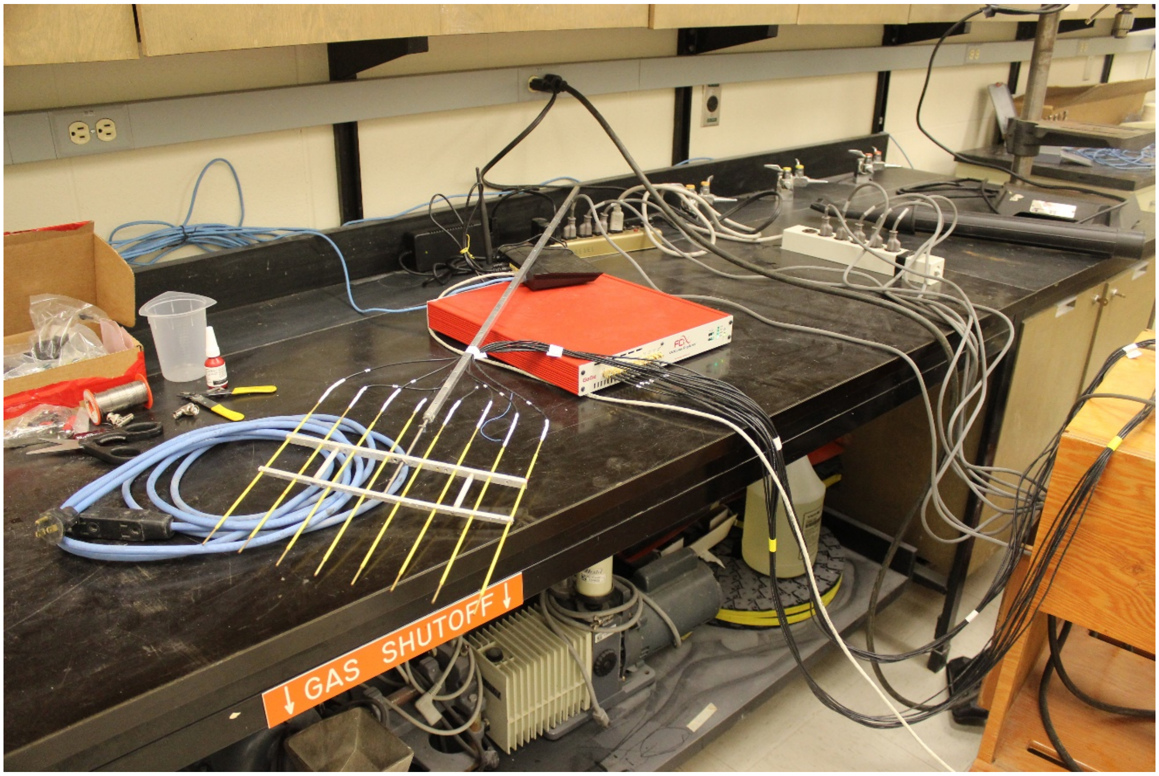


FIG. 3. The eight channel receiver.

Some experimentation has already taken place with using transducers contacting the models instead of being suspended about them in the water. In order to have acceptable coupling some pressure needs to be put on the transducers to hold them against the model. This required some code in the software to lift the transducers before trying to move them.

Some experiments have been carried out using shear wave transducers both as sources and receivers. These work as contact transducers and are much larger than the piezo pins. In order to use these a wax is often placed on the transducer to ensure good coupling. There has been some communication with companies that construct transducers to inquire as to how small they can be made.

## SOFTWARE UPGRADES

The current software is essentially a program written in C#, Figure 3. This program is capable of ready data from a survey a parameters file that is used to modify the instructions the program uses. Things such as the number of sources and receivers, source and receiver locations, file locations, and number of samples taken are modified in this file.

