Design Development Record

DNB311 | ID Studio 7: Capstone

Topic: Design for Pool Safety

Product: Camera-Assisted Drowning Prevention Pool Alarm

Noah Turnbull

Observations | PACT Scoping

People

- Lifeguards keep watch on the area at all times and rush to help people in need of assistance.
- Young children are naturally developing motor skills and how to react to new scenarios. Swimming and water safety are skills that needs to be taught in a safe, controlled environment with undivided attention from parents or swim instructors.
- Parents have a responsibility to look after their children.
- In the context of Australia, there are strict laws around pool safety and a big culture around safe swimming, with many popular areas near water features. Those who travel to Australia may not have the same associations and education around swimming.
- Casual Swimmers
- Competitive Swimmers
- Swimming Instructors

Activities

- Swimming
- Jumping
- Diving
- Running
- Playing
- Splashing
- Holding Breath
- Observing
- Practicing CPR

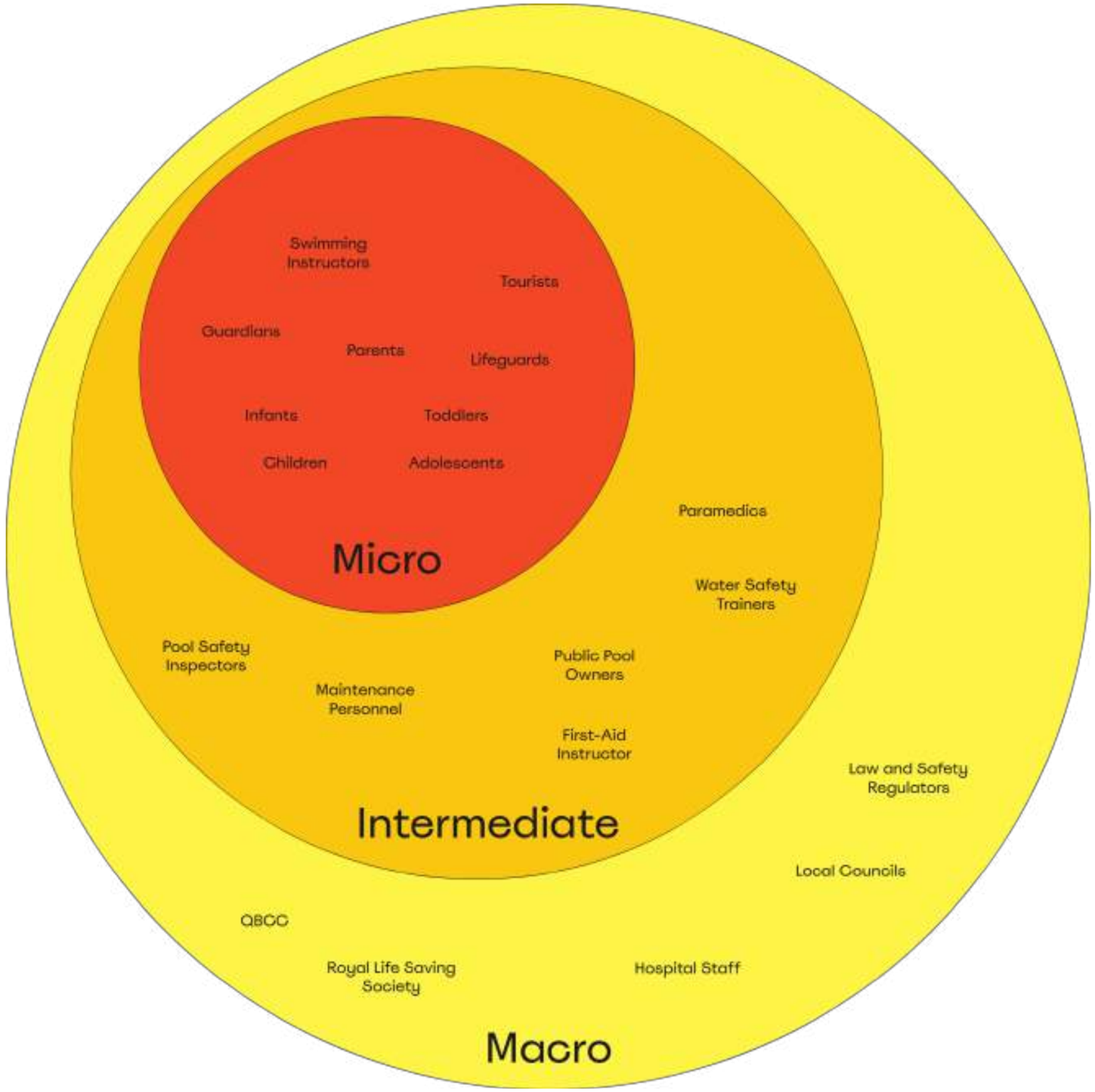
Context

- Private Pools (Home): Must be surrounded by a fence 1.2m tall in Australia.
- Inflatable Pools: Must be surrounded by a fence 1.2m tall in Australia.
- Hotel Pools: Swimmers typically have to look out for their own safety.
- (Air)BNB Pools: Safety regulation can vary depending on country. Parents with children should exercise caution.
- Public Pools: Required to be fenced and have an employed, trained lifeguard on duty.
- Swimming Class Pools: Learning swimmers will always have an instructor keeping watch on them.
- Wave Pools: Very dangerous even for experienced swimmers due to the unpredictability of the waves and high density of people.

Technologies

- Life buoys and rings are effective tools that can help a drowning person climb up and stay out of the water for air. In a drowning incident, reactionary instincts encourage a person to climb up.
- Items such as paddle boards along with wearable inflatables such as life vests and swimming wings help people stay afloat.
- Pool fences are effective at keeping young children out of the pool, but need to be properly installed.
- Pool sensors exist to alarm if something or someone falls into a pool unexpectedly.
- Some parents keeping an eye on their kids will put their phone out of reach to ensure they do not shift their attention away.
- Cameras are sometimes used to monitor pool activity, though this is not common practice.

Observations | Stakeholder MIM Map



Stakeholder Roles:

- Children: Should be taking lessons and developing their swim safety skills.
- Parents: Have a responsibility to watch their children when in the water.
- Guardians: Have a responsibility to watch their children when in the water.
- Lifeguards: Guard public waters, have extensive lifesaving and water safety knowledge.
- Tourists: May come to Australia to visit beaches, at higher risk of fatal drowning due to lack of swimming experience.
- Swimming Instructors: Professionally qualified to teach children how to swim and continually extend their abilities as they grow.

- Pool Safety Inspectors: Inspect private pools once every two years (in QLD). Can give recommendations for safety measures and also write up fines for breaking legislation.
- Maintenance Personnel: Maintain pool cleanliness, pH levels and other technicalities of a pool. Usually work at public pools or can be hired to visit home.
- Public Pool Owners: People who run a public pool facility. They control staff management, ensuring the pool facility is safe and meets regulation.
- First Aid Instructor: Teaches people how to react to different life-threatening scenarios as a victim or bystander. CPR training is a very common skill taught, which is vital for rescuing drowning victims.
- Paramedics: Will intervene if a drowning victim is in danger.

- Royal Life Saving Society: Australian society that hires professional lifeguards, organises sfafety courses and tracks national statistics relating to swim safety.
- Hospital Staff: Broad umbrella of people who may help a drowning victim after a paramedic takes the to the hospital. This includes doctors, nurses and more.
- Local Councils: Enforce public and private pool safety laws, ensuring all private pools are inspected once every two years.
- QBCC (Queensland Building and Construction Commission): Enforces official legislation around safe pool construction, the main reference frame for safety inspectors.

Type of Hazard	Explanation of Severity	Methods of Prevention
Drowning	The most dangerous and feared risk with bodies of water. Young children and the elderly are at greatest risk due to motor function ability. A majority of victims stem from not knowing how to swim safely (no professional training). Drug intoxication also contributes to 23% of all Australian coastal drownings.	• Swim safety education is the most effective method to prevent swimmers from falling victim to a drowning incident. However, this needs to be done over a period of months or years. • Installed pool gates are effective at preventing small children from entering the pool without permission. • Cameras and installed splash detectors can notify of unexpected pool entries. • Alcohol and drug intake should not be involved when swimming. • Supervision from a trusted, able-bodied individual. • Trained lifeguard presence. • Inflatable life-saving devices. • Depth range marks indicate riskier areas. • Overhanging poolside ledges.
Slipping, Tripping and Falling	Water splashing over the edge of the pool creates a slip hazard, especially on hard surfaces. People who run beside the pool are at greatest risk of injury.	• Water-resistant rubber mats can have higher friction than hard surfaces to prevent accidental slipping. • ‘No running’ signs. • Pool sides highlighted (usually yellow for caution).
Slipping off ladders or steps	Ladders and steps are the most common additions for exiting a pool. If an individual slips when exiting the pool, it can send the individual into a state of shock.	• Ladders are typically made of stainless steel 316 for its strength, durability and easy gripping even when wet. • Ladders and steps should have non-slip rubber mats. • More people can climb steps as opposed to a ladder. However, this needs to be factored into the initial design of the pool and cannot be retro-fitted unlike a ladder.
Lack of Supervision	A concerned or drowning swimmer’s best lifeline is to have an able-bodied and trusted bystander to recognise when they are in danger. A lack of supervision can be lethal, especially for children.	• Swimmers should always swim with someone keeping tabs on them at all times. • Medium to low populated pools with a trained lifeguard are inherently the safest place to swim. People can get lost in highly dense pools. • Poolside bystanders should refrain from distractions, especially mobile phones.

Type of Hazard	Explanation of Severity	Methods of Prevention
Jumping and Diving	Jumping and diving can present risks if the swimmer is inexperienced or unaware of their surroundings. Jumping from a high diving board further increases the severity of injuries.	• Effective supervision of all individuals in the pool should be observed. • Only experienced swimmers should dive from a high diving board.
Pool Suction Entrapment	Pool drains have a powerful suction necessary for filtration. This can pose risk when a swimmer is too close to the drain. 70% of entrapment victims are children, due to their natural curiosity and smaller, lighter figure.	• Long hair should be tied back. • Suction covers can be installed which are highly effective safety measures.
Trapped Underwater	Swimmers can be trapped underwater from large floating objects or being overwhelmed with the density of other swimmers in the pool. This poses an extremely severe risk of drowning.	• Large inflatables should be avoided, or at the very least sectioned away from the main area and monitored very closely by trained lifeguards. • Inexperienced, lighter or smaller swimmers should refrain from swimming in a pool congested with other people.
Reduced Visibility due to Poor Filtration	Poor filtration will make a pool cloudy, which can greatly reduce visibility. Swimmers will be unaware of the depth and any foreign objects in the pool, which can pose all degrees of risks.	• Effective filtration measures should be followed and adhered to. • Individuals should refrain from entering a cloudy pool. • Bright coloured swimsuits enhance visibility. Neon colours are best, blue and white should be avoided.
Reduced Visibility due to External Environmental Changes	Swimming during any time that is not a sunny day is inherently riskier for the swimmer and bystanders. Dark skies, fog, rain and hail all impact visibility which is especially dangerous for families with pools at their home.	• Bright lights should illuminate the pool at night. The pool should be positioned in an area that can catch as much moonlight as possible. • Pool fences prevent small children from entering the pool without permission. • Swimmers should refrain from swimming in poor weather conditions.

To date, limited research has explored belief-based predictors of portable pool safety behaviours of parents of young children.

There is significant research that highlights the limitations of home pool safety in an overall context. However, there has not been much specific research around safety with portable pools. People with portable pools usually keep the pool filled outside of use as to not waste water. However, this poses a significant drowning risk, especially as many portable pools are not fenced out of inconvenience.

One study from the United States reporting 209 fatal and 35 nonfatal drownings in portable above ground pools identified children under five years as being at disproportionate risk, accounting for 94% of the submersions (Shields et al., 2011).

There appears to be a common lapse in safety with portable pools, much more severe than built-in pools. This suggests there is an opportunity for safety improvement for portable pools.

https://www.sciencedirect.com/science/article/pii/S0022437525000192

People who would Approve	Family members	16	32
	Everyone	14	28
	Lifeguards, swimming instructors, and emergency services	14	28
	Friends	13	26
	The child's other parent	9	18
	Grandparents	6	12
	Other parents	6	12
People who would Disapprove	No one would disapprove	30	60
Facilitators	A place to sit in the shade	7	14
	Time	5	10
	Fenced pool	5	10
	A clear view of the pool	5	10
	No distractions	5	10
Barriers	No barriers	20	40
	Distractions	7	14
	Too many other things to do – trying to multitask	7	14
	Too many children to monitor	6	12
	Obstructed view	6	12

Table 2
Beliefs associated with supervising young children within arms' reach when using a portable pool as identified in Phase 1 (n = 50).

Beliefs	Theme	Frequency (*n*)	Percent (%)	Representative Quote
Advantages	Prevent drowning or injury and ensures safety	36	72	"My child doesn't die/drown or get injured in any way"
	Quick response to any problem (danger happens quickly)	10	20	"Quick response to any problem, may be able to prevent an accident from occurring"
	Opportunity to spend time engaging with child and seeing their enjoyment	9	18	"It is rewarding watching my child have fun and enjoy themselves in the pool"
	Able to help child learn swimming and pool safety	7	14	"Being able to assist with water play and teach them how to be safe in the pool"
Disadvantages	No disadvantages	29	58	"No disadvantages"
	Time consuming – you cannot do other things	8	16	"Can take up a lot of time"

A good find here, some parents keeping an eye on their kids will put their phones out of reach to ensure they do not shift their attention away.

https://journals.sagepub.com/doi/full/10.1177/13591053241275588

Queensland laws define a swimming pool as any structure that is capable of being filled with water to a depth of 300mm or more is used primarily for swimming, wading, paddling or the like. This notably includes all pools, built or portable. Pools must be registered by the QCBB and have standard approved fencing. However, this does not include fishponds or other ornamental pieces. All bodies of water can pose risk for drowning incidents, and homeowners should take reasonable, diligent action to prevent any occurrences.

Portable swimming pools must display this symbol; else they will be recalled.

https://www.productsafety.gov.au/business/search-mandatory-standards/portable-swimming-pools-mandatory-standard

As per the Queensland Government's legislation *MP 3.4—Swimming pool barriers*, the following laws apply to ensure proper pool fence installation and safety:

Swimming pools must have a barrier which:

(a) is continuous for the full extent of the hazard; and

(b) is of a strength and rigidity to withstand the foreseeable impact of people; and

(c) restricts the access of young children to the pool and the immediate pool surrounds, including access from class 1, 2 or 3 buildings or class 4 parts of buildings located within or outside the pool area; and

(d) has any gates fitted with latching devices not readily operated by young children, and constructed to automatically close and latch; and

(e) except for indoor swimming pools, does not incorporate any doors providing access to or from a building.

https://www.qld.gov.au/housing/buying-owning-home/pool-safety/pool-laws-and-standards/laws

Failure to install an applicable fence surrounding the perimeter of the pool result in an immediate fine for homeowners, starting at $2000.00AUD.

https://www.qbcc.qld.gov.au/resources/media-release/make-sure-your-pool-fence-measures-summer

A boundary fence may be less than 1800 millimetres in height, but not less than 1200 millimetres in height, provided the non-climbable zone is located on the outside of the fence (i.e. the side facing away from the pool area).

Climbable objects are permitted within the upper 900 millimetres quadrant of the non-climbable zone, provided it is not reasonably possible for a young child to gain access to those climbable objects (see figure 9).

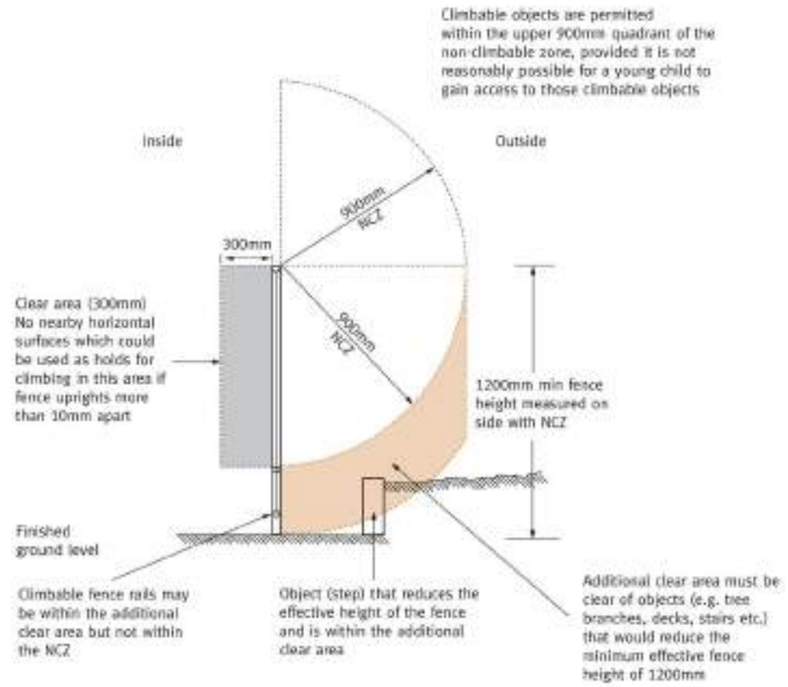


Figure 5
1200mm min high fence NCZ on outside
Not acceptable

The figure above shows a ledge within a 900mm radius of the fence, which is a direct violation.

Field Research | Acceptable Fence Installation Examples

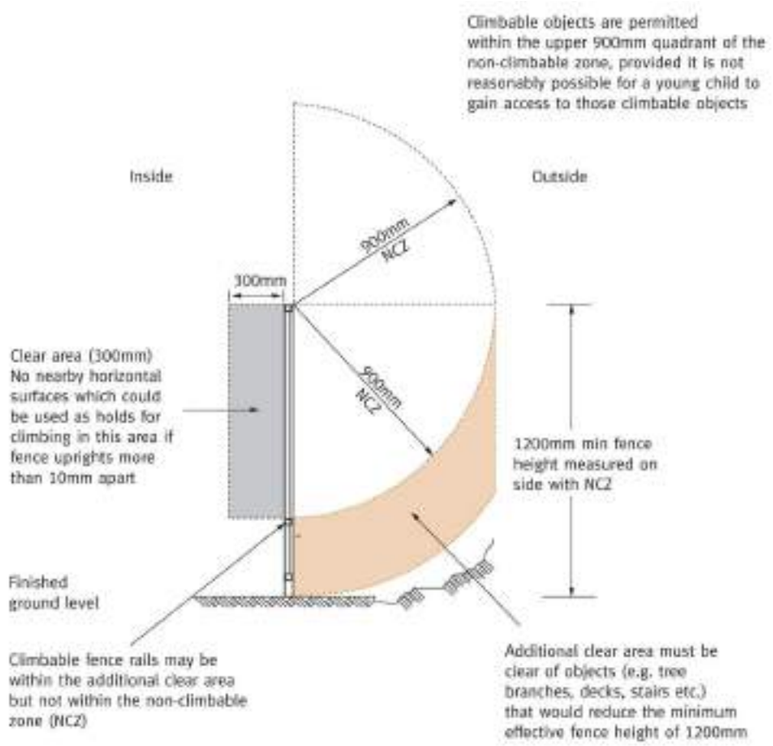


Figure 1
1200mm min high fence NCZ on outside
Acceptable

Regular case of acceptable fencing.

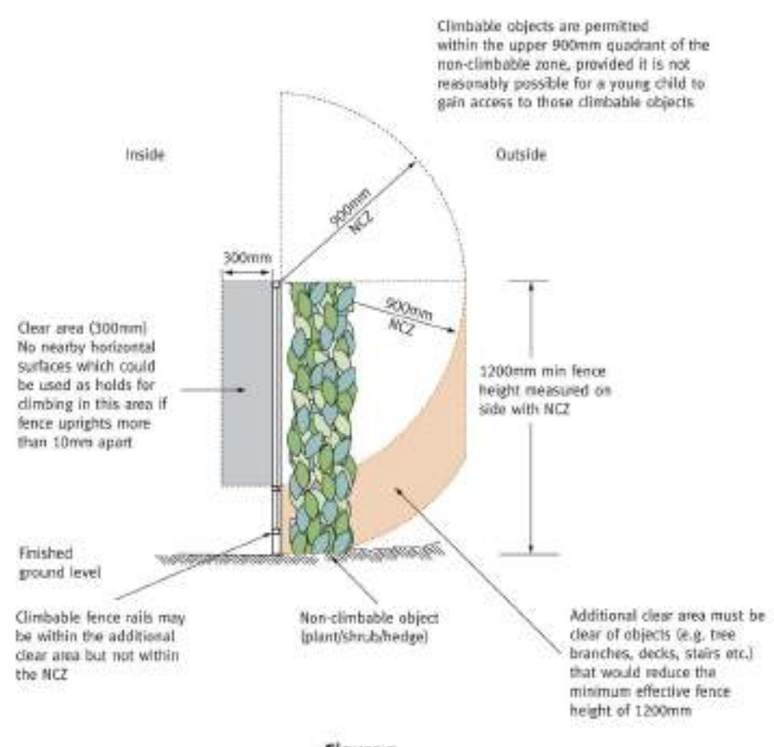


Figure 7
1200mm min high fence NCZ on outside
Acceptable

https://www.hpw.qld.gov.au/__data/assets/pdf_file/0015/4812/qdcmp3.4swimmingpoolbarriers.pdf

Additional objects can be placed in front of a fence, so long as they are not climbable by nature.

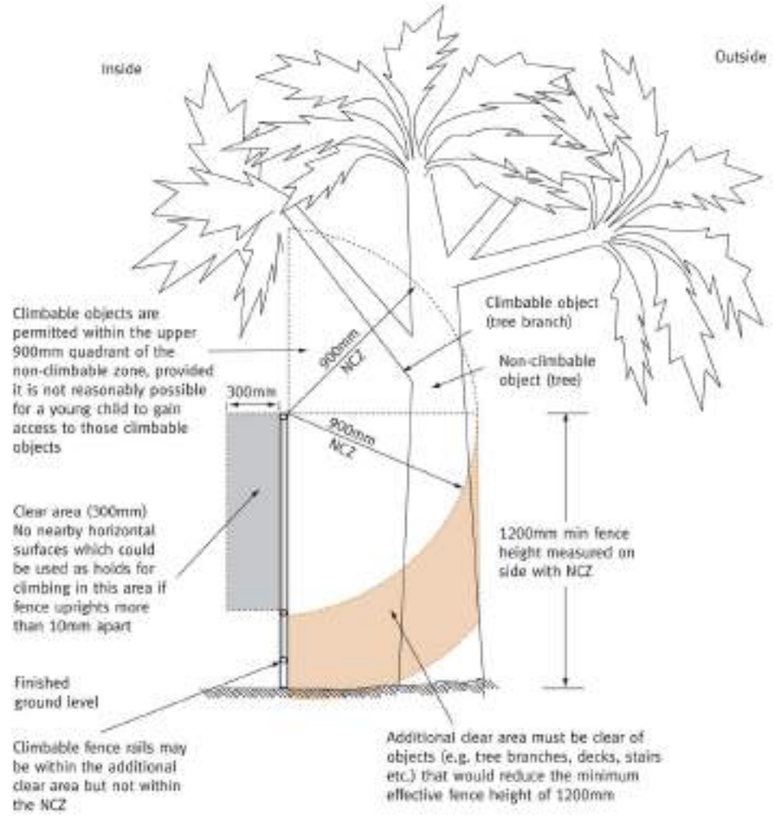


Figure 9
1200mm min high fence NCZ on outside
Acceptable

Even tall trees are acceptable, so long as there are no leverage points for climbing below 1200mm.

Finding out if your pool fence meets regulation is as simple as referring to the standards diagrams which are easily found online. The full diagram list communicates that the only real offences are fencing that is below 1200mm and having objects that are deemed 'climbable' within a 900mm radius of the fence. One could argue that the rules seem lenient, especially Figure 9 above.

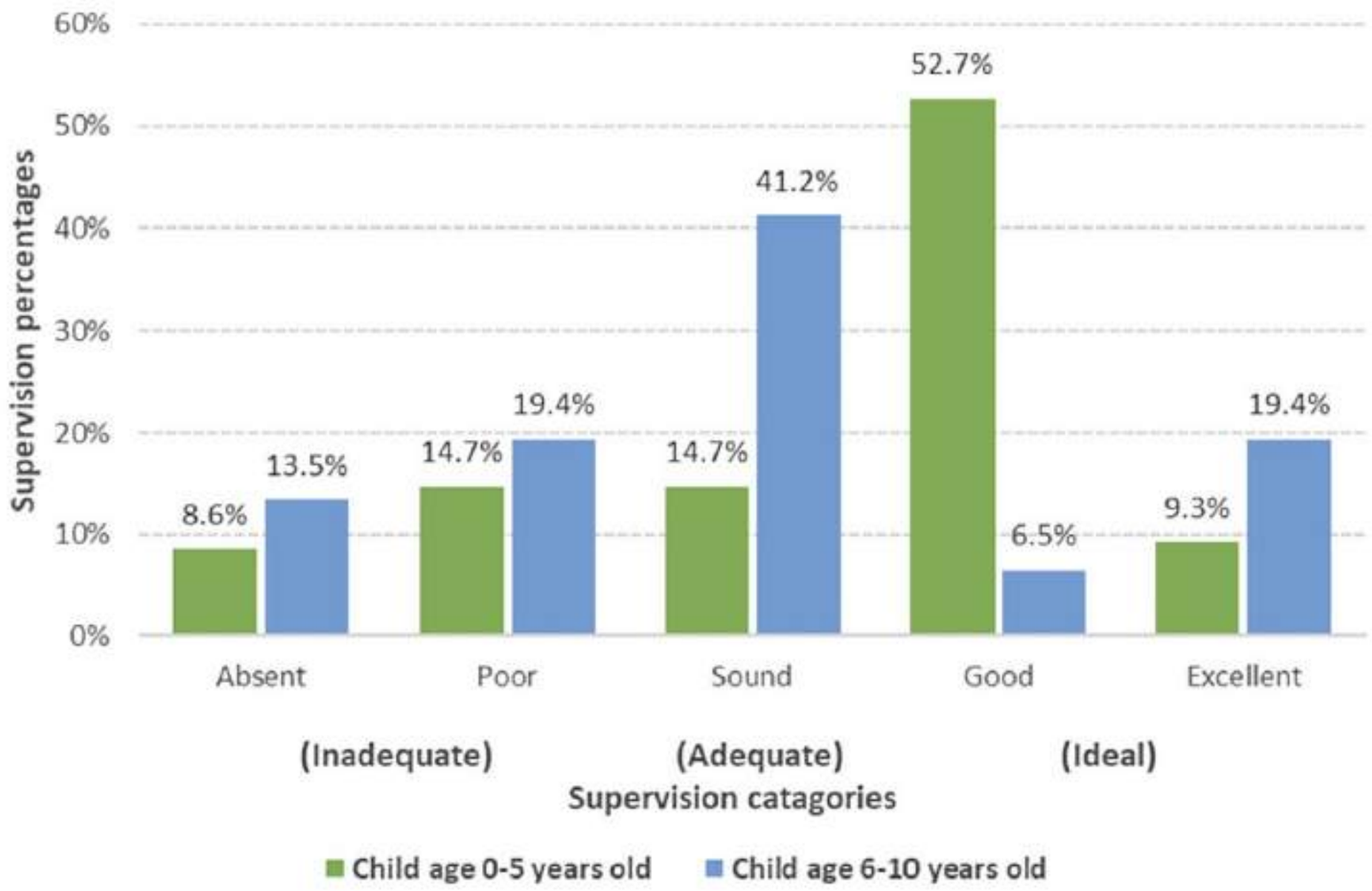
The laws surrounding swimming pool legislation are more lenient with 'ornamental' water features, most commonly being fishponds. Features such as these become more of a case-by-case scenario as to whether pool fencing laws must be followed. Despite the relaxed legislation, it is important to remember that people can drown in virtually any body of water.

This report studied the supervision that caregivers (not parents) showcased towards the children they looked after in a pool area.

Of the 449 children observed, children aged 6-10 years were significantly less likely to be provided with ideal supervision (26%) compared to younger children aged 0-5 years (62%). Of the caregivers who were using their mobile phone while supervising children (n = 100, 22% of children observed), none provided ideal supervision.

Supervision tended to rank better for children under 6 compared to older ages. This is likely due to the common assumption that swimming skills improve with age. However, it is important to note that swimmers of any age can be in danger under the wrong circumstances. This further proves that starting swimming lessons at an early age and continuing them is very important for a child's safety in the water.

https://onlinelibrary.wiley.com/doi/epdf/10.1002/hpja.445?saml_referrer

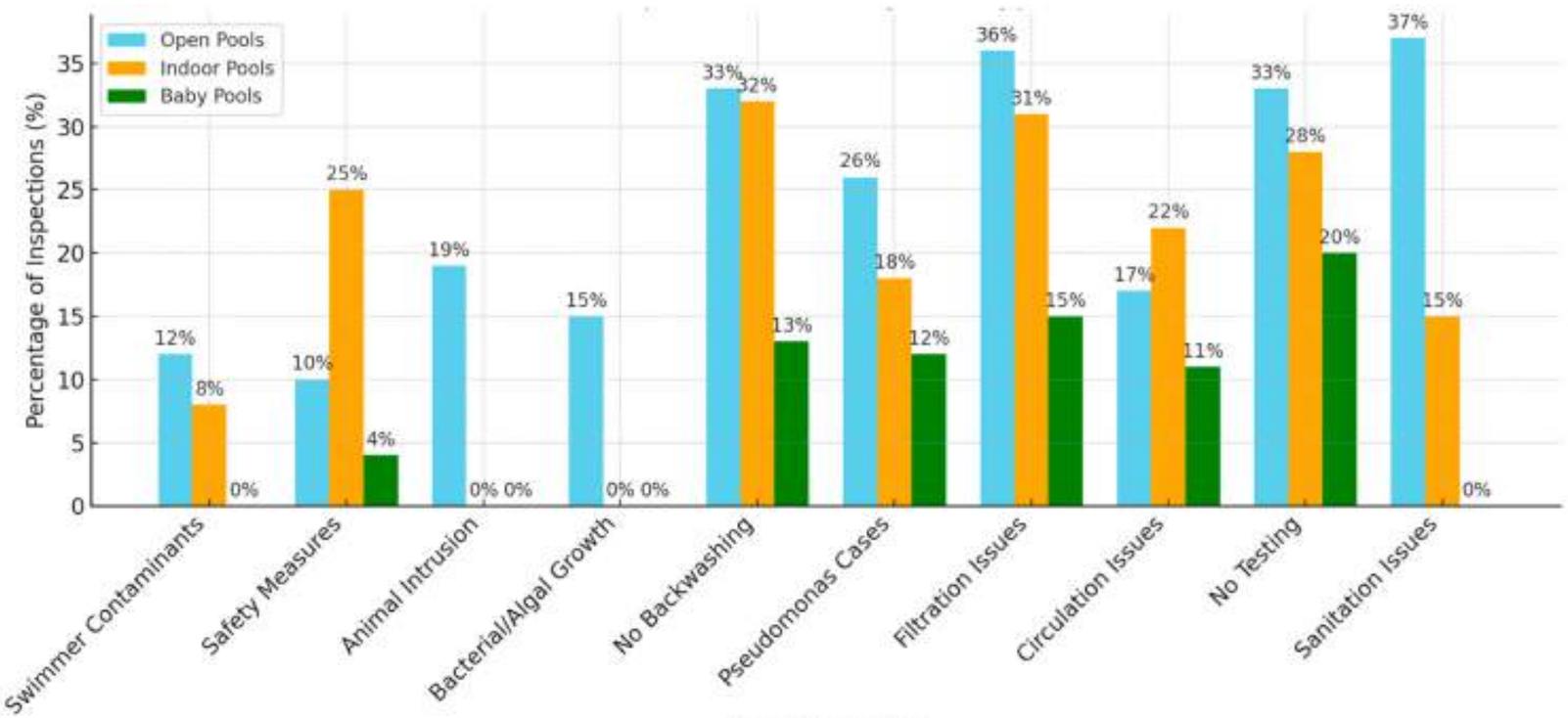


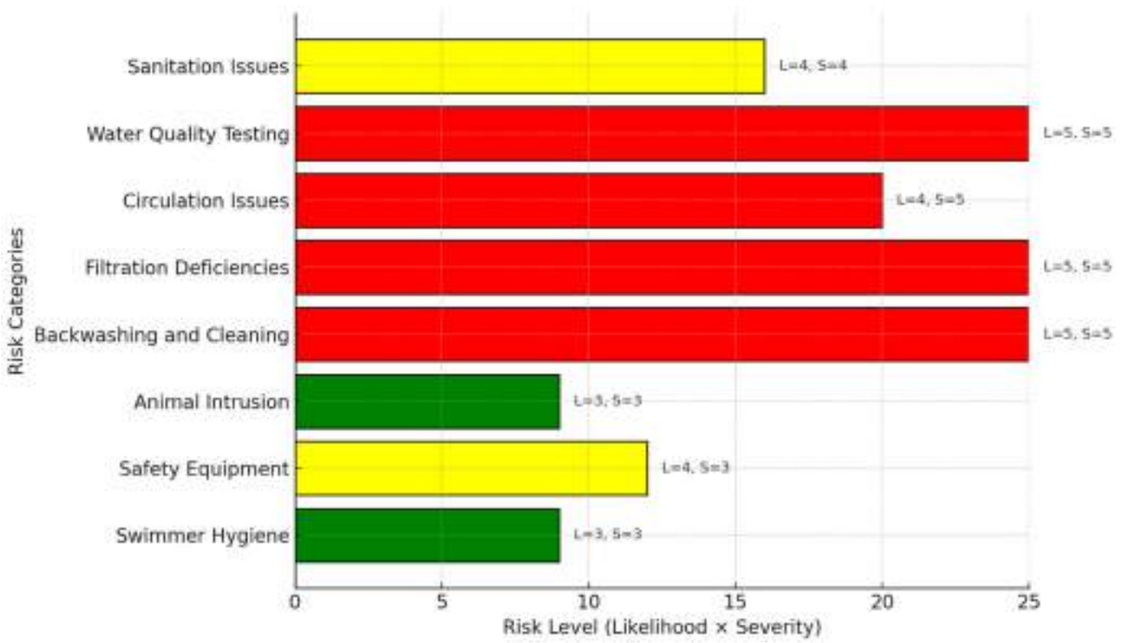
Field Research | Risk Assessment

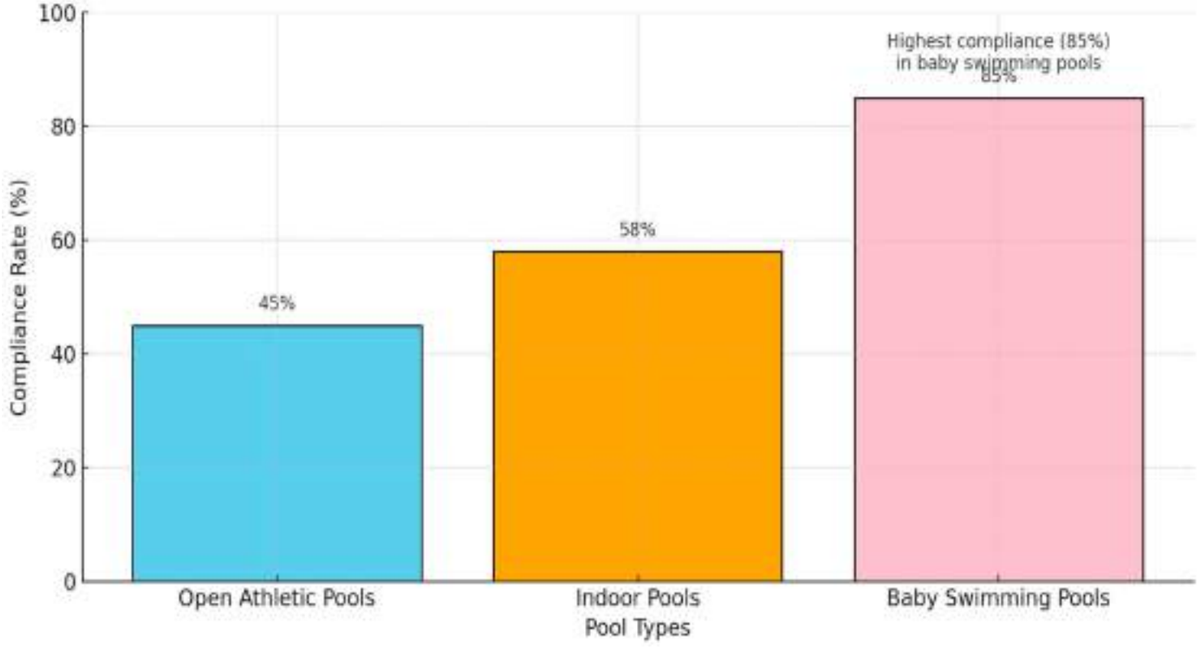
Robust risk assessment and management practices are crucial for ensuring public safety in swimming pools. These risk assessment criteria can also extend to private pools, which should be adequately safe for all swimmers. The graphs pictured demonstrate safety compliance of public pools in Greece, in which they do not have a national organisation for public pool monitoring (as of 2025).

It is important to consider other countries perspectives and legislation around the topic as many are not as strict as Australia's. The concept product I design may have a greater impact internationally, where drowning risks are higher as a consequence on relaxed regulations.

https://www.proquest.com/docview/3188796259/A46519D96394489APQ/3







Of the 2,884 coastal deaths, 80.6% of decedents had known toxicological data. Alcohol and/or drug intoxication contributed to 23% of coastal drowning deaths and 19% of fatalities. For drowning and other fatalities combined, 8.7% were due to alcohol, 8.7% due to drugs, and 4.1% due to both alcohol and drugs.

Whilst drownings are most prevalent in young children aged 1-14, people of all ages are at risk of drowning under the wrong circumstances. Investigating recorded drowning incidents for adults, there was an overwhelming percentage that involved alcohol or illicit substances. Being under the influence naturally reduces a person's motor skills and rationality, which can make swimming incredibly dangerous.

https://www.proquest.com/docview/3188796259/A46519D96394489APQ/3

Participation in formal swimming lessons was associated with an 88% reduction in the risk of drowning in the 1- to 4-year-old children, although estimates are imprecise. Regardless, it is clear from this sample that getting young children 1-4 at least familiar with the pool and a few essential swimming skills significantly reduces the risk of drowning incidents occurring.

https://pmc.ncbi.nlm.nih.gov/articles/PMC4151293/

Table 1

Characteristics of Children Who Drowned With Study Interviews vs Those Without Interviews

Characteristic[a]	No. (%)[b] 1- to 4-Year-Olds: Participants (n=61)	1- to 4-Year-Olds: Nonparticipants (n=98)	5- to 19-Year-Olds: Participants (n=27)	5- to 19-Year-Olds: Nonparticipants (n=78)
Sex				
M	36 (59)	70 (71)	23 (85)	70 (90)
F	25 (41)	28 (29)	4 (15)	8 (10)
Race/ethnicity				
White	36 (65)	54 (55)	11 (42)	20 (27)
African American	7 (13)	17 (17)	11 (42)	34 (45)
Latino	10 (18)	16 (16)	3 (12)	12 (16)
Other	2 (4)	6 (11)	1 (4)	9 (12)
Site of drowning				
Pool/hot tub	47 (77)	75 (77)	10 (37)	35 (45)
Lake/pond	10 (16)	16 (16)	5 (19)	18 (23)
Other	4 (6)	7 (7)	12 (44)	25 (32)
Location of drowning				
Decedent's home	29 (48)	60 (64)	3 (12)	8 (11)
Other home	22 (36)	22 (24)	2 (8)	9 (12)
Other	10 (16)	11 (12)	20 (80)	59 (78)
Participation in formal swimming lessons				
No	47 (94)	50 (94)	10 (62)	30 (81)
Yes	3 (6)	3 (6)	6 (37)	7 (19)
Comfort in water				
Liked the water				.65
No	14 (23)	27 (20)		
Yes	47 (77)	106 (80)		
Comfortable in water				.71
Uncomfortable/slightly uncomfortable	12 (20)	18 (15)		
Comfortable/very comfort	49 (80)	101 (85)		
Comfortable putting whole head in water				.36
No	38 (64)	70 (59)		
Yes	21 (36)	49 (41)		
Swimming ability				
Float on back for 10 s				.01
No	57 (95)	110 (82)		
Yes	3 (5)	24 (18)		
Swim on stomach 15 ft				.07
No	59 (97)	120 (90)		
Yes	2 (3)	14 (10)		
Jump in a pool/swim 5 ft/back to wall				.07
No	59 (97)	106 (88)		
Yes	2 (3)	14 (12)		

[a] Based on reports from medical examiners and coroners.

[b] Totals vary slightly because of missing data; percentage of distribution based on a denominator of those with information.

[a] Characteristic of case or control, except where specified in headings.

TABLE 2.
Significant Outcome Predictors

PnFD Outcomes Table: Outcome Predictor Category	Status Level	Group N	Outcome Group Membership Frequency (% of Group N): Mild	Moderate	Severe
Sites of CPR	Event site only	89	24%	55%	21%
	EMS transit only	24	21%	37%	42%
	Multiple sites	16	25%	38%	37%
Site of pulse return	Event site	37	**41%**[*]	38%	21%
	In ambulance	31	16%	61%	23%
	In hospital	61	16%	51%	33%
Admission status	Not coma	17	**59%**[†]	35%	6%
	Coma	137	22%	50%	28%
In-hospital interventions	None	10	**70%**[‡]	10%	20%
	Minimal	14	7%	57%	36%
	Moderate	33	33%	40%	27%
	Aggressive	98	21%	54%	25%
In-hospital counseling	Poor prognosis	112	16%	53%	**31%**[§]
	Withdraw care	61	5%	58%	**37%**[‖]
	Institutionalize	40	10%	70%	20%
Discharge status	Alert, responsive	36	**81%**[¶]	17%	2%
	Awake, nonresponsive	5	0%	60%	40%
	Groggy	18	28%	50%	22%
	MCS	38	8%	66%	26%
	PVS	46	4%	59%	37%
	Coma	10	0%	50%	50%

Abbreviations:
CPR = Cardiopulmonary resuscitation
EMS = Emergency medical services
MCS = Minimally conscious state
PVS = Persistent vegetative state
PnFD = Pediatric nonfatal drowning
RR = Relative risk ratio

Image	Name	Retail Price	Important Notes:	Link
	**SwamCam Pool Alarm**	$771.65AUD	One of the most expensive pool alarms on the market, also highly effective and reliable. Uses a camera to detect people walking in front of it. Design is wired which limits use, for most people it needs to be placed facing out a window indoors.	SwamCam Camera Pool Alarm System with Built-In WiFi Repeater - SwamCam
	**INNOTIVO Wireless Battery-Powered Pool Alarm System**	RRP: $214.00AUD Sale: $64.95AUD	Cheaper entry-level pool alarm. Must be installed into the ground beside the pool. Round device with infrared sensor needs to be able to detect the main unit from afar to sound the alarm. Battery powered, lasts around 18 months.	INNOTIVO Wireless Battery-Powered Pool Alarm System - need1.com.au
	**Lifebuoy BCone System**	$695.00AUD	Floats in the water. It is heavy and hard to tamper with. Could potentially be improved by doubling as a floatation rescue device, as the current shape is hard to grab when wet. Connects via an app to remotely control alarm settings.	BCone System | Lifebuoy
	**Blue Wave Poolwatch Pool Alarm**	$342.50AUD	Must be installed into the ground beside the pool. Very sensitive, to the point that naturally lowering pool depth can set it off. No way to remotely stop the alarm, which can be frustrating. Reviews cite battery corrosion with salt water, which can pose a safety hazard.	Blue Wave Poolwatch Pool Alarm System - Walmart.com

Benchmarking | Pool Alarms

Image	Name	Retail Price	Important Notes:	Link
	**PoolEye Immersion Mountable Pool Alarm**	$182.96AUD	Cheaper entry-level pool alarm. Must be installed into the ground beside the pool. Reviews are mixed, with some claiming it sets off randomly	PoolEye Immersion Mountable Pool Alarm Compatible with Inground & Aboveground Pools ASTM-Compliant, Water Motion Sensor Advanced Technology Dual Protection, Poolside and in-Home Sirens, Multicolor : Amazon.com.au: Garden
	**Pool Patrol PA-30 Pool Alarm**	$470.00AUD	Sensitivity can be adjusted, which is a welcome feature. Floats in the water. Small compact design makes it useful on the go.	Pool Patrol PA-30 Pool Alarm : Amazon.com.au: Garden

Category	SwamCam Pool Alarm	INNOTIVO Wireless Battery-Powered Pool Alarm System	Lifebuoy BCone System	Blue Wave Poolwatch Pool Alarm	PoolEye Immersion Mountable Pool Alarm	Pool Patrol PA-30 Pool Alarm
Price	$771.65AUD	RRP: $214.00AUD Sale: $64.95AUD	$695.00AUD	$342.50AUD	$182.96AUD	$470.00AUD
Percieved Quality	**7**	**2**	**6**	**1**	**2**	**5**
Appealing Aesthetics	**5**	**2**	**7**	**2**	**3**	**4**
Visibility Under or Near Water	**N/A**	**3**	**7**	**3**	**3**	**1**
Portability	**4**	**1**	**5**	**2**	**2**	**7**

The immediate loud alarm will grab attention from a far way, with most alarms sounding at 100dB. Aside from the SwanCam, all devices have a wave motion sensor built in to sound the alarm. This means it also doubles as an alarm if any larger animals or debris falls in the pool, which could be an emergency within itself.

These devices seem to have a prone tenancy to set off unexpectedly, especially the static installed models which are sensitive to the height of the water. This is especially frustrating when the alarm is so loud. Floating alarms seem to activate more consistently, although they run more expensive in price range.

SMART Goals:

My product concept must play an active role in preventing drowning incidents. This will be successful if it eliminates risks surrounding the occurrence of drowning incidents in an efficient way that no other solution has been able to.

Benchmarking | Pool Alarm Market Matrix

Portability (High)

Price (Low)

Price (High)

There is a clear gap in portable pool alarms under the $500.00AUD price range.

Market Gap

Portability (Low)

Secondary Research | UN Sustainability Goals

I intend to apply these four UN sustainability goals to my concept design process. These goals and their sub-targets are the most applicable and appropriate for the context of designing a consumer product that will enhance pool safety.

Target 3.2: End all preventable deaths under five years of age

Indicator 3.2.1: Under-five mortality rate. The under-five mortality rate measures the number of children per 1,000 live births who die before their fifth birthday.

Indicator 3.2.2: Neonatal mortality rate. The neonatal mortality rate is defined as the share of newborns per 1,000 live births in a given year who die before reaching 28 days of age.

Target 7.2: Increase global percentage of renewable energy

Indicator 7.2.1: Renewable energy share in the total final energy consumption.

The design solution should be reasonable accessible for as many people as possible.

