# Liquid Time

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## The Problem

Many surfers do not have the luxury of living near surf breaks, and must travel long distances in order to surf. Then as local populations increase, and surfing becomes more popular, existing surf breaks are becoming overcrowded, even dysfunctional. Surfers have responded by travelling to more distant and remote locations to chase uncrowded and better waves, however this increases the cost of surfing and does nothing to reduce crowding at their home breaks. Another solution has been to build artificial reefs in the ocean; however these rely on the natural wave conditions. A third solution is to develop new breaks and generate one's own waves; the wave pool.

Wave pools are nothing new. In 1934, the Wembley Swimming Pool in London was the first to thrill its visitors with small artificial waves. In 1966, the first indoor surfers rode waist-high waves in the Summerland wave pool in Tokyo, Japan. Since then, some special surf pools have been built around the world, receiving somewhat mixed reviews from surfers. The original linear moving wave pools try to mimic natural waves with piston-driven paddles or similar mechanical devices. Such man-made waves are not very appealing to surfers although some manufacturers are now bending the pool around a curve to concentrate the swell, or model the pool floor to improve the wave height. Much larger waves are created by standing wave surf pools which push water over a fixed wall curved like a large wave. More water-powered half-pipe than wave, such pools do not provide a very authentic riding experience and, like the linear pools, allow only one rider at a time. A third concept aims to move a central hull along a linear track creating two waves on each side. Key deficiencies with these approaches involve both the lack of an authentic, scalable surfing wave motion and significant limitations on the number of riders able to use the system simultaneously.

## The Approach

In order to find the solution to the problems defined above, a requirements determination phase was commenced, drawing jointly upon the surfing experience of the project team and the fluid dynamics expertise of the engineers. A key driver in the requirements determination phase was to identify low risk, existing technology systems that could provide a high availability and high reliability system. The application and control of these technologies to create authentic, multi-rider waves required a significant investigation phase to determine appropriate mechanisms for wave propagation. Hence, the underlying aim of the project is to understand the wave mechanics, as it allows the creation of repeatable continuous "steady-state" waves.

This project is utilising the system engineering process of requirements determination, analysis and testing to turn the original patented idea of using ship wakes to generate surfing waves, into a commercially viable product. A key benefit to applying systems engineering principles to this project was the management and control of the iterative feedback cycle, as the initial concept developed through definition, requirements analysis and design investigations, technology trials and resultant requirements and design refinement. The project is being supported by SYPAQ Systems Pty Ltd, utilising their in-house systems engineering capabilities.

The resultant system design from Liquid Time Pty Ltd, the Liquid Time Wave Pool, will meet all of the high level system requirements, ensuring multi-rider, authentic, controllable and reliable wave generation. The Liquid Time Wave Pool is capable of providing a theoretically infinitely long ride around a central island. The waves are created by the wave-wakes, whereby a pressure source is rotated within the annular wave pool. The inner ring of the annulus will have a sloping bathymetry to induce wave breaking from the wake of the pressure source. The pool aims to be capable of creating waves from beginner to expert level, with a wave face up to two meters high.

# Background

Greg Webber, like many other surfers, had been watching and playing with tiny waves in rivers and bays since he was a child. Greg went to university in his twenties to do coastal engineering, but found he couldn't handle the slow pace, the lack of field work or lab testing. Subsequently he went back to surfboard shaping, but for fun he still enjoyed playing with tiny waves, almost more than anything else. However, in 2003 Greg started using a small fishing boat in the Clarence River in New South Wales to generate perfect mini-waves. With his brother Monty, a surf film maker, filming the mini-waves, they subsequently made the film *Liquid Time*, (Figure 1) that won an international film award; refer http://liquidtime.info/reviews.htm

**Figure 1 Liquid Time the Movie**

Unfortunately, no-one could ride these perfect waves as they are only a few centimetres tall. So while standing on the sandbank, Greg pondered how to capture these waves – increase their size and achieve his vision of riding them. He wondered if a larger moving hull could be used to generate larger waves capable of being surfed, especially if the hull was running alongside a channel, thereby making a wave pool.

# Concept

In the standard five hull wave pool, shown in Figure 2 and Figure 3 below, with two waves breaking off each hull, ten surfers could be riding at any time. With each surfer getting a standard thirty-second

ride (riding the wave one quarter of the way around the island) and with one wave cycle every five minutes, up to 100 surfers can ride in each surf session. This means each surfer can get twelve thirty-second waves (even barrels) per hour. While the average ride length in the usual beach break conditions is about ten seconds, the circular pool's 30-second rides will challenge the strength of even the fittest surfers.