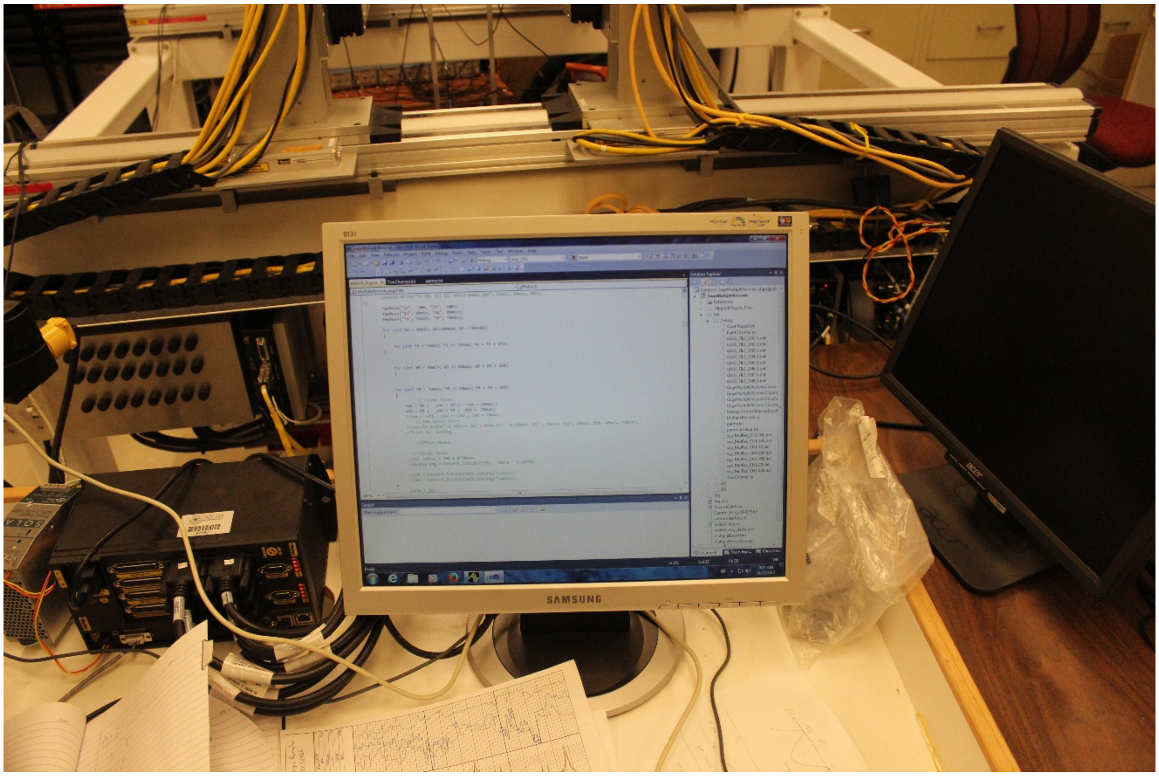

FIG. 3. The software.

Both the program and the parameters file are constantly being tweaked to get the system to do new things. Currently in order to do a survey a request has to be made to one of the few people who can navigate the program language to set it up and complete it. It is desired to have the system more accessible to more CREWES staff and students by creating a graphical user interface (GUI) that is simple to navigate. This would likely increase both the interest in and use of the modeling system for CREWES projects.

Some more safety systems would need to be put in place if the modeling system is to be used without supervision. Theoretically the modelling system software should know exactly where the two robotic arms are at all times and there is some code written that does throw an error message up on the screen if the parameters file puts the two arms in close proximity. However there have been a few times where collisions between the two arms have started to occur and were prevented only by cutting the power to the motors. An independent detection system that cuts the power automatically when the two arms get too close would provide an extra layer of safety.

## CONCLUSIONS

There is much interest in the continuing use and improvements in the physical modelling system. This is a unique and valuable tool for creating seismic data for testing processing methods and tools.

## ACKNOWLEDGEMENTS

The continued use of the physical modelling system is only possible with the continued support of industry sponsors. This work was funded by CREWES industry sponsors and NSERC (Natural Science and Engineering Research Council of Canada) through the grant CRDPJ 461179-13.

## REFERENCES

Wong, Joe, Bertram, Kevin L., Hall, Kevin W., Physically-modeled 3D surveys over a channel structure, **28**.