Target 10.1: By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average

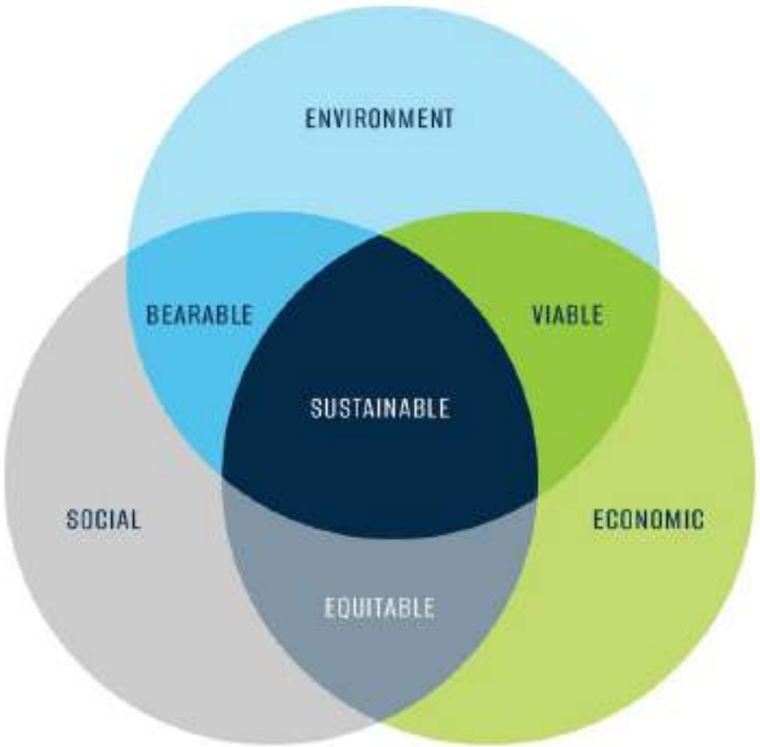
Target 10.2: By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status

Target 12.2: Sustainable management and use of natural resources

Indicator 12.2.1: Material footprint, material footprint per capita, and material footprint per GDP

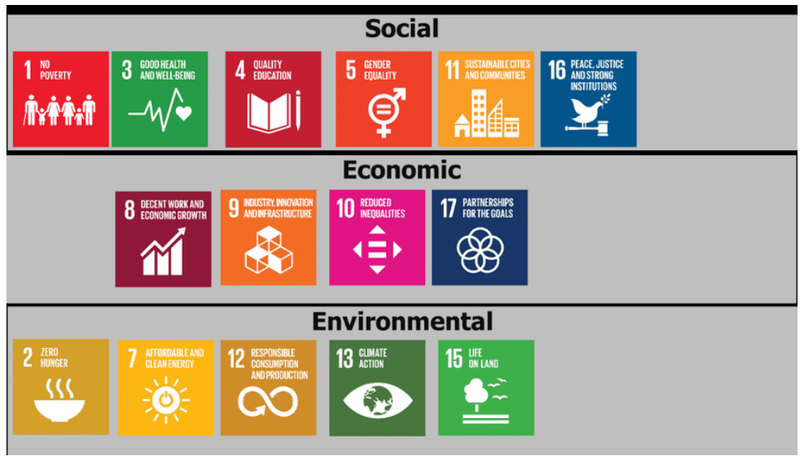
Indicator 12.2.2: Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP

Secondary Research | UN Sustainability Goals



The 17 UN Sustainability Goals are closely interlinked with the Three Pillars of Sustainability model. A sustainable system needs to organise close attention to sustainable environmental, economic and social factors. If it fails to do so, the system will risk failing to be sustainable. This is relevant to the concept design as it will need to closely consider all three pillars to appeal to potential stakeholders more effectively and prove that it will be a successful product.

Understanding where the UN Sustainability Goals apply to the Three Pillars of Sustainability is up to interpretation, and there is often a lot of overlap. Two interpretations are shown right The four goals that my design is focused on make sure to overlap all three pillars in an effective and meaningful way.



https://www.ayro.com/what-is-sustainability/

https://www.researchgate.net/publication/332153179_A_Novel_ICT_Framework_for_Sustainable_Development_Goals

https://www.researchgate.net/publication/333294667_Assessing_SDGs_A_Methodology_to_Measure_Sustainability

Alarm Bracelets:

Image	Name	Retail Price	Important Notes:	Link
	**Safety Turtle 2.0**	Between $225.00 and $300.00AUD	DISCONTINUED for unknown reasons. If the wristband gets wet, it will instantly send a radio signal to the Base Station. The product is permanently sealed and ruggedly built to withstand child's play. Can be seen as a disadvantage, if the battery stops the device is defunct. Only alarms when fully submerged in water (spraying will not alarm). One base station can support an unlimited number of wristbands (or collar attachments for pets).	New Safety Turtle 2.0 Pool Alarm FAQs - DIYControls Blog Safety Turtle Alarm – kids - Safety Store Australia
	**Water Patrol Child Guard**	$180.00AUD	It has a wireless range of up to 60m in open surrounds and the receiver runs of both mains power and a rechargeable battery.	Water Patrol Child Guard - wireless anti-drowning electronic device
	**LunaSafe Pool/Boat Wearable Transmitter**	$307.00AUD	Extremely compact, wear on wrist, life jacket or in pocket. Battery lasts approximately 5 years. Includes carabiner for attachment to a life vest and a Velcro strap for pets. Transmits up to 150ft Multiple buying options, 4 pack comes with a carry case making it suitable for on-the-go usage. Works on 3 days of charge.	Water Activated Transmitter & Receiver Alarm - Lunasea Lighting
	**AMB Water Alarm Set**	$375.00AUD	The bracelet uses a standard flat battery (3V type CR 2032) which can be changed using the screwdriver provided. To ensure water resistance, it is recommended for a professional to replace the battery.	Water alarm set for toddlers playing by the water

Inflatable Wearables:

	**Kingii Single Package**	RRP: $122.88AUD Sale: $107.50AUD	Technically counts as a lifesaving wearable. The bracelet releases and inflates the inflatable when submerged underwater. Ideally used out in the ocean, when boating for instance. It is reusable up to 50 times.	Single package (1 Kingii wearable + 1 cartridge) - Kingii International
	**M-16 Manual Inflatable Belt Pack**	$185.00AUD	Pull the cord to eject and inflate a lifejacket built-in to the pack. The user simply pulls a strap on the jacket over their head. Also comes with a permanently attached rescue whistle that cannot be lost. Adjustable body belt; front buckle closure. Protective cover uses durable nylon fabric. 75 Newtons of buoyancy.	Shop M-16 Inflatable Belt Pack	Reliable Manual PFD – Onyx Outdoor Onyx M16 Belt Worn Life-Vest Demonstration - YouTube

Category	Safety Turtle 2.0	Water Patrol Child Guard	LunaSafe Pool/Boat Wearable Transmitter	AMB Water Alarm Set	Kingii Single Package	M-16 Manual Inflatable Belt Pack
Price	Between $225.00 and $300.00AUD	$180.00AUD	$307.00AUD	$375.00AUD	RRP: $122.88AUD Sale: $107.50AUD	$185.00AUD
Percieved Quality	**4**	**5**	**7**	**6**	**6**	**6**
Appealing Aesthetics	**6**	**5**	**5**	**5**	**4**	**6**
Visibility Under or Near Water	**2**	**5**	**3**	**5**	**7**	**6**
Portability	**4**	**3**	**5**	**6**	**7**	**7**

Benchmarking | Wearable Device Market Matrix

Portability (High)

The ideal market gap seems to have been achieved already, with highly portable and affordable safety wearables.

Price (Low) **Price (High)**

Portability (Low)

Life Jacket:

Swimmer can wear this to avoid sinking in deep waters.

Fixed Pool Alarm:

Alarm sets off when something with enough weight (8kg) falls in the water. Installed by the pool and alarms at the poolside.

Pool Ramp:

Once installed, swimmers can exit the pool without needing to climb.

Floating Pool Alarm:

Alarm sets off when something with enough weight (8kg) falls in the water. Floats in the water and sets off alarm in the house.

Suction Cover:

Covers the suction vents to avoid body entrapment.

Gate Alarm:

Sounds off when opened.

Bracelet Alarm:

Child wears a bracelet which makes an audible alarm when submerged.

Life Ring:

Swimmer can grab onto sides and independently swim to safety.

Rescue buoy:

Swimmer can grab onto sides and be assisted by another person in the water to swim to safety.

Qualitative Questions:

- What is your occupation?
- Is there anything that you think should be taught more thoroughly about pool safety? Describe.
- Is there any furniture near your fence?
- Do you leave your pool door open at any time?
- How important do you think it is to teach swimming as a life skill?
- Have you ever gone to a holiday accommodation with a pool? If so, what was it like, in terms of safety?
- What swimming skills can your child perform at a competent level? Entering and exiting water unassisted, floating, fully submerging whole body, signaling for help, swimming underneath an obstacle, diving, retrieving an object from deep water, sculling for 5 minutes, swimming continuously for 5, 50 and 400 metres, rescuing another person in the water, provide appropriate first aid care (CPR, calling 000 for help).
- Are there any barriers that prevent your child/ children from reaching certain goals? Please explain any reasonings.
- Have you ever made any renovations or alterations to the pool?
- Has your pool fencing changed in any way since you first moved into your current residence?

Quantitative Questions:

- What age group do you belong to?
- From a scale of no experience to proficient swimmer, how would you describe your swimming ability?
- If you felt unsafe in the pool, how confident would you feel that you would be able to exit safely?
- Is there a fence installed surrounding the pool?
- How experienced are you with swimming?
- How confident would you be to rescue your child if they were drowning in a pool?
- How confident would you be to rescue another adult that was drowning in a pool?
- Take a look at these pool safety products. From this selection, which would you find most useful to improve the safety of your pool?
- How old was your eldest child when you first had a pool at home? (If you had a pool when your eldest was born, please say ‘0’.)
- How confident do feel with how safe your pool is?
- Do you like the idea of having a loud pool alarm?
- Is there any furniture near your fence?
- Do you leave your pool door open at any time?
- How important do you think it is to teach swimming as a life skill?
- Rank these pool alarms based on how much you would be willing to install them (fence alarm, fixed pool alarm, floating alarm).

Questions for Lifeguards:

- How old are you?
- How long have you been a professional lifeguard?
- What does a typical day look like for you?
- Do you look over other waters aside from the pool?
- What equipment do you have available to help swimmers in the water?
- Do you feel as though you are under supplied or missing any equipment?
- Is there any equipment you wish you had? If you're not sure that is ok.
- During busy periods (i.e. school summer holidays), how many weekly rescues do you perform on average? Include all involvement where you play a role in swimmer's safety, no matter how minor.
- If you feel comfortable, can you recall the last time you had to rescue a person from the water?
- What was the cause of the swimmer's distress? Try to detail the steps you took to help that individual.
- Outside of your work, have you personally seen any pools that seemed unsafe? Please tell me more.
- Is there anything that you think should be taught better about pool safety? Please describe.

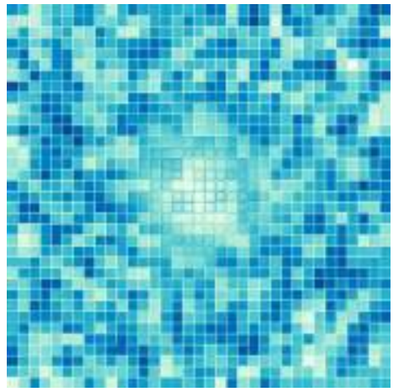
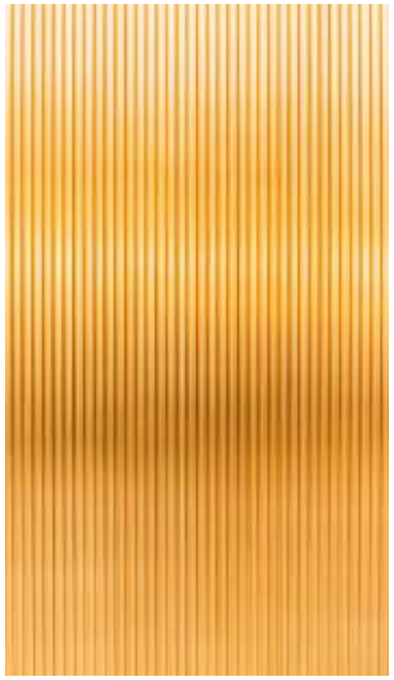
Pool Builder:

- How old are you?
- How long have you worked in the pool building industry?
- What are your primary tasks in your work?
- What would a typical day look like for you?
- Do you also renovate pools that are already built?
- What are the defining stages of a construction project? Which of these parts are you involved in?
- What is done in the construction planning of a pool to make it safer? Including steps, lipped edges to grab onto and ramps are all good examples.
- What are some of the biggest challenges in your line of work?
- Has there ever been an instance where you were confused about how the plans were laid out?
- Outside of your work, have you personally seen any pools that seemed unsafe?
- Is there anything that you think should be taught more thoroughly about pool safety? Describe.

Parent:

- How old are you?
- How old are your children?
- How old was your youngest child when you first had a pool at home?
- What is your occupation?
- What swimming skills can your child perform at a competent level? Entering and exiting water unassisted, floating, fully submerging whole body, signaling for help, swimming underneath an obstacle, diving, retrieving an object from deep water, sculling for 5 minutes, swimming continuously for 5, 50 and 400 metres, rescuing another person in the water, provide appropriate first aid care (CPR, calling 000 for help).
- Are there any barriers that prevent your child/ children from reaching certain goals? Please explain any reasonings.
- Have you ever made any renovations or alterations to the pool?
- Has your pool fencing changed in any way since you first moved into your current residence?
- Have you personally seen any pools that seemed unsafe?
- Is there anything that you think should be taught more thoroughly about pool safety? Describe.



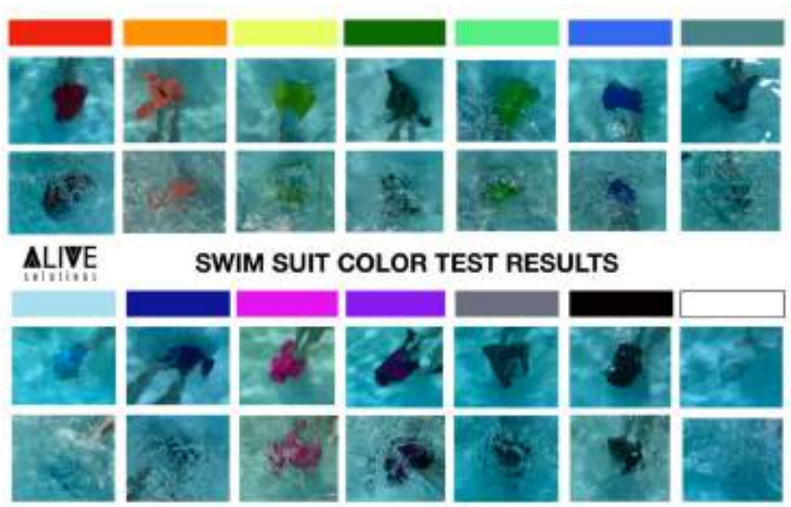



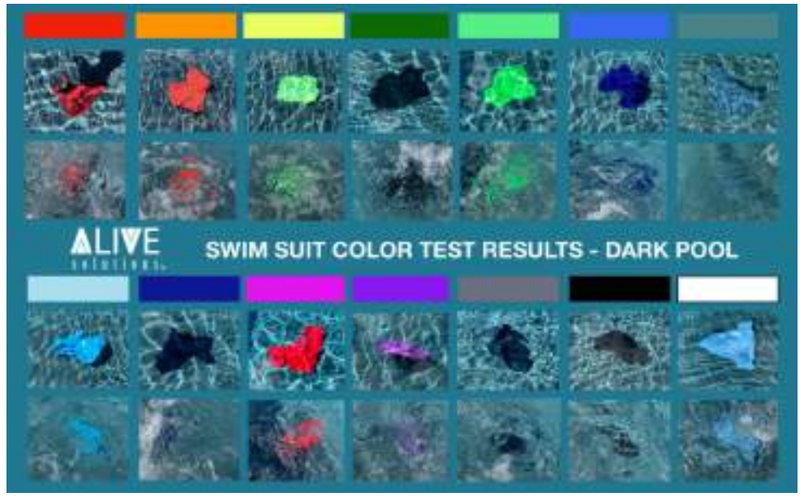


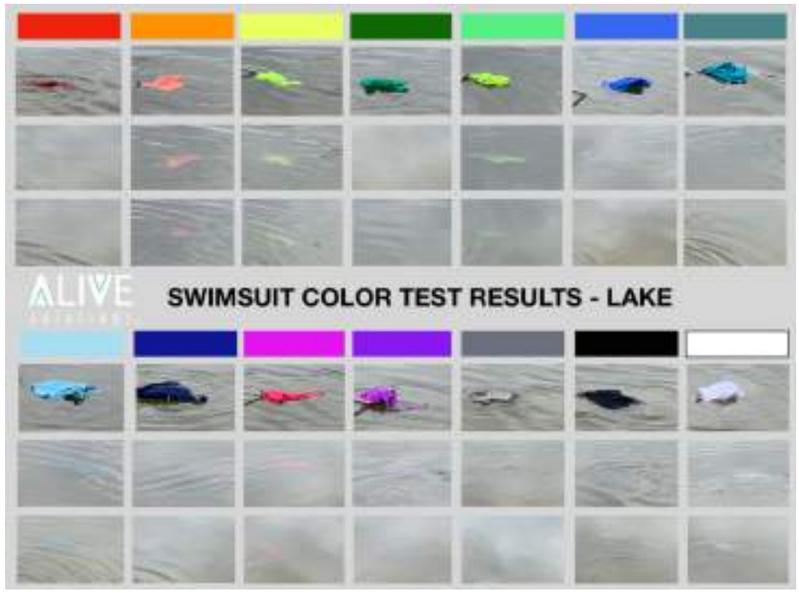




Mapping | Colour Visibility Underwater







These visual graphics clearly show the visibility of different coloured swimsuits underwater in a number of different environments. In all instances, it is clear that vibrant neon colours stand out the most when submerged. Vibrant shades of orange, yellow, green and pink appear most effective. Whites and blues are among the least visible colour choices.

Bringing a vibrant colour scheme to the concept design and its associated branding seems sensible from a water safety perspective. The neon colours should also catch attention on store shelves and in advertising, emphasising safety with a family-friendly evoking colour scheme.

For the lake visibility test, the first row of images show each color on the surface. Second row images were from shore level perspective, and third row are from an elevated perspective similar to standing on a boat or looking at dock view. Neon pink did not perform as well in the lake compared to the pool tests. The study exclaimed that all colours lost visibility when submerged below 2ft.

Brown swimsuits are noticeably missing from these visibility tests. However, as brown does not have visibly vibrant shades to the human eye, it can be safely assumed that it would have poor visibility underwater. Darker colours can easily be dismissed as leaves, dirt or shadow and should be avoided.

It can be observed that the colour can be distorted when submerged underwater. This can have a significant impact in the visibility of certain colours. If a vibrant colour scheme is chosen for the concept branding, a range of colours should be used so it is still recognisable even with colour distortion.

The truth is that swimmers will wear swim suits in a wide variety of colours and shades, which may be incredibly difficult to see underwater. Locating a drowning victim underwater is imperative for their survival.

https://alive-solutions.com/blog/f/buying-swimwearthink-safety

https://alive-solutions.com/f/swim-suit-color-testing-on-a-dark-pool-bottom?blogcategory=Aquatic+Safety

https://alive-solutions.com/water-safety/f/buying-bathing-suits-for-lakes-open-water

Mapping | Colour Visibility Underwater

Another underwater visibility test was done with patterned colours. This time, the test was limited to vibrant or colourful options, ruling out darker shades with low visibility.

Predictably, vibrant neon colours were most visible against a dark water environment. Patterned designs hindered visibility, which will be avoided in the concept design.

https://alive-solutions.com/f/swimsuit-color-and-pattern-testing-results

Field Research | Tourist Drownings

In Australia, three non-fatal incidents occur for every fatal drowning.

It has been established that non-fatal drownings can cause serious brain damage, especially in infants. This highlights that swift reaction to a drowning incident is imperative, when even seconds count in the survival of the victim. Design interventions should reflect this sense of urgency in their function.

Previous research has reported that international visitors represented 4% of drowning deaths in Australia and were five times more likely than residents to experience a non-fatal drowning.

Few public health or injury prevention strategies include visitors as a specific population for safety promotion, currently there is no comprehensive strategy focusing on visitor safety in Australia.

It has also been observed that tourists visiting Australia have a high risk of drowning. This typically stems from a lack of swimming experience and knowledge, which is more prevalent in Australia than many other countries.

This serves as a good reminder that people of all backgrounds and experiences may use the concept product. Relying on text as an important signifier should be completely avoided in the design. Universally recognisable icons are highly effective at communicating functionality to anyone, which will be an important part of the design language for the concept product.

https://www.sciencedirect.com/science/article/pii/S1326020023046277

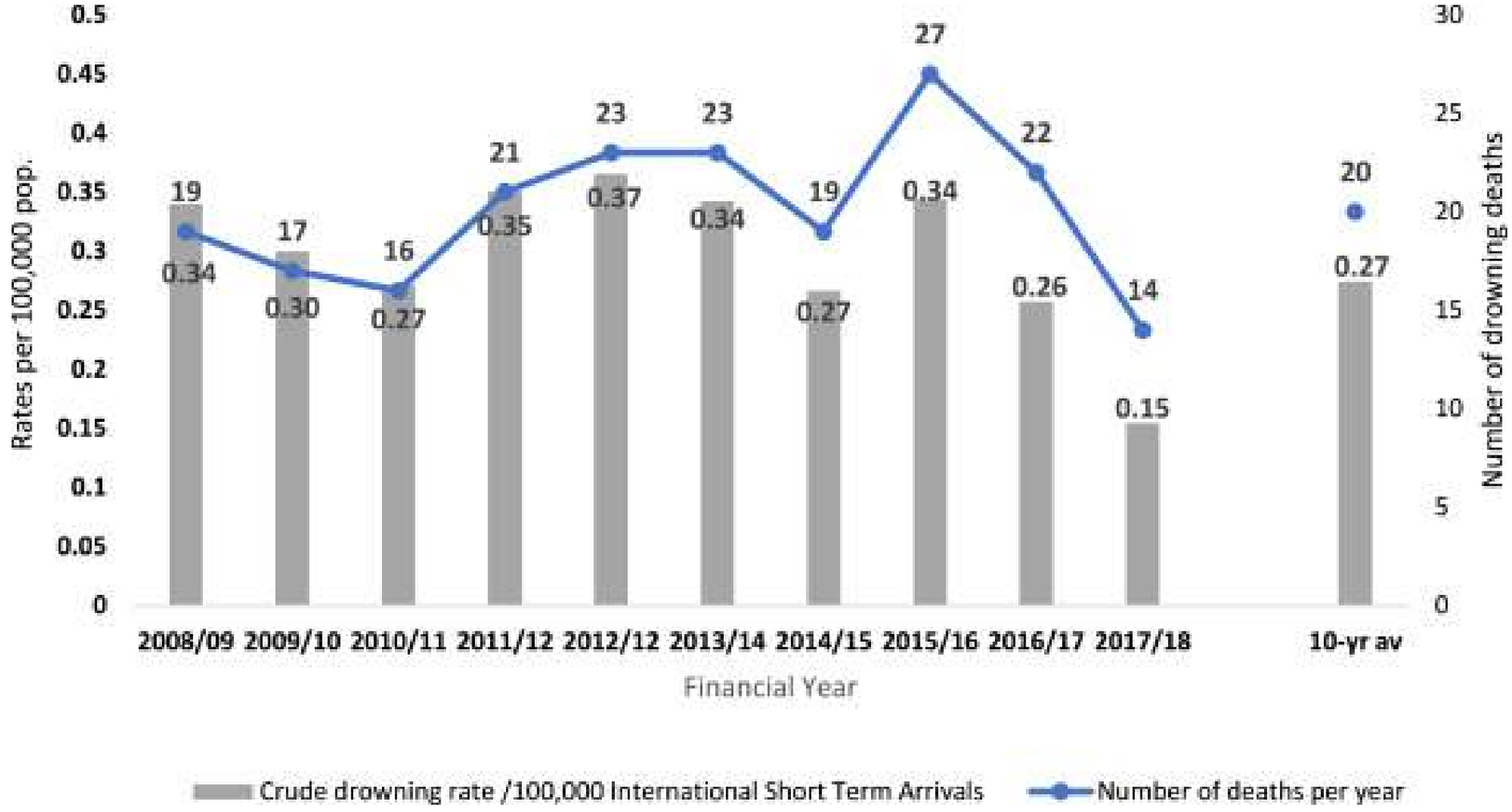


Figure: Number and rate of drowning per 100,000 short-term international visitors in Australia by financial year (2008/09 to 2017/18).

It should also be considered that tourists are another demographic at higher risk of drowning. Between 2008 to 2018, an average of 20 tourists would die from drowning per year in Australia. Almost half of all tourist drowning deaths occurred in Queensland (49.8%). The same source of this figure claims that tourists are also five times more likely to experience a non-fatal drowning compared to residents.

It would be incredible to design a product that could be used to make all water bodies safer for swimmers. These figures reaffirm that the product must be accessible to as many people as possible. Necessary written text instructions should be avoid as much as possible, instead focusing on universal symbols. Familiar affordances and signifiers should also be implemented so anyone who has never seen the product before can have a good idea about what it will do and how to use it at first glance.

Drowning is responsible for approximately 7% of all injury deaths and is ranked the third leading cause of accidental-injury-related death by the World Health Organisation (WHO, Geneva, Switzerland). Globally, an estimated 230,000 people lose their lives to drowning each year, making it a threat to individuals of all age groups.

These are important numbers that clearly highlight how lethal drowning is on a global scale. This source also corroborates with previous sources that infant drownings occur most commonly in pools. To counter this, the concept design should appeal to a wide range of people and save the lives of many.

Drowning is often a silent event, and victims rarely exhibit convulsive movements. Instead, they exert considerable energy to keep their heads above water, often unable to call for help or signal their distress.

Without the intervention of a trained lifeguard, individuals may remain on the water's surface for only 20 to 60 s before submersion occurs. Therefore, locating a missing person in the water is crucial for their survival.

It is important to consider that drowning individuals are unlikely to be able to save themselves. The concept device should be able to intervene and actively help to save the individual.

https://www.mdpi.com/1424-8220/24/2/331

Very Important: The World Health Organisation has highlighted that 92% of drowning incidents occur in low- and middle-income countries. Therefore, the cost-effectiveness and ease of access to drowning prevention technologies are crucial factors in determining their applicability in these regions compared to high-income countries. Sensor-based methods offer a more accessible and affordable option for drowning detection.

This source claims that drowning can be detected through video surveillance in three ways:

(1) A submerged camera to monitor whether the swimmer's body is sunken.

(2) A stationary camera to detect the location of forceful splashes on the water, and a spinning underwater camera to assess the location of the splashes by submerged individuals.

(3) a camera that distinguishes only the drowning characteristics.

Using cameras for drowning detection and prevention could provide an interesting angle for the concept design. A camera alarm was analysed earlier in the product benchmarking for instance. Maybe there could be untapped potential here? I will explore this further.

https://pmc.ncbi.nlm.nih.gov/articles/PMC4151293/

Participation in formal swimming lessons was associated with an 88% reduction in the risk of drowning in the 1- to 4-year-old children, although estimates are imprecise. Regardless, it is clear from this sample that getting young children 1-4 at least familiar with the pool and a few essential swimming skills significantly reduces the risk of drowning incidents occurring.

It could be really beneficial to have a concept design that is educational in nature.

Table 1. Summary of recent methods of drowning detection with advantages and limitations.

Method	Advantages	Limitations
Lifeguard	• Human judgment and experience • Immediate response and rescue capability • Communication and coordination with authorities	• Limited physical endurance and potential for fatigue • Restricted field of view and potential for human error
Video processing-drones	• Aerial view for wide coverage and surveillance • Rapid response and quick deployment • Real-time video feed for situational awareness	• Limited battery life and flight time • Restricted flight regulations and airspace limitations • Vulnerability to environmental conditions (e.g., wind) • Affordability and accessibility in low-to-medium income countries.
Image-processing technology	• Continuous monitoring and real-time data collection • Accuracy and effectiveness in recognising and differentiating drowning incidents. • Customisable thresholds for personalised detection • Underwater drowning detection	• Limited detection range and requires regular maintenance and calibration. • Expensive and complex to implement. • Requiring high-end AI techniques and infrastructure. • Affordability and accessibility in low-to-medium income countries. • Dependence on camera placement and quality
Wearable sensors	• Continuous monitoring and real-time data collection • Cost-effectiveness and wide availability • Customisable thresholds for personalised detection • Easy integration with artificial intelligence system which increases the accuracy. • Affordability and accessibility in low-to-medium income countries.	• Sensitivity to environmental conditions and false alarms • Limited detection range and coverage • Maintenance and calibration requirements • Limited underwater communication

https://www.mdpi.com/1424-8220/24/2/331

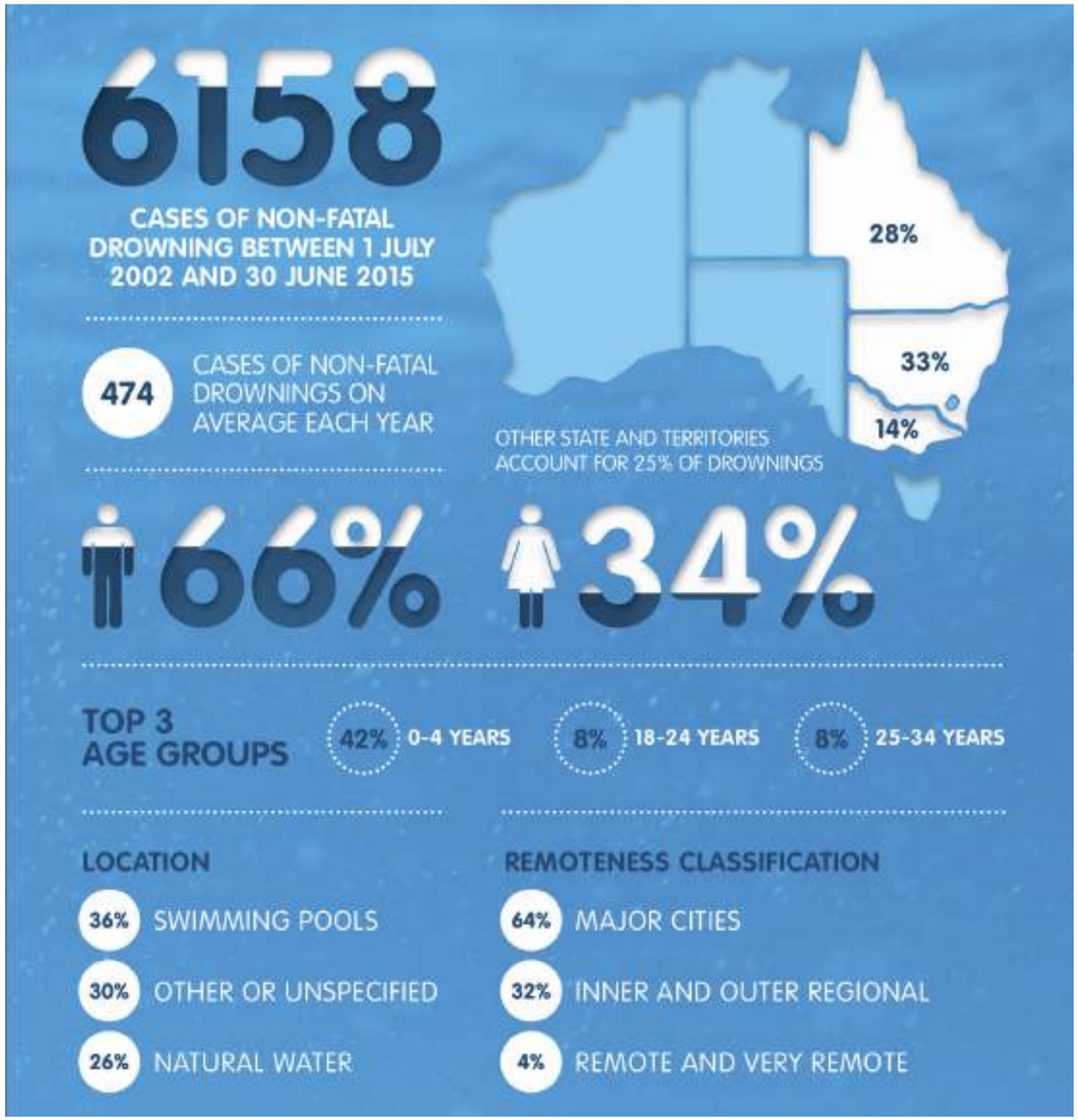
Table 2. Overview of functionality and key limitations of child safety devices for home pools and baths.

Device	Functionality	Limitations
Triaxial accelerometer device for bathtub [89]	• Monitor water wave motion in a bathtub using a triaxial accelerometer. • Identify aberrant wave motion. • Alerts are sent to guardians through radio transmission.	• **Limited to Bathtubs**: Specifically designed for bathtubs, its effectiveness in larger bodies of water like swimming pools needs to be clarified. • **Dependence on Wave Motion Detection**: It may only detect drowning if the water wave motion is sufficiently aberrant. • **Radio Transmission Range**: The effectiveness of alerts depends on the range and reliability of the radio transmission.
WiEyeTNB [93]	• Designed for use in wireless networks at homes or schools. • The water-level detection sensor activates upon contact with water above a predetermined level. • A small, wearable earring sensor is positioned at the same level as a person's mouth. • It includes a central processing unit comprising a low-power microprocessor with modest storage (on-chip and flash memory). • A ZigBee transceiver is used for low-cost wireless communication within the unlicensed RF Industrial, Scientific, and Medical (ISM) bands (Range: 100 m). • Powered by a lightweight, rechargeable, or non-rechargeable battery.	• **Water-Level Detection Limitation**: This relies on water reaching a certain level; it may not detect if a child enters the water without significantly raising the level. • **Wearable Sensor Challenges**: As an earring, it may need to be consistently worn or removed, reducing its effectiveness. • **Limited Communication Range**: Utilises ZigBee with a 100 m range, which might not cover more significant properties or distances. • **Battery Dependency**: The need for regular battery recharge or replacement could lead to lapses in monitoring.
Safety Turtle Pool Alarm [94], Water Patrol Child Guard [95]	• Features a house-based base station and a wristband worn by children. • The product is sealed and sturdy enough to endure children's play. • The wristband detects water immersion immediately and sends a radio signal to the base station, triggering a loud alarm. • A single base station supports multiple wristbands. • The alert system distinguishes between immersion and incidental contact with precipitation or sprinkler mist.	• **Immersion Detection**: While immediate, it may not detect scenarios where a child is in danger without being fully immersed. • **Wristband Design**: The effectiveness depends on the child consistently wearing the wristband. • **Signal Interference**: Although it can ignore precipitation, other interference might affect the functionality of the alarm. • **Single Base Station Limitation**: While it can connect to multiple wristbands, the single base station might have limited coverage for larger areas.

Highlighted above are specific statistics relating to child drownings in Australia. The most concerning statistic shown is that 78% of drownings involved falling into the water. Falling near water is highly risky, and there can be other minor or major injuries at play alongside drowning risks.

53% of drowning incidents occurred at a swimming pool, and it has been estimated that 42% of all non-fatal drowning incidents involved children. This reaffirms that designing a safety device primarily for pool use will have greater benefits over other waters. The fatal to non-fatal drowning ratio also stresses that there are many more non-fatal incidents. This means that a device that can actively prevent entry into the water will be more beneficial, as it will minimise the risks of drownings occurring.

https://www.watersafety.com.au/australian-water-safety-strategy/



https://www.royallifesaving.com.au/__data/assets/pdf_file/0016/37312/3985_v4_RLS_NonFatalSymposium_ReportHR_PROOF_LR.pdf

	Number of incidents		Ratio	
Year	Fatal	Non-fatal	Fatal	Non-fatal
2002/03	192	394	1	2.05
2003/04	176	460	1	2.61
2004/05	164	436	1	2.65
2005/06	176	466	1	2.64
2006/07	167	462	1	2.77
2007/08	157	423	1	2.70
2008/09	180	450	1	2.49
2009/10	181	511	1	2.82
2010/11	165	474	1	2.87
2011/12	162	447	1	2.76
2012/13	179	526	1	2.93
2013/14	158	548	1	3.47
2014/15	159	561	1	3.53
Total	**2217**	**6158**	**1**	**2.78**

Table 3: Fatal and non-fatal drowning by financial year with ratios, 2002/03 to 2014/15

In a report by the Royal Lifesaving club, they scoped out figures for projected numbers of fatal to non-fatal drownings. The projected ratio is much lower than that found on the previous page. However, this source only considers recorded incidents, whereas the previous was estimated.

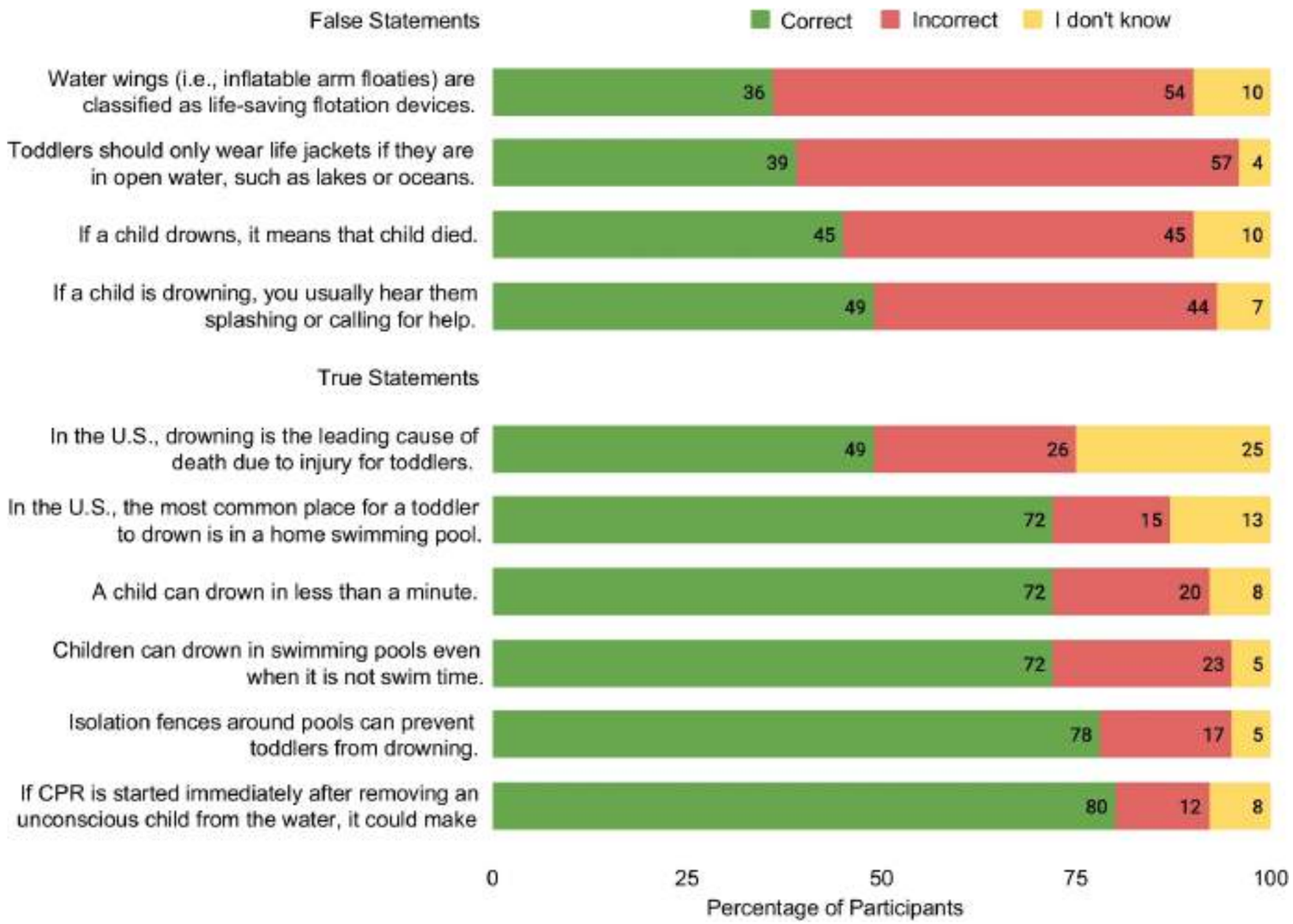
This source corroborates that swimming pools are the most common location for non-fatal drownings and mostly occur in major cities. This may be skewed due to higher population density, but still proves important to consider. It is also observed that infants 0-4 are at a significantly higher risk than other age groups. These findings further solidify that designing a device marketed towards parents with young children for drowning prevention in pools will be the most effective market.

Field Research | Parent Perceptions Around Pool Safety

An online survey of 650 parents/caregivers of 1–4-year-old toddlers. On average, caregivers selected the correct answer on six out of ten water safety knowledge questions. One third of caregivers believed that after a toddler has had swimming lessons, they don't need to be watched as closely when they are in a pool.

Findings suggest that water safety knowledge is poor and that there are misconceptions about toddler supervision needs. Only 6% of participants responded correctly to all 10 knowledge questions.

Participants were most knowledgeable about the usefulness of CPR as a first response for drowning and least knowledgeable about what counts as flotation device.



The survey also reveals the common misconception that drowning is only defined as such in the event of death (Caregiver water safety knowledge and views of toddler water competency | Injury Epidemiology | Full Text). Drowning is defined when respiration is impaired due to submersion in liquid. In Australia, three non-fatal incidents occur for every fatal drowning (The characteristics of drowning among different types of international visitors to Australia and how this contributes to their drowning risk - ScienceDirect). Statistics are scarce on non-fatal drownings as incidents are rarely shared. However, reports have indicated that 35.6% of non-fatal incidents occurred in swimming pools.

Only 36% of participants accurately identified that swimming wings are not life-saving flotation devices. It can be argued argue that people are misled by their assumptions about flotation devices. If I make a concept that seems like it should float, I should make the utmost priority to make it constitute as a life-saving piece of equipment as to not mislead anyone.

https://injepijournal.biomedcentral.com/articles/10.1186/s40621-023-00479-w

Field Research | Dangers of Drowning Incidents

Slipping and falling into the pool is a very big risk that factors into fatal drownings. In Australia, 78% of fatal drownings involve a fall (Australian Water Safety Strategy – Australian Water Safety Council). If a fall is involved, the victim is most likely not expecting to enter the water, which can make them more panicked.

In a state of panic, drowning victims respond by attempting to keep their head out of the water, grabbing onto what they can. A life-saving flotation device is most likely to help a drowning individual lift themselves out for air followed by pool railing and ledges. Bystanders should not get too close to the drowning individual as they will likely pull the rescuer under the water in an attempt to breathe air.

Non-slip pool mats are an effective preventative measure against accidental slipping. These are usually made from a highly water-resistant material with rubbery, ribbed texture such as Polyvinyl Chloride. These are incredibly common in public pool centres and also as bath/shower mats for home use. Mandating non-slip mats around a pool could have a positive influence in reducing the number of slips and accidental entries into the water, which are the overwhelming leading cause to fatal drowning.

Drowning is a leading cause of brain injury in children. Long-term outcome data for drowning survivors are sparse. Coma was the most common admission status for drowning victims who were hospitalised.

Response time to drowning incidents is imperative, especially for younger children who will be more susceptible to brain damage. It is extremely important that the concept device has an active role in drowning prevention to minimise the chances of drowning.

https://www.sciencedirect.com/science/article/abs/pii/S0887899423003910

It is often overlooked that drowning survivors can suffer long-term health effects. It is known that permanent damage to the brain is the most severe damage that drowning victims suffer, as the brain is cut off from needed oxygen (Brain Resuscitation in the Drowning Victim | Neurocritical Care).

Unfortunately, drowning is also the leading cause of brain injury in children, with impacts including motor impairment and falling into a coma. (Long-Term Neurocognitive Outcomes in Pediatric Nonfatal Drowning: Results of a Family Caregiver Survey - ScienceDirect). Observing the severe long-term effects of drowning survivors highlights that the most effective method of drowning prevention is to minimise the risk of a drowning occurring in the first instance.

In short, design solutions should be focused around prevention of pool entry instead of rescuing drowning individuals. Both products are equally important to exist, though the former will actively aid to eliminate drowning risks altogether.

The greatest permanent harm in drowning accidents is to the brain. Data on non-fatal drownings are difficult to obtain. The circumstances of these events can be complex, making it difficult to extract data from hospitals and other sources.

The fact that the brain endures the most harm in drowning further emphasises that drowning victims will be in an unfit state to rescue themselves in the water. The concept device should be able to actively help an individual who is at risk of drowning.

https://link.springer.com/article/10.1007/s12028-012-9747-4

Benchmarking | Lifesaving Flotation Equipment

Image	Name	Retail Price	Important Notes:	Link
	**SLSA Water Tube**	$120.00AUD	A soft, flexible tube made with closed cell plastic foam. Lanyard and rope already attached (lanyard and rope available separately if required). Must be a vibrant shade of yellow, orange or red. Consideration could be given to: The word "RESCUE' in bold letters on the body of the tube and the date of manufacture. The Rescue Tube is to have a minimum buoyancy factor of 100 newtons in freshwater. Design and Manufacture of Rescue Tubes- Shipfield Safety Device Part of the official Surf Life Saving Australia's equipment supply list: SLSA-Gear-and-Equipment-List-2023-24.pdf	A Rescue Tube - Surf Life Saving Australia Online Store
	**Ardeno Rescue Float**	$70.00AUD	A solid hard injection moulded rescue buoy made of HDPE with Nylon strap.	Adreno Rescue Float - Adreno - Ocean Outfitters
	**RWB SOLAS Approved Lifebuoy 720mm**	$109.00AUD	Tough Polyethylene Outer Shell with White Poly Rope, Foam Filled for Buoyancy, Includes Retro-Reflective Patches	RWB SOLAS Approved Lifebuoy 720mm | BCF
	**BLA Horseshoe Buoy**	$150.00AUD	The BLA Horseshoe Lifebuoy is constructed with a flexible closed-cell foam inner and a polyurethane zip removable cover. It features a full circumference cord with quick release hooks, reflective tape patches, and pockets for storing drogue and danbuoy lines, complying with AYF requirements.	BLA Horseshoe Lifebuoy | BCF
	**Burke Retriever Float Rescue Sling and Stowbag**	RRP: $229.00AUD Sale Price: $176.50	45 metres of 8mm floating retrieval rope 195 Newtons Buoyancy	Burke Retriever Float Lifesling and Stowbag (RETZ27) | Boat Warehouse
	**Restube Lifeguard**	$273.00AUD	Inflatable rescue tube that fits into a compact hip mounted bag. Inflates when triggered with a CO2 cartridge, which can be replaced. Also includes reflectors for enhanced visibility. Buoyancy 75N.	Restube lifeguard - Self-inflating rescue tube for water rescue professionals | RESTUBE

Category	SLSA Water Tube	Ardeno Rescue Float	RWB SOLAS Approved Lifebuoy 720mm	BLA Horseshoe Buoy	Burke Retriever Float Rescue Sling and Stowbag	Restube Lifeguard
Price	$120.00AUD	$70.00AUD	$109.00AUD	$150.00AUD	RRP: $229.00AUD Sale: $176.50	$273.00AUD
Percieved Quality	**6**	**5**	**6**	**6**	**6**	**7**
Visibility Under or Near Water	**7**	**7**	**7**	**7**	**7**	**7**
Portability	**5**	**5**	**3**	**4**	**6**	**7**

Portability (High)

Standalone flotation devices are already affordable and easy to use at a moments notice.

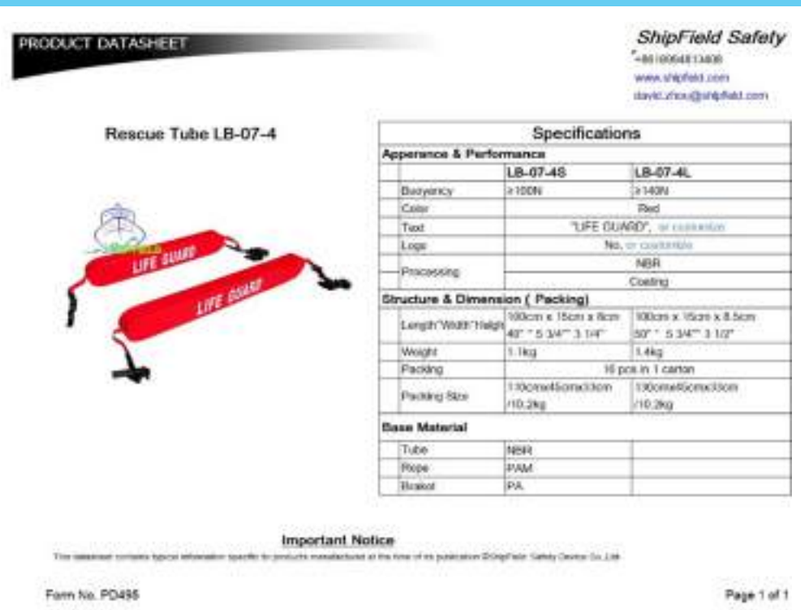
Price (Low)

Price (High)

All lifesaving flotation equipment uses vibrant yellow or orange shades. This enhances their visibility in the water, which was shown in the colour visibility tests earlier.