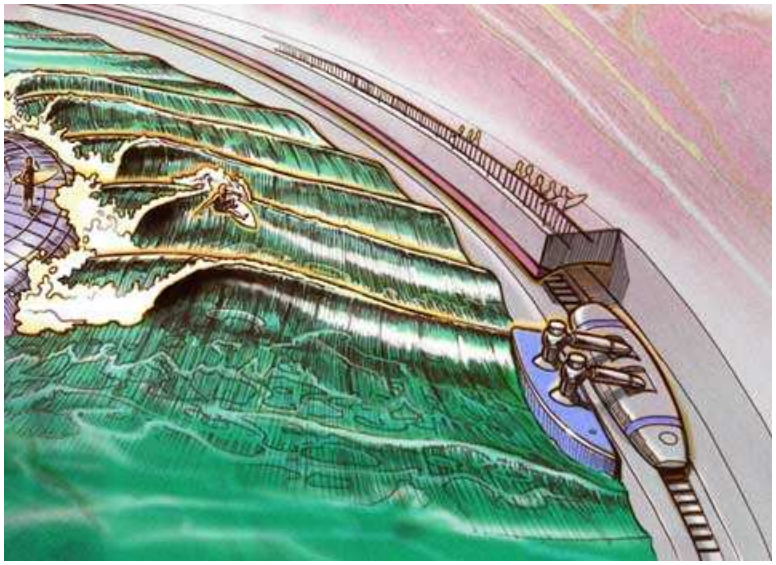

**Figure 2 Wave Pool Concept**

**Figure 3 A view of the complex with the central island and "surf dome"**

Another benefit of this design is the alignment of the wave and the shoreline. Waves break perfectly along the edge of the circular island. This is an exciting prospect for both competent and expert surfers. More importantly, however, this alignment affords an opportunity to learn to ride waves in a way that has never been possible before. A total beginner can catch the whitewash and then 'cut'

towards the shoulder. In one attempt, beginners will be on the ‘green face’, where they can ride on the belly, then knees and finally feet.

The advantages of the concept are striking: a safe learning environment as well as a challenge for expert surfers, multiple surfers at a time and long-lasting large waves. A circular surf-pool has the potential to finally bring an authentic surf experience to everyone, no matter their experience or how far away from the coast they live.

The pool is designed to produce both left and right hand waves simply by changing the directions of the hulls and counter-current, as well as changing the size and shape of the waves by varying the speed of the hulls and counter-current. The operator would then run a timetable of waves; for example expert rights from 0600-0700 for people before work, intermediate rights from 0700-0900 for children before school, and from 0900-1000 beginner lefts for the mums and visitors.

## Early Results

Trying to catch waves generated by large ships, fast ferries or tankers is nothing new. Surfers in environments as diverse as Vancouver and the Netherlands are surfing the somewhat dangerous places where ship wakes hit the shore and break. On Vancouver Island in Canada, surfers nicknamed the PacifiCat Ferry the “two-hundred million-dollar wave generator”. Each time the ferry passes, at least 30 or more waves are formed. Several of them are very rideable and some even form the desired barrel shapes. The most extreme ship-wake surfers are probably those in the Netherlands, surfing the polluted and rubbish-ridden River de Waal where they battle sewage, general river pollution and the risk of being run over by the same ships that created their waves.

These examples show that wake surfing is feasible, but only if the wake is large enough and the bottom contours of the river bank have the right shape. So, Greg decided to do his own experiments to better understand the forces at work in producing these ship hull waves. Using a fishing trawler of similar size to his theorised hull design, waves capable of being ridden were generated up to chest high. Furthermore, even in the imperfect conditions of a river, barrels could be produced; refer Figure 4**Error! Reference source not found.** to Figure 6 below**.** The tests were successful and concluded that with a faster vessel, even bigger waves could have been generated. Also, by further experimenting with the boat path, it was realised that a curved approach further compressed the wake waves, steepening the face at the outer edges, where it would otherwise be weakening.

**Figure 4 River Testing – glassy walls**

**Figure 5. Surf Testing**

**Figure 6. First Barrel**

To further verify the design feasibility, Liquid Time Pty Ltd and SYPAQ supervised two Delft University of Technology (TUDelft) masters students Matthieu De Schipper and Sierd De Vries. Matthieu and Sierd conducted computation fluid dynamics (CFD) analysis (and scale model testing of a series of hulls travelling a linear track. These initial tests, completed in 2007, confirmed the design's feasibility and provided an improved design.

