AUCKLAND BIOENGINEERING INSTITUTE
THE UNIVERSITY OF AUCKLAND NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

# Design of a waterproof housing for high-speed underwater stereo imaging.

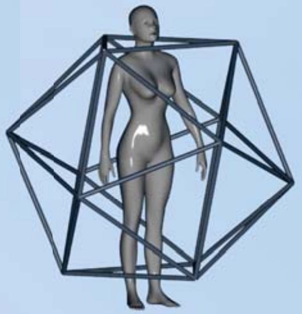

**By Andrew Bollen** *Supervised by Prof. Poul Nielsen, Prof. Martyn Nash, Associate Prof. Andrew Taberner, Amir HajiRassouliha*


## Background

The soft tissues group at the Auckland Bioengineering Institute have been developing computational models for the deformation analyses of soft tissues, with a strong focus on breast tissue. The three dimensional surface geometry of the body is an important component involved in building these models.

Gravitational loading of soft tissue makes it difficult to determine its geometry in an unloaded state. This effect can be greatly reduced by immersing the body in water, allowing tissues to assume a neutrally buoyant state, due to the similar density of the fluid to the tissue.

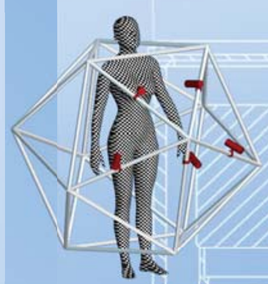
An aluminium icosahedron frame has been developed, which is to be lowered into a pool of water over a person (see figure). The intention has been to mount cameras on the frame, positioned in such a way that every region on the surface of the torso can be photographed from a number of angles. These overlapping 2D images could then be used to reconstruct in 3D the surface geometry.



## Project Brief

To design, construct, and test a waterproof casing to house a high-speed PointGrey Flea3 camera, as well as developing a suitable mounting to affix the housing to the existing icosahedron frame.
There was also the need to determine a suitable layout for the cameras on the frame in order to obtain sufficient overlap in the images.

## Field of View Simulations



A to-scale model of the icosahedron frame with a female manikin standing inside was created in Solidworks. Virtual cameras were placed in different configurations around the frame, allowing us to visualise the regions of overlap between views, accounting for different lens types as well as the refraction due to the water/air interface.

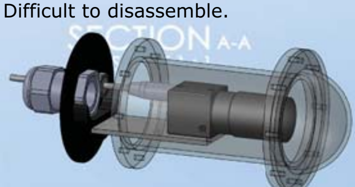
It was found that the best level of overlap was achieved when five cameras were placed on the bars of the frame, rather than the vertices. This led to the development of a bar-fixed mount for the camera housing later in the project.

## Design Constraints

- Reliably seal out water at depth of 2 m
- Minimize size.
- Keep manufacturing costs low, without compromising performance.
- Incorporate good quality optics.
- Hold camera very rigidly to prevent movement.
- Two cables to enter housing from outside in the water. USB3.0 and GPIO.
- Camera to be easily accessed for adjusting focus and aperture of lens.
- Allow for different sized lenses to be used on camera.
- Materials to be appropriate for repeated exposure to chlorinated water, without degradation.
- Mount to allow housing 4 degrees of freedom: pitch, roll, yaw, and lateral sliding along bars.
- Mount to hold housing very rigidly, yet be quickly and easily removed.

## Development of Housing CAD Models

**Initial Design:**
Easy to construct, very cheap, but…
- Too big
- Not enough support for camera.
- Potentially poor optics with acrylic dome.
- Difficult to disassemble.



**Final Design:**
•Much more camera support
•Easy to access camera
•Good optics

## Product Realisation

- Camera fixed firmly inside acetal block.
- Viewing window is a Hoya 49 mm UV filter.
- All housed inside 50 mm aluminium tube.
- Thread parts screw together, easy to access camera.
- Sealing gaskets laser cut from 1.5 mm neoprene.
- Cables clamped tightly between two half circle acetal discs, and sealed in place with urethane bond.
- Low cost. Material costs in the order of $100 per unit.

## Mount Design and Construction

- All shapes easily cut from either 6 mm or 10 mm acrylic sheets.
- Fixed parts bonded by solvent welding.
- Tube twists within mount (roll), mount twists and slides on bar (lateral sliding and pitch), and mount can swivel left and right by a maximum of 180 ° (yaw).
- All but roll are allowed by loosening a single screw.


**Acknowledgements:** The Breast Philanthropic fund for funding this research.
The University of Auckland summer studentship program.
With thanks to all the team in the Bioinstrumentation lab, ABI