Portability (Low)

Field Research | Flotation Device Manufacturing Insights



PRODUCT DATASHEET

ShipField Safety
+8618994814119/18994813408
www.shipfield.com
david.zhou@shipfield.com

Rescue Tube LB-07-4

Specifications			
Apperance & Performance			
		LB-07-4S	LB-07-4L
	Buoyancy	≥100N	≥140N
	Color	Red	
	Text	"LIFE GUARD", or customize	
	Logo	No, or customize	
	Processing	NBR	
		Coating	
Structure & Dimension (Packing)			
	Length*Width*Height	100cm x 15cm x 8cm 40" * 5 3/4"* 3 1/4"	100cm x 15cm x 8.5cm 50" * 5 3/4"* 3 1/2"
	Weight	1.1kg	1.4kg
	Packing	16 pcs in 1 carton	
	Packing Size	110cmx65cmx33cm /10.2kg	130cmx65cmx33cm /10.2kg
Base Material			
	Tube	NBR	
	Rope	PAM	
	Braket	PA	

Important Notice

This datasheet contains typical information specific to products manufactured at the time of its publication ©ShipField Safety Device Co.,Ltd

Form No. PD495

Page 1 of 1

PRODUCT DATASHEET

ShipField Safety
+8618994814119/18994813408
www.shipfield.com
peter.chen@shipfield.com
david.zhou@shipfield.com

Torpedo Rescue bouy LB-03-7

Specifications

Performance

Color	Orange
Buoyancy (kg)	160 N
Attached Lines	1

Structure & Dimension(Packing)

Out Diameter	710mm*430mm/27"L x 9"W
Thickness	345mm/5.5" H
Weight	1.9 kg

Base Material

Inner Blad	Foam inside
Outer Shell	High Density Polyethylene

Accessories Optional

Bracket	steel/Stainless 201/304/316
Rescue Line	220mm, 5mm in diameter
Lanyard	50mm in width

I was able to find a Chinese manufacturer of lifesaving flotation devices, which provided some useful manufacturing insights. The choice of materials between products is important to note, as the concept device may end up floating in the water.

https://www.shipfield.com/

PRODUCT DATASHEET

ShipField Safety
+8618994814119/18994813408
www.shipfield.com
david.zhou@shipfield.com

Rescue Tube LB-07-2

Specifications

Apperance & Performance

Buoyancy	≥100N	
Color	Yellow/Orange	Customize (Qty>200pcs)
Text	"Rescue"	Customize (Qty>200pcs)
Logo	No	Customize (Qty>200pcs)
Processing Know-hows	Mold Hot Pressed XPE pre-treating	
Strength (Stress) longitudinal	1000 pounds(454kg)	

Structure & Dimension (Packing)

Length*Width*Height	94cm x 14cm x 8.5cm 37" * 5 3/4"* 3 1/2"	
Weight	1.0kg	
Packing	10 pcs in 1 carton	Customize
Packing Size	100cmx45cmx33cm/10.2kg	

Base Material

Tube	XPE
Rope	PAM
Strap	PES

2019 New Features Description

1.Constructed with a new performance foam technology that boosts strength and resilience.
2. Bright, light weight and "RESCUE" embossed.
3. Stainless steel clip and rings for secure "wrap'n'snap" around victim or manikin.
4. Braided orange leash with high quality shoulder strap designed for comfort and durability.
5. Length: 37" Width: 5 3/4" Height: 3 1/2"
6. Ideal for indoor and outdoor lifeguarding in any aquatic setting

Inner 3 layers of straps combined

Regulation Accomplishment

1. Comply with International Life Saving Federation (ILS) specifications for lifesaving sport competition
2. Material to be as specified in Australian Standard AS 2259

Important Notice

This datasheet contains typical information specific to products manufactured at the time of its publication ©ShipField Safety Device Co.,Ltd
Contents herein do not constitute a warranty

Form No. PD290

Page 1 of 1

PRODUCT DATASHEET

ShipField Safety
+8618994814119/18994813408
www.shipfield.com
peter.chen@shipfield.com
david.zhou@shipfield.com

2.5kg life buoy ring LB-03

Specifications

Performance

Color	Orange
Buoyancy (kg)	14.5
Night visible	4 Reflective tapes
Attached Lines	4

Structure & Dimension(Packing)

Out Diameter	710mm
Inner Diameter	440mm
Weight	2.5KG

Base Material

Inner Blad	Polyurethane foam
Outer Shell	High Density Polyethylene

Certification Optional(CoC reports)

EC	☐ LB-03-3
CCS	☐ LB-03-2
Not available	☐ Economic Type LB-03

Accessories Optional

Bracket	☐steel/Stainless 201/304/316
Rescue Line	☐30m/45m 8mm in diameter
Lamp	☐

Application & Features

1. Marine Ship/Vessel Safety system mandatory equipped
2. Lifeguard aids nearby seashore/river/lake/bank/bridges
2. Both for water entertainment and commercial usage.
3. Features a rigid cross - linked polyethylene outer shell.
4. Inner polyurethane foam.
5. For Rigid using at extreme weather conditions
6.It is antioxidant and anti-aging.

A sample of product sheets for various lifesaving equipment are shown on this page. These give a brief, coherent overview of the product's functionality, dimensions and material choices. Moving into deeper refinement of the concept device, it will be important to develop information sheets similar to these to pitch to potential manufacturing stakeholders. These will provide a good reference point for items to include in the bill of materials and specifications of the product once the final design has been selected.

Field Research | Goals and Challenges for Swimming Ability in Children

Every Australian at the age of 6 years should be able to:

- Identify rules for safe behaviour at aquatic environments at or near the home
- Enter and exit shallow water unassisted
- Float and recover to a standing or secure position
- Move continuously for 5 metres
- Submerge the body and move through an obstacle
- Identify people and actions to help in an aquatic emergency
- Perform a survival sequence to simulate an accidental entry

Every Australian at the age of 12 years should be able to:

- Understand and respect safety rules for a range of aquatic environments
- Enter and exit the water for a range of environments
- Float, scull or tread water for 2 minutes and signal for help
- Swim continuously for 50 metres
- Surface dive, swim underwater and search to recover an object from deep water
- Respond to an emergency and perform a primary assessment
- Rescue a person using a non-swimming rescue technique with non-rigid aids
- Perform a survival sequence wearing light clothing

50% of all Australians at the age of 17 years should be able to:

- Understand behaviours that affect personal safety in aquatic environments and activities
- Assist others to exit deep water using bystanders
- Float, scull or tread water for 5 minutes and signal for help
- Swim continuously for 400 metres
- Search in a deep water environment and recover a person
- Respond to an emergency and provide first aid
- Rescue an unconscious person in deep water
- Perform a survival sequence wearing heavy clothing

KEY INSIGHTS: STATUS OF CHILDREN'S SWIMMING AND WATER SAFETY SKILLS

TEACHERS PERCEIVE THAT:

- **48%** of year 6 students cannot swim 50 metres and tread water for 2 minutes.
- **40%** of year 7-10 students cannot achieve the National Benchmark for primary school students.
- **After year 7** there is little improvement in swimming ability.
- **84%** of year 10 students cannot swim 400 metres, the National Benchmark for 17 years.

TEACHERS REPORT THAT:

- **7.5 hours** is the median time allocated by schools to learn-to-swim programs.
- **31%** of schools do not offer a learn to swim program.

The three top reasons for schools not offering a learn to swim program are:

- **54%** cost of lessons
- **48%** limited staff resources or capability
- **36%** lack of time

- **One in four** schools do not conduct a school swimming carnival.
- **55%** indicated that low swimming skills of students are a leading reason for not conducting swimming carnival.

PARENTS PERCEIVE THAT:

- **46%** of children aged 11-12 years (year 5 & 6) cannot swim 50 metres.
- **8%** of children aged 11-12 years cannot float or tread water for 2 minutes.
- **46%** of children aged 7-14 years cannot achieve the National Benchmark for 6 years (of this 13% are aged 11-14 years)

PARENTS REPORT THAT:

- **One in ten** children aged 5-14 years have never attended swimming lessons
- The majority being from low socio-economic backgrounds and those living in regional locations
- **33%** of children stop lessons between ages 7-9 years.
- **59%** of children first enrol in formal swim lessons between 0-3 years old.

Types of swimming lessons school-aged children are attending

- **60%** of kids attend weekly group lessons outside of school hours
- **36%** attend swimming lessons during school hours

The goals outlined (shown left) are guidelines set by the Royal Lifesaving Society for Australian children to meet at certain ages. Unfortunately, these goals are far from being achieved nationwide. The statistics above highlight some of the biggest challenges that prevent children from developing their swimming ability.

While 59% of children start swimming lessons before age three, most stop between ages 7-9, often before learning critical lifesaving skills that could protect them from drowning as teenagers and adults. Concluding lessons this early will only teach children rudimentary swim safety skills, preventing them the time needed to develop skills to meet the 12yo and 17yo threshold goals.

Swim education programs organised by schools often cite that they cannot provide lessons due to prohibitive costs. This suggests that the concept device should be affordable, as swim education is seen as prohibitive for many.

https://www.royallifesaving.com.au/educate-participate/swimming/national-swimming-and-water-safety-framework

https://www.royallifesaving.com.au/__data/assets/pdf_file/0010/89956/RLS_ChildrensWaterSafetySkills_Report25_V2.pdf

The Royal Lifesaving Society Australia has extensive strategies for people to carry out successful rescues from the water. The strategies below are a good frame of reference for personal safety and could be used for inspiration for the functionality of the concept device.

The rescuer should consider:

- *Can I talk to the person, calming them down and directing them to a safer location?*
- *Is there something on hand that I could use to reach the person, such as a rope, stick, or towel?*
- *Is there something I could throw to the person to aid their buoyancy, such as a lifejacket, kickboard, or esky (cooler) lid?*
- *Can I wade out to the person and then reach out to give them a rope, stick or towel to pull them to safety?*
- *Is there a canoe or something similar I can row out and have them hold on to?*
- *Can I swim out to them and, while keeping a safe distance, pass them a buoyancy aid and accompany them to safety, encouraging and instructing them?*
- *Can I swim out to them and, while keeping a safe distance, hand them a buoyancy aid and tow them back to safety? (non-contact tow)*
- *If all else has failed, do I know how to perform a contact tow to get them back to safety? Do I have the strength, skill and fitness to do this while ensuring my own safety is the number one priority? Am I capable of dealing with a panicked person wanting to grab hold of me?*

https://www.royallifesaving.com.au/stay-safe-active/in-an-emergency/how-to-carry-out-a-rescue-safely

This study paper records the accounts of 4914 adults attending swimming lessons in Australia. The conducted study with inexperienced adult swimmers specifically referred to the Royal Lifesaving Society goals on the previous page to track and measure key milestones. At their final assessment, 69% could swim at least 5 m (6-year-old benchmark), and 8% could swim 50 m continuously (12-year-old benchmark). This makes a clear statement that it is much harder to build swimming skills at a later age.

https://onlinelibrary.wiley.com/doi/full/10.1002/hpja.70010

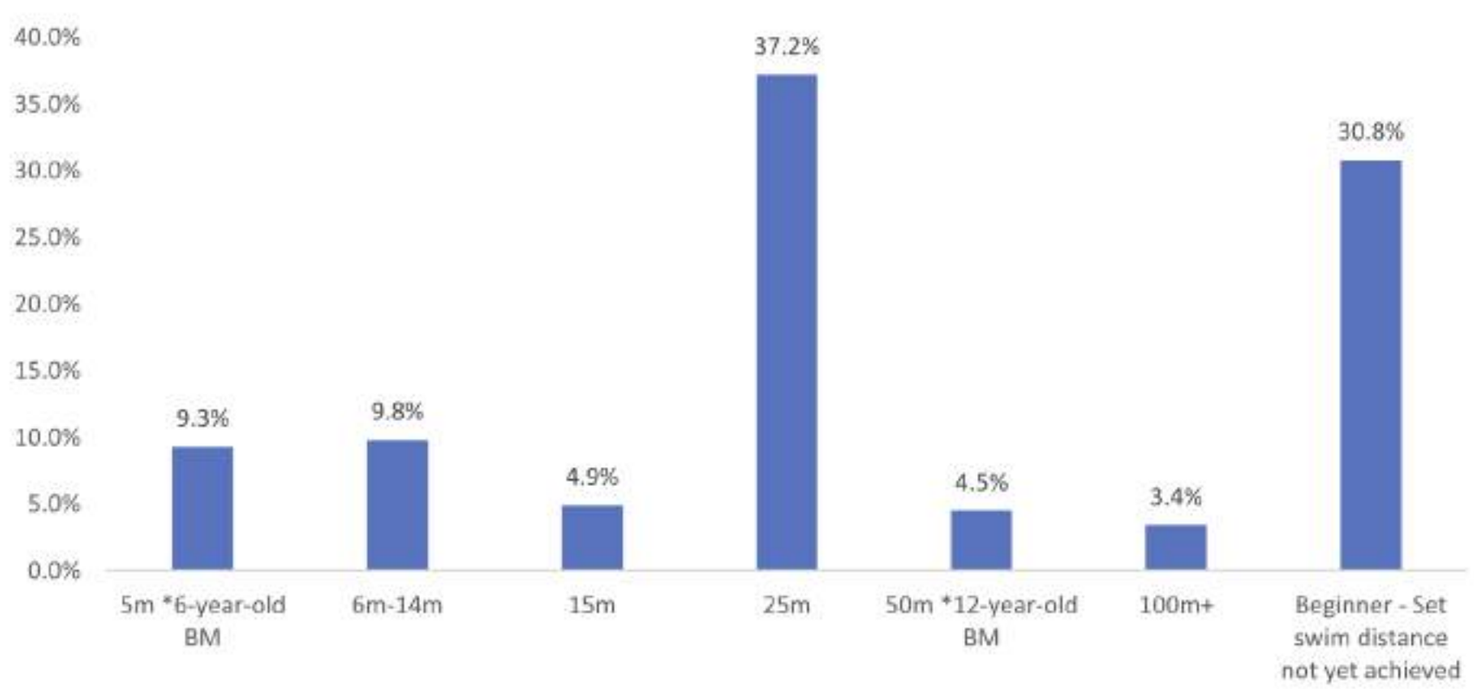
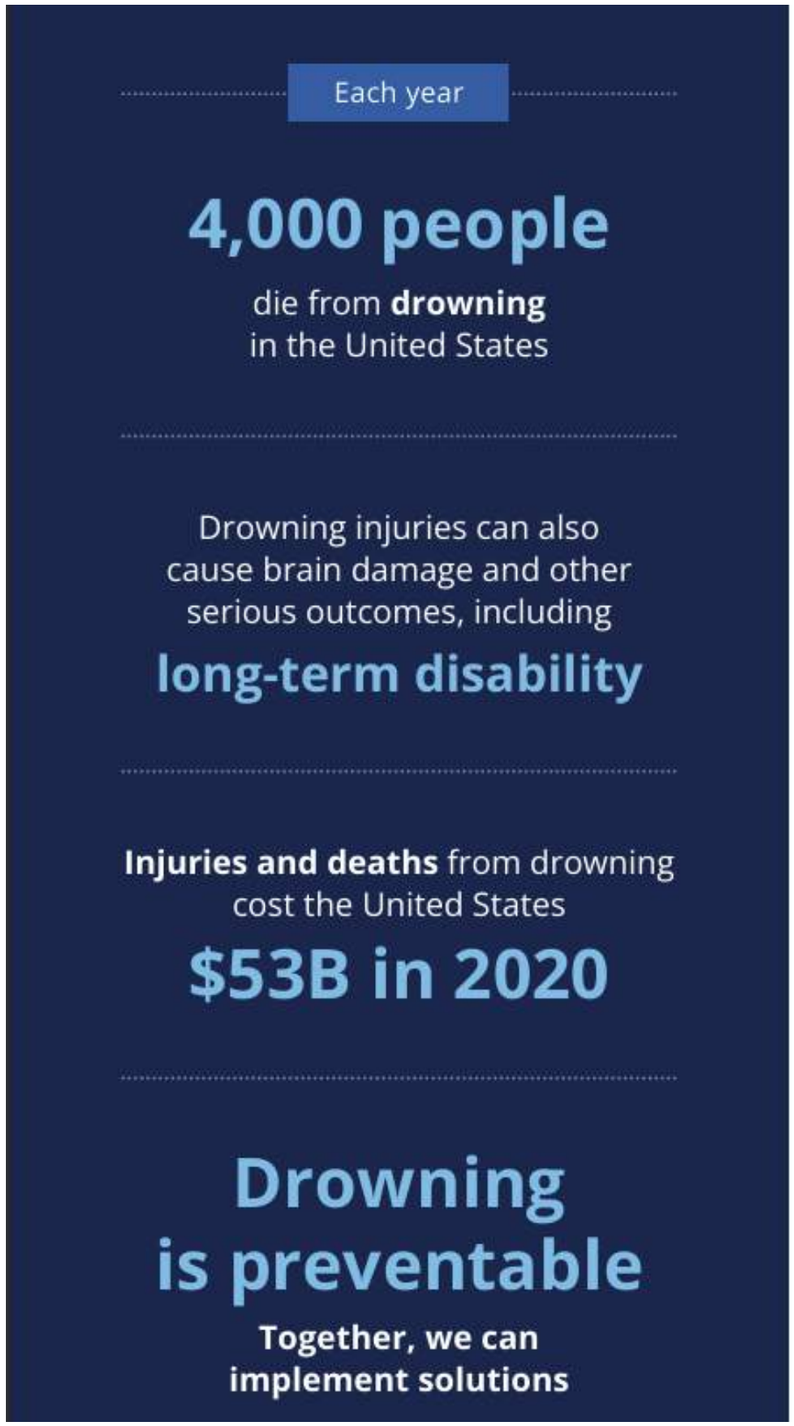


FIGURE 1 | Swimming distance being achieved by adults in swimming lessons at their final assessment.



The consequent costs of drowning incidents is staggering, eating into the economy under unfortunate circumstances. If a device can be made that can prevent drownings, it can have a role to prevent funnelling billions of dollars recovering from preventable drownings.

https://www.cdc.gov/drowning/pdf/CDC-DIP_At-a-Glance_Drowning_508.pdf

Fortunately, childhood unintentional drowning fatality rates [in the US] have decreased steadily from 2.68 per 100 000 in 1985 to 1.09 per 100 000 in 2018.

This report helps affirm that tightening safety regulations and promoting swimming education has had a positive effect within recent decades. Devices that can help to actively prevent drowning will undoubtedly have a positive influence.

Often, a fence law pertains only to new pool construction or to homes in which a young child is actually living at the time of the pool installation. Furthermore, in the United States, pool fences are rarely inspected and ordinances are often not enforced.

This reaffirms that pool safety laws are not as strict in most other countries. This can present a serious risk and barrier for tourists who may otherwise be interested in an accommodation with a pool. The concept device should appeal to a global market and be easy to install to ensure success.

https://publications.aap.org/pediatrics/article/148/2/e2021052227/179784/Prevention-of-Drowning

Most infants drown in bathtubs and buckets, whereas the majority of preschool-aged children drown in swimming pools. Older children and adolescents are more likely to drown in natural bodies of water.

The most common waters for drownings vary depending on age. This source corroborates that younger children typically drowning in swimming pools while older demographics (above 10) are at greater risk in natural bodies of water.

Approximately 15% to 30% of caregivers have reported leaving their children younger than 2 years unsupervised in the bath for a period ranging from 1 minute to slightly over 5 minutes. The caregivers were distracted by a phone, getting diapers or clothes for the child, or completing household chores.

These findings corroborate with previous studies that conclude that caregiver supervision is not as strong as it should be. People are susceptible to being distracted, which suggests a need for constant supervision even when there are other important tasks at hand.

Unfortunately, many parents and pool and spa owners are not aware of the risk of entrapment and entanglement; only 15% have installed antivortex drain covers, only 14% have multiple drain systems, and only 12% have SVRSs in their pools or spas.

A lack of knowledge and intervention around entrapment hazards is a significant lapse in pool safety. Children are at much greater risk with typically weaker strength and smaller statures. Promotion of entrapment safety measures could be a good angle to approach for the concept device.

In a recent Australian study, researchers found that government inspections raised the rate of compliance with pool fencing laws from approximately 50% to 97%. Another study from Australia revealed that in the 5 years after enactment of legislation to improve the effectiveness of pool fencing, the number of private swimming pool drowning deaths halved.

Enforced pool safety laws have a very positive influence in drowning prevention. Where possible, global stakeholders should be encouraged to follow these interventions.

Retractable pool covers and pool nets capable of holding the weight of a child have been advertised as effective barriers for drowning prevention. Because these covers must be removed and replaced each time the pool is used, they are less likely to be effective. ***Active interventions requiring an action each time they are to be used are proven to be less effective than passive interventions, which are always in effect.***

Alarms should not be relied on as a substitute for supervision or a barrier completely surrounding the pool. Alarms should be distinct from other noises in the house and have an automatic resetting feature. This means a pool alarm should not sound similar to a fire alarm, evacuation alarm, common phone alarm or any other type of audible alarm.

The figure pictured corroborates that ages 0-4, especially 1-2 are at greater risk in drowning incidents. Since very young children are most commonly affected, prevention should be geared towards parents, especially new parents.

Unintentional Drowning Deaths, United States, 2014–2018

Age Group, y	Average Annual (Crude Rate No. Deaths Per 100 000)		
	Boys	Girls	Total[a]
<1	19 (0.93)	17 (0.90)	36 (0.91)
1–2	175 (4.32)	93 (2.40)	269 (3.38)
3–4	104 (2.55)	41 (1.05)	145 (1.81)
0–4	298 (2.93)	152 (1.56)	450 (2.26)
5–9	95 (0.91)	36 (0.36)	131 (0.64)
10–14	71 (0.68)	27 (0.26)	98 (0.47)
15–19	205 (1.90)	21 (0.21)	226 (1.07)
0–19	670 (1.60)	236 (0.59)	906 (1.10)

Source: Centers for Disease Control and Prevention Web-based Injury Statistics Query and Reporting System.

https://publications.aap.org/pediatrics/article/148/2/e2021052227/179784/Prevention-of-Drowning

Field Research | Conceptual Wristband Model

- *Phase 1: Victim recognizes the danger and starts to panic. The victim's mouth sinks below the surface of the water and then reappears as they try to breathe. Arms will be at water surface making random grasping or flipping motions.*

Some victims could experience hyperventilation which is rapid or deep breathing caused by anxiety.

- *Phase 2: The person experiences an increase in heart rate. As a defense mechanism the human body triggers laryngospasm by closing the epiglottis over the wind pipe i.e., trachea. By this mechanism the human body prevents water from entering the lungs. However, this also shuts the flow of oxygen into the body.*
- *Phase 3: Generally, adults can hold their breath for only 30 seconds while it is even lesser for kids at 21 seconds. Beyond this time frame the victim's body starts to experience hypoxia. Hypoxia is a condition where the blood does not carry enough oxygen to the tissues.*
- *Phase 4: Oxygen level drops further leading to anoxia which is severe hypoxia. The person loses consciousness and starts to sink to the bottom of the pool.*
- *Phase 5: Several minutes past losing consciousness, without medical help the victim's brain dies and the victim passes away.*

It is very essential to identify and revive a drowning person within the third phase as the chances of full recovery is very slim beyond that phase.

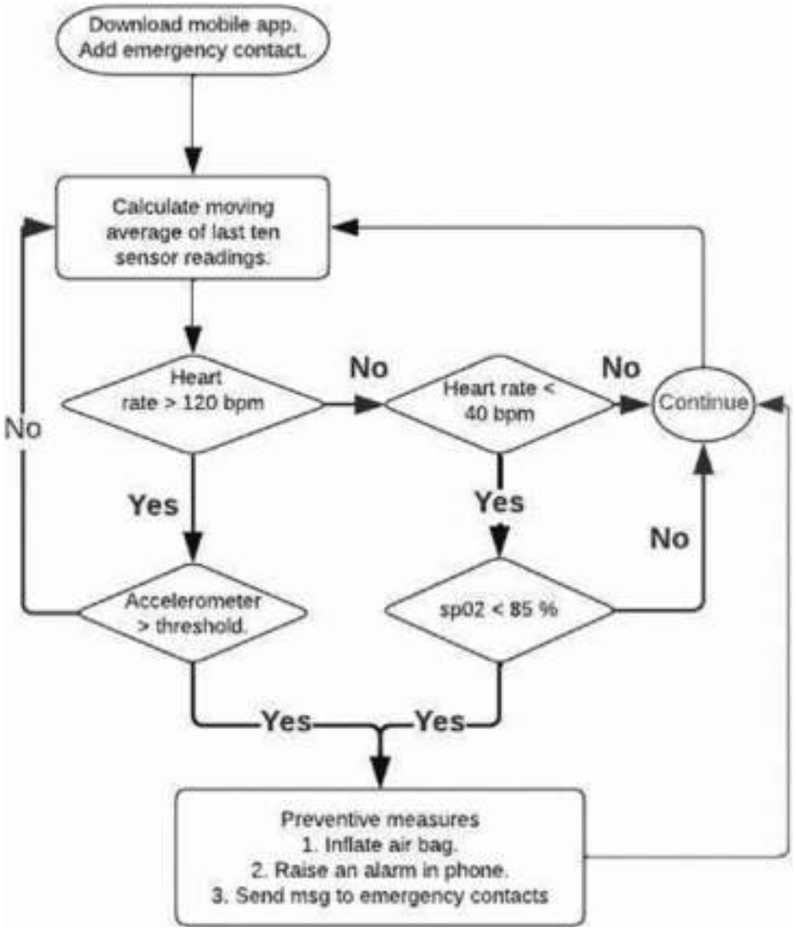
https://ieeexplore.ieee.org/abstract/document/10040336

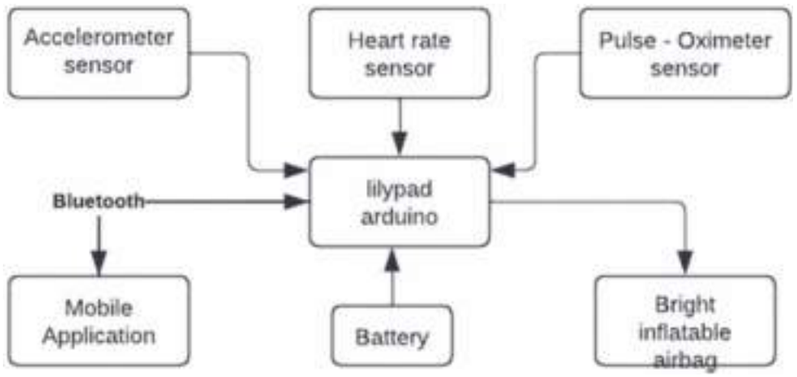
This paper proposes a smart wristband model to mitigate drowning risks. There are not pictures of the model as it is purely conceptual and presented from a technical standpoint. The device would be embedded with a pulse-oximeter sensor, heart rate sensor, accelerometer sensor to track the person's vitals. In addition to the sensors the smart band would also have a vibrantly coloured inflatable airbag. This smart band is linked to a mobile device through a specially built mobile application.

The system uses the last ten readings of the heart rate sensor and calculates the moving average value for the heart rate sensor. If this value is above 15 beats per 10 seconds, then the accelerometer sensor is measured similarly by finding the moving average of last ten readings. If the accelerometer average shows a spike in the value than usual movement, the air bag in the wristband is inflated and an alarm is raised in the mobile phone.

The inflated air bag will provide buoyancy to the victim and help them stay afloat until help arrives, thereby preventing hypoxia and asphyxiation. Also, the bright colour of the air bag will help a rescuer to identify the victim even if the area is crowded.

The diagrams pictured right illustrate how the wristband device would function. The sensors should prove highly accurate at interpreting a drowning incident based on this model. This concept provides good inspiration as it actively prevents drowning and is also very unlikely to set off accidentally. Of course, the device will only work of the swimmer is wearing it, which limits how effective it would be in a real world scenario.

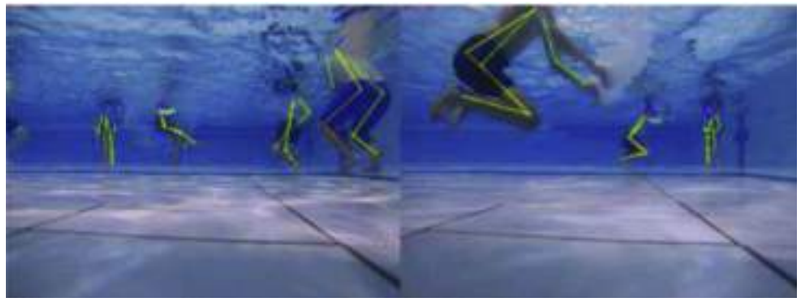


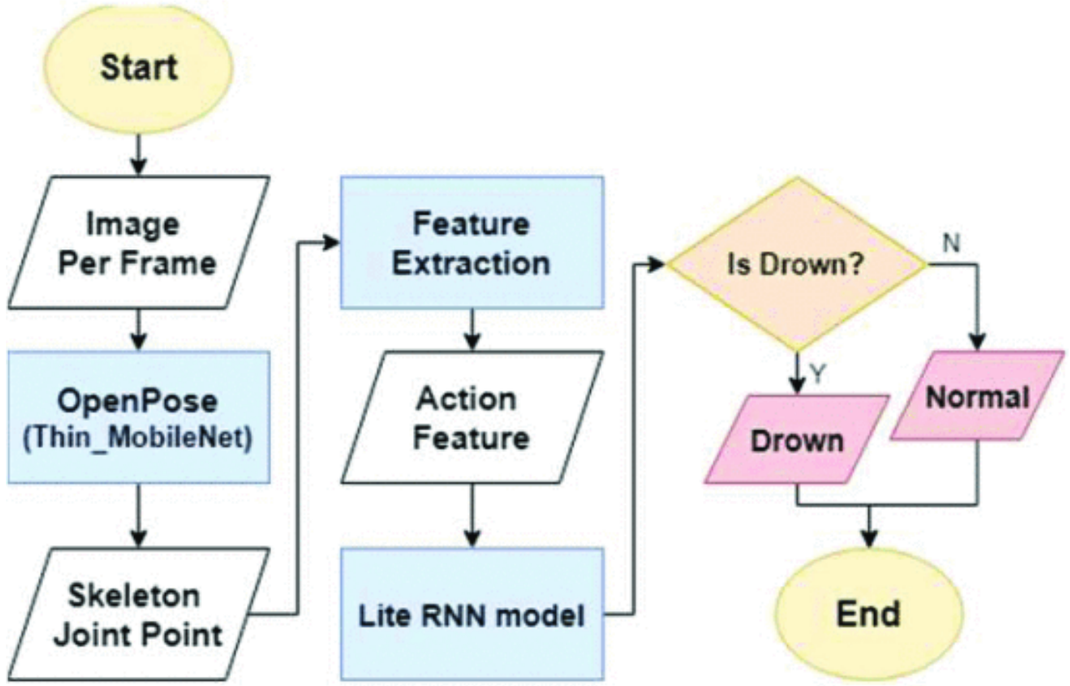


Field Research | AI Drowning Detection

Deep Learning AI has been experimented with to examine and determine if a swimmer is drowning based of imagery and footage.

The actual test images found that if there are several continuous images in the general swimming or splashing action that are similar to the drowning action in the training set, it will be recognized as a drowning situation. In addition, too much air bubbles generated by the drowning swimmer in the water will also occur.



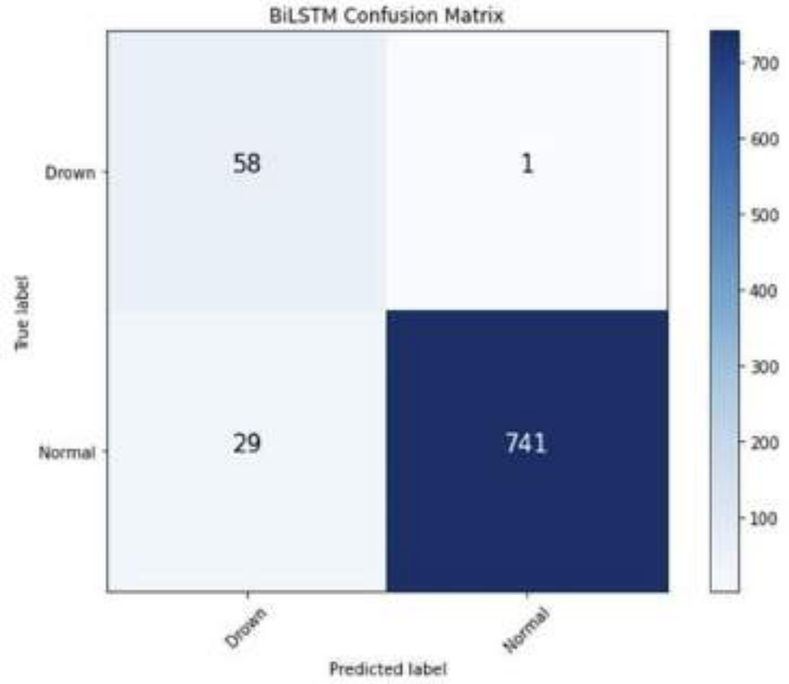


AI drowning detection appears to be relatively reliable at identifying drowning incidents in the water. The flowchart right illustrates how the camera AI operates, and the above image shows the camera's view, outlining swimmers with a digital skeleton that tracks their movements to identify drowning behaviours.

The confusion matrix on the far right highlights the accuracy of tests conducted. This experimental model correctly identified drowning incidents with an accuracy of 89.4%. This technology could prove highly effective for developing water safety measures in the near future.

TABLE III. CONFUSE MATRIX

Actual \ Predicted	Positive	Negative
Positive	True Positive (TP)	False Negative (FN)
Negative	False Positive (FP)	True Negative (TN)

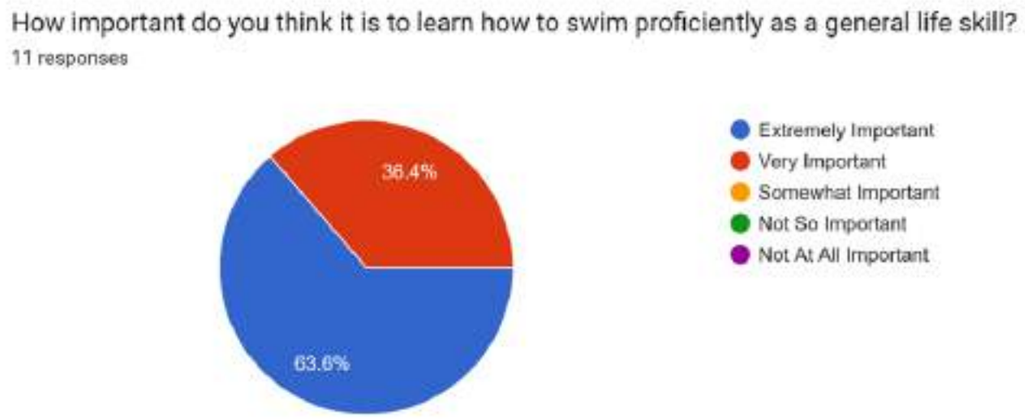


https://ieeexplore.ieee.org/abstract/document/9704884

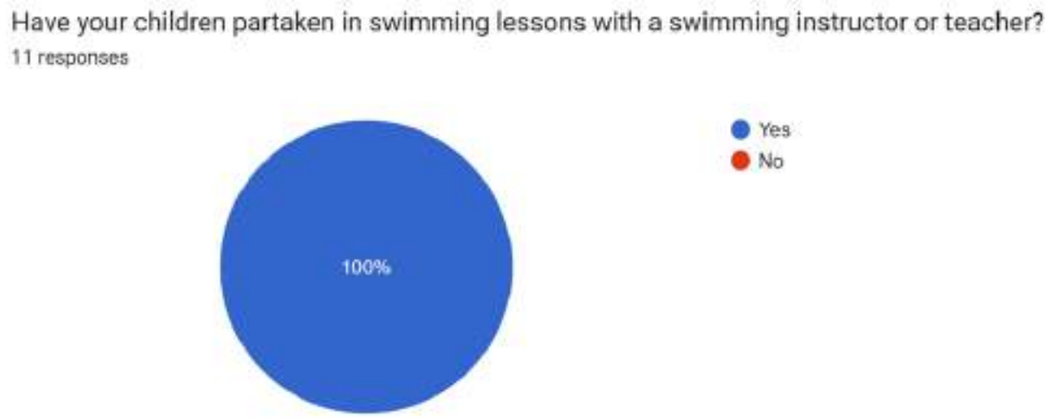
Survey Results | Recorded Findings

What is your age?	What is your gender orientation?	How old was your youngest child when you first had a pool at home? (Over 18's do not count. If you already had a pool when your eldest was born, please select '0'.)
45-54	Female	14
45-54	Female	2
45-54	Female	8
55-64	Female	10
45-54	Male	14
35-44	Female	0
55-64	Female	7
55-64	Female	1
35-44	Female	6
45-54	Male	0
45-54	Female	5

11 participants completed the survey. A majority of participants were aged between 45-64, and no participants were under 35 years of age. 9 out of 11 participants were female, making the resulting findings more indicative of female caregivers' perspectives.

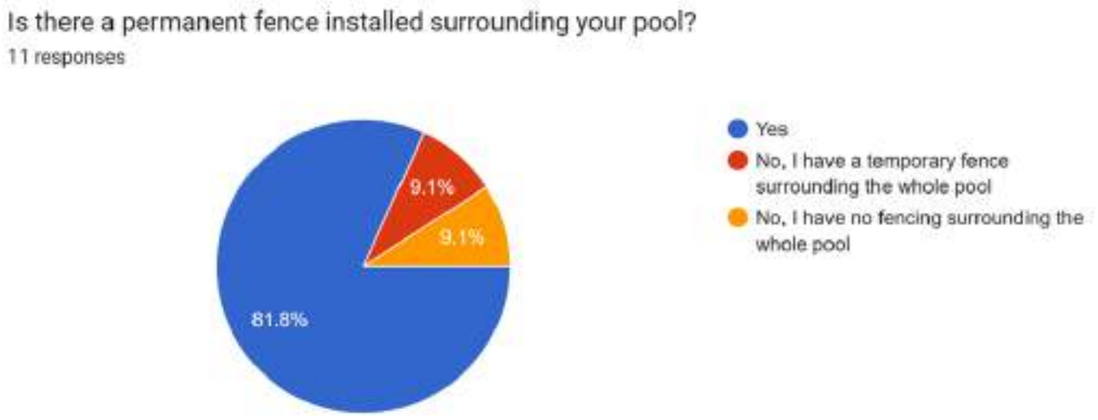


Every participant agreed that learning to swim is a very important life skill.

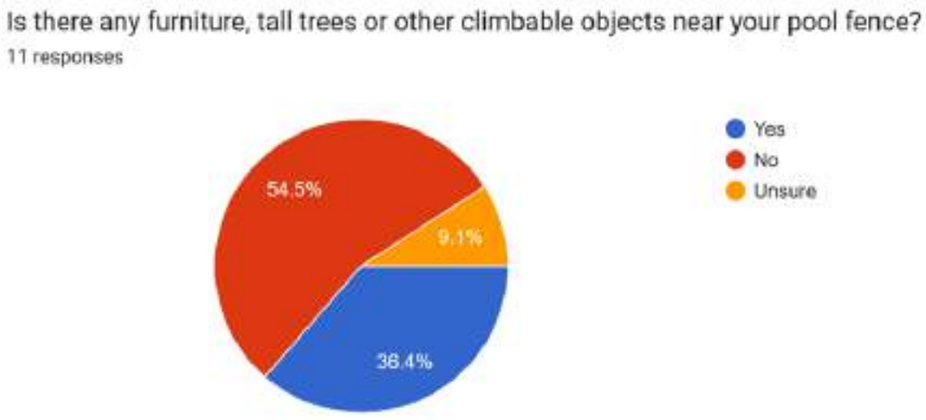


Every parent's child has partaken in lessons, which suggests that the participants are water safety conscious.

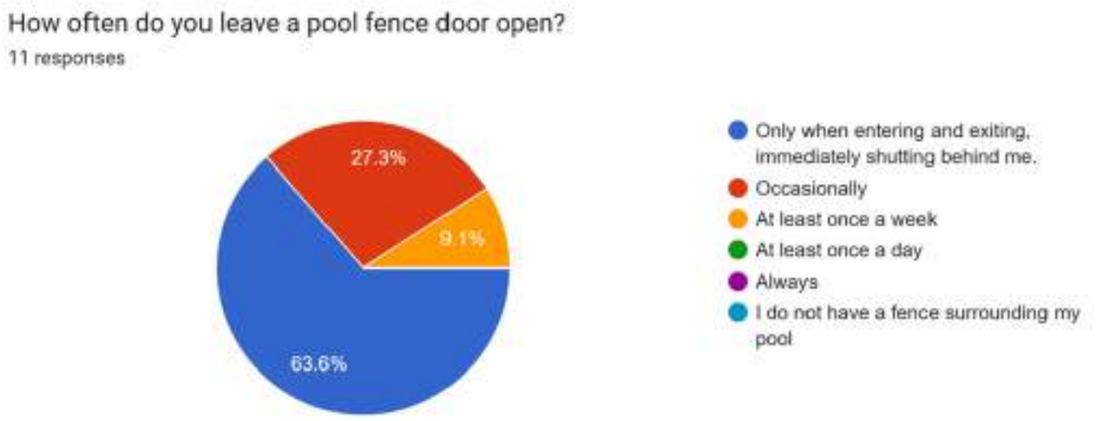
Survey Results | Recorded Findings



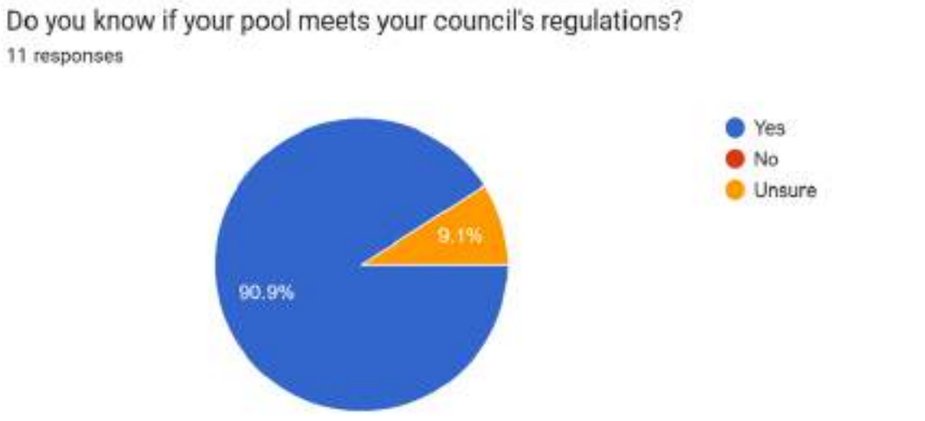
Most participants have a fence surrounding their pool aside from one. This is based on the participants word, there is possibility that participants may not have a fence surrounding their pool but avoided saying this in the survey as it could be incriminating despite anonymity.



5 out of 11 of participants noted that they have climbable objects near their pool. This can present significant risk for young children who may try to climb over the fence and suggests that this is a potential area that needs design intervention to mitigate.

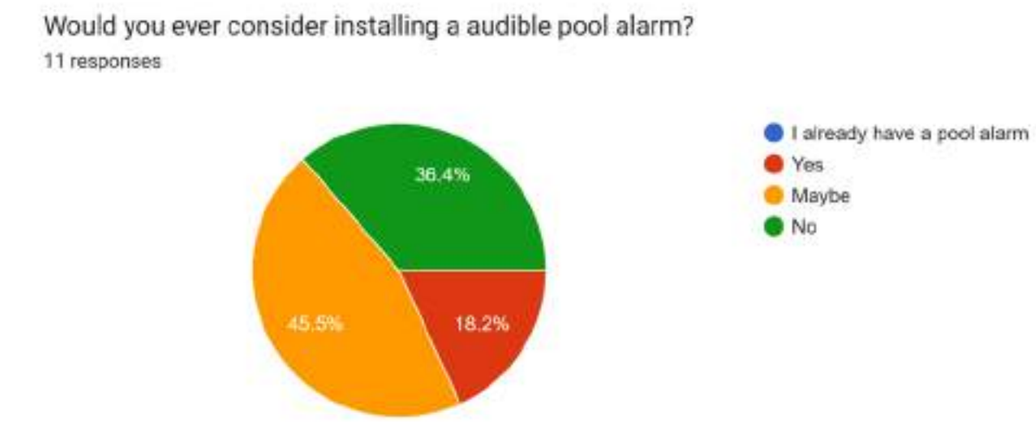


Pool fence gates are closely monitored by most, excluding the individual without a fence.

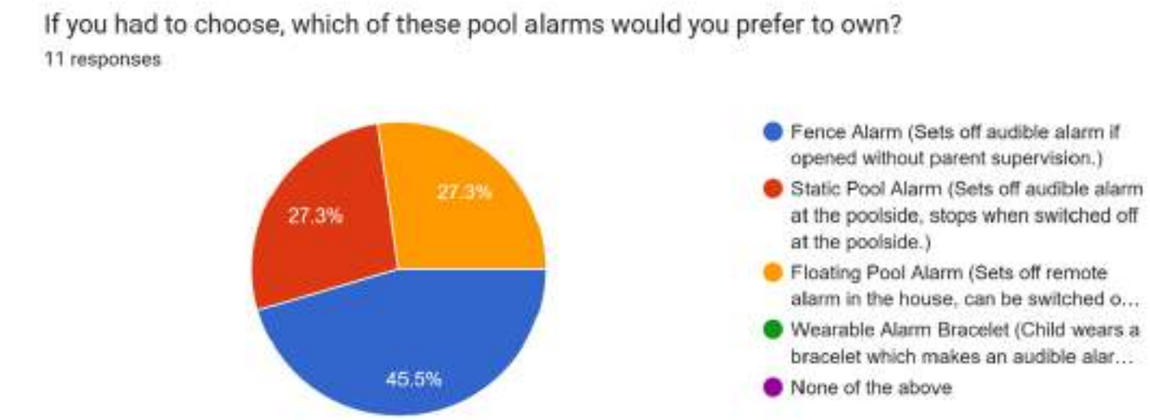


Most claim that their pool meets their council's regulations. The one exception is the participant with a temporary fence. This raises concern when more participants noted that they had climbable objects near their fence.

Survey Results | Recorded Findings



The idea of installing a pool alarm did not seem too receptive among participants. None had a pool alarm already installed.