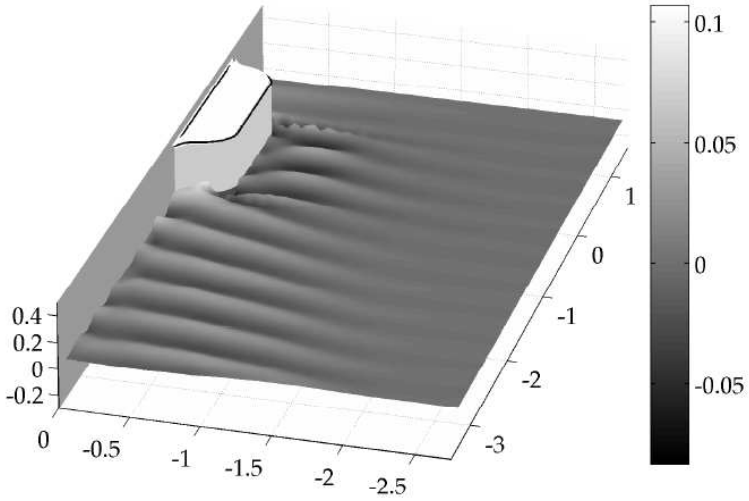


**Figure 7. Initial CFD analysis**

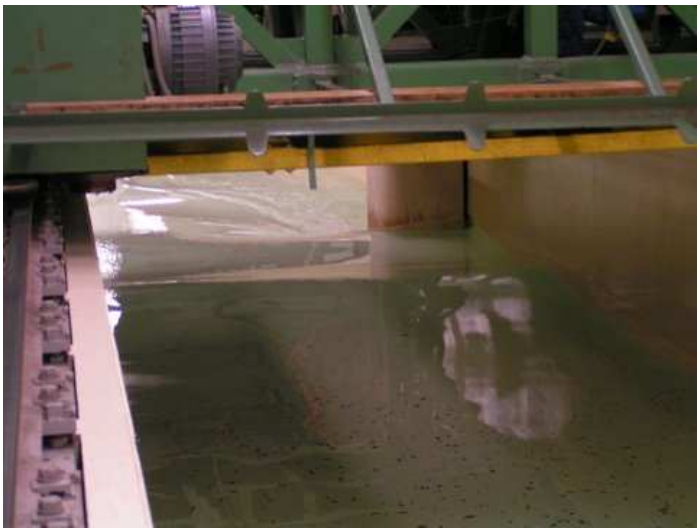

**Figure 8. Initial Scale Model Testing**

# Future Plans

Liquid Time Pty Ltd is continuing the relationship with TUDelft, and now Australian Maritime College (AMC), through a doctorate program being conducted by SYPAQ's senior systems engineer Steven Schmied. Commenced in 2008, the program is utilising both CFD (using both panel methods in Michlet and DELKELV, and finite volume methods in Finlab and Ansys Workbench) and a 1:20 scale model of the entire pool complex to give the ability to physically and numerically produce predetermined continuously generated breaking waves in a circular pool; the control of the wave transformation process; and design of the optimum moving disturbance. Further, this production of a continuous steady-state wave will allow breaking wave analysis and fundamental knowledge of wave mechanics to be significantly extended.

# Conclusion and recommendation

In conclusion, Liquid Time Pty Ltd and SYPAQ are utilising the system engineering process to continue to develop the Liquid Time Wave Pool. This innovative solution has been able to be developed in a timely and successful manner due to the benefits of applying the iterative systems engineering processes to date.

Liquid Time Pty Ltd and SYPAQ believe that there is a strong need for a wave pool that delivers quality barrelling waves. Wave pools are being built around the world, however these either do not give an authentic surfing experience (a moving wave breaking on a shoreline), a long duration ride or a high surfer throughput. Therefore, Liquid Time Pty Ltd believes that there is a viable market for a wave pool that gives an authentic surfing experience with a long ride. Liquid Time Pty Ltd and SYPAQ also believe that the wave pool should cater equally for beginner to advanced surfers. For inland surfing communities, or areas where there is poor or irregular surf, or overcrowding, wave pools fill an important niche as an alternative to natural surf. As an added benefit, by providing a safe learning environment, this will help improve the overall surfing ability of the participants.

Further, the ability to produce a continuous steady-state wave will allow breaking wave analysis and fundamental knowledge of wave mechanics to be significantly extended.