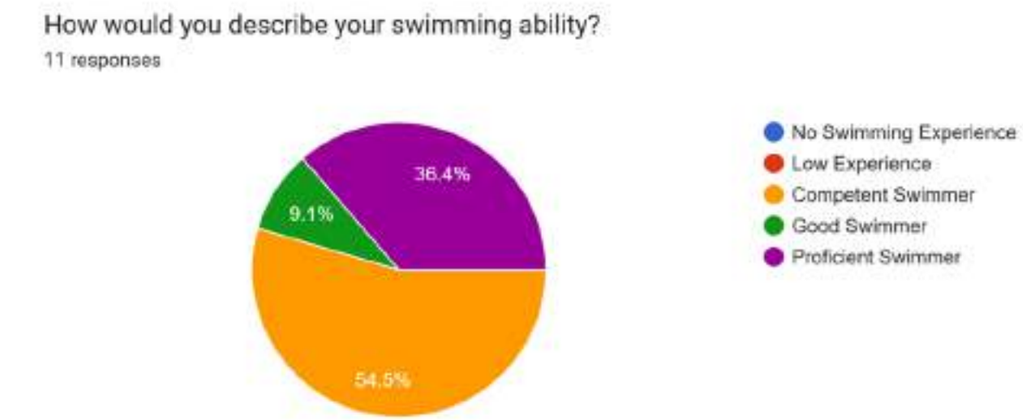


5 participants preferred the fence alarm, and there was an even split interest between static and floating pool alarms. Nobody preferred the wearable bracelet alarm, likely because it is highly inconvenient to have a child wear a bracelet for extended periods of time.

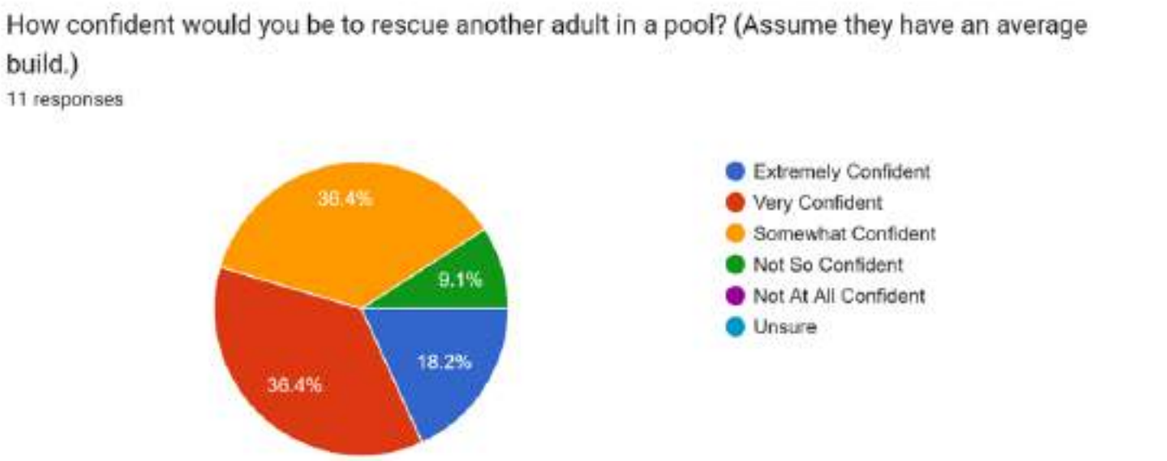
Please explain your decision as to which pool alarm you prefer. (Dot points or full sentences are welcome.)
Alarms when someone enters the water unexpectedly or unsupervised.
You turn it off when you've checked the pool
Better to hear an alarm as a child enters the pool area, rather than when they are in the pool.
Looks easy and doesn't go into the water
Seems more effective than just a gate alarm and is removable when entertaining guests, without an unsightly static alarm
Able to turn on and off at poolside and not unsightly
Water is often moved by wind or birds (ducks) so water motion alarms would go off unnecessarily. I don't like the idea of tagging a child with a bracelet like putting a collar on a dog. Kids are good at working out how to reach the fence gate latch so a fence alarm is a good idea
Don't really know just want something loud
na
Fence alarm would t go off if kids cloned the fence. Static pool alarm would be ok but would go off as pool level raises with heavy rain. Bracelet we wouldn't use as we watch kids in the pool at ages where they would wear this.
At point of entering pool enclosure

The fence alarm was more popular as it acts as a pre-emptive safety measure. In-water alarms only set off once someone is in the water, allowing for less reaction time. People liked the floating alarm for its portability outside of use. Some liked the static pool alarm thinking it would be easy to switch off, though others criticised how it would set off when raining.

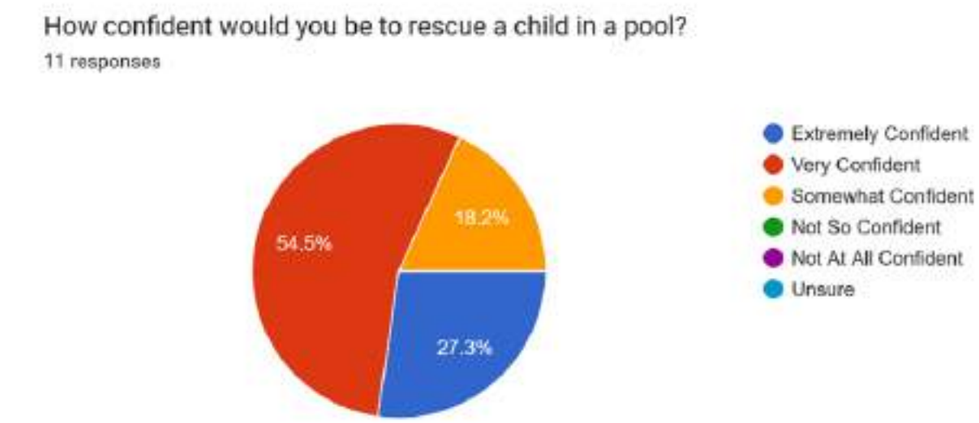
Survey Results | Recorded Findings



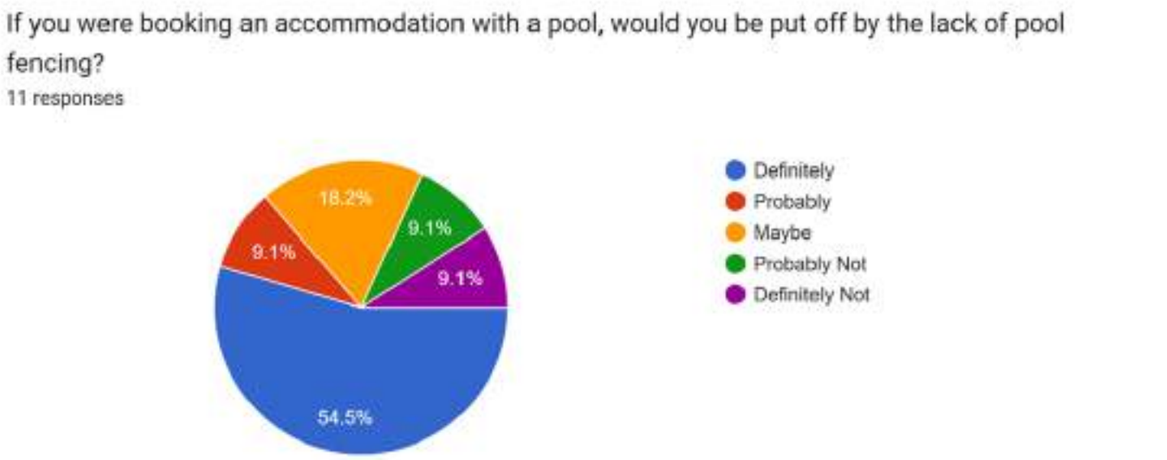
Participants were more likely to say their swimming ability was competent rather than good or proficient. This suggests that swimming ability in parents may not be as strong as it could be.



Answers were quite divided, although most participants had some confidence they could rescue an adult in the water. It is important to stress that many people not be able to rescue another adult in the water due to a variety of individual circumstances.

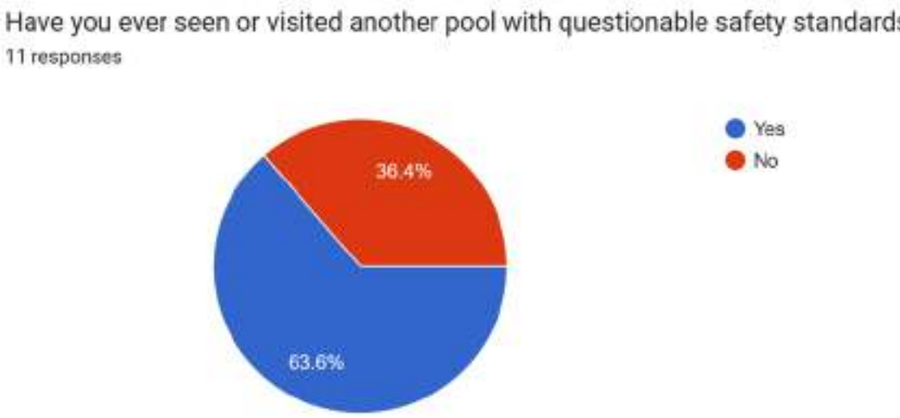


Answers varied, but everyone felt they would likely be able to rescue a child in a pool.

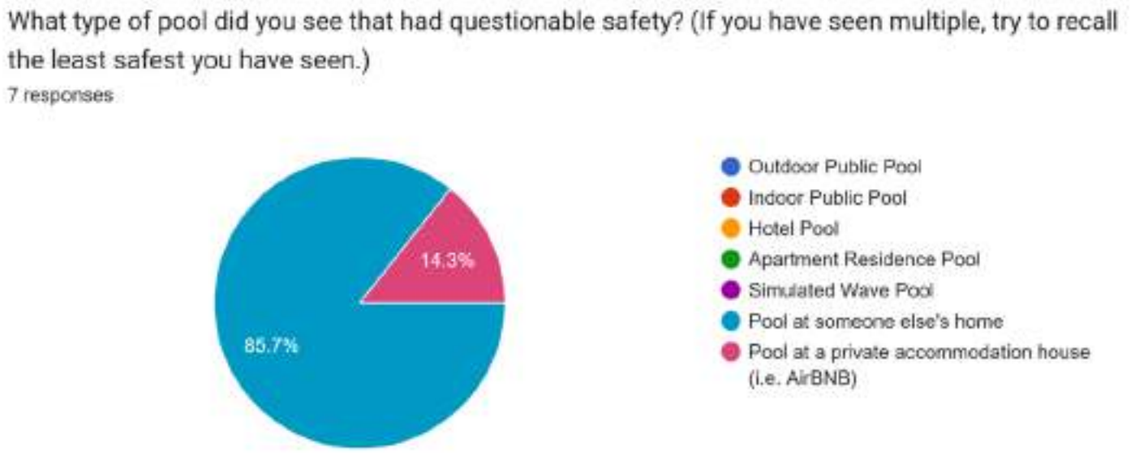


6 out of 11 participants were completely against accommodation that does not have a fence around its pool. Considering that most countries do not have the strict safety regulations that Australia enforces, there could be opportunity to design a device that can make pools safer in any location.

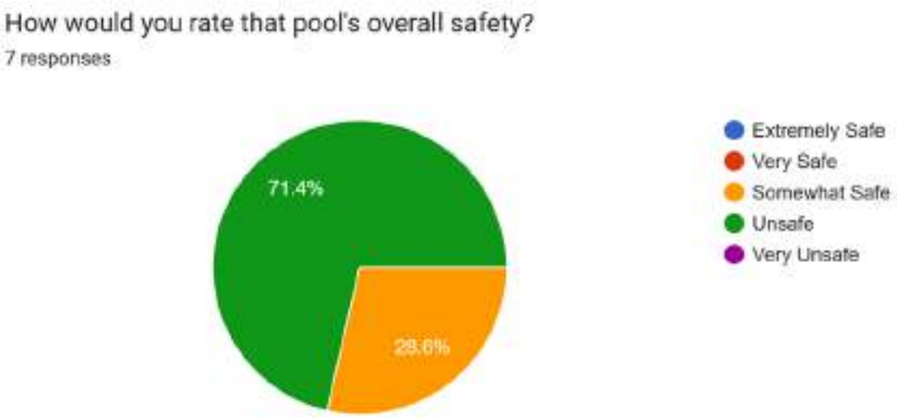
Survey Results | Recorded Findings



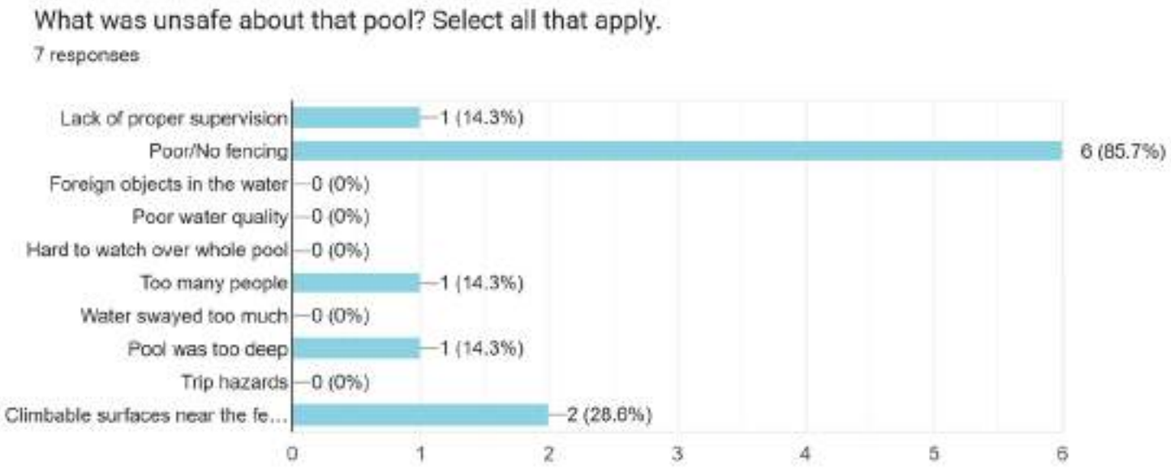
7 out of 11 participants have visited a pool with questionable safety standards. Those who have visited an unsafe pool were much more put off by pools that lack fencing rather than those who were not worried about it. The following questions on this page were taken with this sample of 7 participants.



Most pools with questionable safety were observed at another person's house. One person cited an unsafe pool at a private accommodation. This ties back to secondary research that corroborates that a majority of child drownings occur in swimming pools. Clearly, pools are very dangerous when proper measures are not implemented.

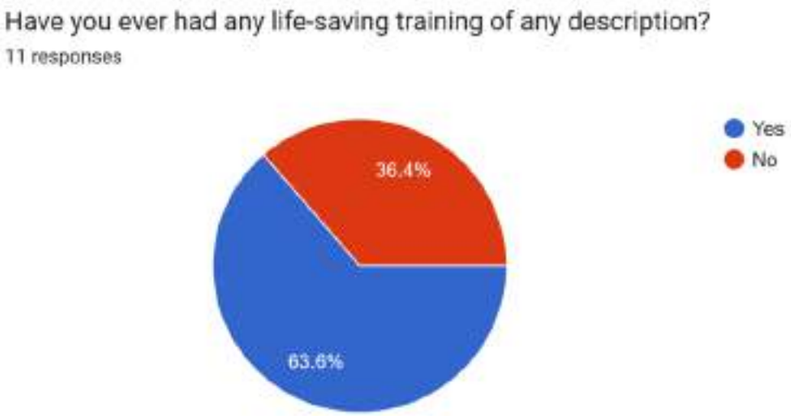


5 out of 7 participants deemed that the pool was unsafe, although not completely egregious (Very Unsafe).



Fencing was by far the most problematic safety approach ignored. Climbable objects were also observed in two instances. 5 out of 10 of the safety hazard options were not observed in any scenario.

Survey Results | Recorded Findings



7 out of 11 participants have had lifesaving training. This suggests that lifesaving training is accessible, but could be further implemented.

If you have had life-saving training, please describe what you learned. (You can list dot points or write full sentences.)
CPR
Bronze medallion
Basic life support
CPR
CPR training
First aid BLS
na
Completed surf rescue certificate, bronze medallion and previously held level 1 coaching certificate

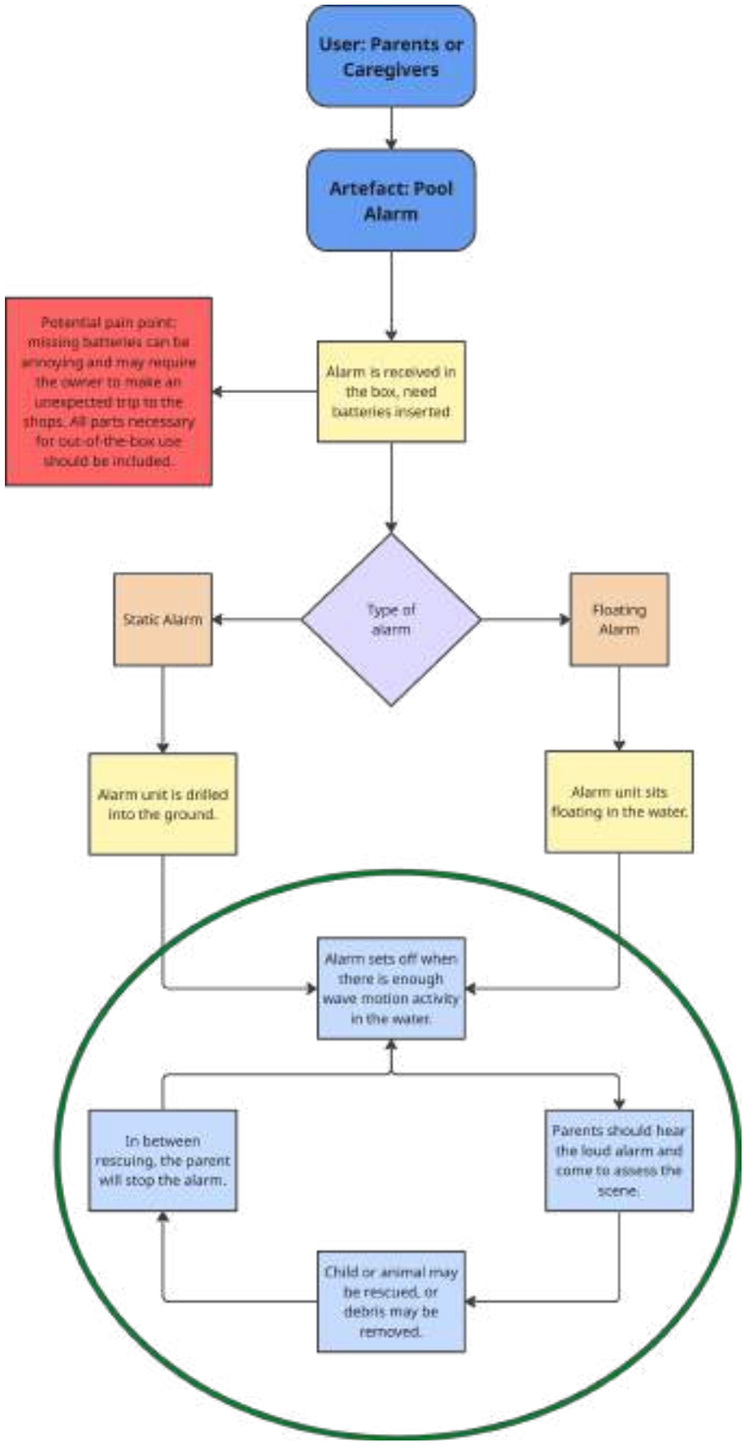
CPR training is common which is good to observe as it shows that CPR training is being taught well.

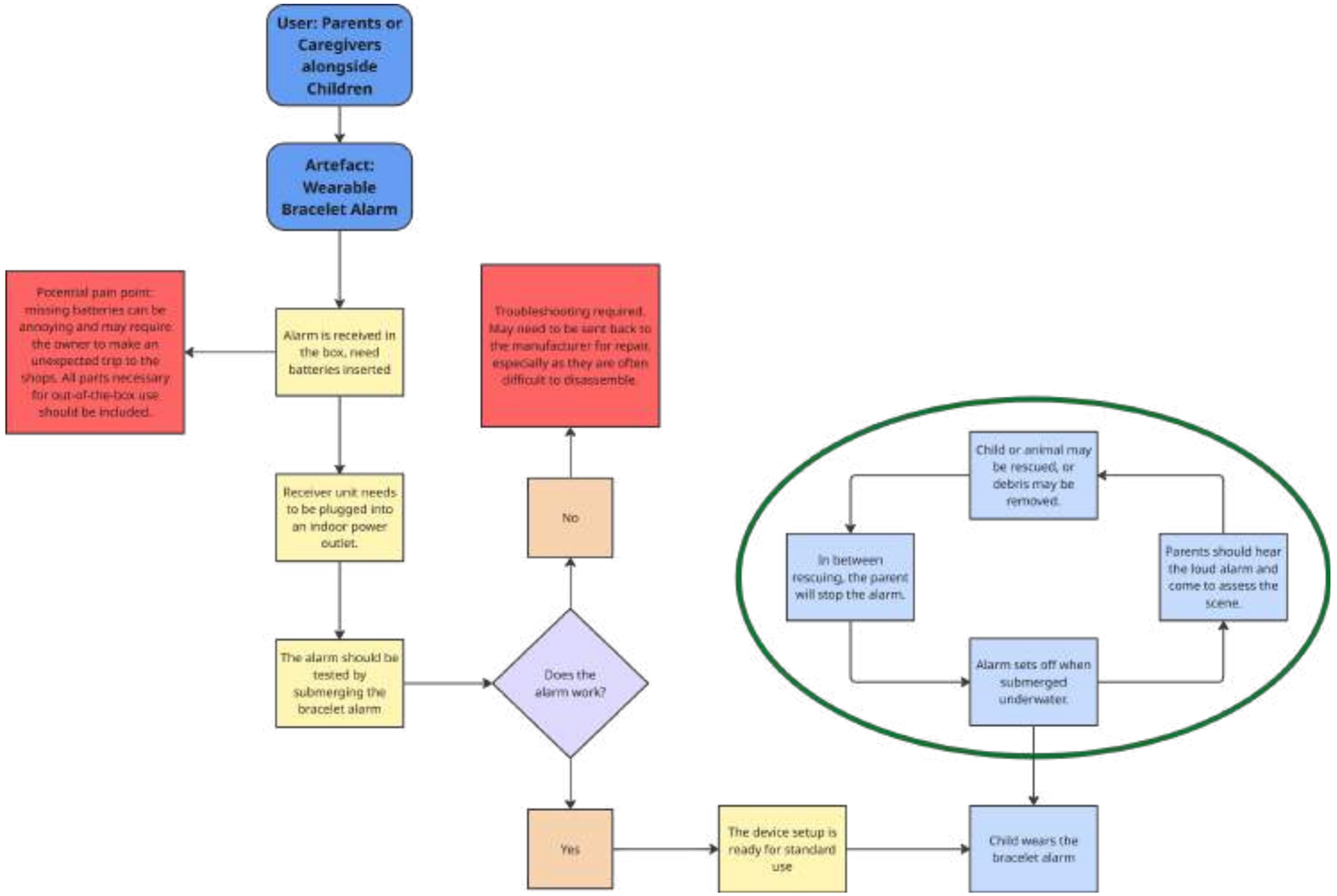
Is there anything that you think should be taught better about pool safety? (Please describe below. One topic is enough, but more are welcome.)
That many drownings are silent. Visual supervision is imperative for safe pool usage
Children should have to do compulsory school swimming lessons
Unsure
Ensure pool safety also includes CPR, playing safely in pools
I have a real concern about temporary or inflatable pools and the fact they are usually file with water all summer and most often aren't fenced. I also think many of the owners would not be aware of fencing laws. Awareness advertising like swimming between the flags campaigns could work.
Not having furniture near the fence
Not really
Hazards for parents
na
Kids doing swimming at school is a good thing Subsidise early learning swimming
First aid is worth learning if you own a pool just incase

No specifically common trends between responses, important teaching points varied between individual participants. Improving the education curriculum by involving parents appears to be well agreed upon as an important step towards swim safety for children. Through the survey responses, participants responded positively about improving swim safety education and measures.

	**Poolguard PGRM-2**	$454.50AUD	Highly portable, does not need to screw into the poolside. The unit simply rests over a ledge as it is well weighted. With enough force, the unit can still be pushed over which impacts reliability. An optional handle can be screwed on top of the unit, which encourages taking it to different locations. The bottom part of the unit unscrews with ease, promoting the Right to Repair by allowing the owner to change the 9-volt battery. A faint LED light also flashes periodically to demonstrate that the alarm is active and working, which is a feature that other alarms are missing. The unit comes with an orange magnetic key that disables the alarm. There is no other convenient way to stop the alarm, which would be highly frustrating as the small key can be lost very easily.	Alarms | Poolguard
	**Poolguard PGRM-SB**	$297.00AUD	Similar in function to the Poolguard PGRM-2, except that it is in a floating alarm design instead of static. Red cone design can be easily removed to reveal the circuit board, promoting the consumers Right to Repair. Contains the same key as the Poolguard PGRM-2, but it can be attached to a string on the unit, so it will always be close by, and the user does not need to keep the key with them. Whilst decently compact, the shape is awkward for storing and packaging. There is a lot of unutilised space inside the cone which means that a more compact design would be very easy to make.	Alarms | Poolguard

Benchmarking | Pool Alarms Initial Use Flowcharts

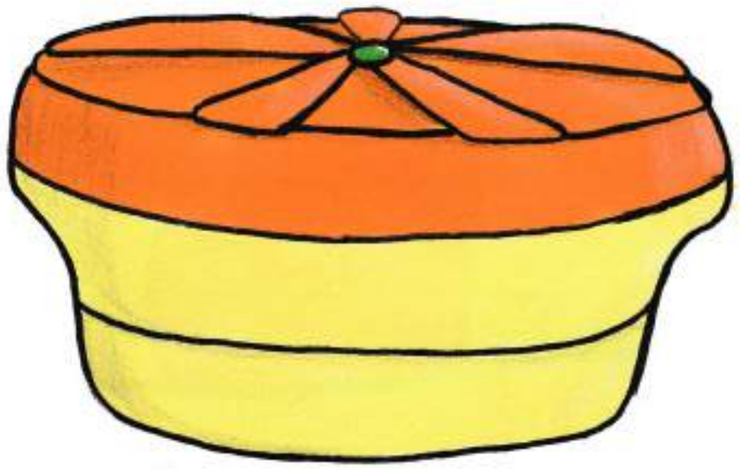


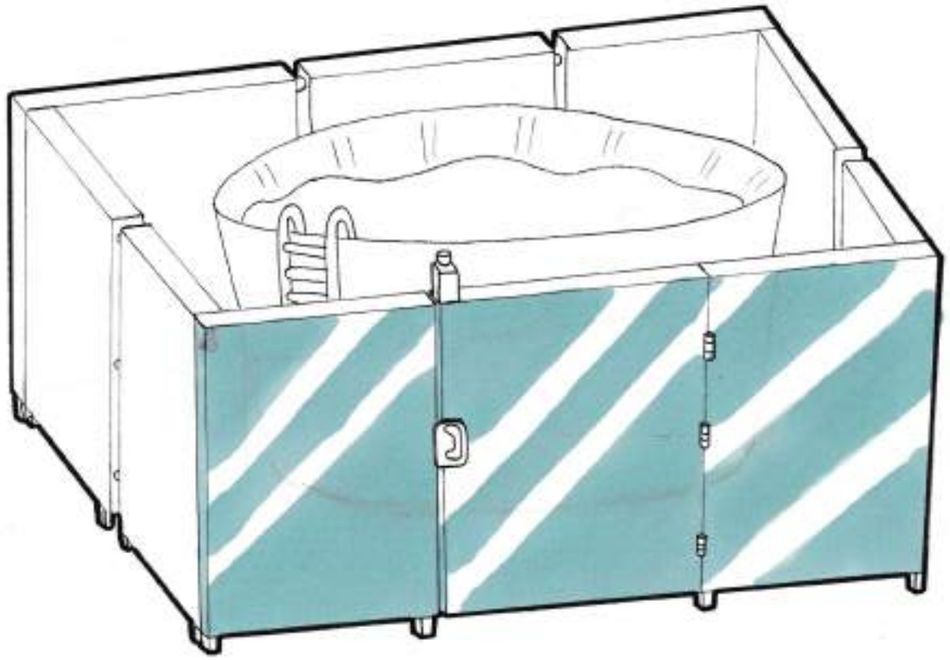


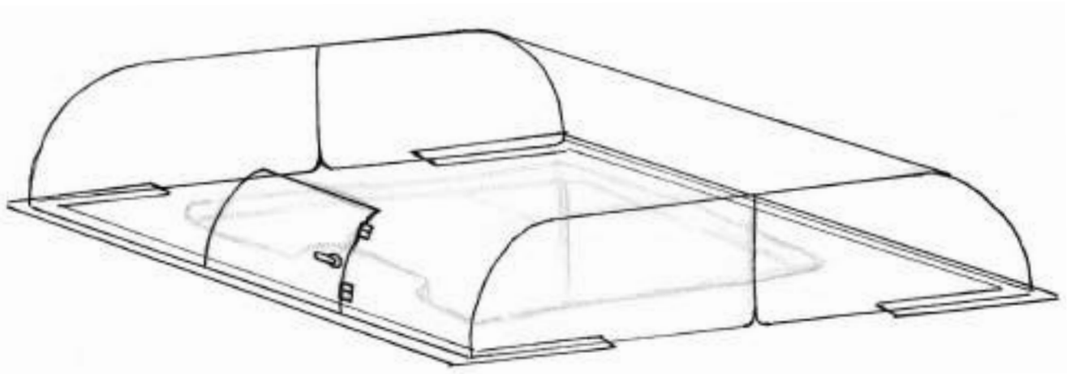
Initial Concepts

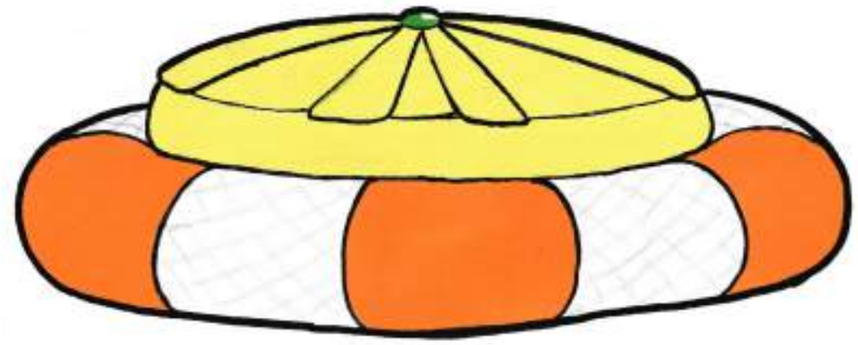
DNB311 | Industrial Design Studio 7: Capstone

Researching Home Pool Safety Strategies









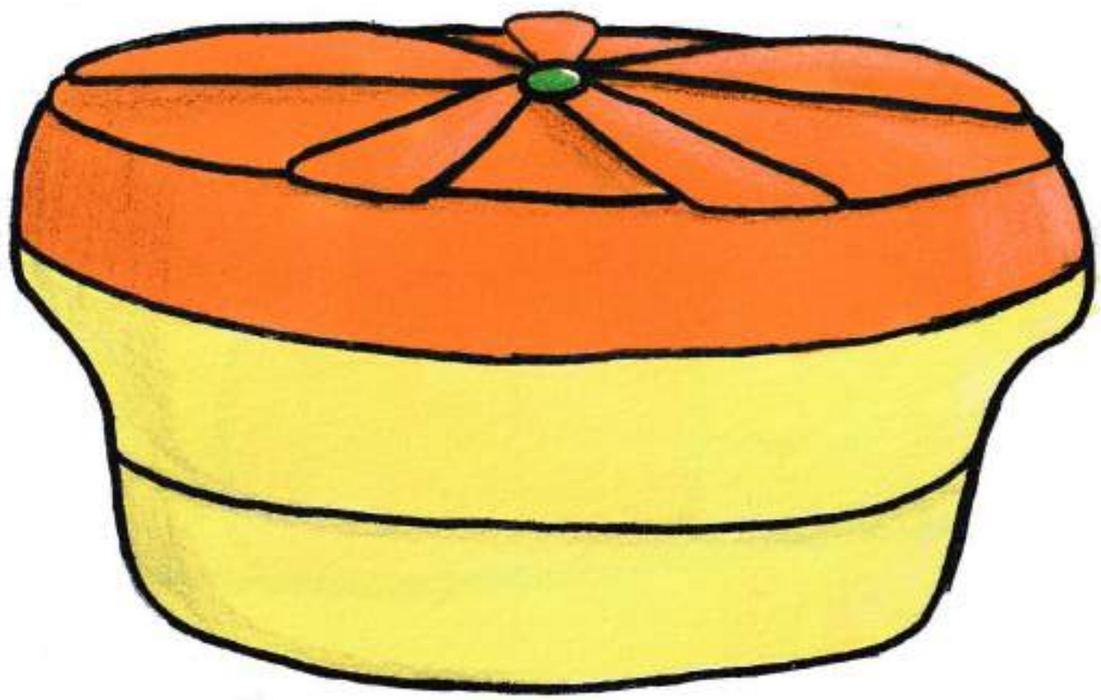
Noah Turnbull

Concept Ideation | Compact Pool Alarm

Overview

If you are staying at accommodation with relaxed pool safety measures, how can you ensure the safety of others? The compact pool alarm is the answer, as its lightweight design encourages parents to take it during holiday travels.

This alarm will work like other similar pool alarms, alerting when there is sufficient activity in the water. It will detect wave motion equivalent to 0.5kg or higher, as not to make the alarm too sensitive. The design will be very compact and float in the water, which will make it very easy to take on the go.



BOM

- 1x Top Cover (PPE)
- 1x Middle Housing (PPE)
- 1x Buoyant Base (PPE)
- 1x PCB with alarm and LED
- 4x Standard Phillips head screws

Estimated Dimensions:

150 x 150 x 120 mm

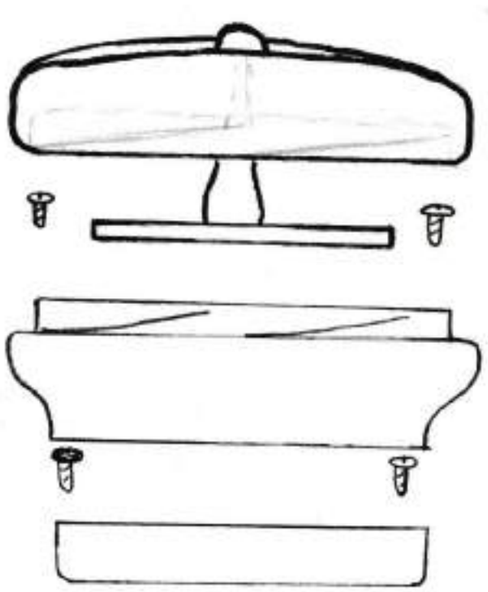
(To be finalised if selected)

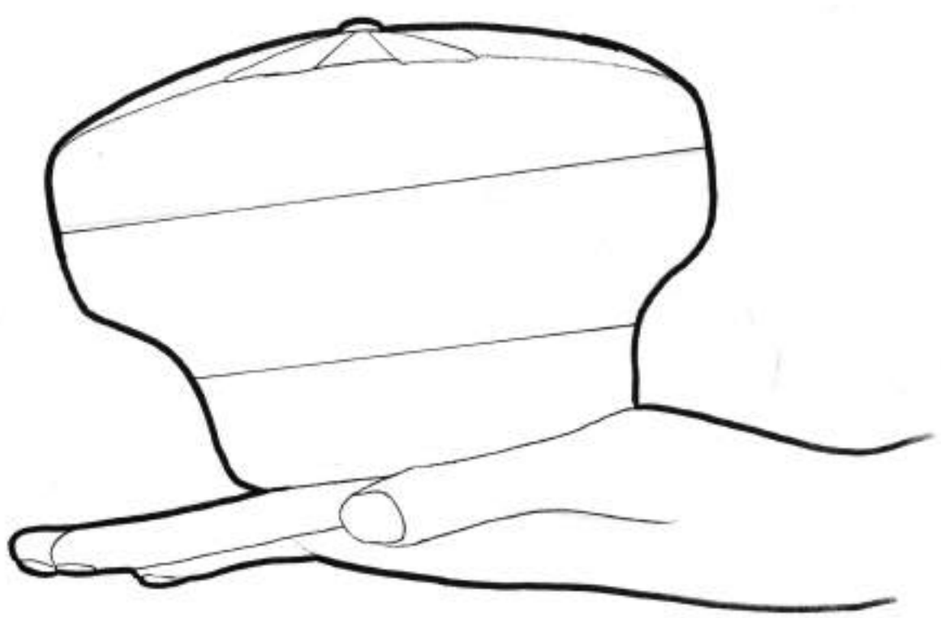
Pros

- Compact lightweight design makes it easy to take on the go.
- The loud alarm will alert nearby bystanders.
- Easy to store away when out of use.
- Vibrant colour scheme makes the product eye-catching on store shelves.

Cons

- Does not actively prevent accidental entry into the water.
- It may or may not be feasible to release this design at a retail price lower than its competitors.
- May accidentally tip over if weather forces are too strong, setting off a false alarm.

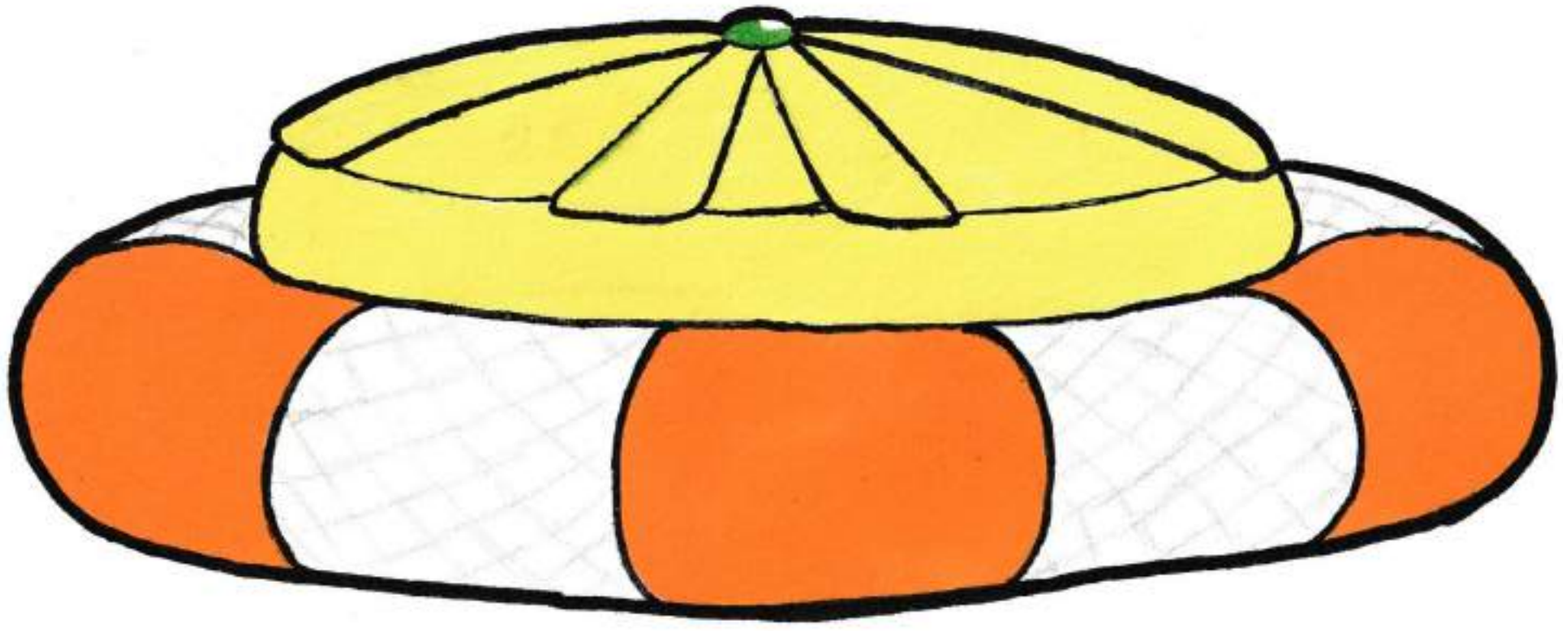




Concept Ideation | Inflating Pool Alarm

Overview

The biggest issue with current pool alarms is that they only play a passive role in rescuing a drowning victim. The inflating pool alarm aims to bring swimmers an immediate, clear point of safety. When wave motion equivalent to 0.5kg or higher is detected, the device will automatically inflate with the use of a CO2 cartridge. The inflatable will have high buoyancy, making it suitable to the standard of other lifesaving inflatable equipment.

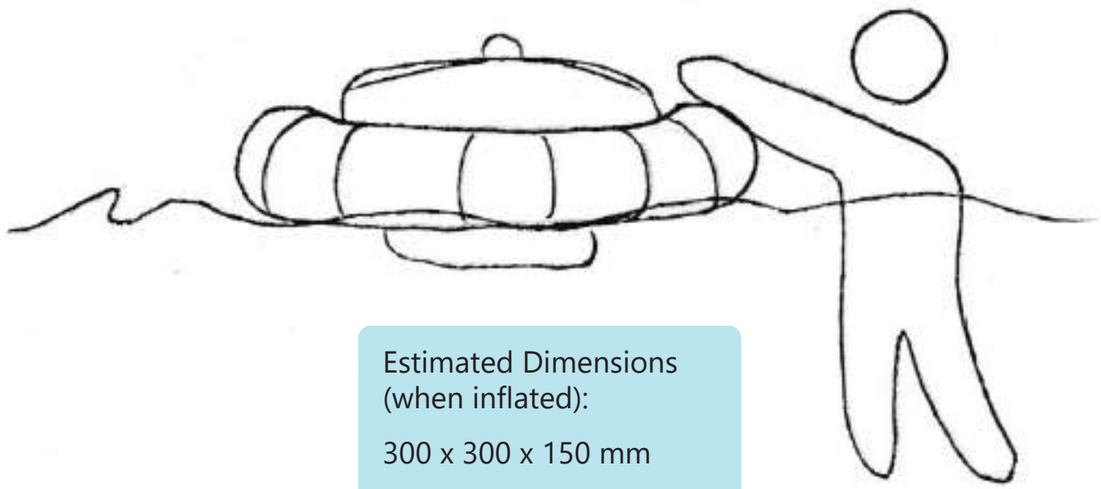


Pros

- Compact lightweight design makes it easy to take on the go.
- Gives swimmers an extra point of safety in a drowning incident.
- Vibrant colour options make the device highly visible, even underwater.
- The loud alarm will alert nearby bystanders.

Cons

- Does not actively prevent accidental entry into the water.
- Infants tend to sink rather than trying to climb up to safety in a drowning incident.
- This device will only prove useful to those who have enough physical energy to climb up to safety.
- Design will need to be refined and tested to limit chances of a swimmer being trapped underneath the inflatable.



Estimated Dimensions (when inflated):

300 x 300 x 150 mm

(To be finalised if selected)

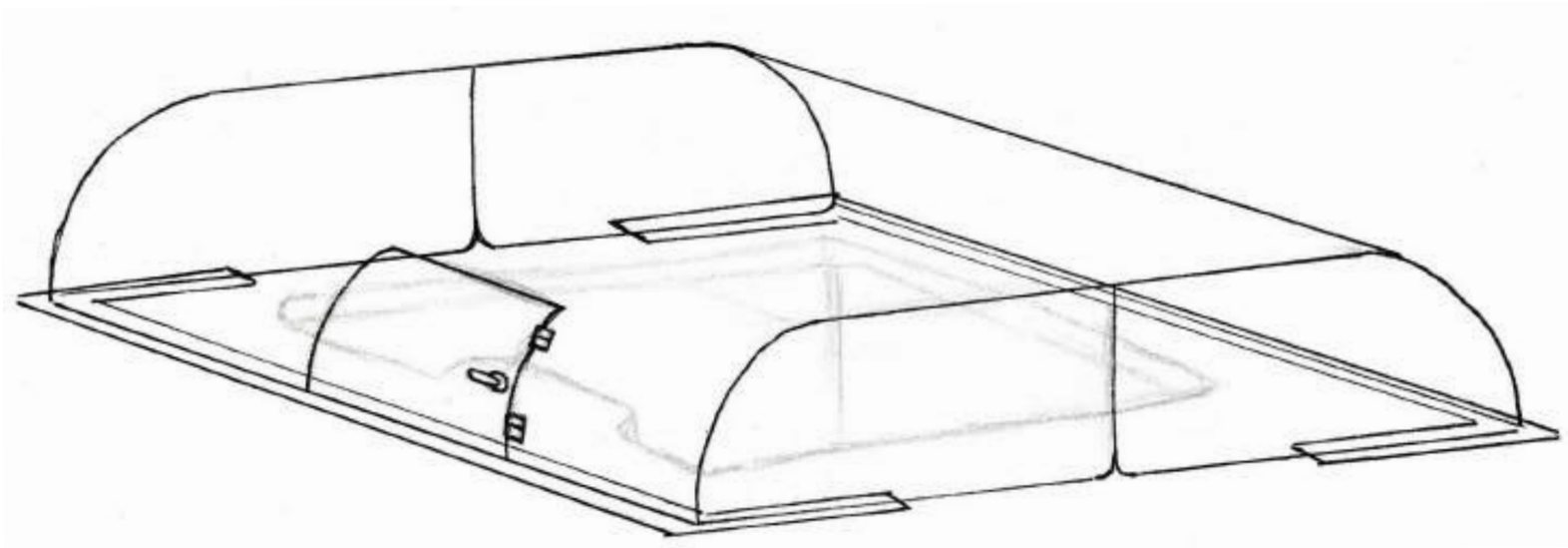
BOM

- 1x Top Cover (PPE)
- 1x Middle Housing (PPE)
- 1x Buoyant Base (PPE)
- 1x CO2 cartridge
- 1x Inflatable Ring (nylon cover with TPU coating)
- 1x PCB with alarm and LED
- 4x Standard Phillips head screws

Concept Ideation | Closing Pool Cover

Overview

When a pool is not in use, can we prevent accidental entry altogether? This retractable pool cover ensures that no one will be able to enter the water without permission. The cover will be primarily made from transparent polycarbonate, which is very difficult to damage and highly durable against natural weather influences. The cover can be easily retracted with an infrared remote key for use, and closed again when out of use. A door is also included to allow people to exit on the unlikely chance they are accidentally trapped inside. The key can unlock it from the outside.

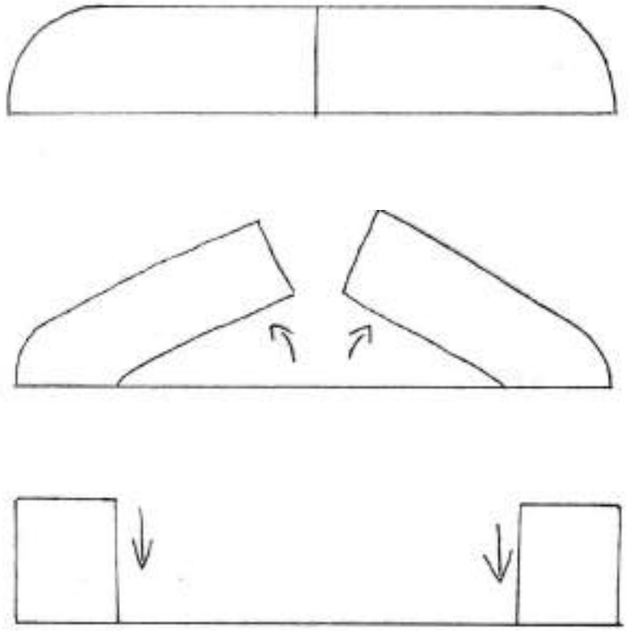


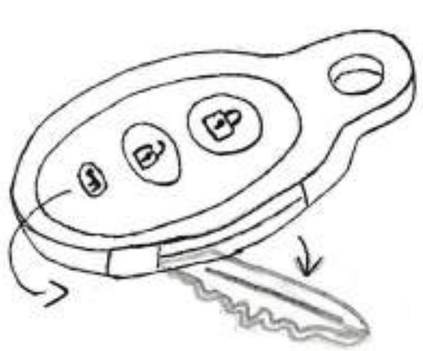
Pros

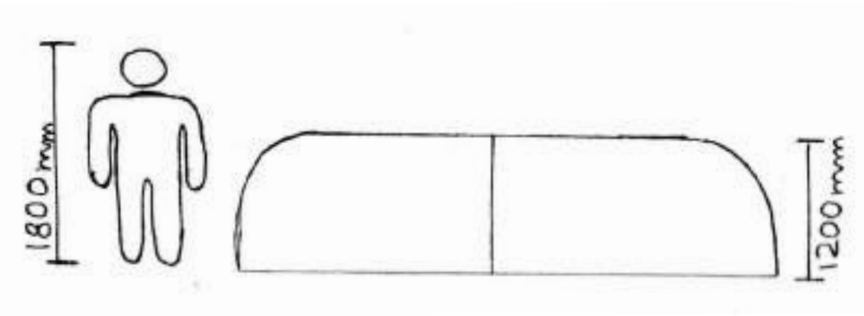
- Actively prevents people from accidentally falling into the water.
- Blocks big debris from falling into the water.
- Includes optional tiny slots to allow for natural condensation.

Cons

- Will need to be made bespoke for existing pools.
- Will be expensive, especially if worked around to fit an existing pool.
- May need a door that opens from the inside only, in case a person happens to be trapped under the closed cover.







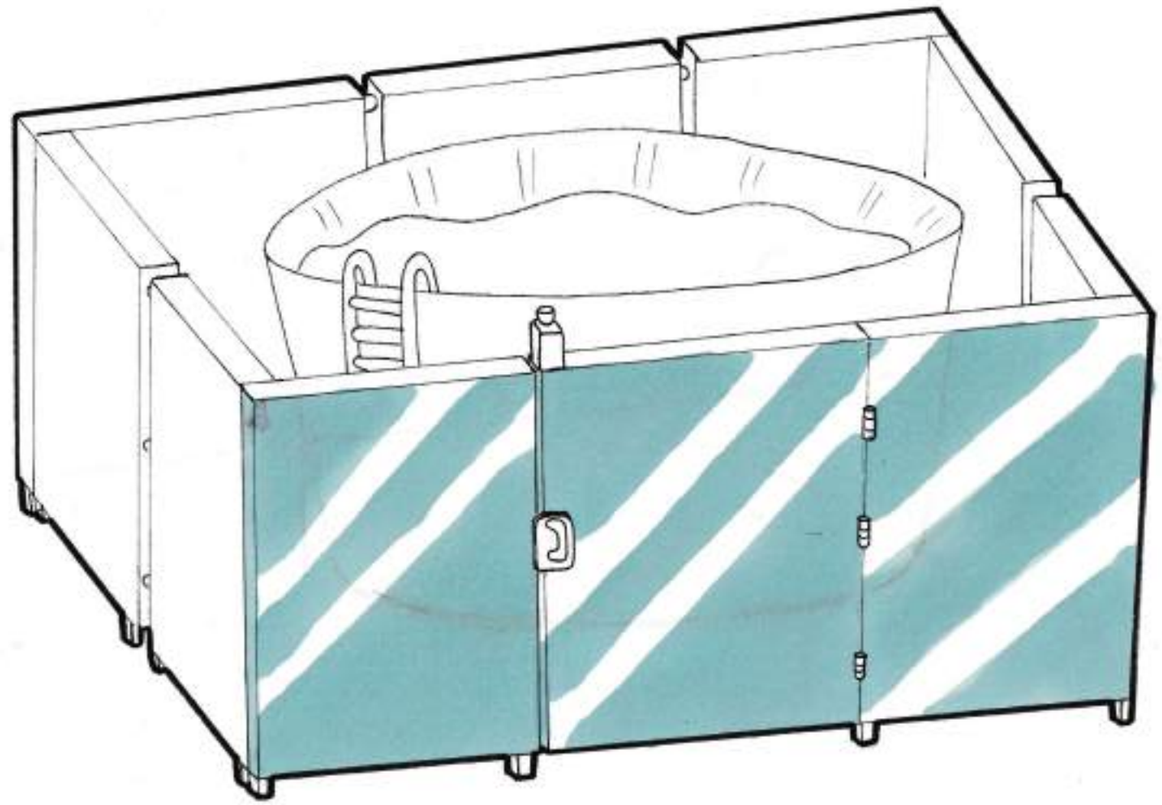
Concept Ideation | Portable Fence

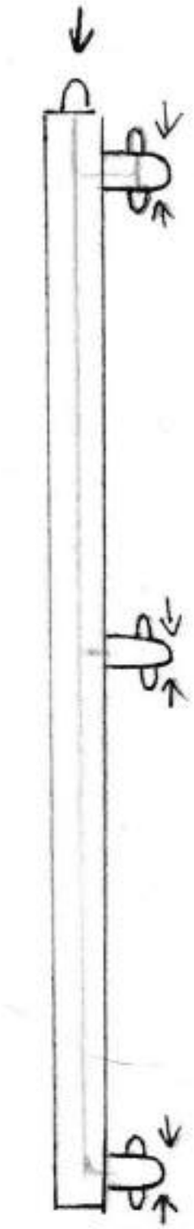
Overview

Installing a permanent fence is highly inconvenient for inflatable pool owners as they typically only get used for a few months per year. As such, many people are unwilling to install a fence which risks the safety of others and can result in hefty fines if discovered by the pool safety commission.

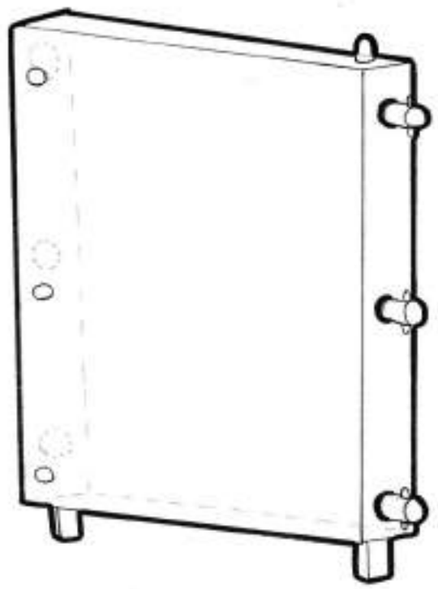
This is where the portable pool fence comes into the scene. The fence is 1200mm tall to fit Queensland guideline regulations and modular sections can be attached with ease, allowing the fence to surround any pool.

The fences are made from transparent polycarbonate to withstand heavy weather and scratches. The modular system allows each gate part to be shipped and packaged in a thin box, which also means that stacking and storing the fence away will be convenient and unobtrusive.





Locking pins are located on two ends to allow all standard fence pieces to either act as a longer edge or corner piece.



Estimated Dimensions (for one fence piece):

1200 x 700 x 50 mm

(To be finalised if selected)

Pros

- Actively prevents people from accidentally falling into the water.
- Can be used for other fencing needs outside of pool fencing as well.

Cons

- Stability will need to be closely considered and heavily refined in testing.
- Currently only works on grass, as the fences slot into the ground.

Concept Ideation | Underwater Camera Alarm

Overview

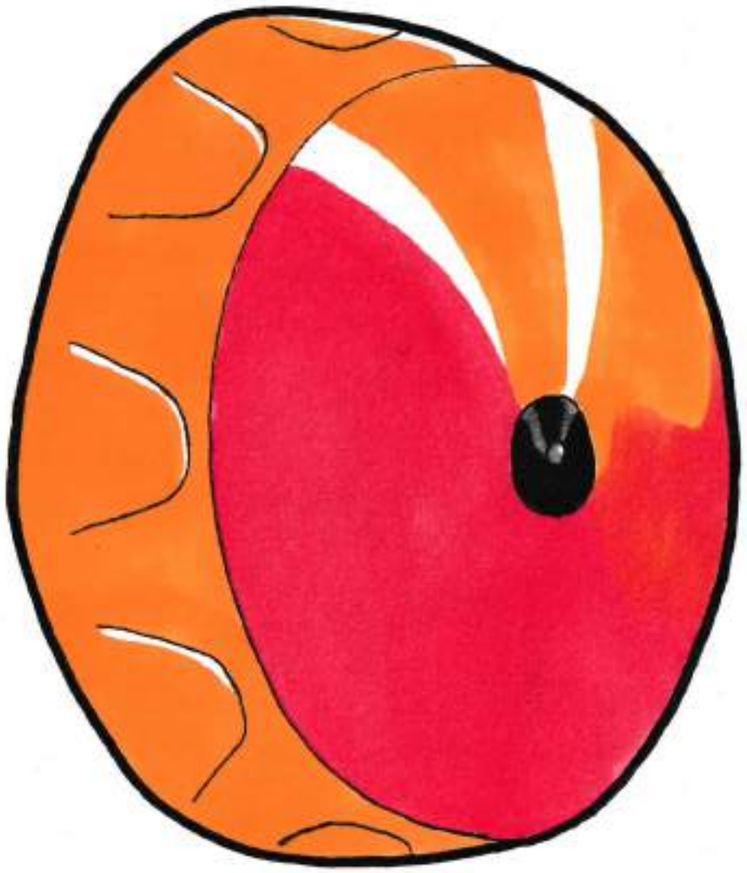
Developing technology has proven quite successful at detecting a drowning individual. Underwater cameras can use AI camera recognition to accurately identify if a person is drowning or not based on their movements (Roughly 90% as of 2021) (Jian & Wang, 2021). Using this underwater camera, instant alerts can be sent via an app when a swimmer appears panicked. This app should allow owners to view through the camera as well. The camera could also be used to detect other animals and debris in the water. Different alarm sounds could play in the event of these three conditions so bystanders know what the situation is before they can see the pool.

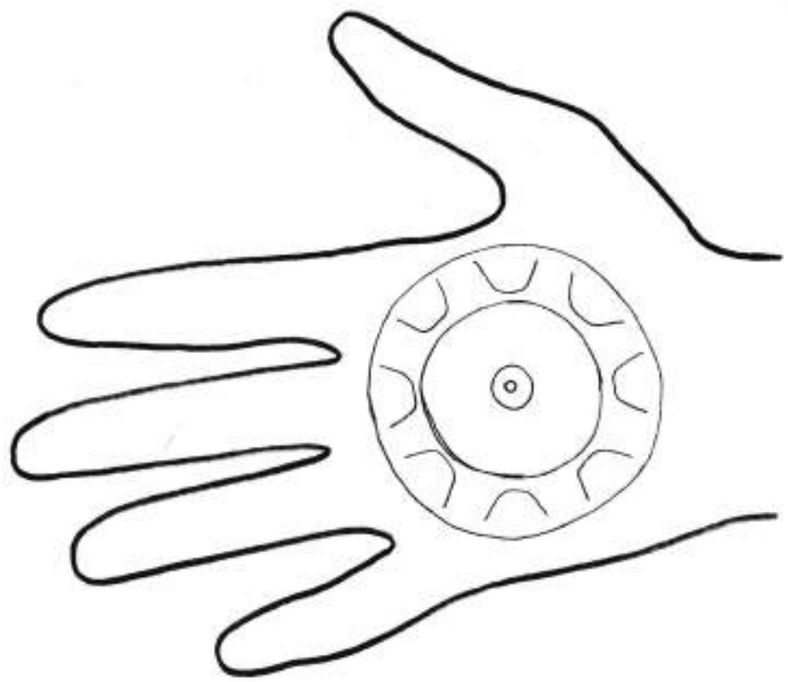
Pros

- Uses smart, leading-edge AI image recognition to recognise the exact situation.
- The underwater camera design will be quite discrete.
- Sounding different alarms for different scenarios will inform bystanders of the situation, even before they arrive at the scene.

Cons

- Requires leading-edge AI image recognition technology, therefore will be quite expensive.
- Does not actively prevent accidental entry into the water.
- There may be privacy concerns that will need to be considered in the design and use of this camera.





Jian, J.-X., & Wang, C.-M. (2021). Deep Learning Used to Recognition Swimmers Drowning. https://doi.org/10.1109/snpd51163.2021.9704884

Estimated Dimensions:

70 x 70 x 40 mm

(To be finalised if selected)

Concept Chart Guide:

Feasibility:
- 5: Can be implemented as soon as the product is manufactured
- 4: Requires a fully functioning prototype to be used in the field before confirming its effectiveness
- 3: Could work, but may have a flaw that would need ironing out
- 2: May not be plausible with current day technology
- 1: Unfeasible as a real-world concept

Ease of Manufacturing:
- 5: Design will be cheap to manufacture, technology is easily accessible
- 4: Technology is readily available, though somewhat costly
- 3: A combination of existing functions is needed, which will require testing
- 2: Uses advanced technologies that come with a high price
- 1: Out of the scope of feasibility

Portability:
- 5: Specifically designed to store and/or take on the go
- 4: Easy to carry around, though not specifically designed for ease of carrying
- 3: Difficult for one person to carry or distribute
- 2: Easy to distribute, but designed to be permanently installed
- 1: Very large, heavy and permanently installed

Ease of Use:
- 5: Almost anybody can use this design concept
- 4: Requires an initial set-up, but then good to use
- 3: May require instructions or an explaination to fully understand
- 2: Requires a training course
- 1: Will require staff to learn advanced skills outside of their current expertise

Design Concept	Compact Pool Alarm	Inflating Pool Alarm	Closing Pool Cover	Portable Fence	Underwater Camera Alarm
Feasibility	5	3	2	3	4
Visibility Under or Near Water	5	5	3	3	4
Ease of Manufacturing	5	3	3	4	2
Ease of Use	4	3	4	4	3
Portability	5	4	1	5	2
Drowning Prevention	An adult needs to be able to hear the alarm and access the pool area quickly.	An adult needs to be able to hear the alarm and access the pool area quickly.	Yes, fully closes and locks pool area, no one can enter the water without the included key.	Yes, if installed properly it will fully enclose the perimeter of the pool.	An adult needs to be able to hear the alarm and access the pool area quickly.
Technology Requirements	Moderate, technology is readily available on the market	Moderate, combining the technology of pool alarms with self-inflating equipment	High, but technology exists. It works similarly to an electronic garage rolling door	No technology required	Very high, but technology exists in a rapidly developing state
Price Estimations (based off competitors)	Likely $400-500AUD	Likely $600-800AUD	Above $1000, will vary on pool dimensions	Likely $100 per fence part. Cost will vary on pool dimensions	Very High, definitely above $1000AUD

Tutor Feedback

- You can combine elements of your concepts for your final. For instance it could be good to lean into the underwater camera alarm, then combine a self-inflating device to emerge when the alarm goes off.

Compact Pool Alarm: May be a bit too similar to existing designs, needs an angle to make it stand out.

Inflatable Pool Alarm: Looks like it belongs in a larger pool body. Has a few details to work out but seems fair in concept.

Closing Pool Cover: Steer away from this one. Basically just another pool fence. A lot of small details can make the whole mechanism go wrong here.

Portable Fence: Definitely looks too expensive for the targeted consumer market based on the glass fencing. If people were going to put up fencing around their portable pool, they would have already.

Underwater Camera Alarm: Need to figure out how it attaches to the pool and gets power. If you can work out how to make this work, it could be really good. Has the most potential out of the concepts here.

Implementation

- I will focus on refining the underwater camera concept, as it was the most well received by both tutors and students. I will investigate the specifics on how the camera will attach in the pool, how it will get power and how the technology works more thoroughly.

Student 1

Compact Pool Alarm: Centre-of-mass should be lowered so the alarm does not flip over.

Inflatable Pool Alarm: Good idea, but as you noted it will not work for infants who will sink to the bottom of the pool.

Closing Pool Cover: May be a little too similar to other pool covers. Unsure about the key fob, alternate options could be useful.

Portable Fence: Seems fair,

Underwater Camera Alarm: Favourite idea of the bunch. Think about how the camera will attach in the pool. Will it be hooked up to electricity? You could use solar panel charging, it could connect to your phone, all sorts of opportunities here. There are a lot of other existing camera technologies you can explore to make this concept even better.

Student 2

Compact Pool Alarm: Definitely seems good, it would be quite affordable. It would be great to take on the go on AirBNB locations.

Inflatable Pool Alarm: I like the expansion on the initial alarm design. Good that it is still compact until it fully inflates.

Closing Pool Cover: This is really cool and quite novel. Creating that second barrier of entry is good to see.

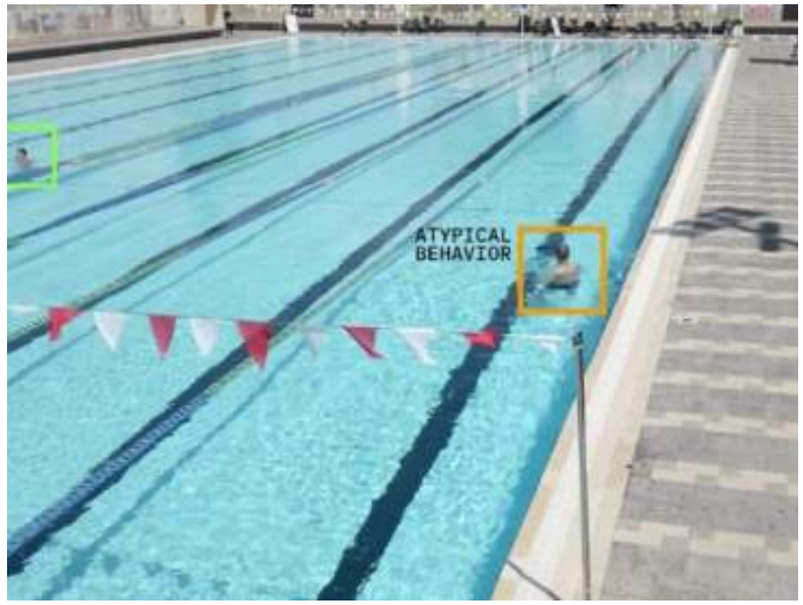
Portable Fence: Pretty good idea here, I like how easily flexible the fencing system is. Probably my second choice (after the underwater camera alarm).

Underwater Camera Alarm: The concept is really cool and utilises some really cool developing technologies. I like how it acts multipurpose, as you can detect people, animals and foreign objects. I strongly suggest you go with this one.

Field Research | Lynxight

Lynxight is one of the biggest leading companies developing and distributing AI-assisted drowning prevention technologies. The technology detects people on camera and tracks their activity in the water. Updates are sent to lifeguards via a wearable electronic watch which provides important live updates. The company is based in Australia, and a range of public pool centres and the Royal Lifesaving Society Australia have adopted their technologies in CCTV cameras.

To translate the special wearable device to regular consumers, the live updates could be sent to common smartphones and smartwatches. An optional companion app could be created to send live updates if there is unusual or dangerous activity in the water. If someone owns a smartwatch, it could effectively act the same way as Lynxight's smartwatch.



https://lynxight.com/blog/cameras-vs-wearables-what-can-keep-us-safe-in-pools/

https://enviroprocess.com/en/product/pool-management-safety

Above Ground Camera

Pros:

- Easier to setup and operate
- Can record security incidents, such as unauthorized entry, theft, etc.
- Provides a live view of the pool
- Can connect to a smart device to send live updates of the pool
- Has LED light that blinks notifying if the light is on or if there is a technical area
- The camera could remotely move in place to extend its view and reduce potential blind spots
- Difficult to obstruct, as it will likely be outside of arms reach
- Allows for solar powering that is not intrusive
- Easier to retrofit, will be installed just like any other wall-mounted camera

Cons:

- Cannot see under the water's surface
- Could be inconvenient to replace or recharge battery if out of arms reach

Underwater Camera

Pros

- Provides a live view of the pool
- Can connect to a smart device to send live updates of the pool
- Has LED light that blinks notifying if the light is on or if there is a technical area
- The camera could remotely move in place to extend its view and reduce potential blind spots
- Should be able to provide clear picture footage so long as the pool is well filtered and the camera is unobstructed

Cons

- As it is stuck to one side of the pool, there will be blind spots outside of the camera's view, even if it can remotely turn
- Easier to obstruct as it will likely be within arms reach
- Would be hard to retrofit if wired
- Solar power will be intrusive as a separate wire would need to attach a solar panel, creating a trip hazard near the pool.

Wired

Battery

Rechargeable

Ethernet

Solar

Wired

Pros:

- *Reliable energy sourcing produces minimal waste*
- *The unit should never need to be removed outside of occasional maintenance*
- *Installation is typically simple and straightforward*

Cons:

- *Can present a trip hazard if exposed*
- *If built into the pool, very difficult to retrofit*
- *If wire deteriorates, may be difficult to repair*
- *Limited in use by the length of the wire*

Battery

Pros:

- *Reliable energy sourcing*
- *Unit will be entirely self-contained with no external wires or other features required*
- *Highly portable and easy to install*
- *Should communicate that battery is low to users, perhaps an LED light could signify charge percentage, or it could be tracked on a mobile device*

Cons:

- *Will create e-waste once battery has expired*
- *Replacing battery will incur ongoing cost*

Rechargeable

Pros:

- *Reliable energy sourcing produces minimal waste*
- *Unit will be entirely self-contained with no external wires or other features required*
- *Highly portable and easy to install*
- *Recharging batteries exist which would minimise e-waste concerns with discarding used batteries*

Cons:

- *Battery life will only last so long, meaning it will have to be constantly recharged*
- *Inactive when taken out to recharge, presenting risk in pool supervision*

Ethernet

Pros:

- *Transfers data to a network device instantly, no remote communication to devices required*
- *Reliable energy sourcing transmitting data and power through one cable, produces minimal waste*
- *The unit should never need to be removed outside of occasional maintenance*

Cons:

- *Can present a trip hazard if exposed*
- *If built into the pool, very difficult to retrofit*
- *More expensive, better suited for fully dedicated surveillance setups around a whole property*

Solar

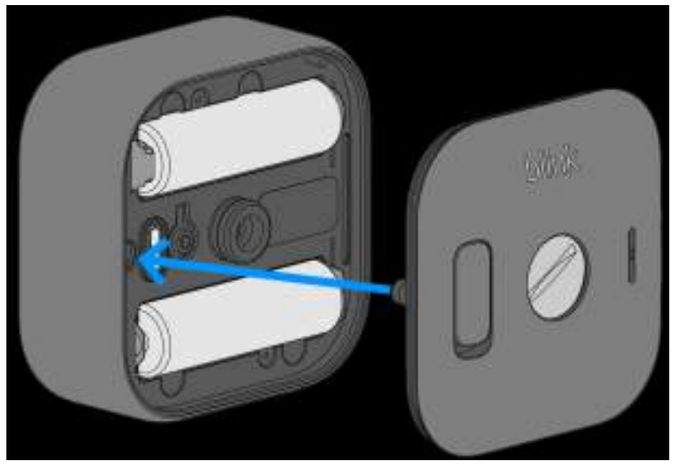
Pros:

- *Installation is typically simple and straightforward*
- *Green energy sourcing, produces minimal waste*

Cons:

- *Can be impacted in shady areas*
- *Will be ineffective if the sun is covered for extended periods of time*
- *Solar panel needs to be out of the water to work, connecting wire can present a trip hazard*
- *If wire deteriorates, may be difficult to repair*

Field Research | Battery Options



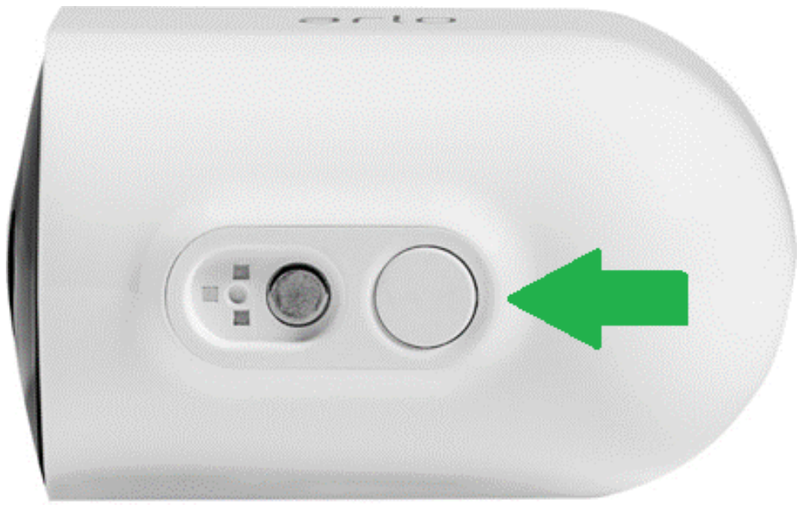
The Blink Outdoor 4 (above) takes AA batteries. Technically speaking, rechargeable AA exist but are uncommon due to cost and reliability concerns. The device simply opens with a common flat-head screwdriver, turning a locking latch.

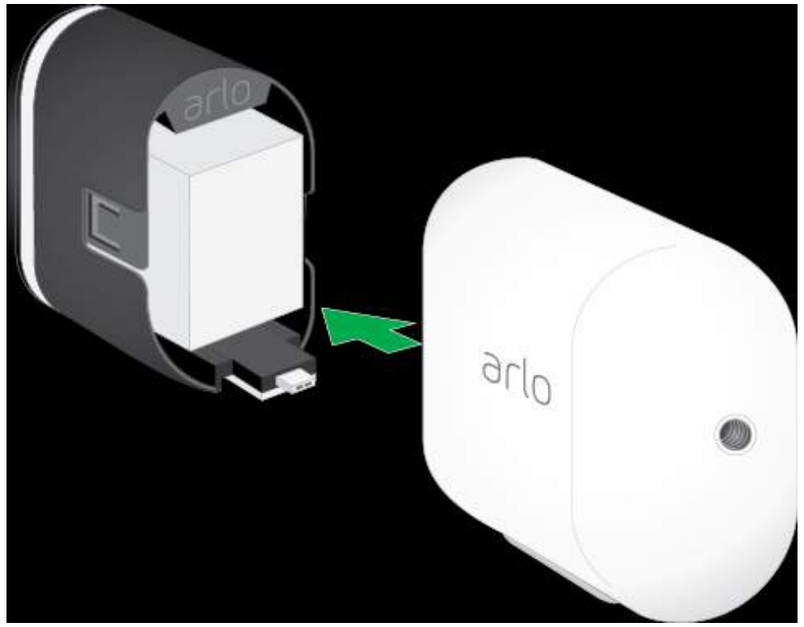
https://support.blinkforhome.com/en_GB/f-a-q/how-to-remove-the-battery-cover-from-blink-cameras

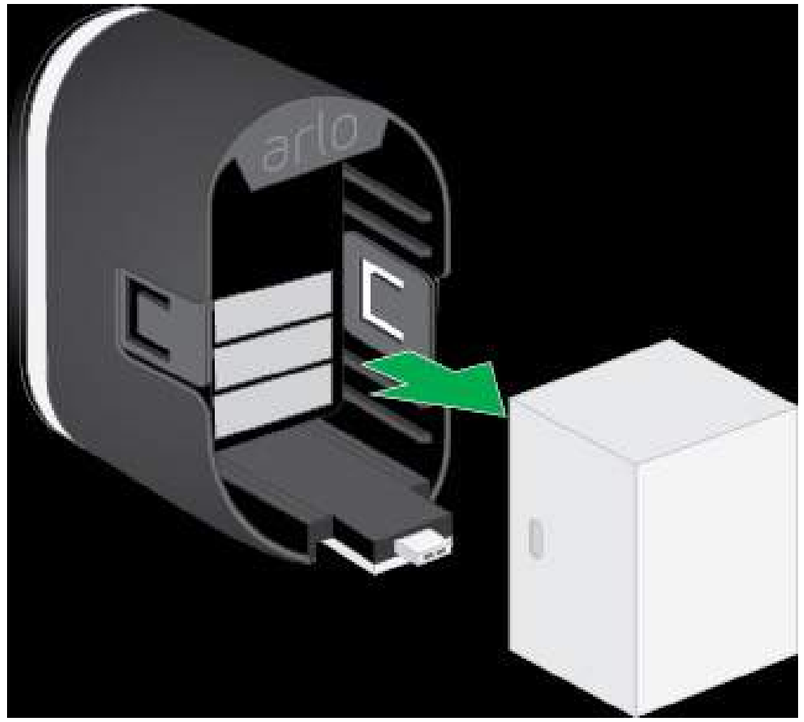
https://www.bunnings.com.au/ring-quick-release-battery-pack_p0067522

Above battery claims to last 1-5 months on one charge and can also be recharged. The Ring camera batteries shown right last up to 6 months and are rechargeable via a micro-USB port.

https://www.amazon.com.au/Security-Wireless-Detection-Spotlight-Weatherproof/dp/B0CPYC469R







A different approach to recharging camera batteries, the Arlo camera family uses a custom-made battery. To change and recharge the battery, the camera casing can be unlocked with a button push. The battery slots out and can be nestled into a charging station which connects to a power point.

https://kb.arlo.com/000062681/Arlo-Dual-Charging-Station-LED-Behavior

https://kb.arlo.com/000062126/How-do-I-change-the-battery-in-my-Arlo-Ultra-Arlo-Ultra-2-Arlo-Pro-3-Arlo-Pro-4-or-Arlo-Pro-5S-camera

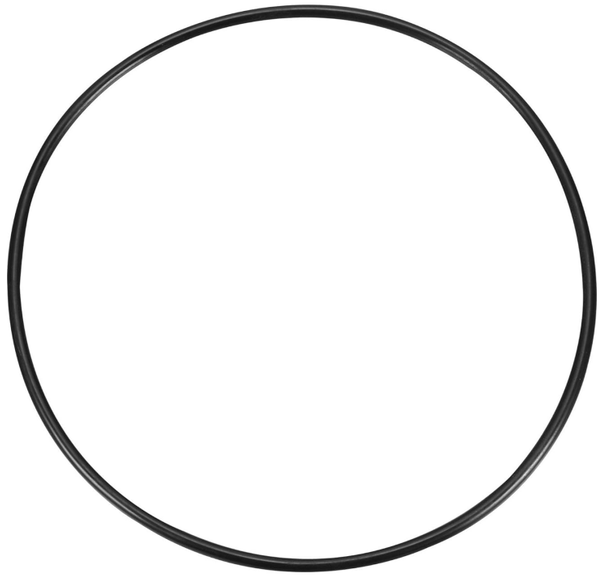
Field Research | Pool Light Mounting Bracket

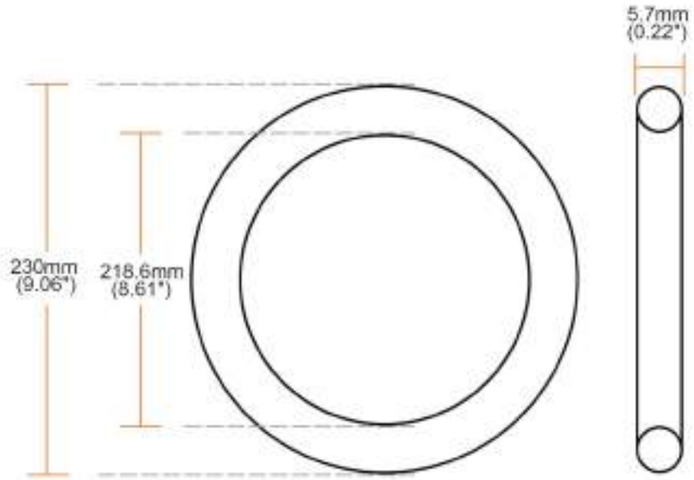
Pictured below is a pool light mounting bracket. It can be drilled into the side of most pools and it allows a range of pool light brands to be retrofitted with the pool.

Being able to design a camera that could fit this ring or a similar product would be beneficial as it will ensure that people can easily install the camera underwater. Additionally, if the ring breaks for any reason, it can always be replaced with a similar model.

Dimensions: 230mm x 230mm x 30mm

https://poolandspawarehouse.com.au/aqua-quip-qc-series-retro-fit-pool-light-apl050-universal-mounting-bracket-short-posts.html





To make cameras waterproof and airtight, o-rings (top middle) or gaskets (bottom middle) are typically used to repel water from the joining seams and gaps between joining parts. Either option will be essential to ensuring the camera is airtight and resistant to water damage.

https://www.amazon.com.au/uxcell-Sealing-Gasket-Washer-Automobile/dp/B008ASXPOC

https://www.acpools.com.au/display/1213-flange-gasket%0D%0Anatural-rubber-3mm-thickness%0D%0A200mm-table-d-e/

Field Research | Pool Light Mounting Bracket

A decent security camera available on the market. Roughly middle ranged in terms of price (listed in USD), quite affordable for its specified features.

The camera component can be manually turned and locked into the cover unit, as shown below. The camera simply unlocks from the base with an hex (allen) key.

The device includes a range of functioning elements, including an alarm light, microphone to pick up sound and infrared LEDs to improve vision. The unit be wired to a computer, record video to an SD card, and even hook up to an alarm light.

https://www.cctvcamerapros.com/Alarm-Security-Camera-p/ip-ax4d.htm

Security Camera with Alarm Light, Siren Audio, 4mp Dome IP Camera, IR

Security Camera with Alarm

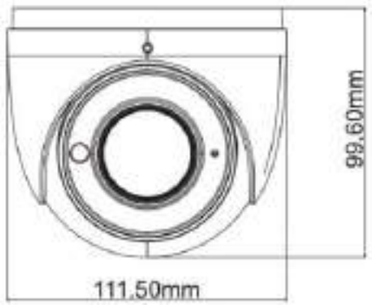
Purchase from a merchant you can trust!

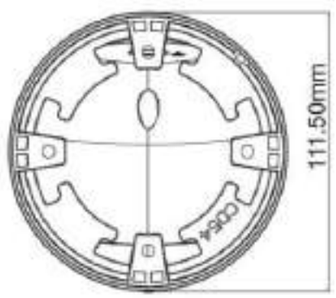
** This camera has been replaced with this 4K Viewtron alarm camera.

★★★★★
Rated Company

Click to see our customer reviews.

Price: $299.99
Sale Price: $249.99
You save $50.00!





It can be argued for my camera that recording video should not be necessary, as it is primarily intended for swimmer's safety in the water, not surveillance. However, the camera's feed should be able to be transferred to a remote device such as a smartphone for remote viewing. This camera allows for remote viewing via its own smart app.

Ingress protection (IP) ratings guide

IP ratings are represented by combining the first and second digits of the below columns

1st numeral - solid foreign objects	
0	No protection
1	Protected against solid foreign objects of 50 mm Ø and greater
2	Protected against solid foreign objects of 12,5 mm Ø and greater
3	Protected against solid foreign objects of 2,5 mm Ø and greater
4	Protected against solid foreign objects of 1,0 mm Ø and greater
5	Dust-protected
6	Dust-tight

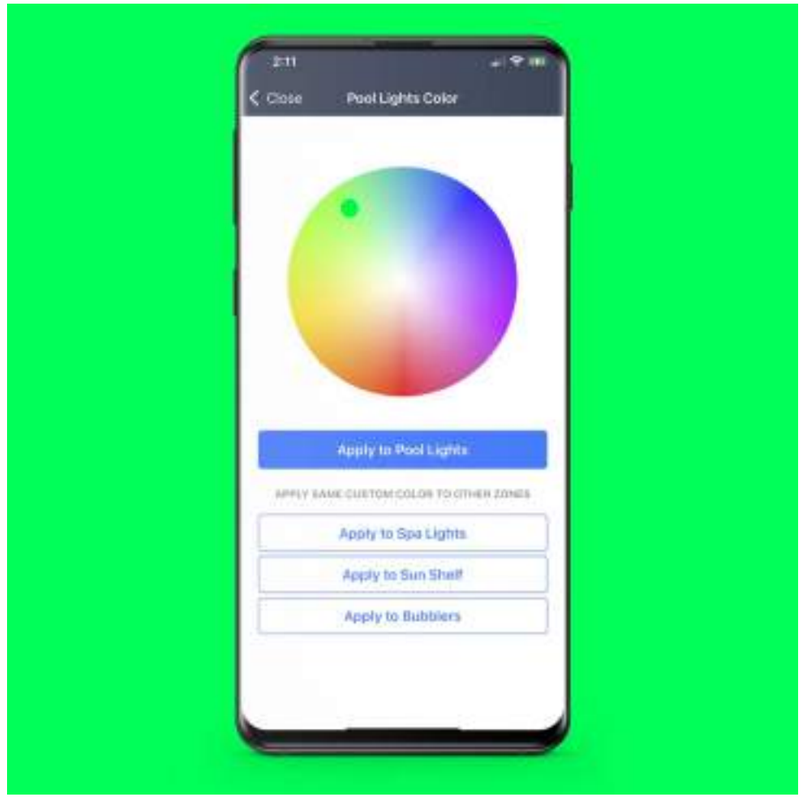
Example: IP 6 5 → Protected against water jets; → Dust-tight

2nd numeral - water	
0	No protection
1	Protected against vertically falling water drops
2	Protected against vertically falling water drops when enclosure tilted up to 15°
3	Protected against spraying water
4	Protected against splashing water
5	Protected against water jets
6	Protected against powerful water jets
7	Protected against the effects of temporary immersion in water
8	Protected against the effects of continuous immersion in water
9	Protected against high pressure and temperature water jets

-	
Vertically falling drops shall have no harmful effects	
Vertically falling drops shall have no harmful effects when the enclosure is tilted at any angle up to15° on either side of the vertical	
Water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects	
Water splashed against the enclosure from any direction shall have no harmful effects	
Water projected in jets against the enclosure from any directions shall have no harmful effects	
Water projected in powerful jets against the enclosure from any direction shall have no harmful effects	
Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is temporarily immersed in water under standardized conditions of pressure and time	
Ingress of water in quantities causing harmful effects shall not be possible when the enclosure is continuously immersed in water under conditions which shall be agreed between manufacturer and user but which are more severe than for numeral 7	
Water projected at high pressure and high temperature against the enclosure from any direction shall not have harmful effects	

The ingress protection guide is a necessary benchmark to closely consider for the camera, especially as it is intended to function underwater. Referring to the standardised chart above, this means the camera will have to adhere to either IP68 or ideally IP69 ingress protection to ensure it will function without issue underwater.

https://www.iec.ch/ip-ratings



Jandy is one of many brands that designs and installs underwater pool lights. The pool light variant takes 50 watts while the spa light version takes 25 watts.

It is important to note that Jandy equipment cannot be bought off the shelf and is only sold through qualified pool professionals due to the complexity of setup. Looking at devices that are permanently installed underwater is vital to understanding how the camera concept will work and operate when submerged.

https://www.jandy.com/en/products/pool-lights/niched-lighting/infinite-watercolors-niched-led-lights

Jandy lights can be linked up to a smartphone app for remote control. The user interface is very simple, which makes it clear and easy to understand. If my camera concept links up to an app, it should take notes from interfaces such as this one that make it easy to understand and operate at a moments notice.

Unfortunately, the lights do not appear to operate without this app. This will inevitably render the lights useless when the app is delisted. I will avoid this caveat in my concept design by ensuring that the camera can still operate out of the box, without needing any external technologies or tools.

Field Research | Jandy LED Lights Components

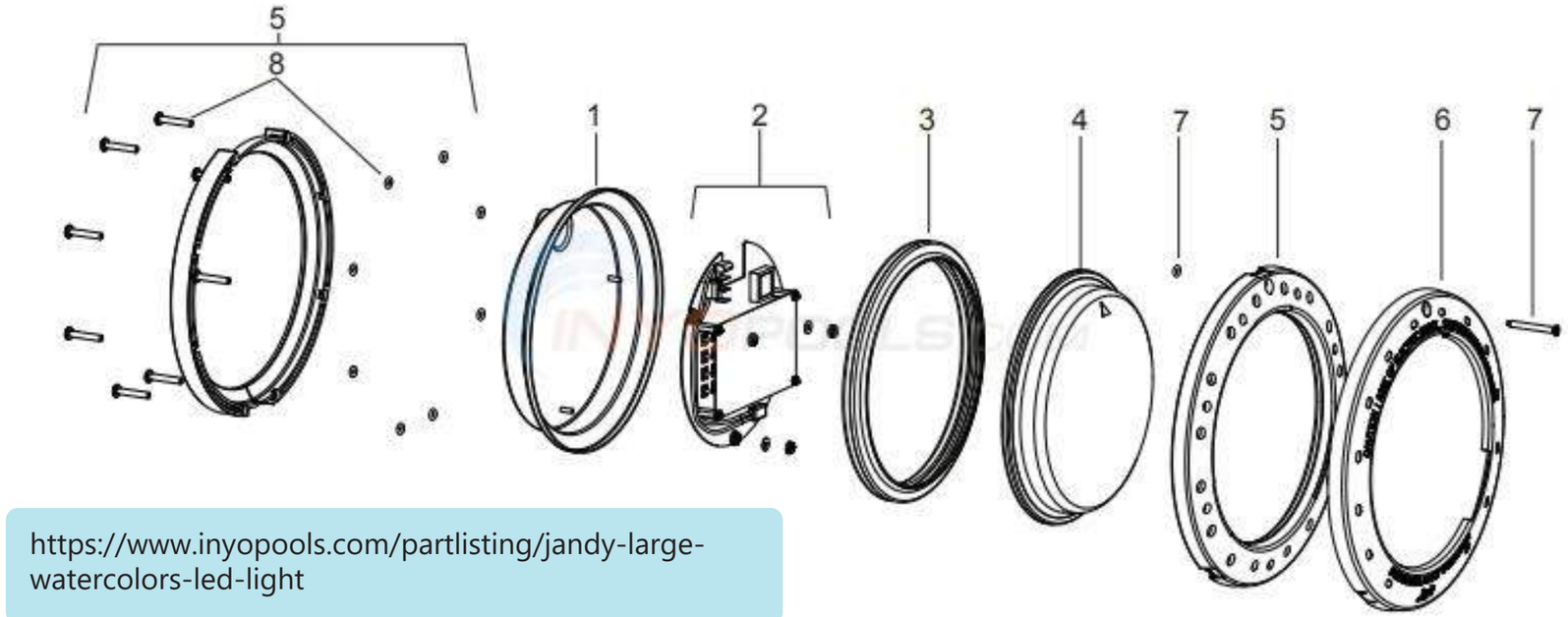


Diagram #	Part Title
1	WaterColors Light Housing
2	Light Engine PCB, 12V Large LED Light w/ Light Shaping Diverger
3	Silicone Gasket
4	Glass Lens
5	Clamp Assembly
6	Face Ring, Stainless Steel (SS)
7	Pilot Screw, w/ Retainer
8	Clamp Screw Kit (8 screws/retainers)

https://www.inyopools.com/partlisting/jandy-large-watercolors-led-light

Online retailer Inyo Pools lists the individual components of a standard Jandy LED light for sale. This deconstruction is useful to understanding how electronics such as these are designed to be watertight. As of 30/09/2025, none of the listed parts are available for purchase, though still show a projected retail price.

2.

$1,005.88USD

The PCB board contains all electronic components, making up the majority of manufacturing and retail prices.

3.

$51.17USD

Important silicone lining between part gaps to prevent water leakage.

4.

$138.60USD

The main cover that allows the LED lights to shine through whilst protecting the PCB board behind it.

5.

$100.21USD

This clamp assembly houses all the previously listed components (1-4) in between the two ends.

6.

$168.45USD

The face ring secures the entire assembly together and acts as an extra lining of protection from all damages.

Part 1. is not listed on the website. This housing completes the threading screw (7.) entering from part 6.

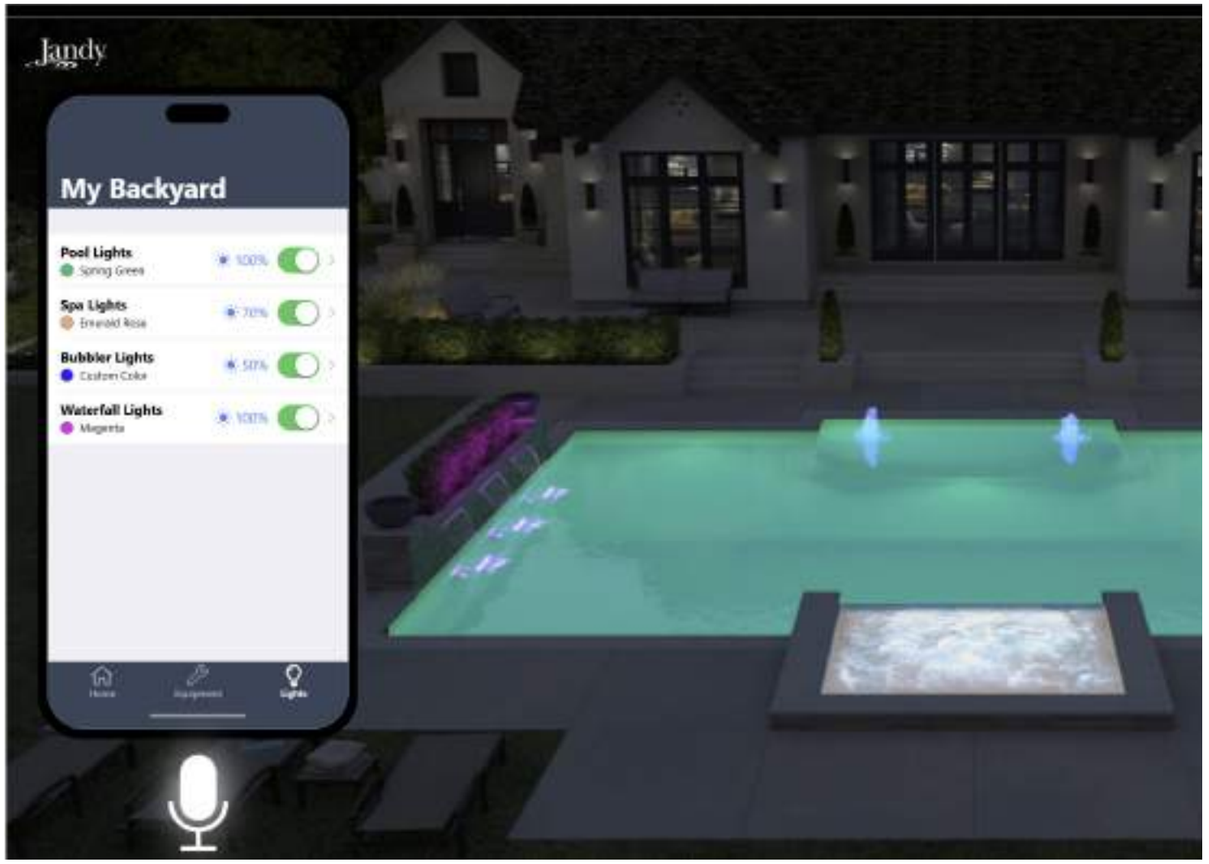
The above image highlights how these parts interact to create a complete watertight unit. Many layers of rings are utilised to ensure that the light has several preventative barriers from damage at all sides.

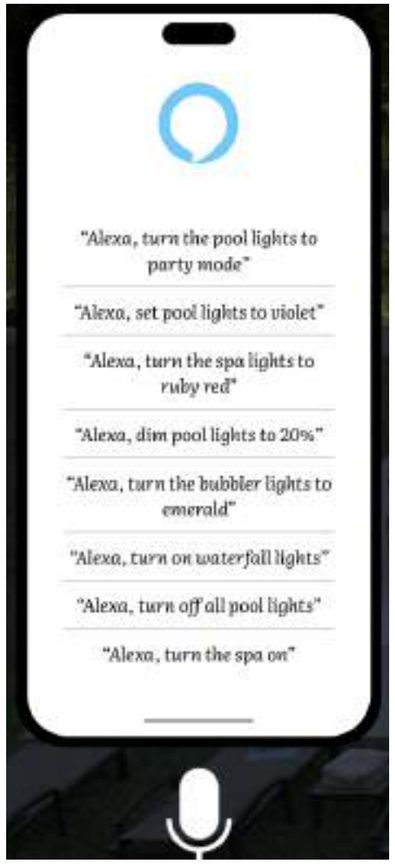
https://www.inyopools.com/Products/02601352086645.htm

The gasket is very important as it acts as a sealant between the part line gaps of the different outer rings. Combined with the glass lens, these two components do the heavy lifting of PCB protection. The wider outer rings act as a first line of defence from damage and also act as guides for installation into a wall.

The PCB itself is closer to the back of the unit. This is smart design, as it will be permanently installed into a wall. The PCB takes full advantage of its position, as the other parts made of stainless steel and hard injection moulded plastics to create several layers of protection from the areas the unit will be exposed.

Field Research | Jandy LED Lights Trial App





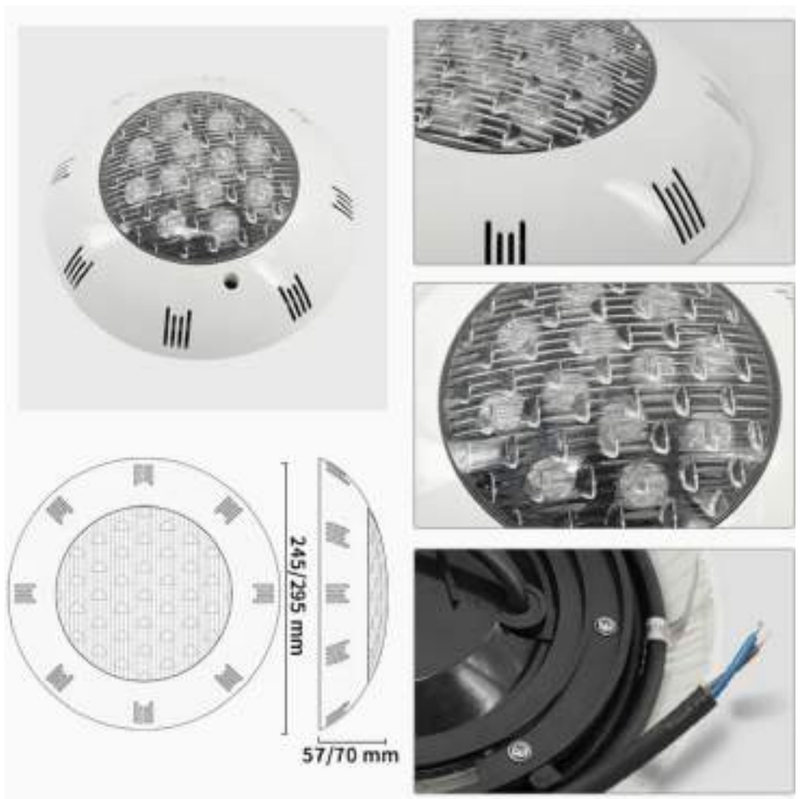
Their website allows visitors to trial how the app works. Above is an example of how multiple lights can be connected to one device, each individually customisable. This is a useful feature as it unifies multiple units together and also encourages consumers to purchase multiple. I have already planned that consumers may want multiple cameras above and under water for better human detection visibility, so a simple unified setup like this would be beneficial.

https://www.jandy.com/en/products/pool-lights/niched-lighting/infinite-watercolors-niched-led-lights

The homepage is laid out in a clear hierarchy of relevant information. It only shows general information about the pool without overwhelming users with too many specific details.

The equipment page neatly organises additional features around the water. Certain features such as the fire bowl are only for show on this conceptual model and not indicative of the full functionality of the app.

Suggested voice prompts are also included for testing. Integrating voice commands could be a good inclusion for remote control of the camera, especially as the user will be preoccupied with rescuing a drowning swimmer when notified.

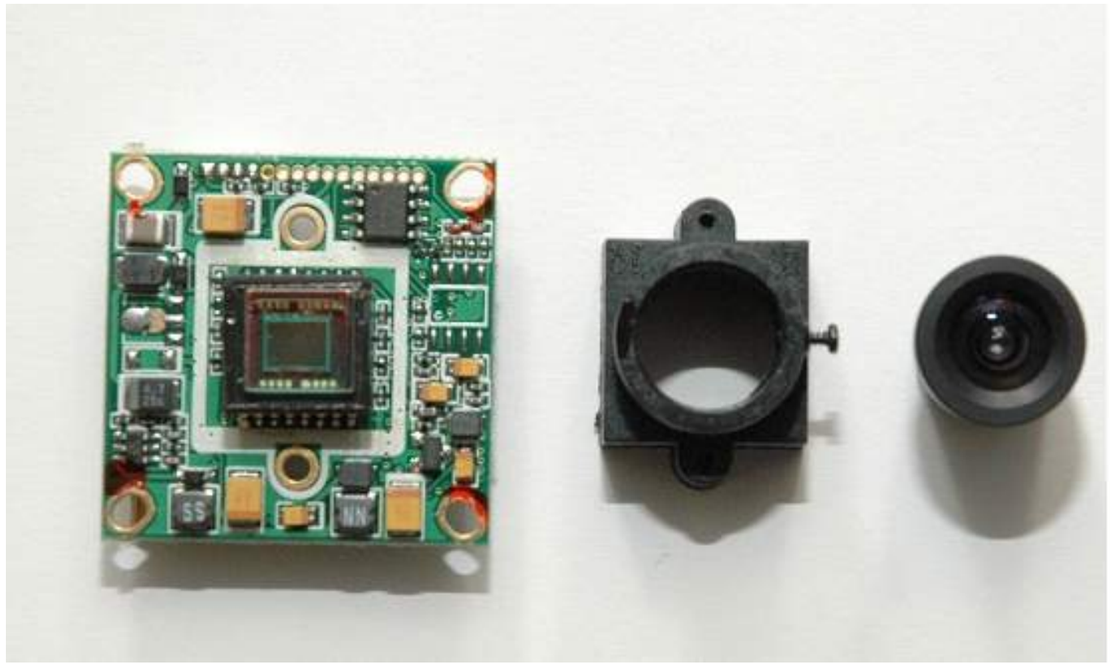


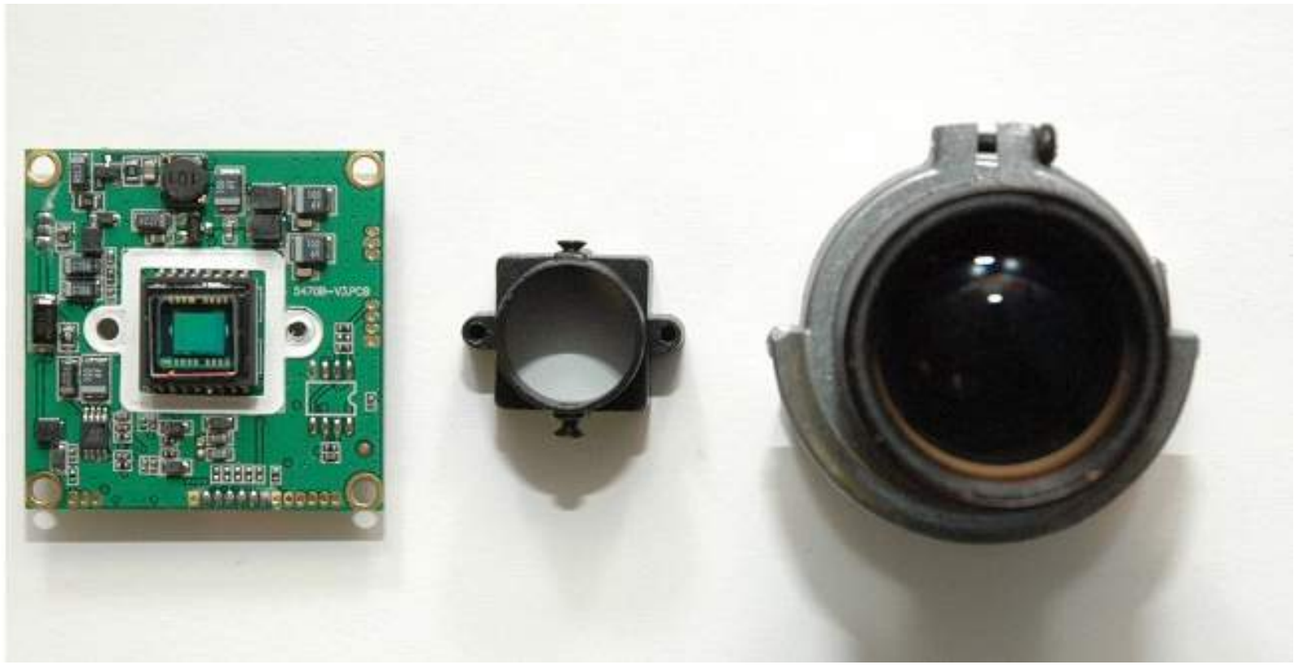
This is a much more affordable pool light option manufactured by Jiangmen Synno Lighting Co. These lights are IP68 approved and encouraged to be bought in bulk. The installation diagram above provides a good frame of reference for installation, including how the mounting bracket and screws hold the unit in place. I will aim for a similar level of simple installation for the camera design.

https://synnoled.en.made-in-china.com/product/cFBTSoOCPikI/China-Swimming-Pool-Light-for-Wall-Mounted-12W-IP68-Waterproof-RGB-LED-Pool-Lights-Standard-Crosshead-CE-RoHS.html

The light unit also comes packaged with a remote control (erroneously misspelled above) to control the LED light output. The inclusion of a standalone controller is useful as the device is not reliant on online features unlike the Jandy lights analysed previously. The functions on the controller could be a lot clearer, perhaps using common symbols or colours would communicate the affordances a lot better.

The photographs shown left provide good detail on size, fasteners and material finishes. The fasteners are clear but not aesthetically intrusive, making the disassembly process straightforward. I will incorporate common screws and similar fasteners to ensure the camera unit can be easily repaired or dismantled.





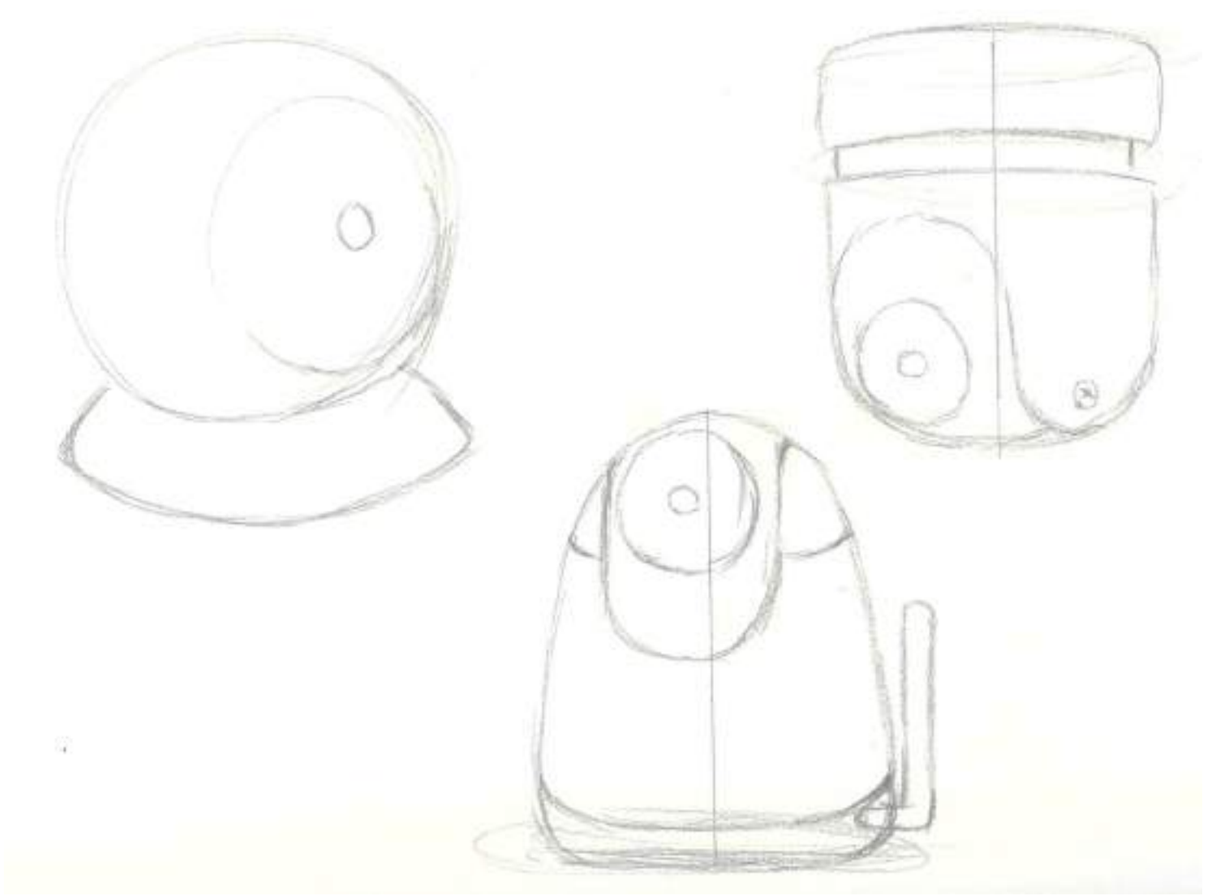
Above is a clear deconstruction of a camera PCB. The camera lens thread screws into a holder pieces, which in itself screws through the PCB board. These parts could prove useful for the camera design. An LED ring surrounds the camera to illuminate the viewing area.

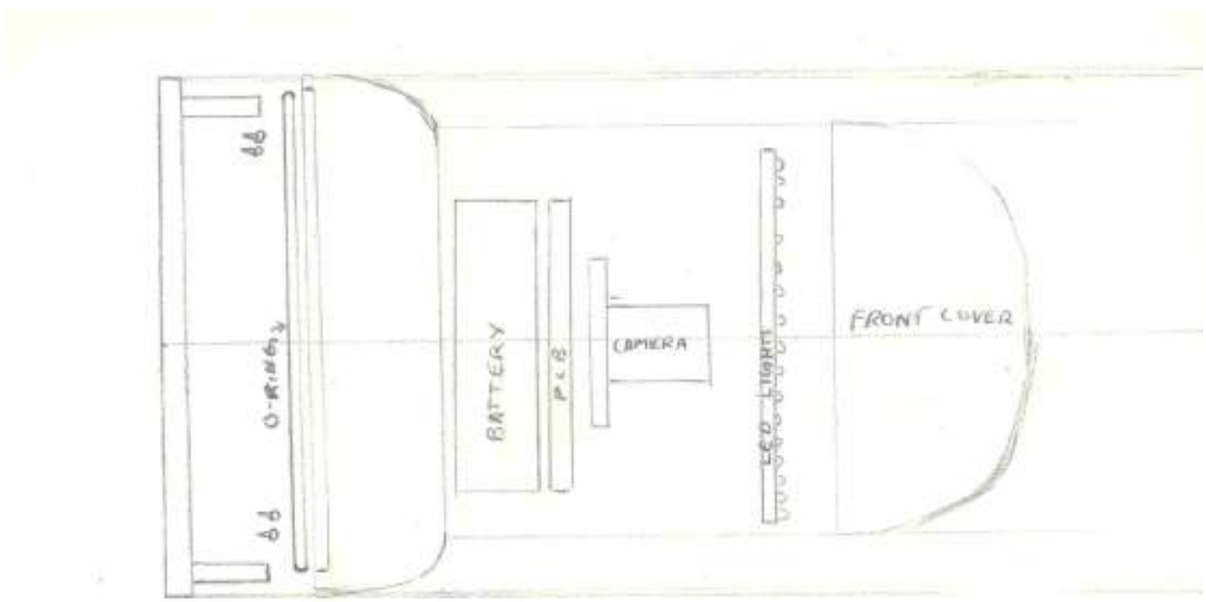
The camera on the right demonstrates a similar teardown. Clearly, the internal parts do not need to be big to work well, which is important to note for my design. It should not be any bigger than it needs to be, which I will need to remember when sketching.

https://www.cctvcameraworld.com/cctv-cameras-repair/

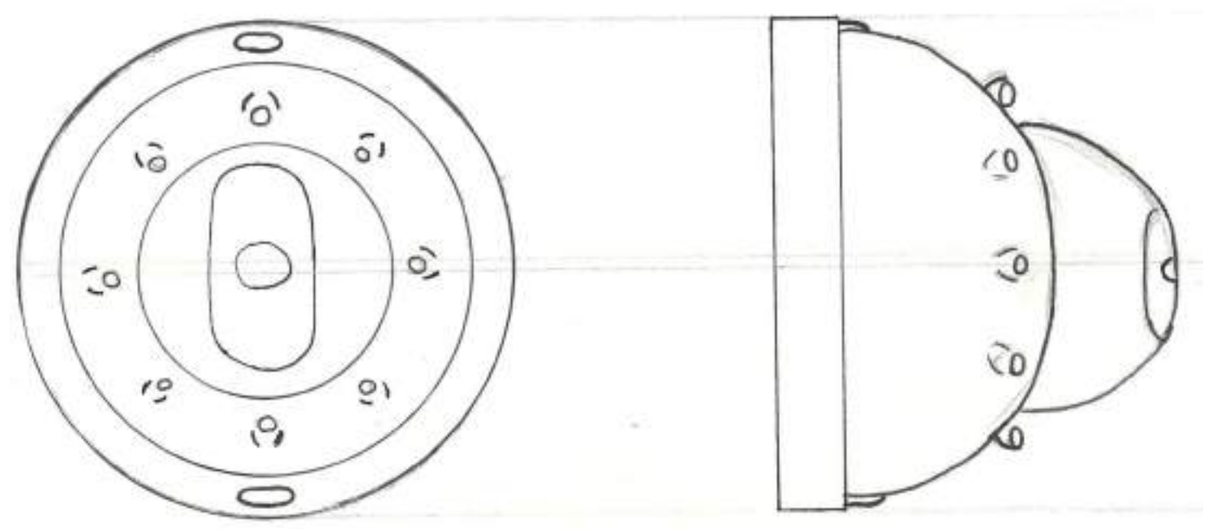
https://www.amazon.com/ZOSI-8-Channel-Surveillance-Weatherproof-Security/dp/B00XHOX52Q

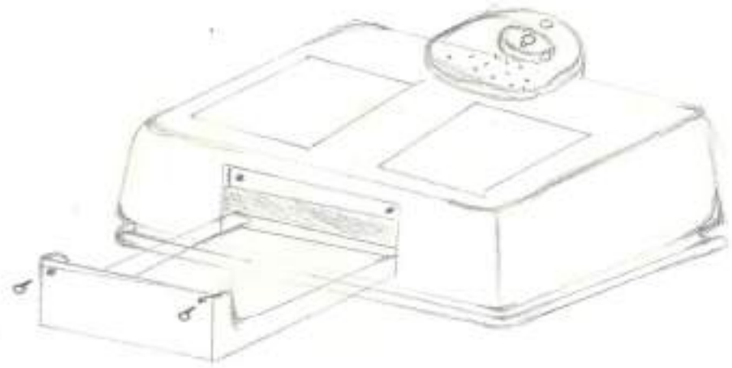
Sketch Iteration | Form and Teardown Exploration



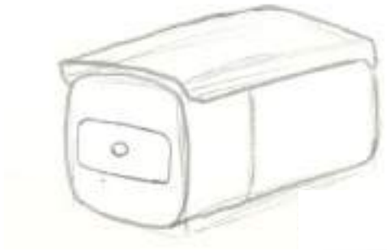


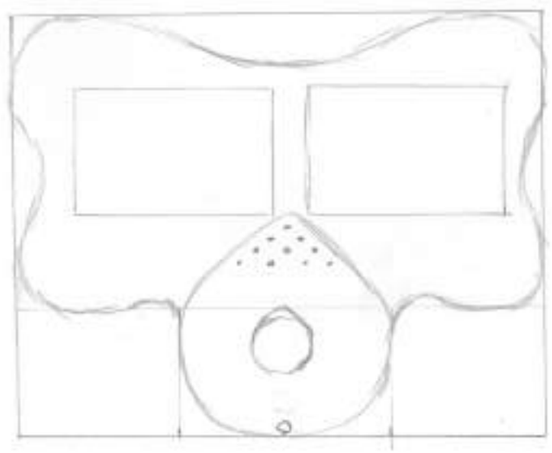
To my current understanding of camera design, the above teardown diagram should highlight the key components needed to create a functioning underwater camera. The o-ring is extremely important as the rubber will repel water that may otherwise seep through connecting part lines with varying tolerances. A mounting bracket will be needed to attach the camera unit securely to a wall.





Slide-out battery housing, simply unscrew to take out a rechargeable battery. Solar panels provide alternate energy to power the unit for as long as they can. The rechargeable battery acts as a backup energy source.

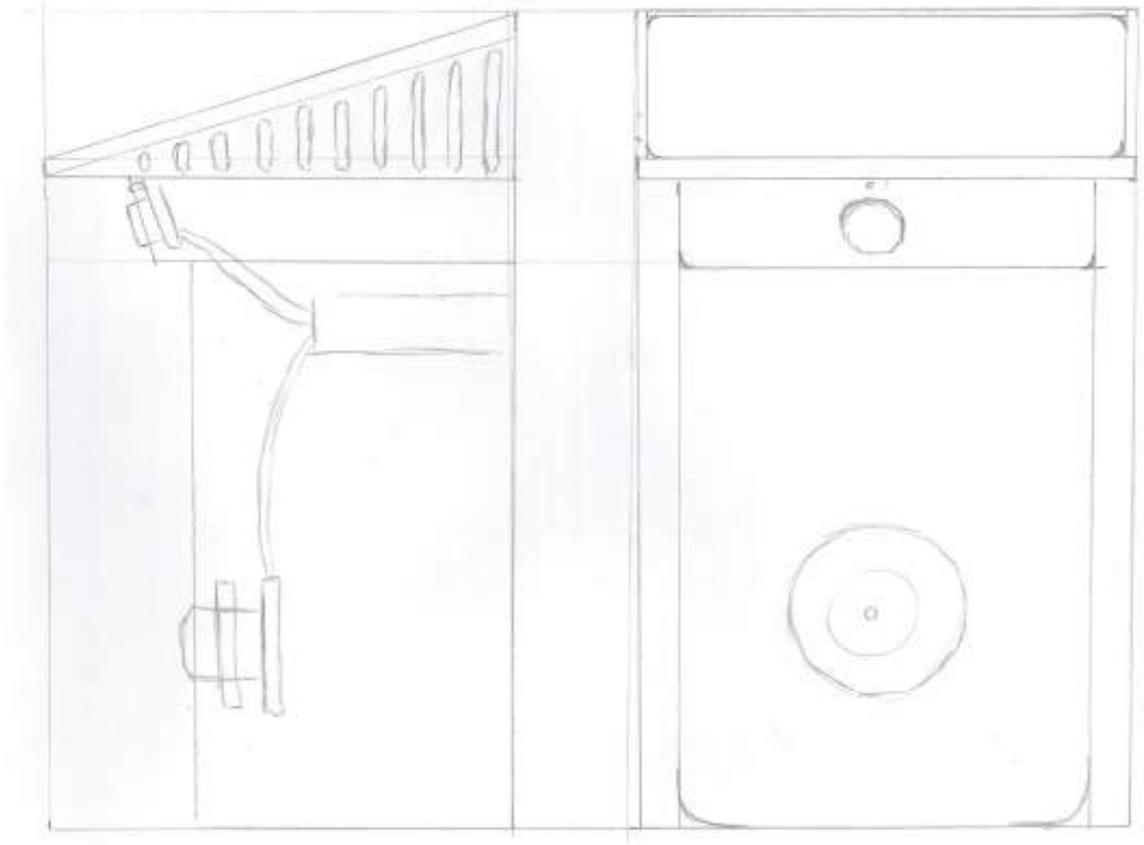




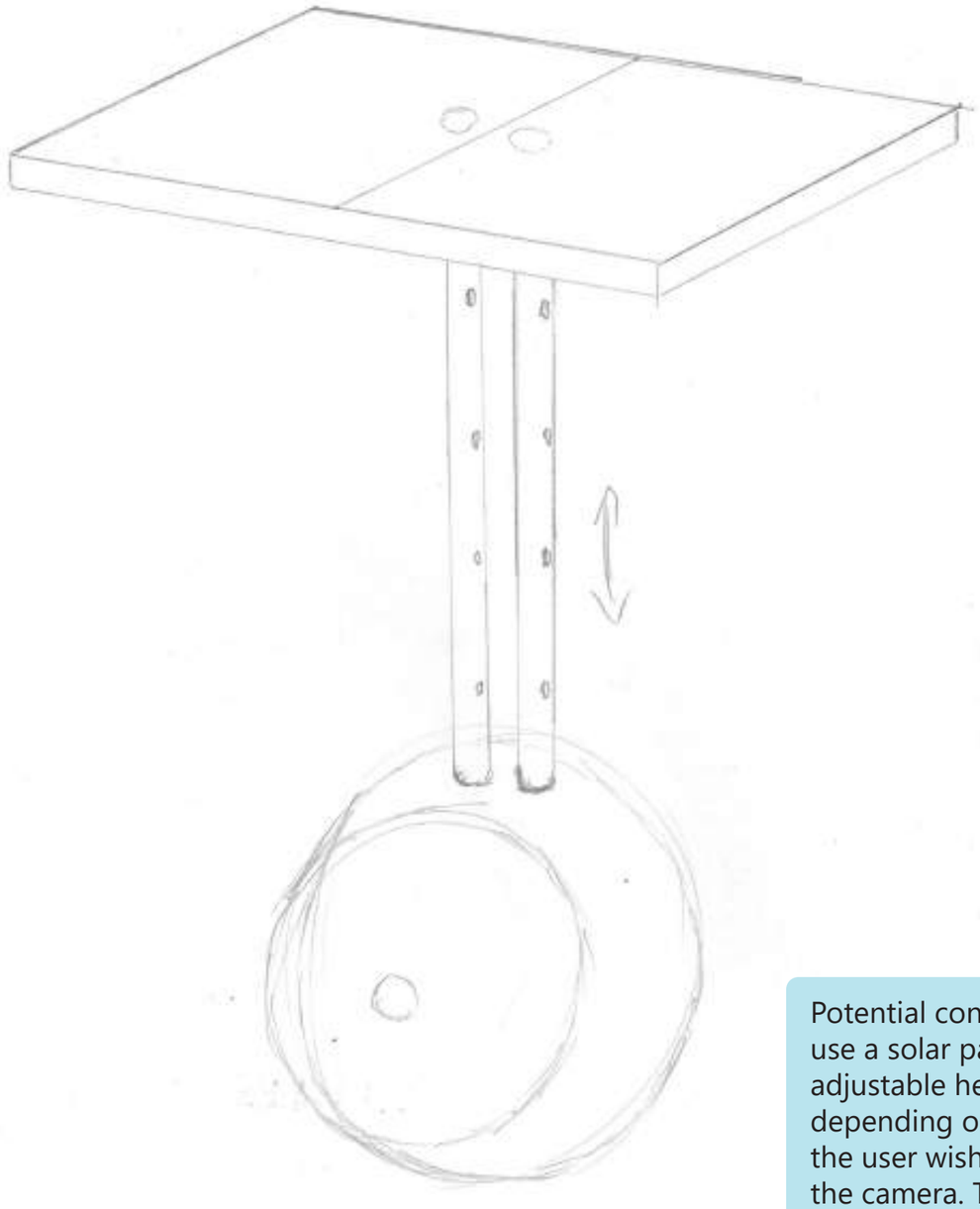
Water drop motif could be a novel idea. Form ideation should be more rounded than using hard edges to feel more inviting to potential consumers and stand out in the current market.

Over ledge pool camera, can be taken on the go which is encouraged with a rear handle. This could be removed if the user does not need it. Top interface includes an alarm speaker, LED light and button to stop the alarm.

Sketch Iteration | Wall Attached Concepts

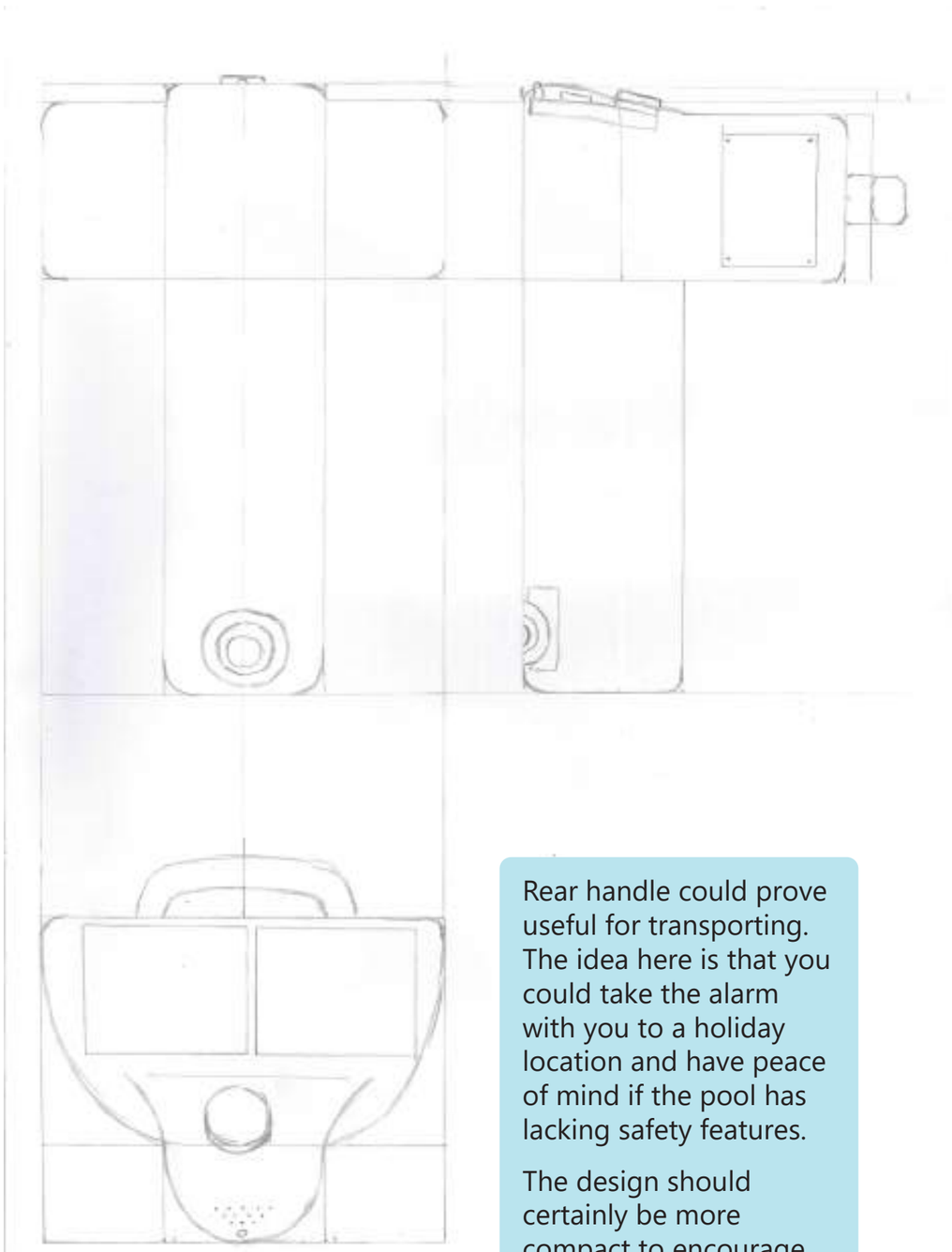


Potential 1:1 scale model. The angled solar panel up top conceals the rest of the unit from potential damage. Internals show how the camera, interface buttons and battery may be attached. The overall form seems efficient whilst still ensuring the solar panel is above water and the camera will be underwater.



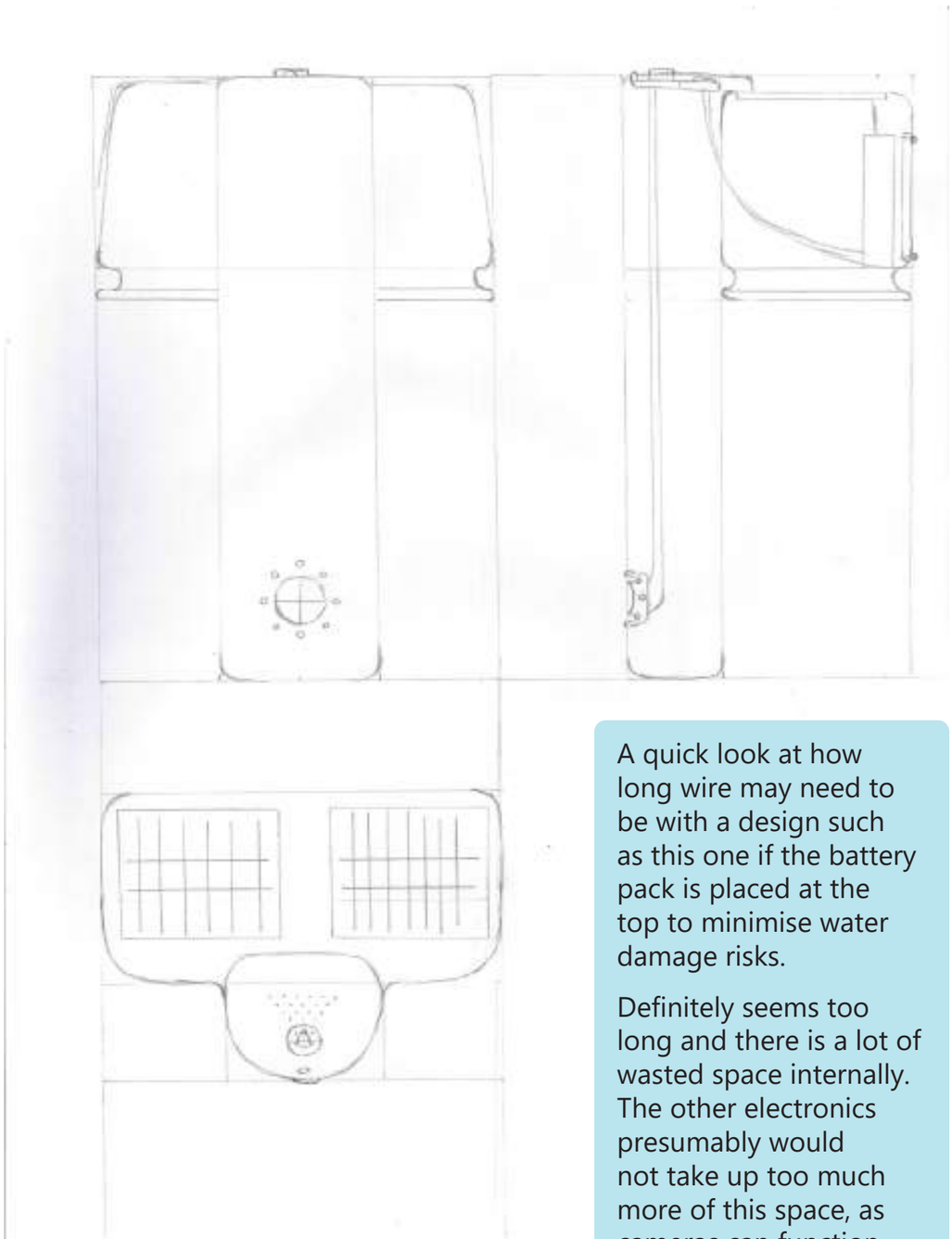
Potential concept to use a solar panel with adjustable height depending on how deep the user wishes to place the camera. The concept is probably superfluous and would risk stability issues that can otherwise be avoided.

Sketch Iteration | 1:1 Scale Over Ledge Cameras



Rear handle could prove useful for transporting. The idea here is that you could take the alarm with you to a holiday location and have peace of mind if the pool has lacking safety features.

The design should certainly be more compact to encourage people to try this more effectively.



A quick look at how long wire may need to be with a design such as this one if the battery pack is placed at the top to minimise water damage risks.

Definitely seems too long and there is a lot of wasted space internally. The other electronics presumably would not take up too much more of this space, as cameras can function exceptionally well at such a small scale.

Field Research | Lighting Options in the Dark

EFFICIENCY	LEAST			MOST
BULB TYPE	STANDARD	HALOGEN	CFL	LED
450 LUMENS	40W	29W	9W	6W
800 LUMENS	60W	42W	14W	9W
1100 LUMENS	75W	53W	18W	11W
1600 LUMENS	100W	72W	23W	14W
RATED LIFE	1 YEAR	1-3 YEARS	6-10 YEARS	12-25 YEARS
SAVINGS	X	UP TO 30%	UP TO 75%	UP TO 90%

Underwater visibility is very important for the camera, especially in the dark, fog or heavy rain. The brightness or lumens the LED's produce is important to consider for visibility. 800 lumens is a common range for everyday flashlights or low beams on cars and should be suitable for improving the camera's vision.

The alternative to using light for illumination is to rely on night vision cameras. The above camera grabs show just how effective night vision can be at assessing the area. It should be noted that night vision relies on extrapolating the minimal light within its vision. It will be ineffective if the area is too dark, which could be an issue in certain pools depending on location. Thermal imaging is another technology used in security cameras, but is highly ineffective underwater and as such will be dismissed.

https://www.westinghouselighting.com/lighting-education/brightness-lumens.aspx

https://www.security.org/security-cameras/best/infrared/

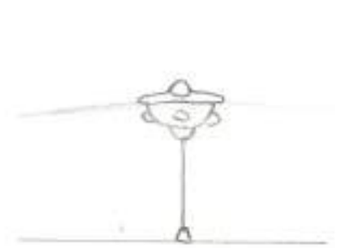
Quick clarification that this is not my own work. The teardown images of this camera are sourced from the blog post linked below.

https://www.simplexitypd.com/blog/pan-tilt-security-camera-teardown-pt2/

Here is a closeup of the main PCB with the camera lens attached. A ring of LED lights is attached to the main PCB via a ribbon cable wire. The setup of LEDs around the camera lens is an efficient way to enhance the lens vision in the dark, which could prove beneficial for my camera design.

Two separate PCB units are found in this model. The dark grey PCB houses the camera lens, micro-SD card slot and LEDs. This PCB is responsible for the primary functions of the camera unit, which is recording clear footage. The green PCB exists to provide a micro-USB slot neatly and discretely near the surface of the unit. Using multiple PCB units may be necessary to create an aesthetically resolved finish.

Product Types:

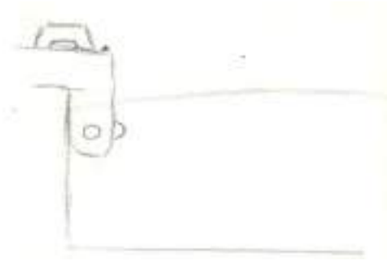


Tethered

Secure, but can still move and tether creates a hazard in the water. Not suitable.

Wall Attached in Water

Will be secured in place and will never move on accident, even with heavy force.



Side Mounted in Water

Quite big and bulky, a lot of underutilised space internally.

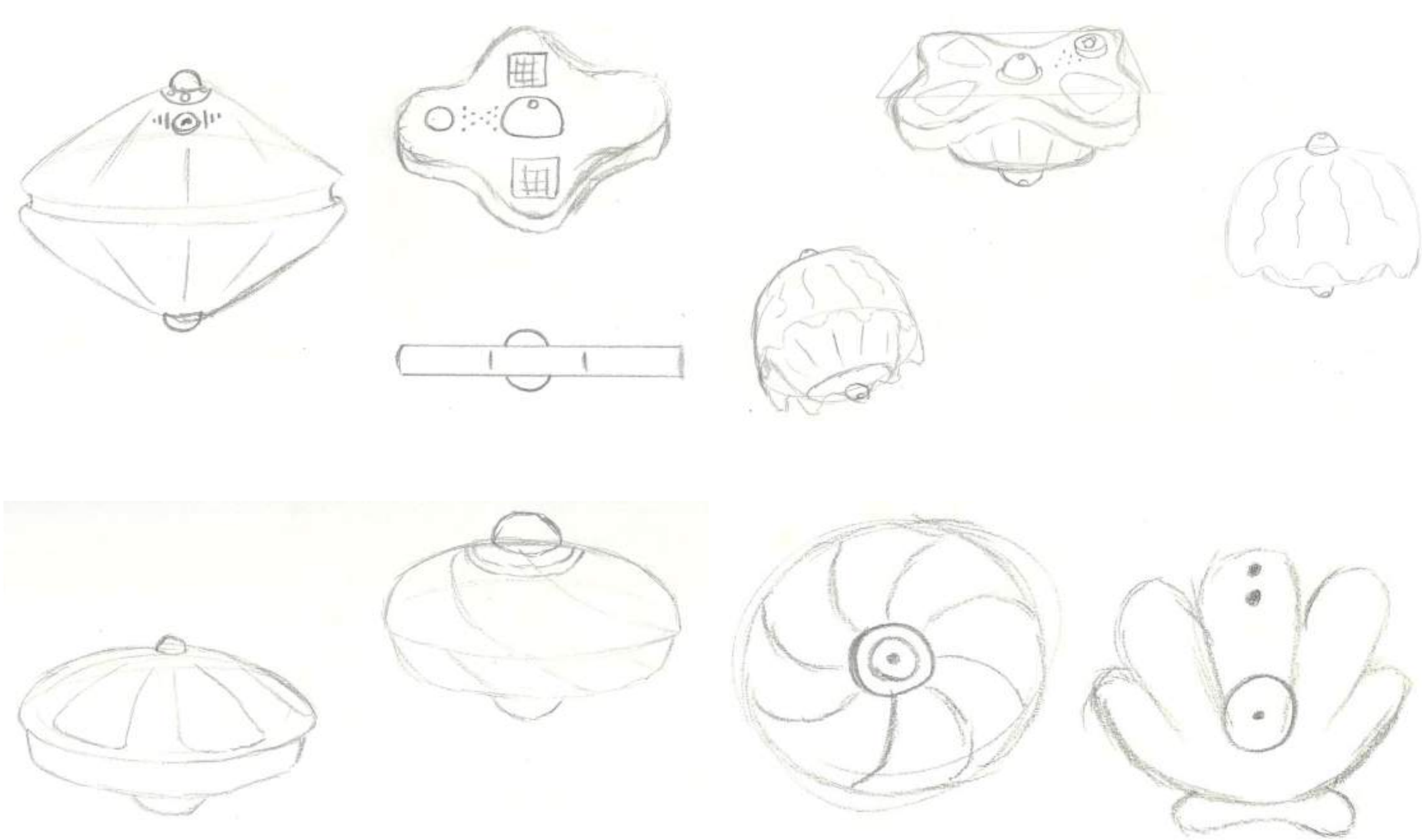
Floating

Presents a unique opportunity to monitor activity both above and under the water.

Wall Attached Infrared

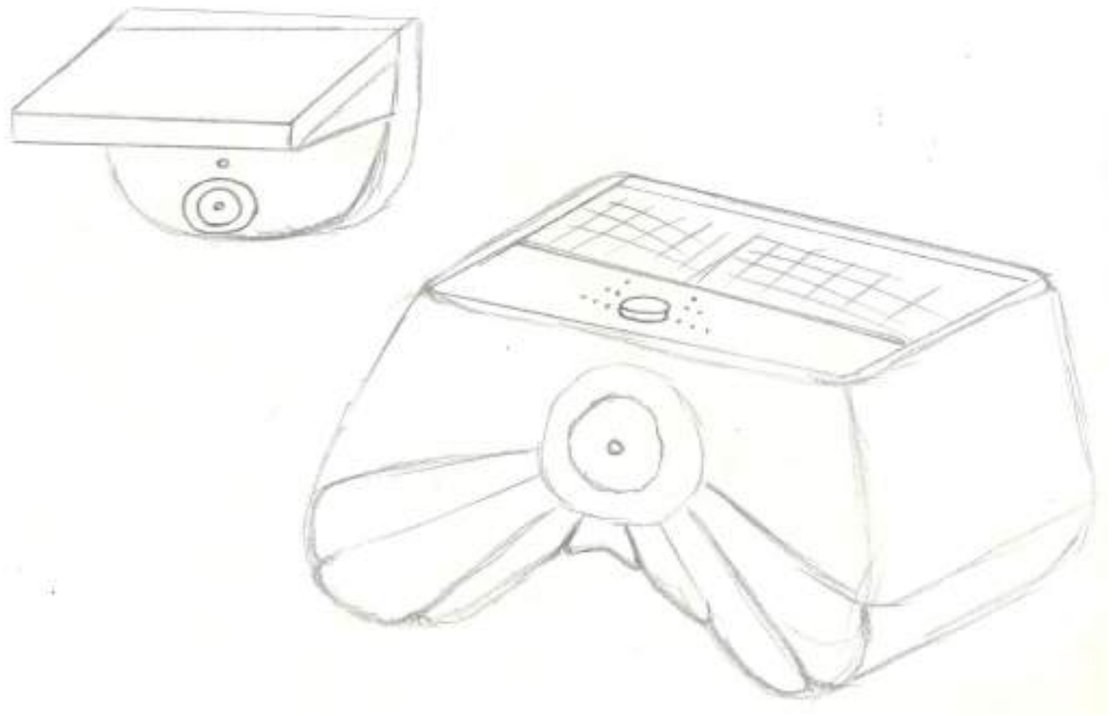
Can communicate emergency to remote device without requiring Bluetooth.

Wall attached and floating alarms are the strongest designs functionally. I will focus on these two camera types moving forward to narrow my scope.

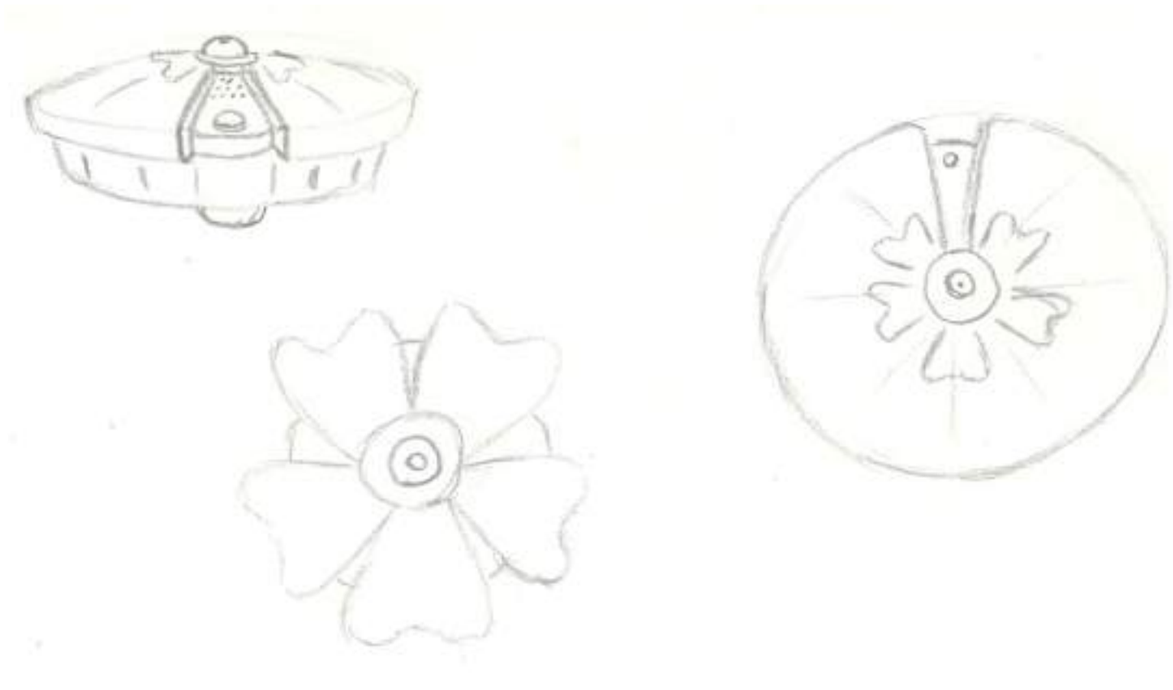


Sketch Iteration | Inspiration from Nature

These two concepts explore functionality more than form. The top left is an idea for a compact solar powered camera. It could be attached to the side of a pool or wall very easily and remain discrete. The larger camera takes a seashell pattern and embodies it into a more geometric abstract shape.



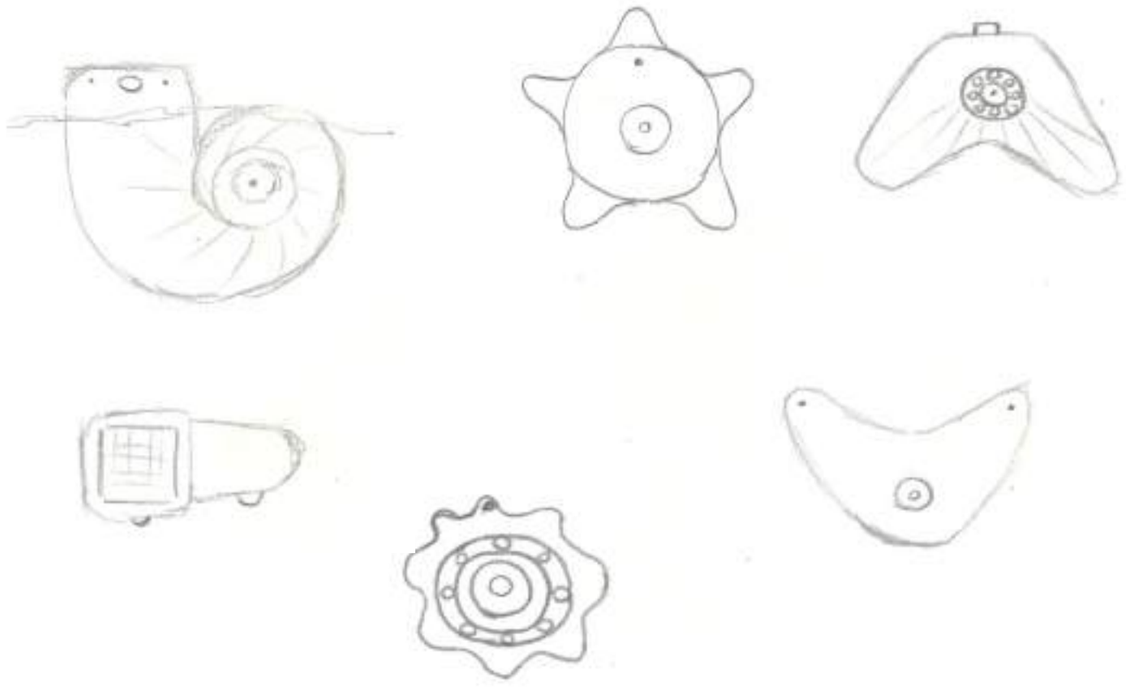
These alarms take clear inspiration from lily pads. This was inspired having looked back at the existing floating alarms and how they resembled this shape. A small cutout could be the perfect area for user interface buttons as it will be visually distinct and signify interaction.



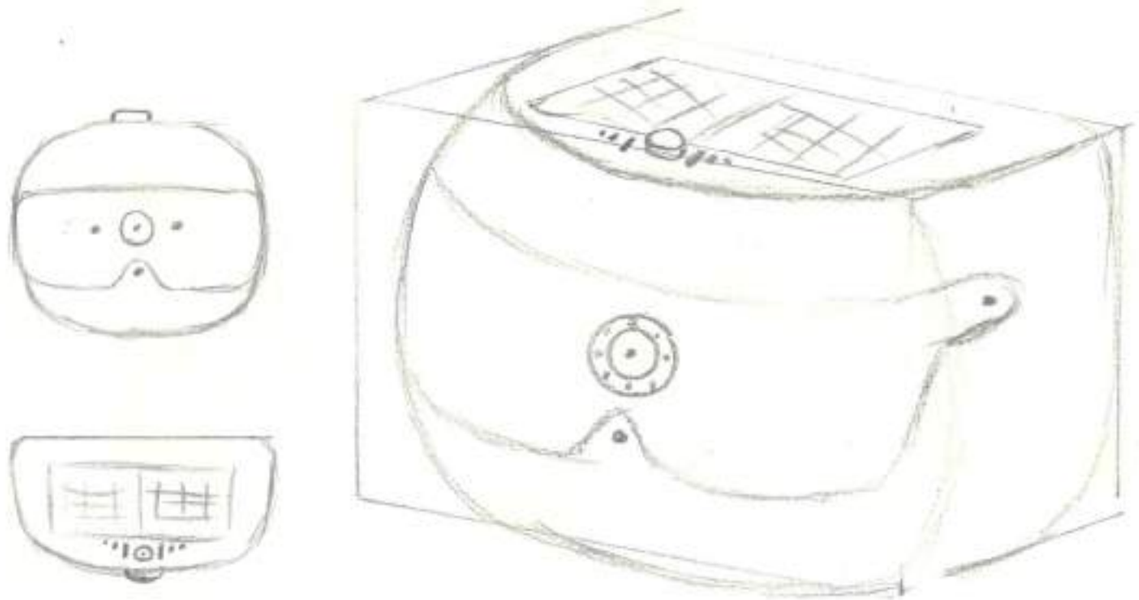
Inspiration:

Sketch Iteration | Biomimicry and Snorkel Form

Taking aesthetic cues from nature and employing biomimicry would be a great way to make the camera stand out in the existing market. Existing cameras and alarms are largely geometry and have simple, smooth form. Ideas from biomimicry and more geometric shapes were experimented with.

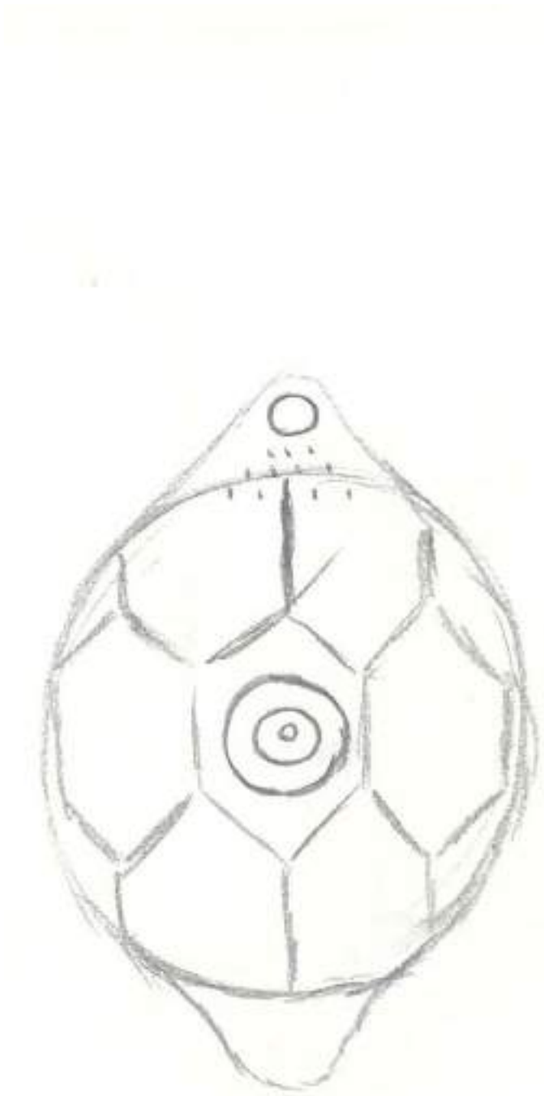


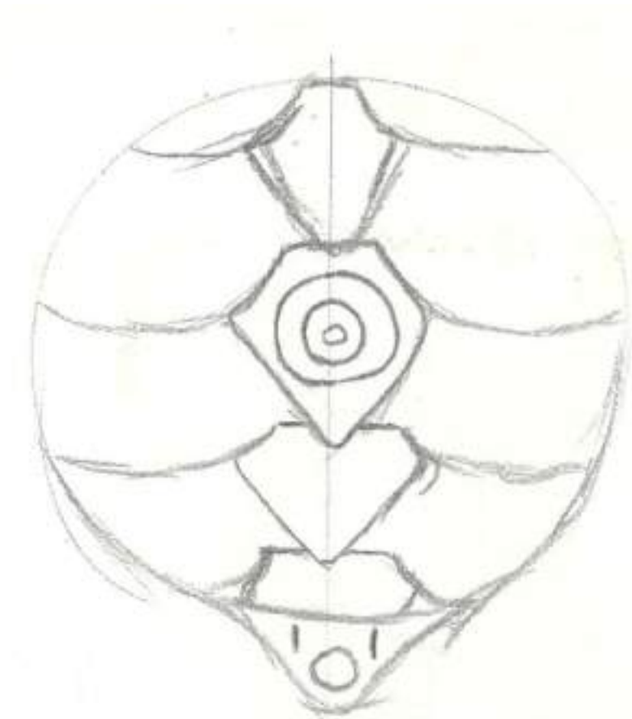
Taking a different approach, this wall mounted camera resembles a diver with snorkel. The nose indent personifies the alarm but the form is kept minimalist to avoid the uncanny valley and communicate that the camera is reliable.



Inspiration:

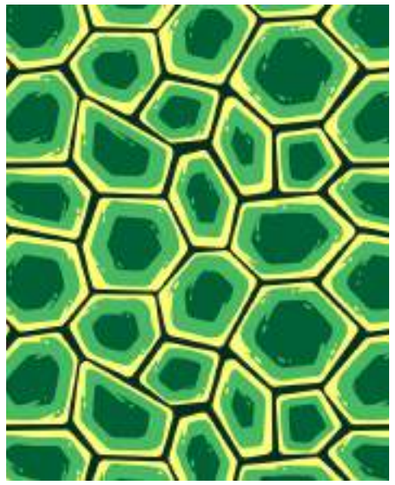
Sketch Iteration | Turtle Shell Design





This design seems promising, it borrows a lot of the best aspects from the previous devices together. It employs biomimicry, the electronic components use the shape to their advantage and there is opportunity to create many different patterns from the same form.

Inspiration:



Field Research | Off-the-Shelf Parts (Part 1)

LED Strip Lights

Cost: $4.28AUD per 5 metres
= $0.856AUD per metre
300mm needed = $0.257AUD

RGB strip lights will illuminate the pool. Different colours will shine depending on the hazard identified. This acts as a secondary signifier especially useful for people who cannot hear the device for any reason.

https://www.alibaba.com/product-detail/High-Lumen-Smd-4014-Hard-0_60815256761.html

Solar Panels

Cost: $0.8512AUD per unit

Provide the primary power source for the device. Two 45mm x 45mm solar panels will be built into the unit to provide adequate power.

https://www.alibaba.com/product-detail/Customizable-40-28mm-Polysilicon-Solar-Panels_1601584781753.html

Battery

Cost: $1.37AUD per unit
(>100000 pcs)

This lithium-ion battery will store and retain power to be used over time, sourced from the solar energy.

https://www.alibaba.com/product-detail/HYLN-factory-price-1200mah-lithium-ion_1600706276472.html

Waterproof Fisheye Camera Lens

Cost: $5.27AUD per unit
(>10000 pcs)

Waterproof IP68 fisheye lens will record footage and detect any potential hazards in the water. The lens has high definition resolution (1920x1080p) suitable for AI human detection.

https://www.alibaba.com/product-detail/Waterproof-1-2mm-Fisheye-Lens-Ip68_1601524053110.html

Camera Lens Holder

Cost: $0.2477AUD per unit
(>5000 pcs)

The camera lens will need to be secured in place with a lens holder. This common component uses a common thread size (M12x0.5) commonly used on small camera lens', including the one selected for use.

https://www.alibaba.com/product-detail/Metal-CCTV-Lens-Holder-Threaded-M12_1600695926393.html

Field Research | Off-the-Shelf Parts (Part 2)

LED Diode

Cost: $0.0155AUD per unit (>30000 pcs)

This LED diode will be included on one end of the unit and emit once every five seconds to confirm that the device is currently working.

https://www.alibaba.com/product-detail/Custom-Led-Diode-5mm-3mm-Through_1600617520888.html

Alarm Buzzer

Cost: $1.12AUD per unit (>50000 pcs)

A generic alarm buzzer that emits a loud noise at 85db. This device will be simple to include and will work effectively, but is limited to the one sound.

https://www.alibaba.com/product-detail/High-Quality-2616-12v-Buzzer-Dc_1600476146983.html

OR Alternatively for sound:

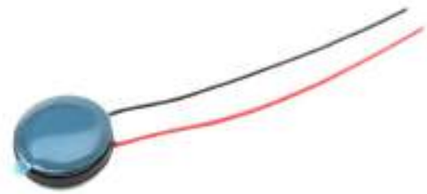
Sound Chip

Cost: $0.4489AUD per unit (>30000 pcs)

This electronic chip is programmable to emit different sounds based on different actions. It could sound an urgent alarm sound if there is human or animal drowning risk detected. A less intense sound could be used for debris detection so that bystanders know what the camera is alerting as soon as they hear the sound.

https://www.alibaba.com/product-detail/ISD1806-WTV380-8s-Sound-Recordable-Chip_1600749898497.html

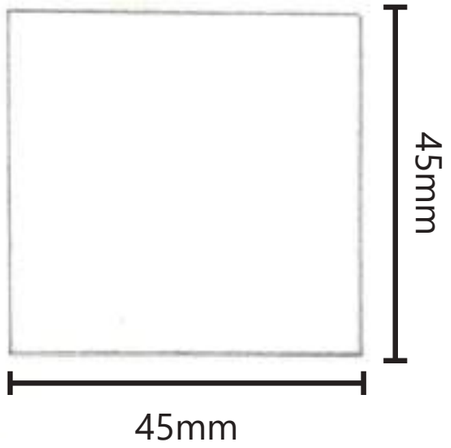
Waterproof Speaker

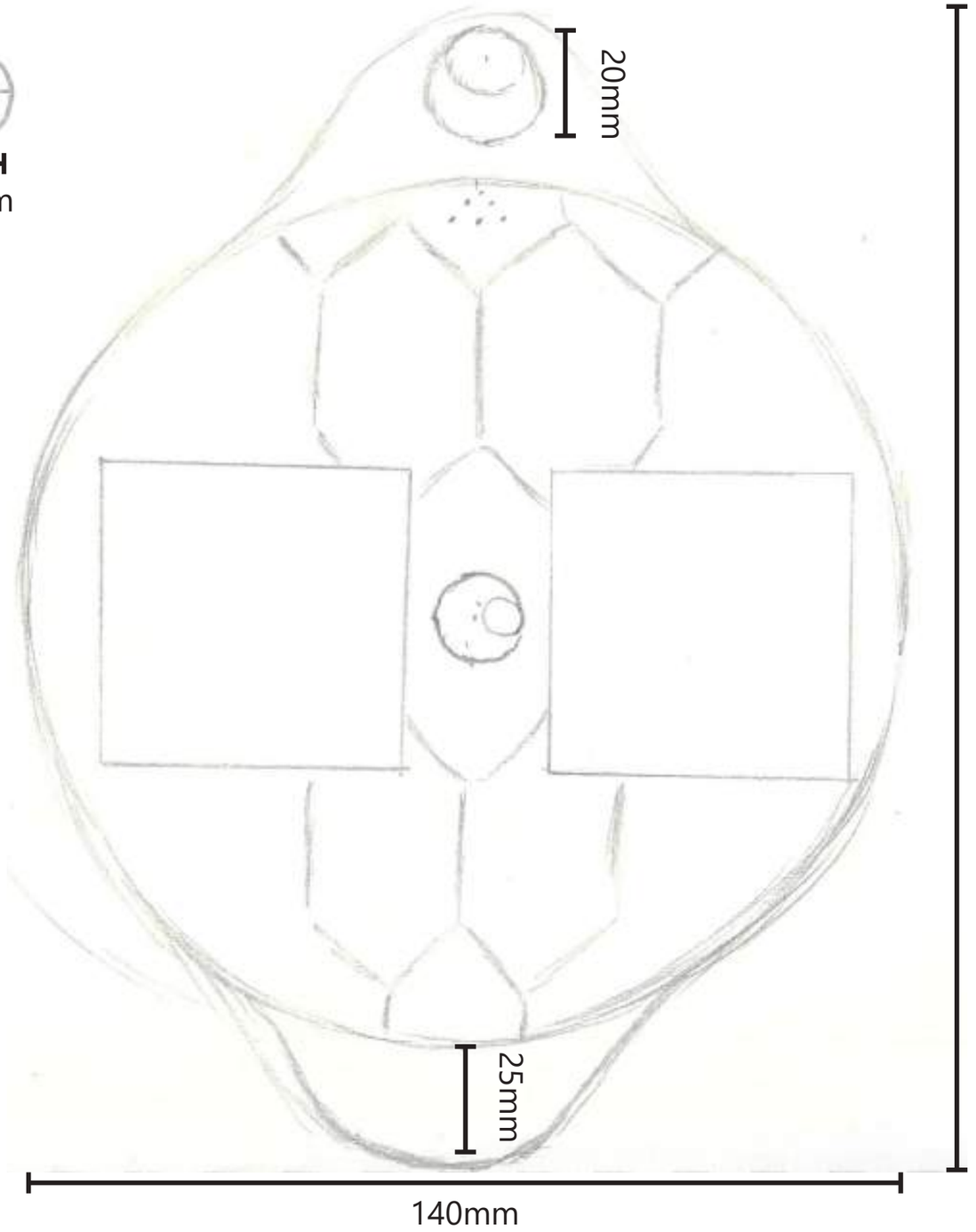


Cost: $0.3405AUD per unit (>10000 pcs)

The sound chip needs an audio output, which is where a speaker is required. The speaker is compact at only 16mm diameter and can produce sound up to 88db.

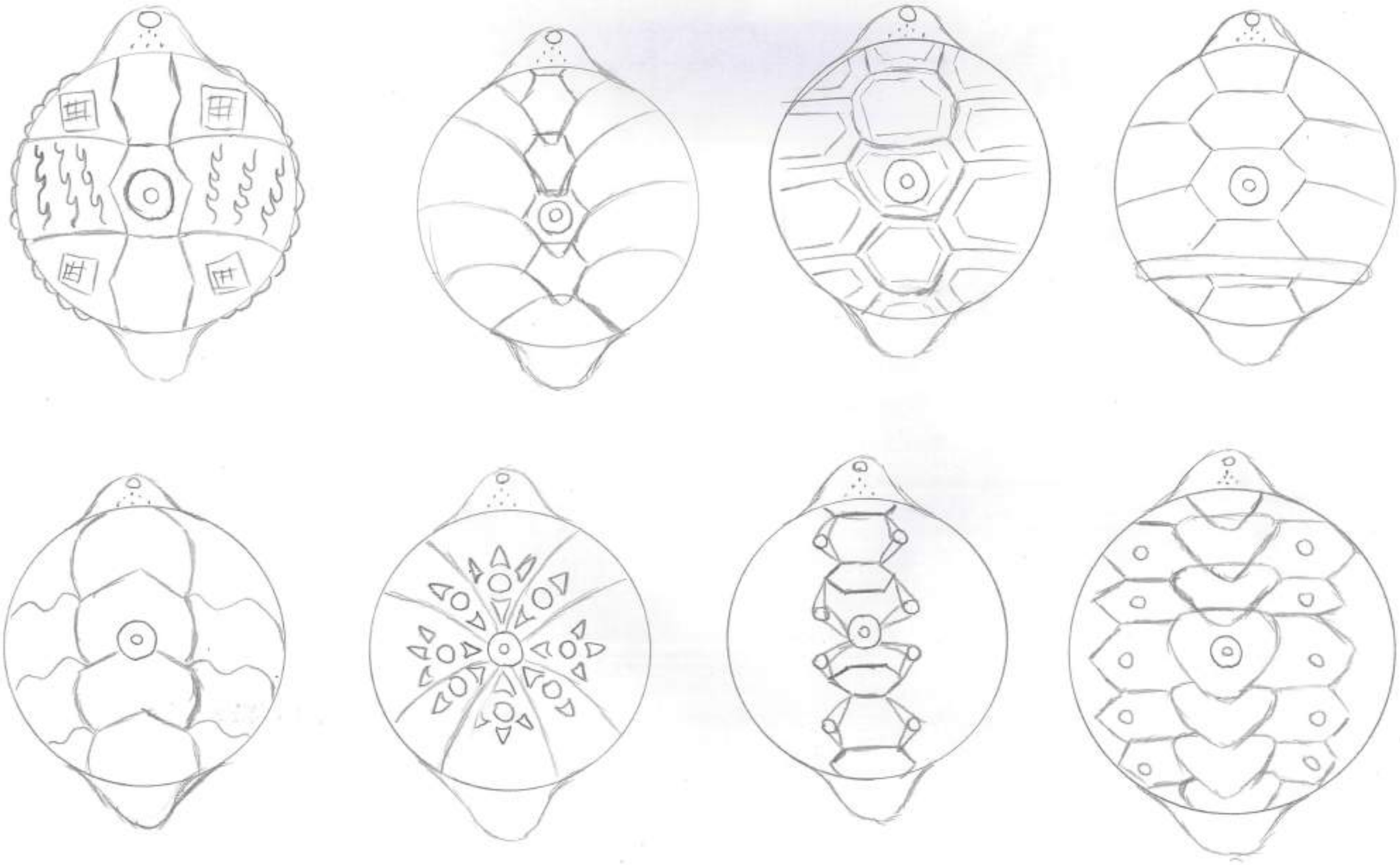
https://www.alibaba.com/product-detail/16MM-IP68-Waterproof-Plastic-Magnetic-Micro_1601010966582.html



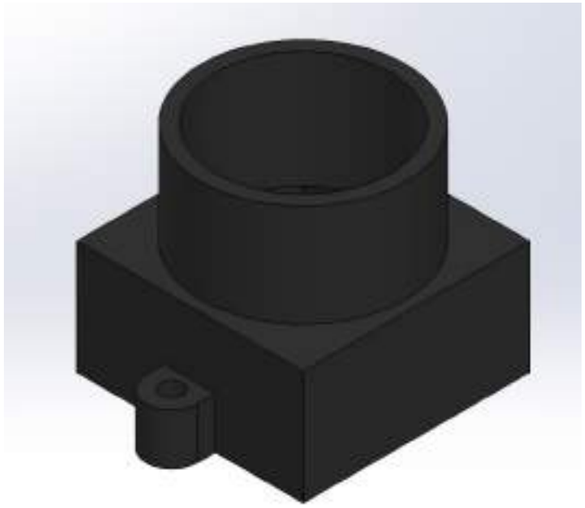


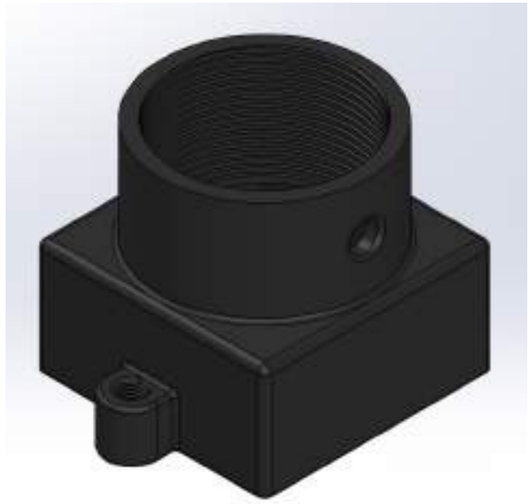
I drew a 1:1 scale version of the turtle shell to understand its overall size. I informed these dimensions based on the size of the solar panels and camera pieces found earlier.

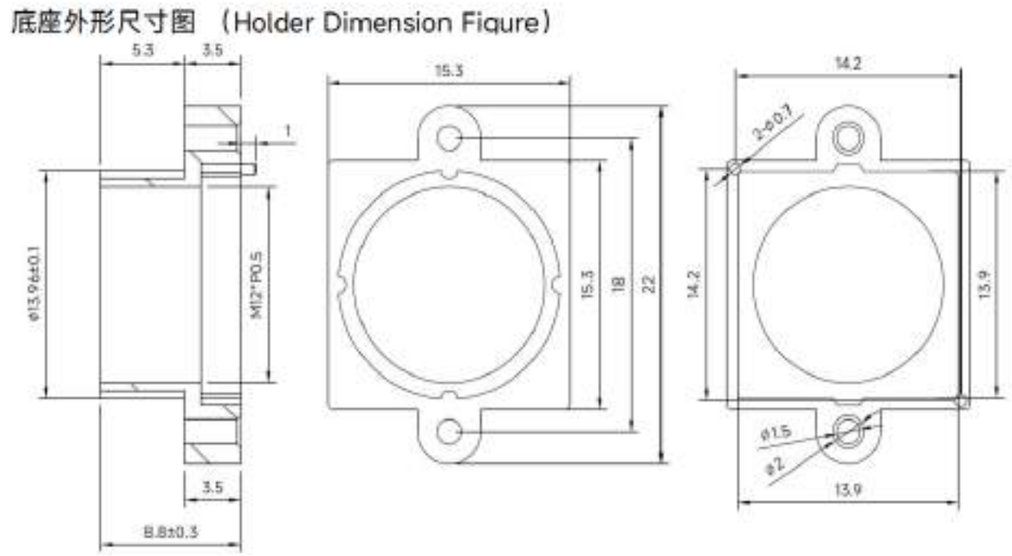
Sketch Iteration | Alternate Shell Pattern Concepts

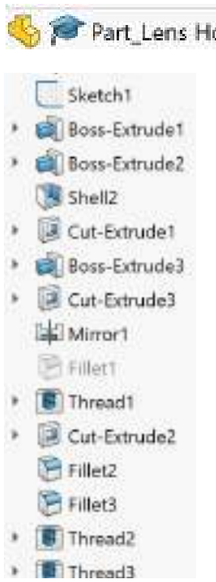


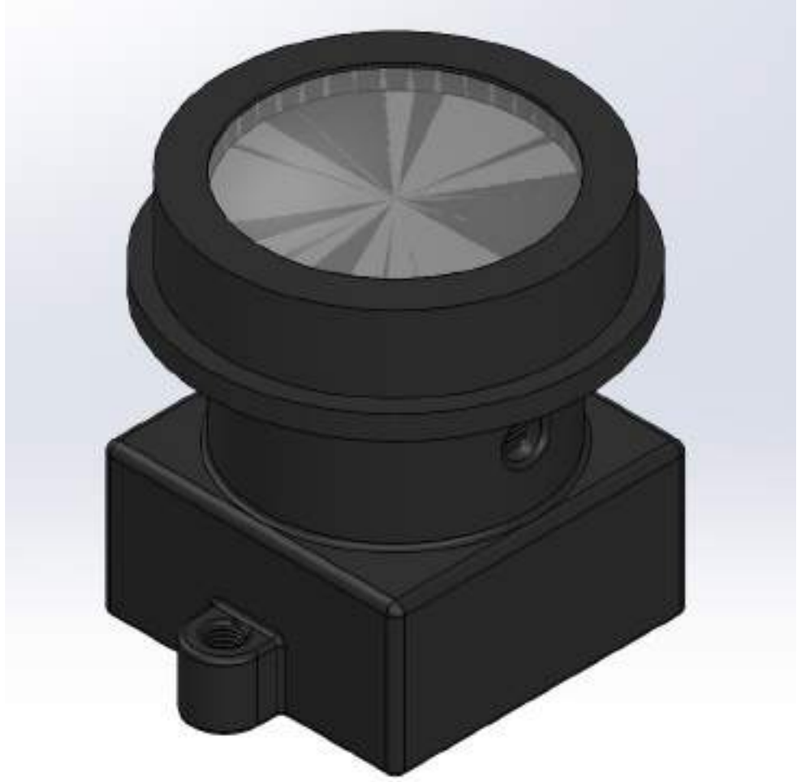
CAD Workflow | Camera Lens Assembly











I started CAD with the camera lens and holder. These parts should not change no matter how the model does, so these will be an important frame of reference. The lens holder was made with the assistance of a supplied technical drawing on the product page. The camera lens itself was made with a series of revolve features. The threads on both parts align perfectly in an assembly. This subassembly will be used later.

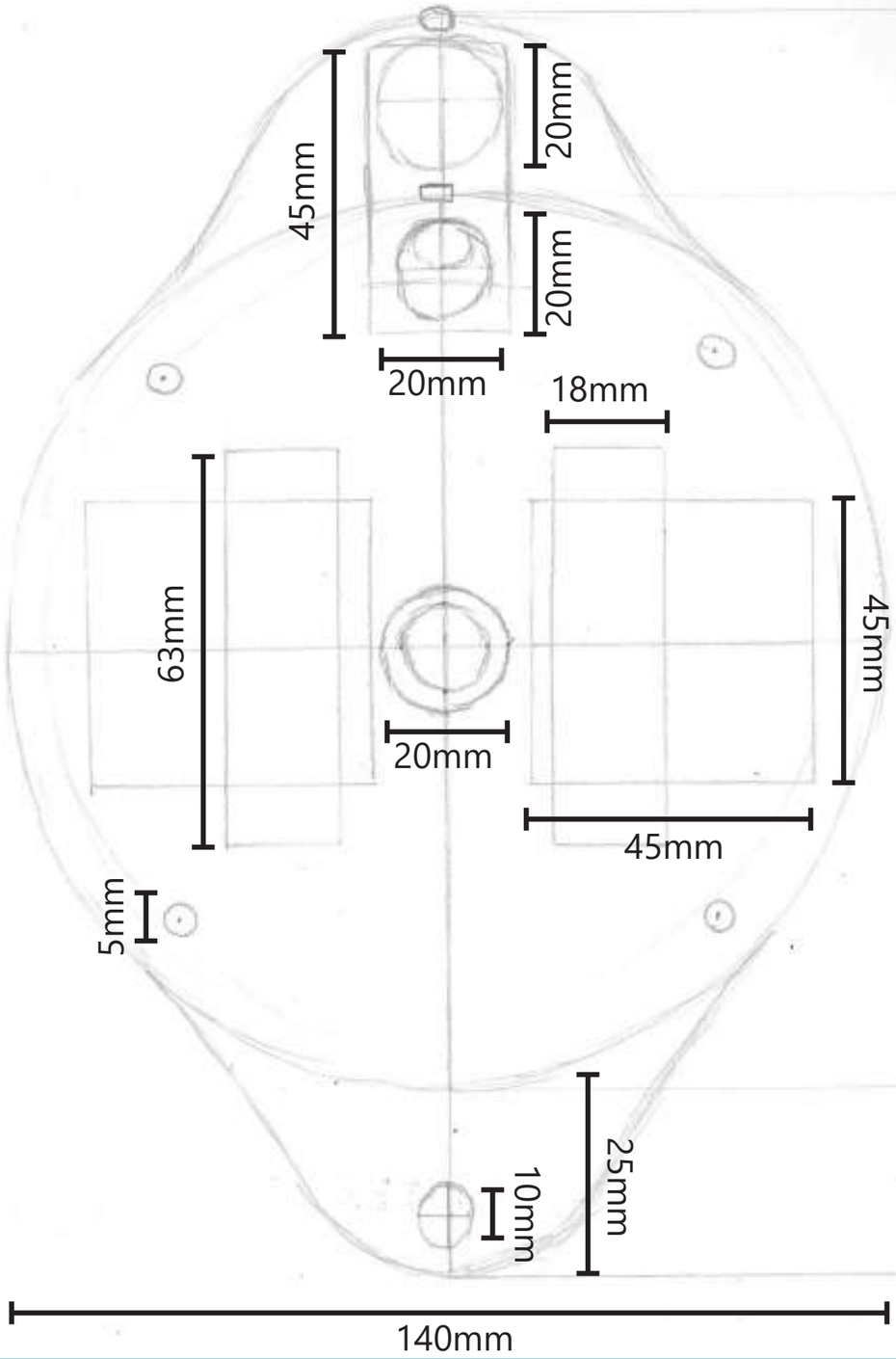
Prototyping | Shell Clay Model

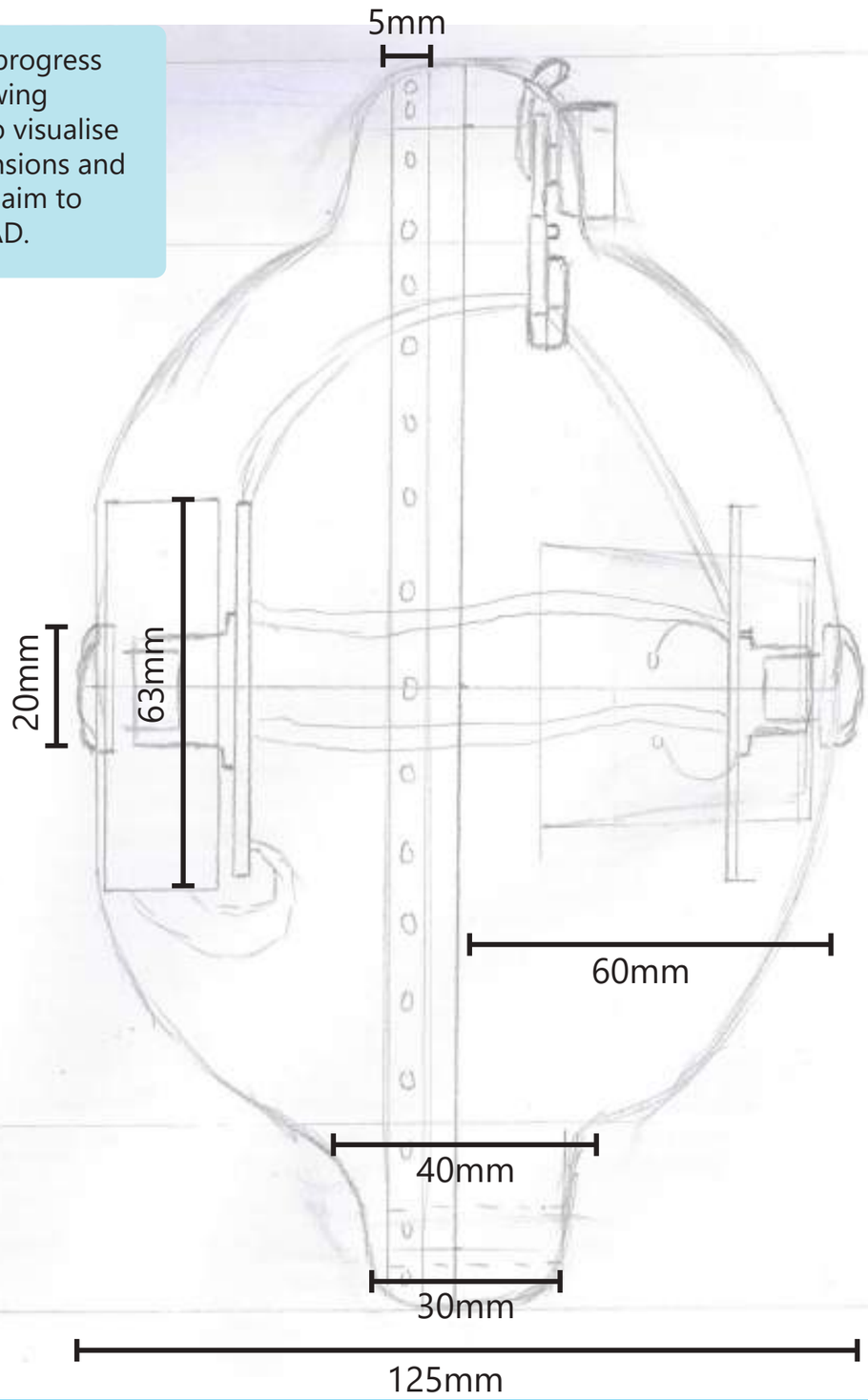
This 1:2 clay model was formed to develop and understand the rounded form of the turtle style shell. The two halves were moulded evenly and split in half, as the final model shall do when disassembled. The cardboard circle represents the camera piece to scale for reference.

The images below are of the resolved prototype. The top and bottom shells have patterns carved inspired by turtle shell and underside detailing. Cardboard cutouts also represent the solar panels and buttons that the final model may include.

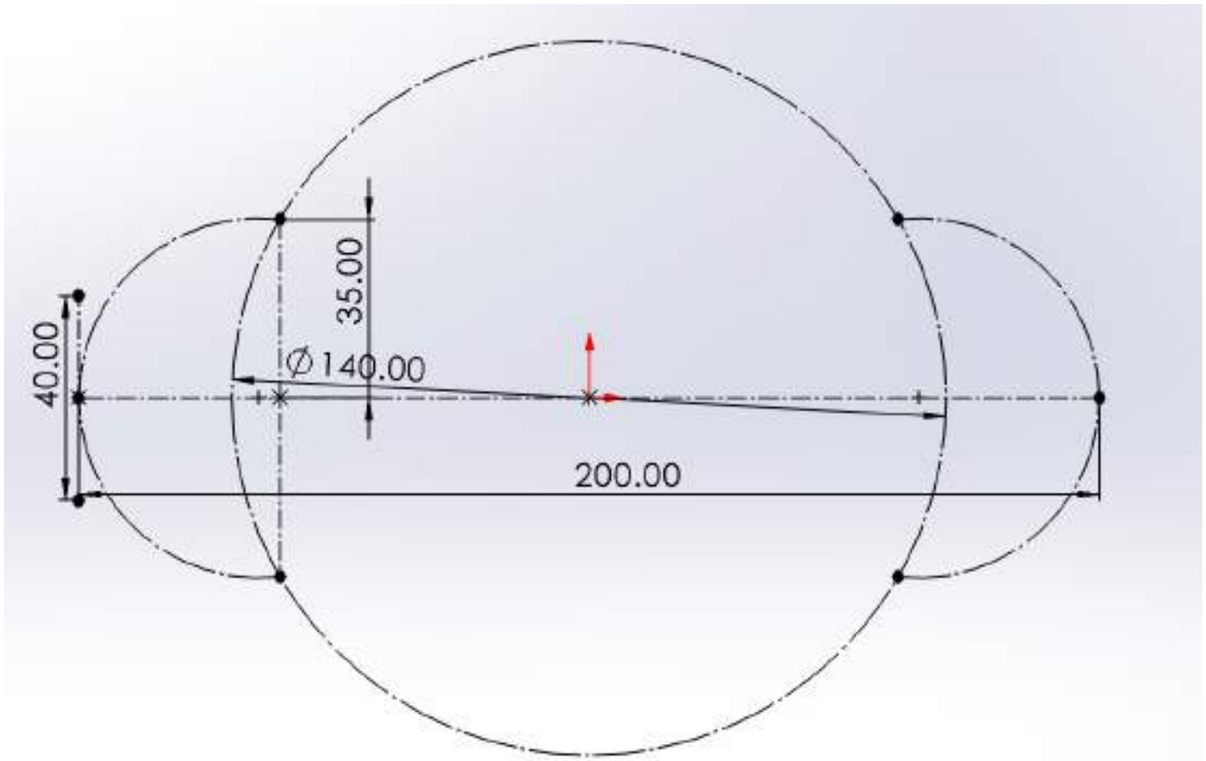
Sketch Ideation | 1:1 Scale Technical Drawing

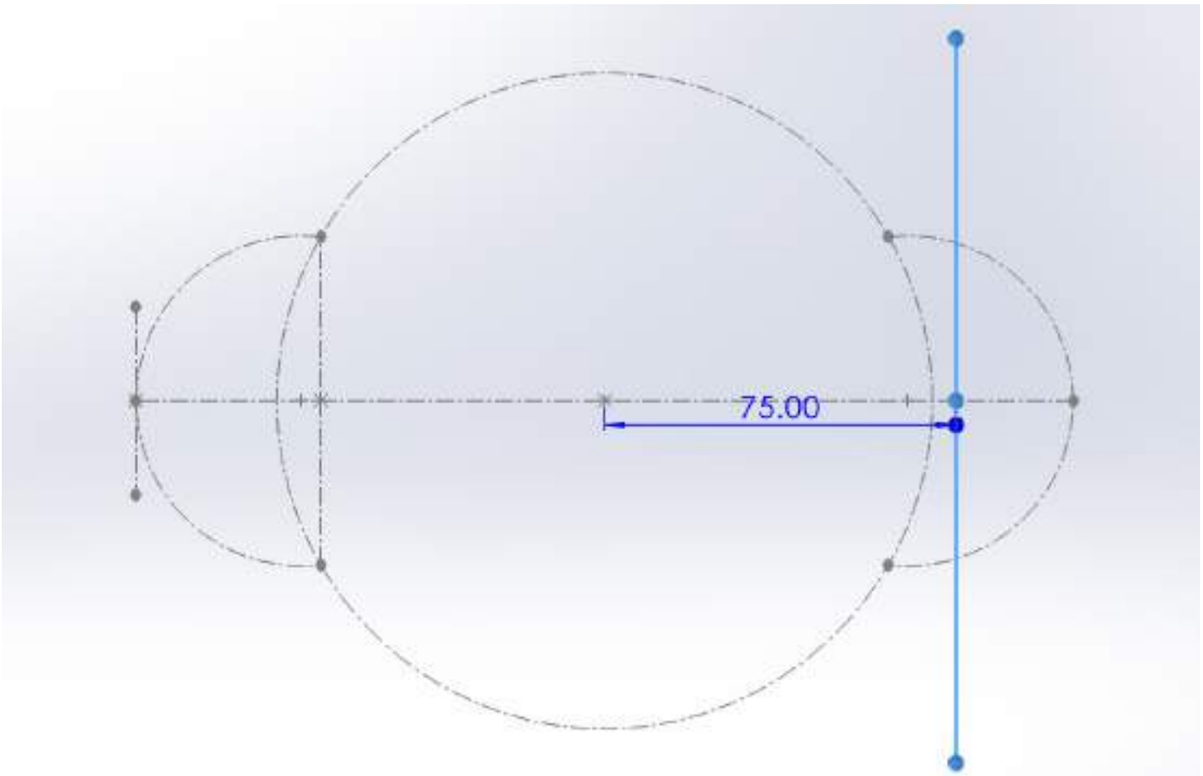
This work-in-progress technical drawing allowed me to visualise the key dimensions and overall form I aim to recreate in CAD.





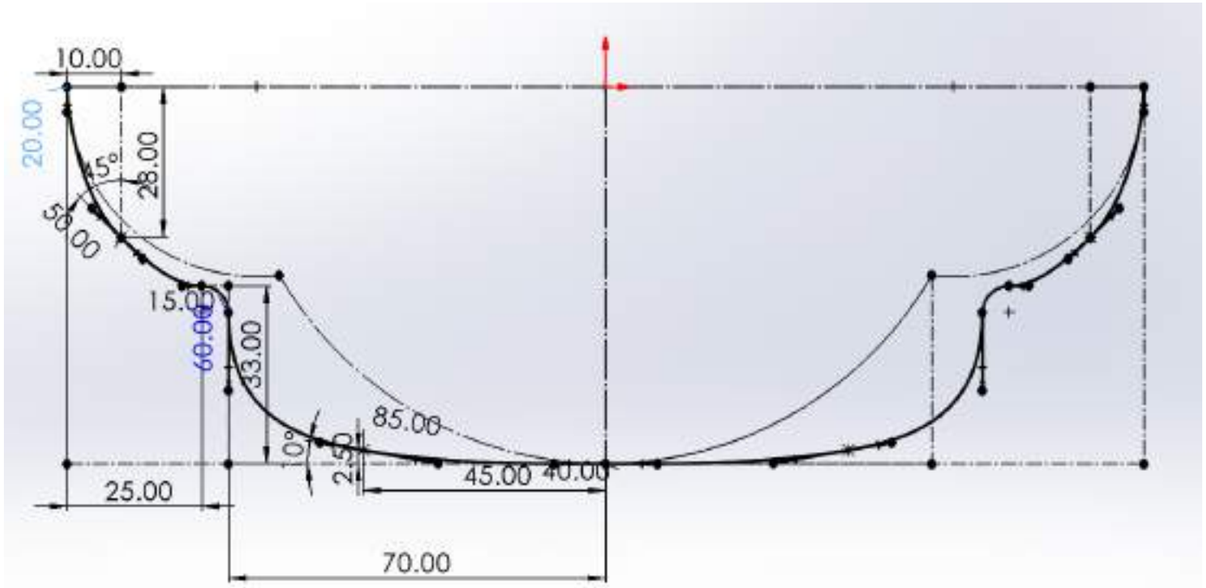
CAD Workflow | Initial Sketches



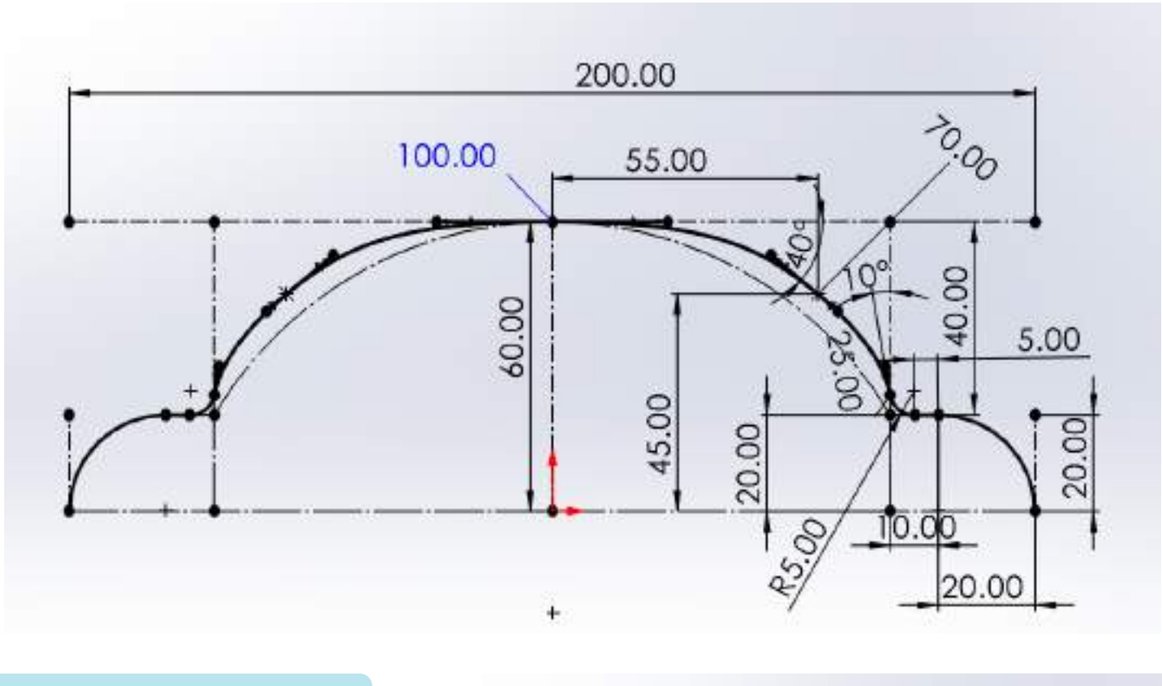


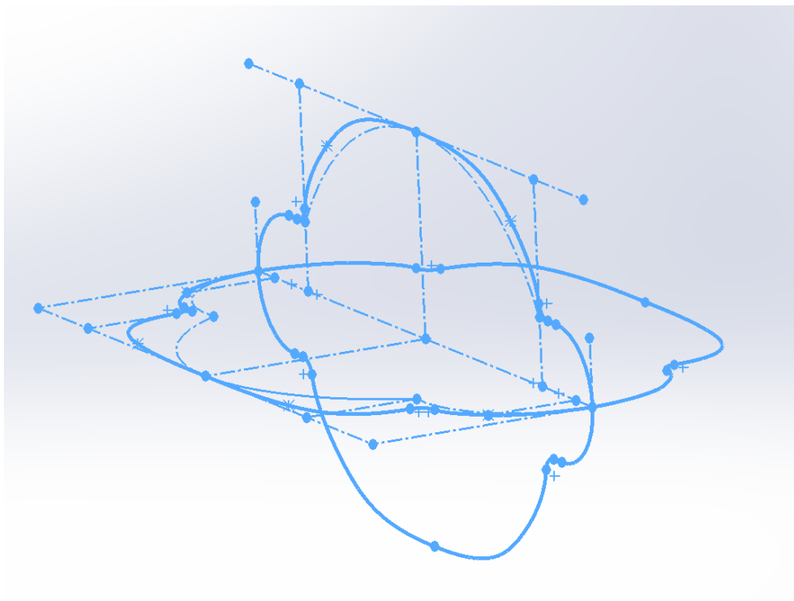
To begin modelling, a very rudimentary reference sketch was set up using simple shapes. This would provide good reference points for the refined sketches, which I plan to create with complex splines to achieve perfect shaping. A plane was also created at the point where I plan to transition the main body from the smaller head sections.

Left Half Form



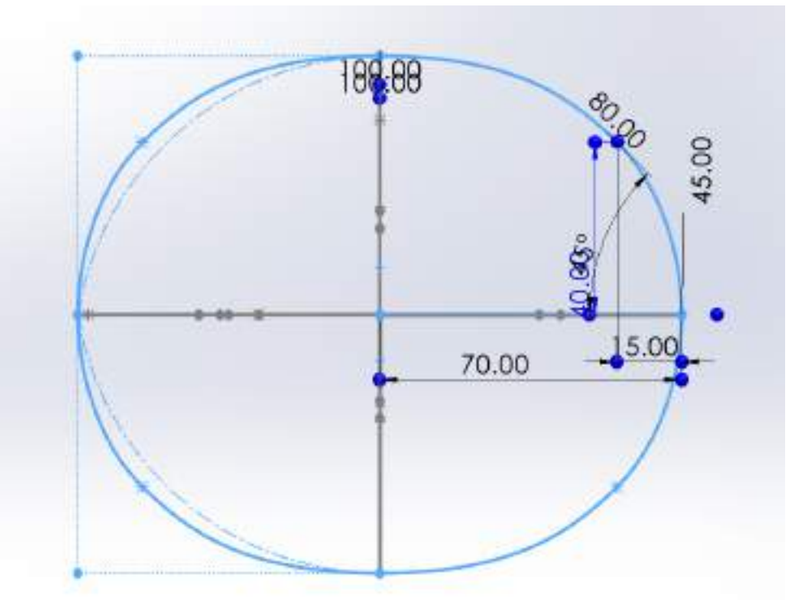
Top Half Form



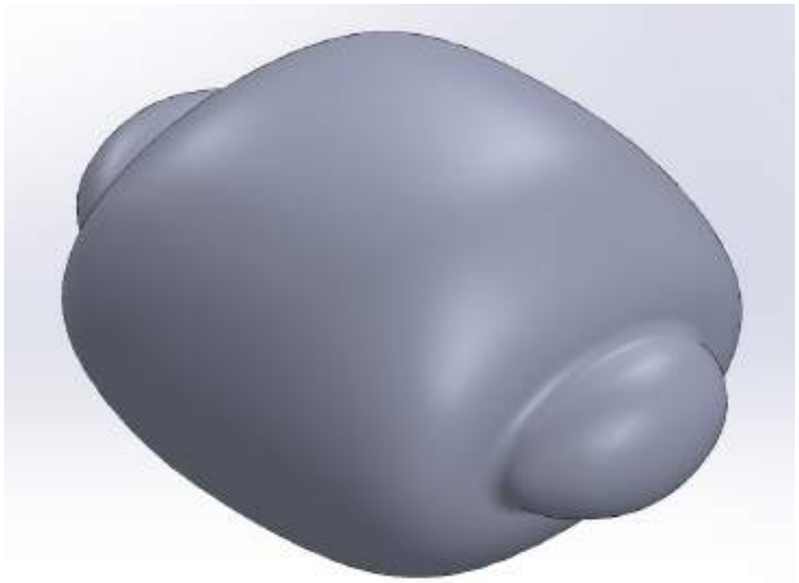


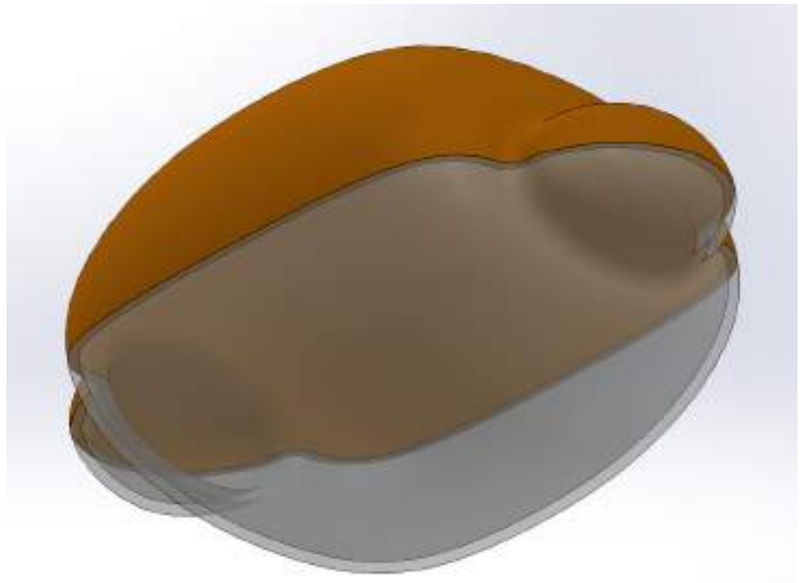
To create a curvature continuous rounded form, the shell sketches were split up to create a complex Surface Loft. Important measurements were inferred by measuring the 1:2 scale model I created earlier. As shown in both sketches above, one quarter of the sketch is fully defined. Tangent splines were utilised to create a seamlessly curved form.

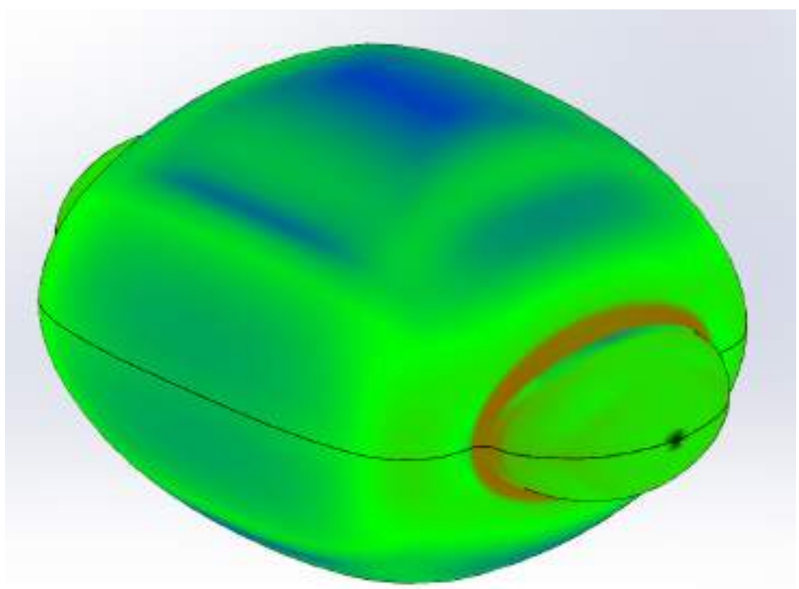
These quarter sketches are mirrored to create a half. The halves are mirrored again in new sketch entities in order for the surface loft to operate properly (pictured left). To keep the surface loft nicely curved, a sketch was made on the third axis in the centre of the other joining sketches. This set up the perfect shaping for the primary form.



CAD Workflow | Overall Form Setup



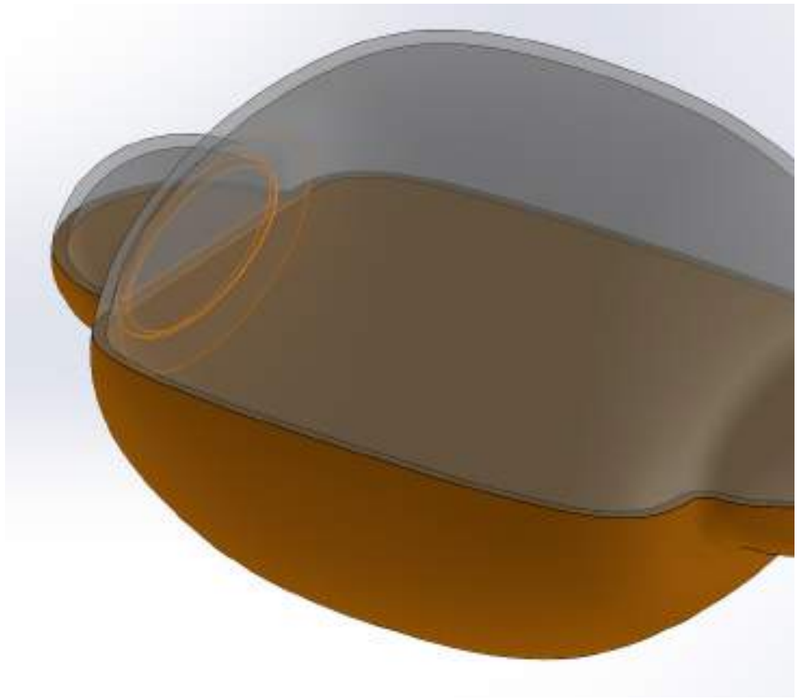




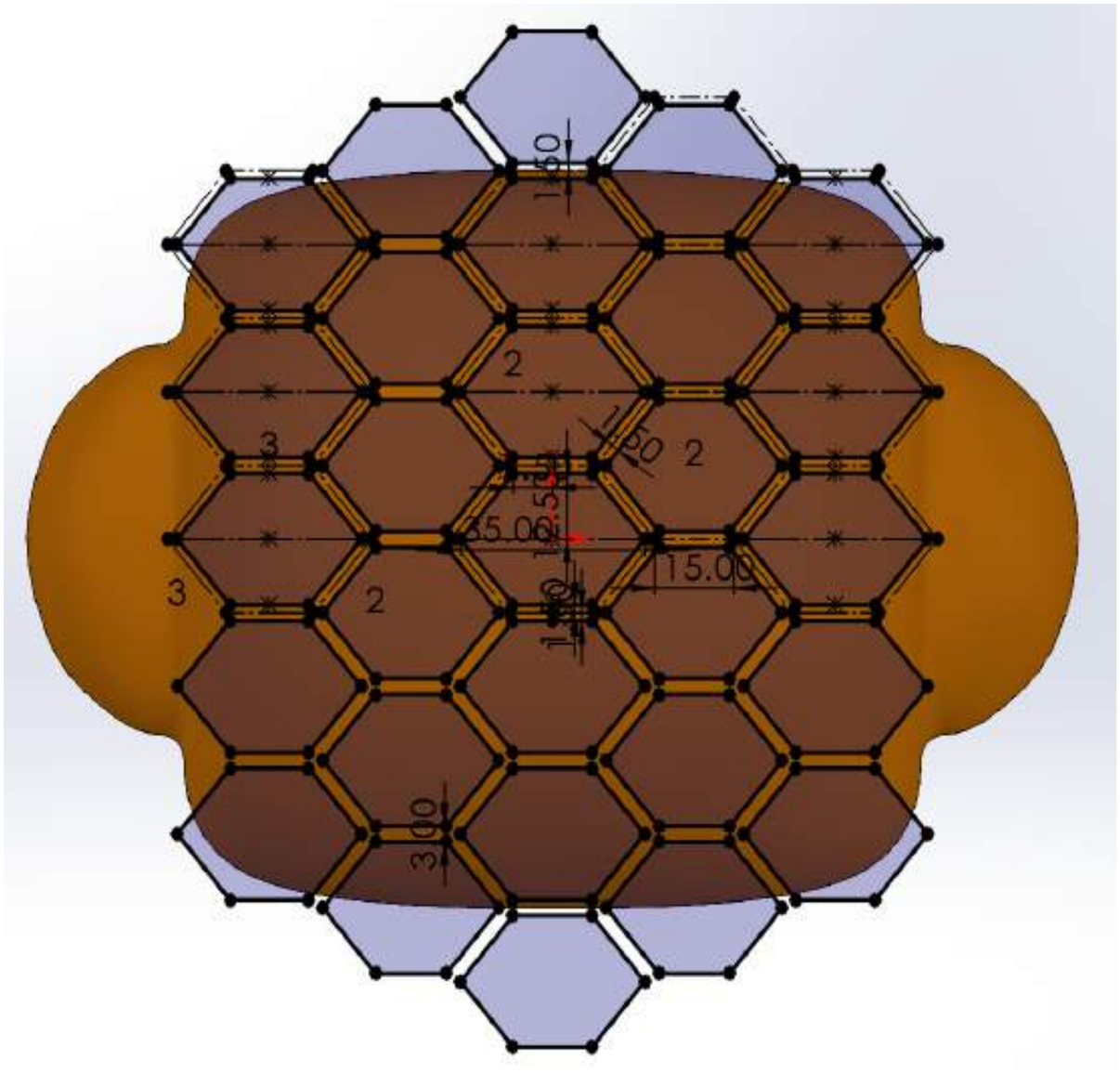
Once the Surface Loft was refined to look as I intended, I was able to thicken the part to 3mm inward. This is a good standard wall thickness for injection moulded parts, which is how I intend the shells to be manufactured. A split line was created directly through the middle to separate the two halves of the shell.

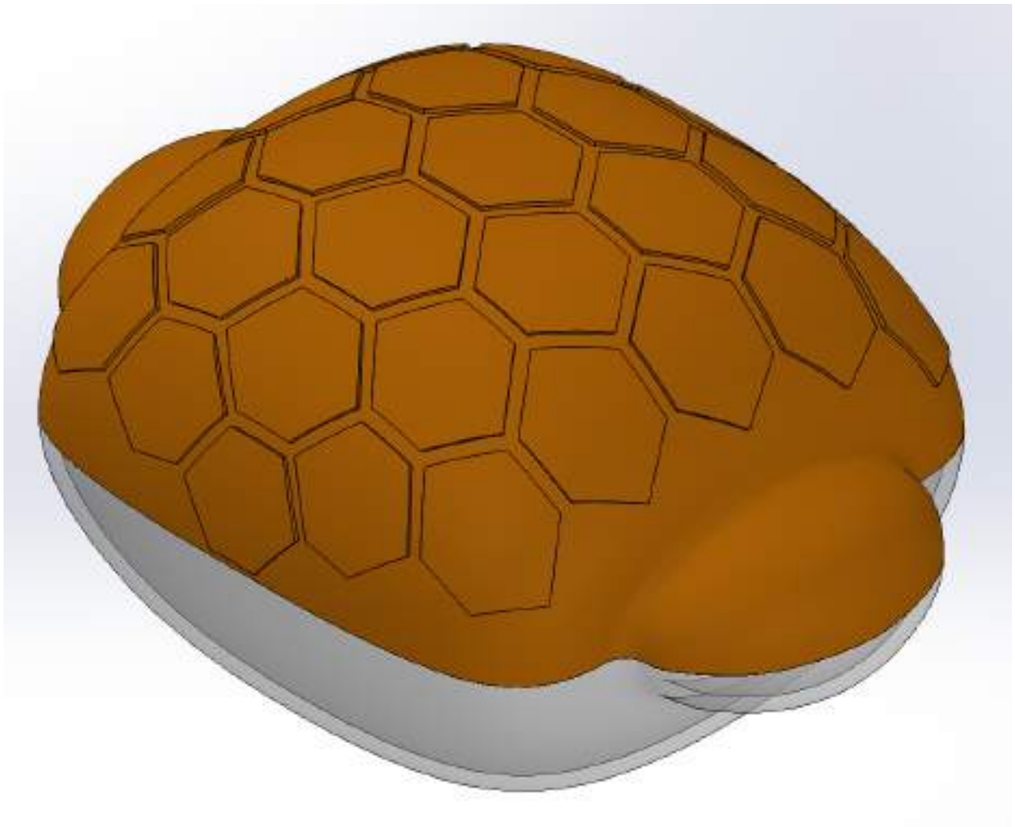
I kept working in the same part file for the two shell halves as it makes it much easier to refer to both shells at the same time. This allowed me to ensure ribs, holes and fasteners were properly aligned in an efficient way.

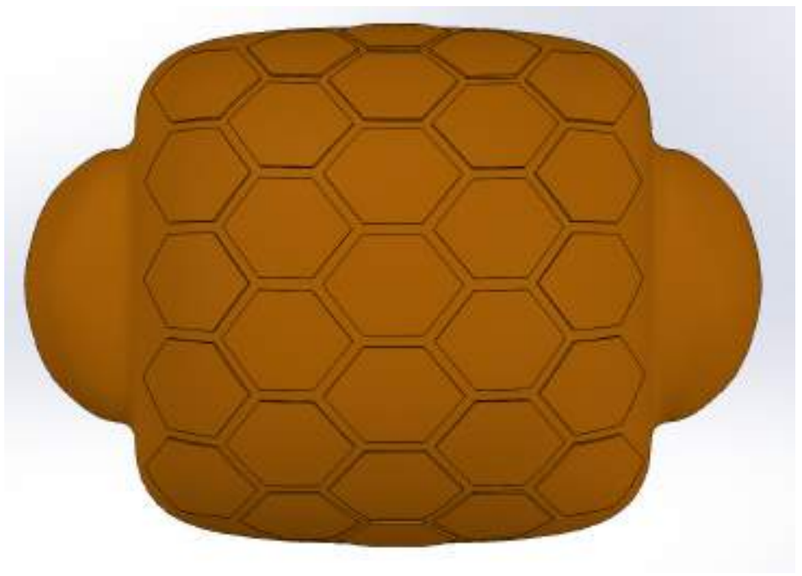
A rib lining was added to the rear end, as this head will be disconnected from the rest of the body (pictured right). This enclosed section will allow for a hole that goes through the entire body, which a rope can thread through to be tied to a wall or surface.



CAD Workflow | Shell Pattern







Originally I planned to cut the camera holes at this stage. However, the shell pattern needed to be created next, as I found that the wrap feature will not work if there is a cut hole in the centre. A simple hexagonal shape was created once, then duplicated in a series of sketch patterns.

Field Research | Off-the-Shelf Parts (Part 3)

Circular Solar Panels

Cost: $0.69AUD per unit
(< 100000 pcs)

Provide the primary power source for the device. Two 45mm x 45mm solar panels will be built into the unit to provide adequate power. Being made of epoxy, the panels will have a slight degree of flexibility that can fit the rounded shell shape.

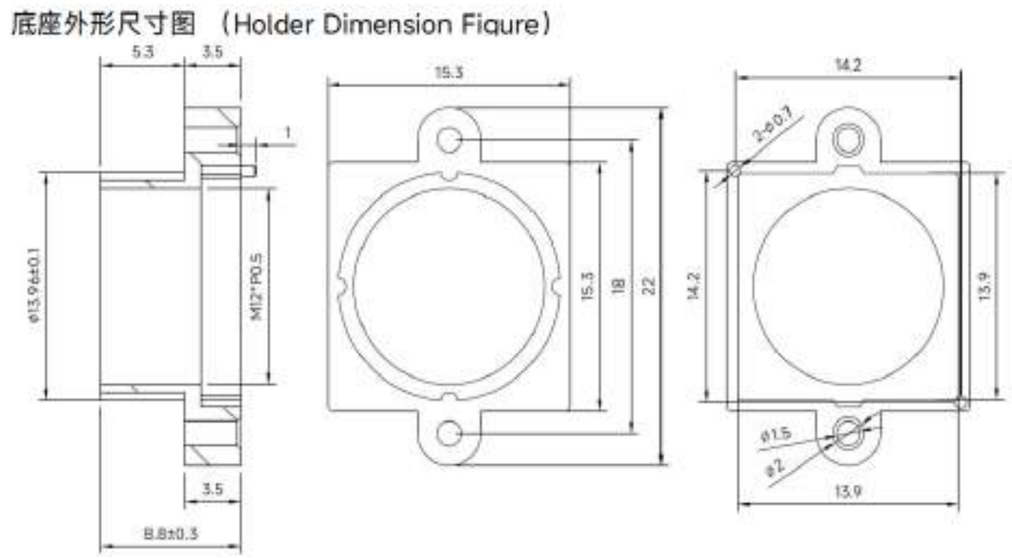
https://www.alibaba.com/product-detail/45mm-Waterproof-Mini-Solar-Panel-1W_1601061577804.html

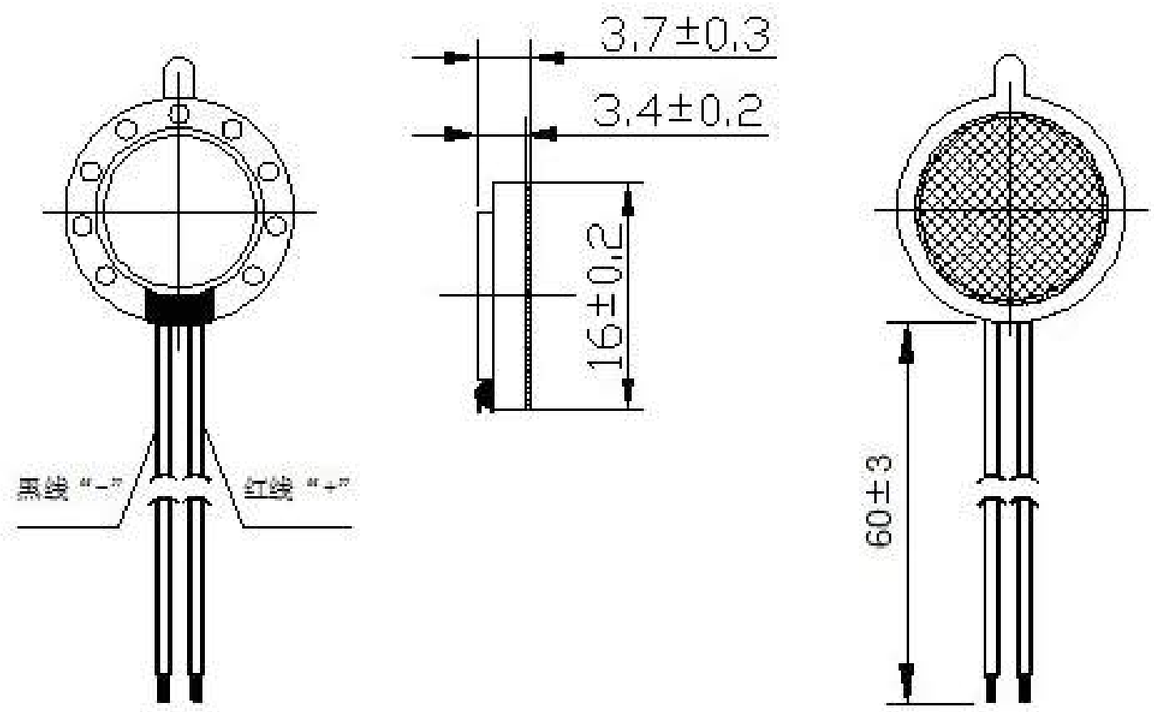
Some of the off-the-shelf parts identified for use in the design have already supplied their own technical drawings. Pictured right are the technical drawings released for the camera lens holder and waterproof speaker units. These were referred to when reverse engineering the components to scale in CAD.

All other electronics required for the PCB are assumed to be present. Particularly, the hardware and software required for the AI detection model. The specifics of individual components will be confirmed by an electrical engineer.

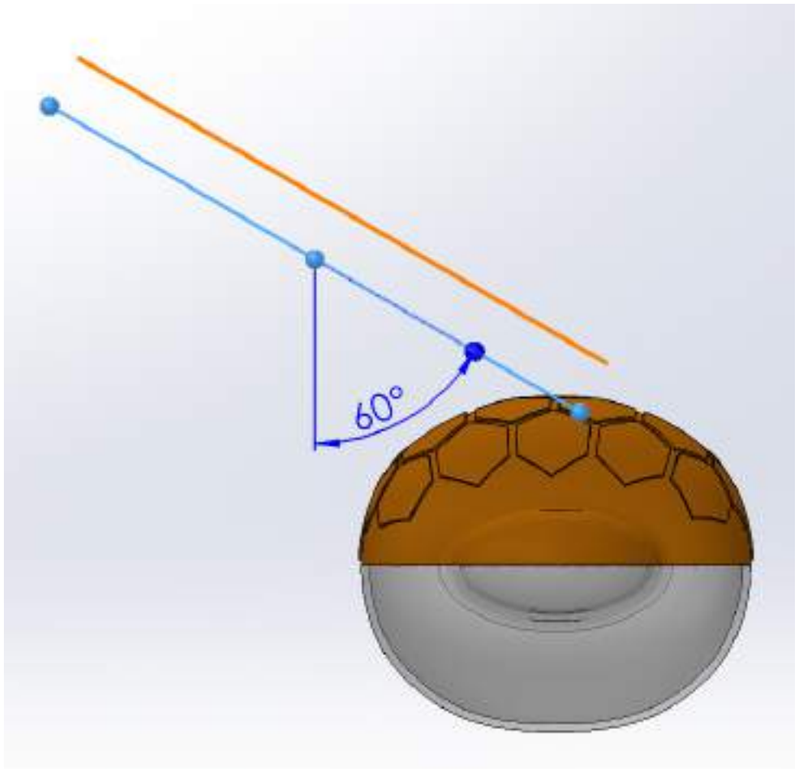
The parts selected are only representative and may not reflect the final product identically. It is assumed that electronics should reasonably work based upon the research conducted on how similar products are manufactured.

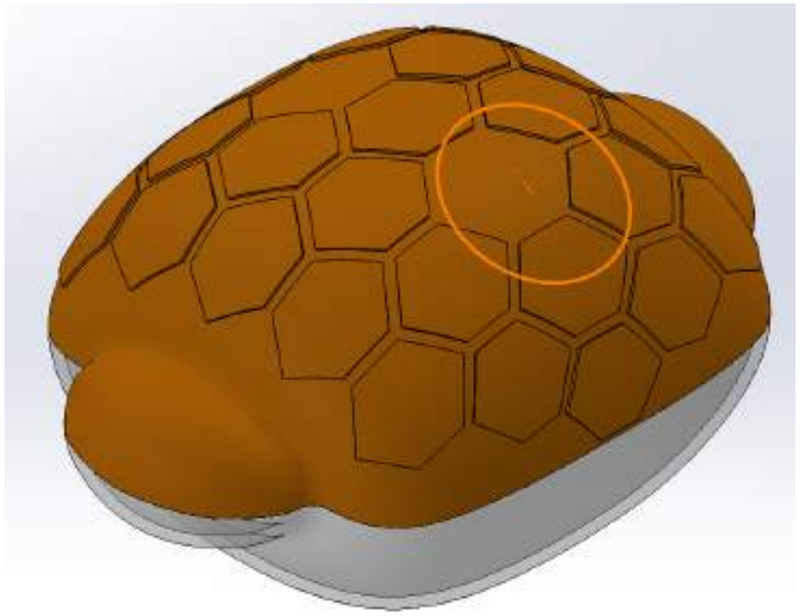
It is not imperative that these specific components are used in this design, so the shell will be adaptable should these components need to be altered.

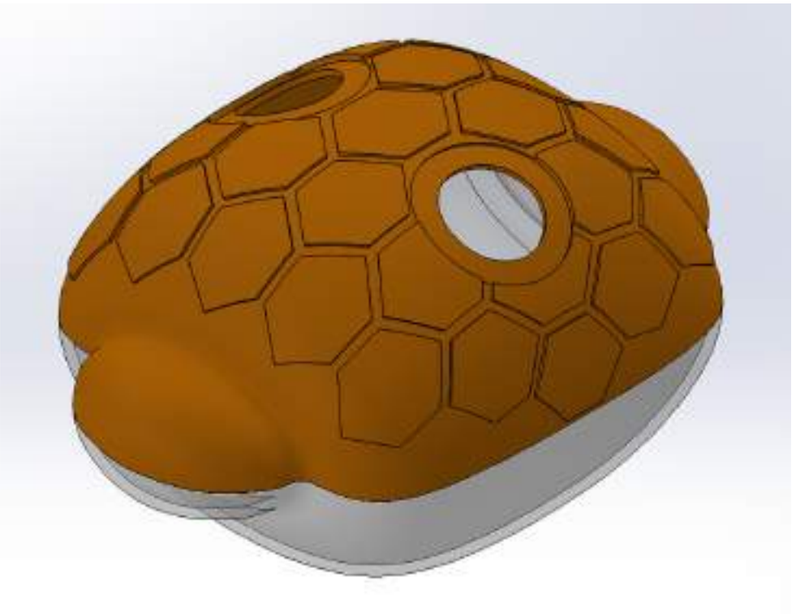


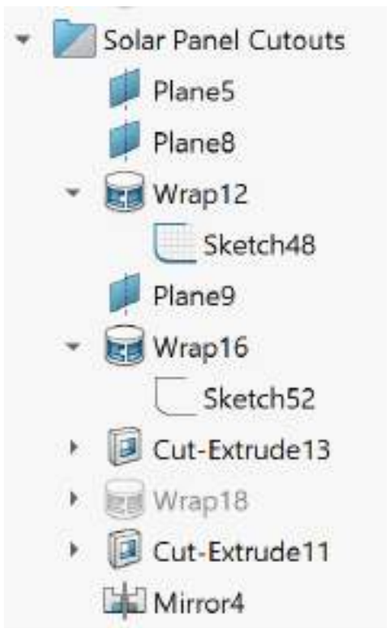


CAD Workflow | Solar Panel Cutouts









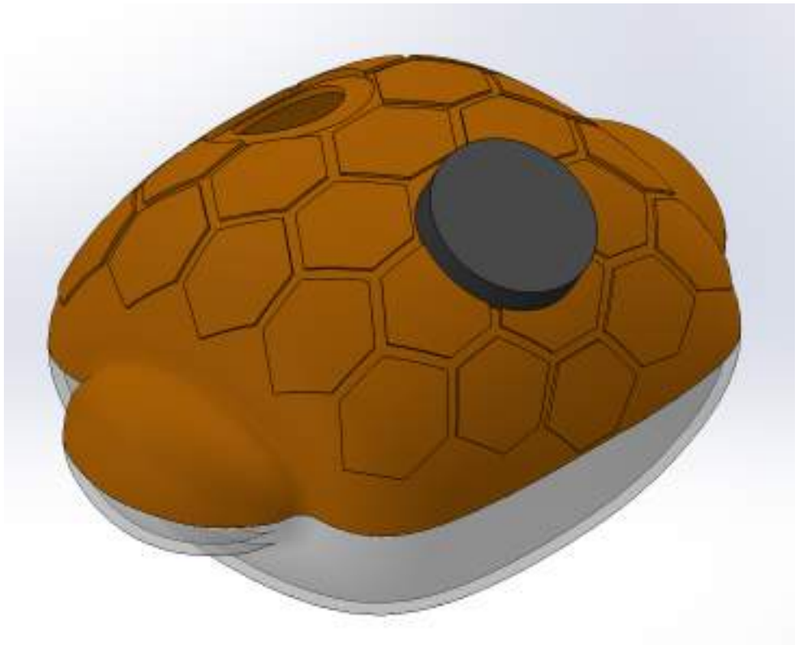
Fitting the circular solar panels in an aesthetically pleasing way with the current form was challenging. To work around this, I created planes at a 60-degree angle from the vertical. From here, I could accurately pinpoint the hexagons that needed to be removed for the offset cuts from the smooth surface to create solar panel resting cutouts.

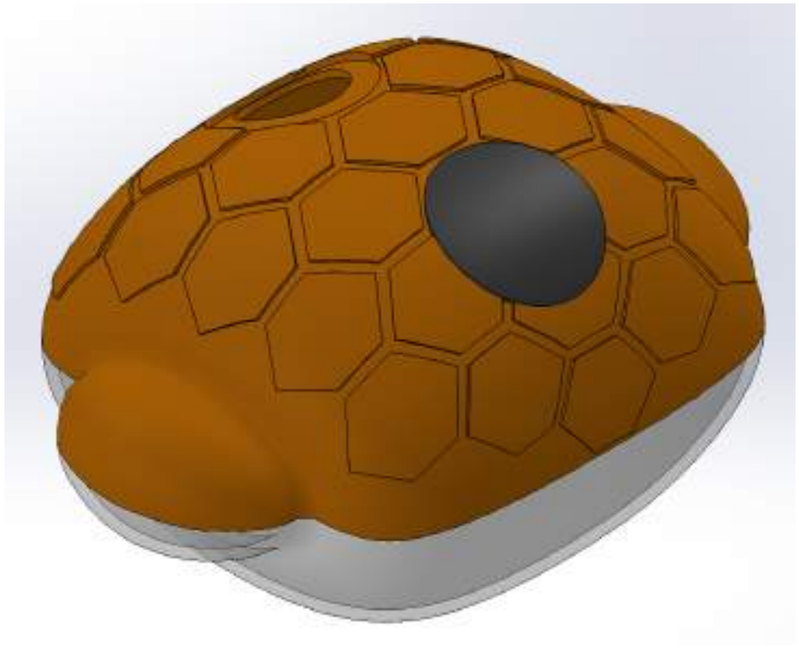
Ideal panel angle in major Australian cities

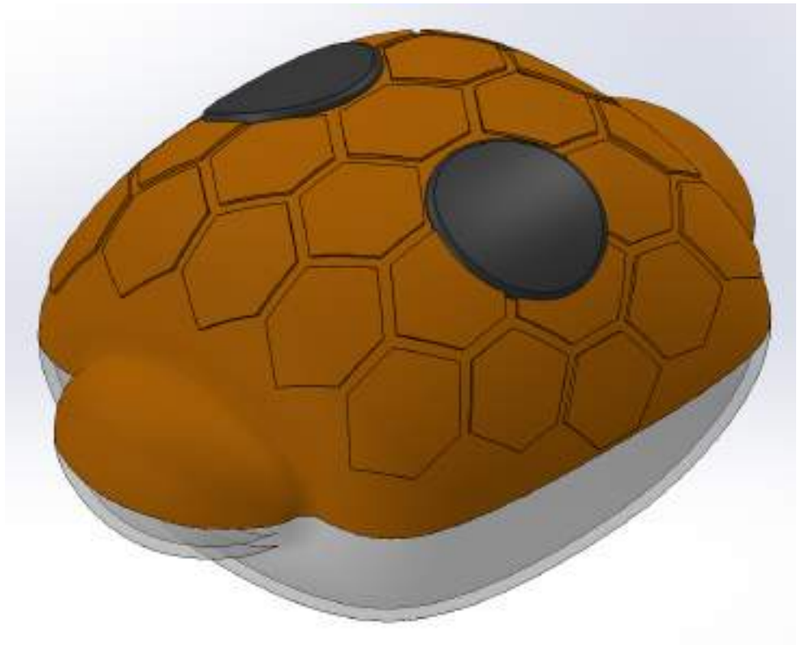
SYDNEY	MELBOURNE	PERTH	BRISBANE	HOBART	ADELAIDE	DARWIN
34°	38°	32°	27°	43°	35°	12°

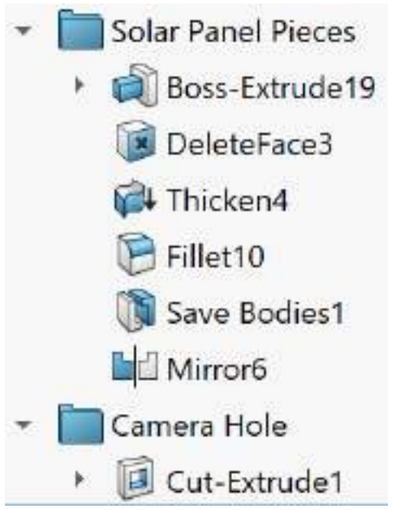
Optimal solar panel angle positioning is highly dependent on your geographical location. However, an angle between 20-45 degrees is optimal for almost all locations across the globe. In Australia, the average between states and sources suggests that 30 degrees is a best fit angle. The variation in angle should not matter too much, so long as the panels are receiving direct sunlight.

https://solarcalculator.com.au/solar-panel-angle/

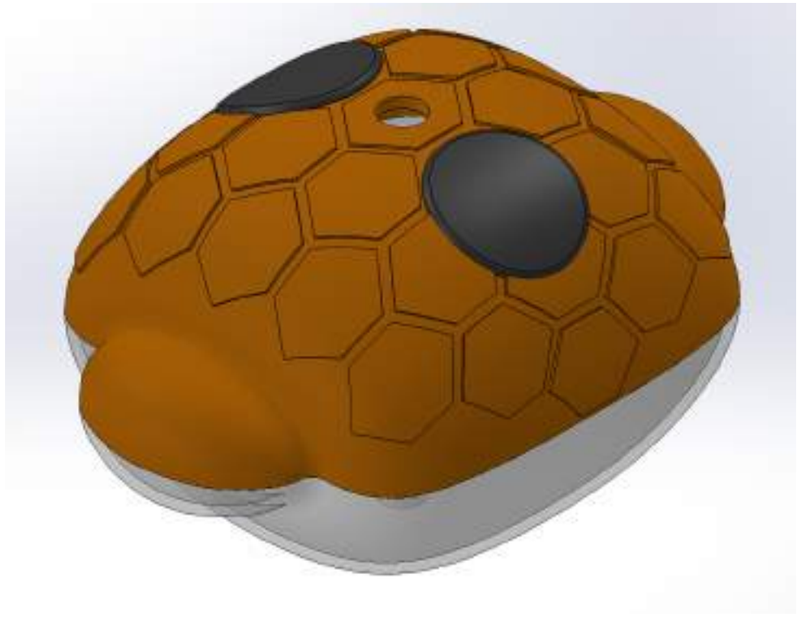


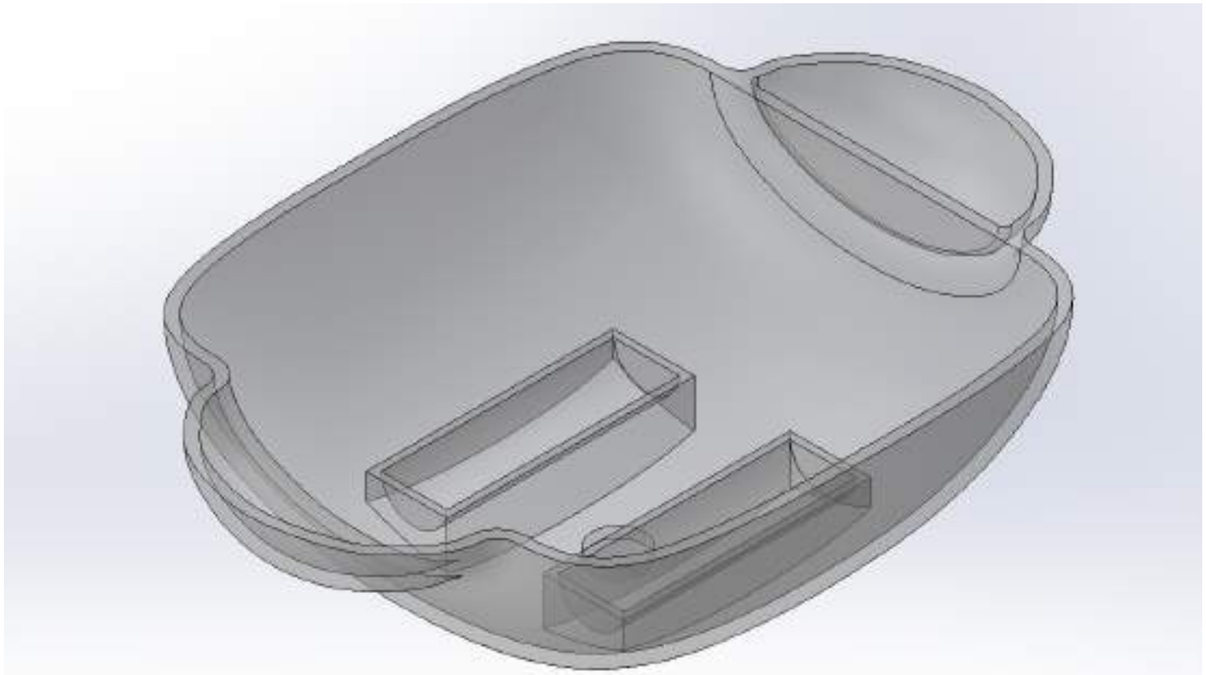


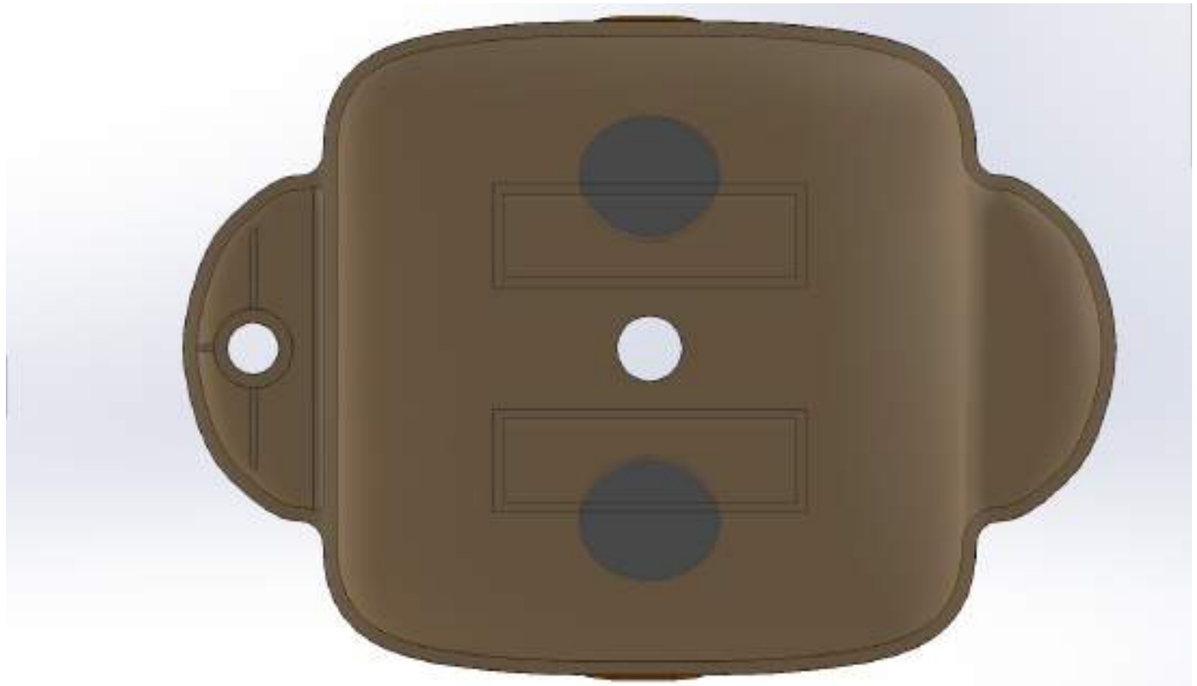


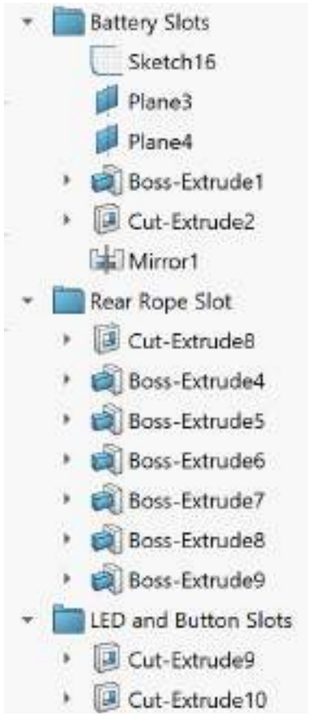


Creating the solar panels themselves was also difficult given the complex curved shape of the shell. I had to create a separate surface and thicken it to make the solar panel fit perfectly with the shell as it would in real life. The complex geometry refused to mate the solar panels to the shell in an assembly file, so I had to resort to keeping the solar panels attached to this part file.





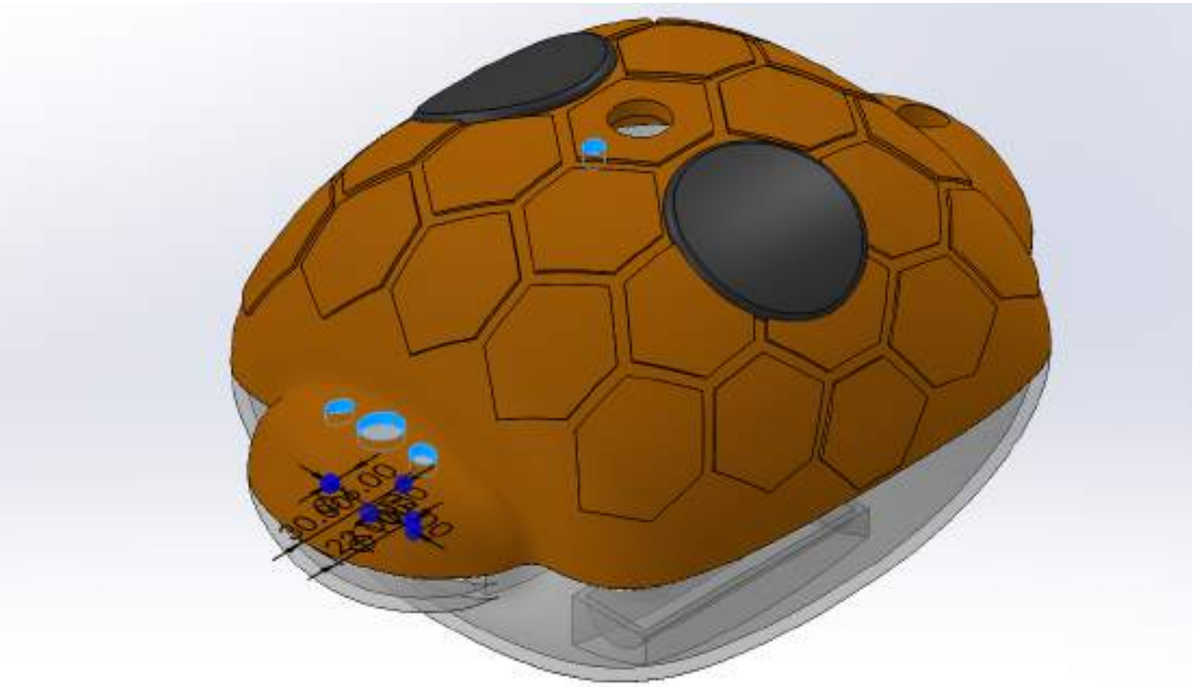




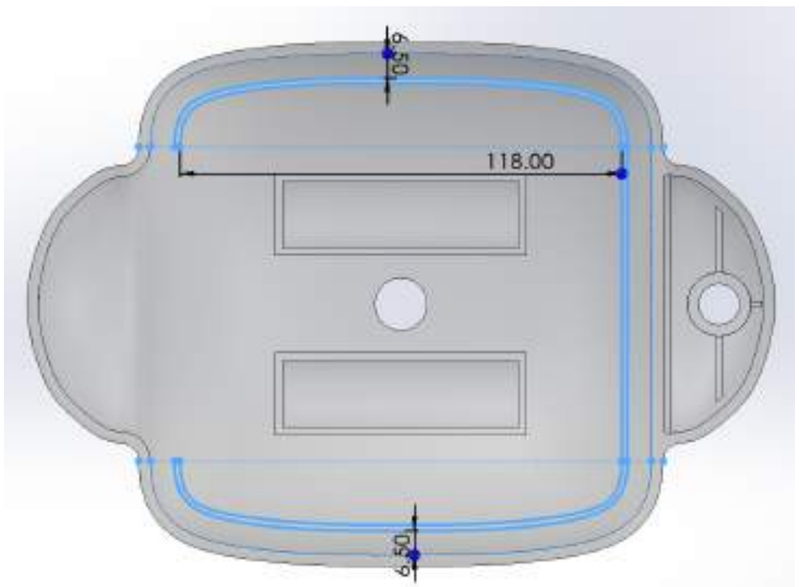
The battery was easily made from simple geometry. The length and diameter informed the construction of battery housing slots on the bottom shell. The batteries will have good weight to them and also play a role in keeping the model upright when afloat.

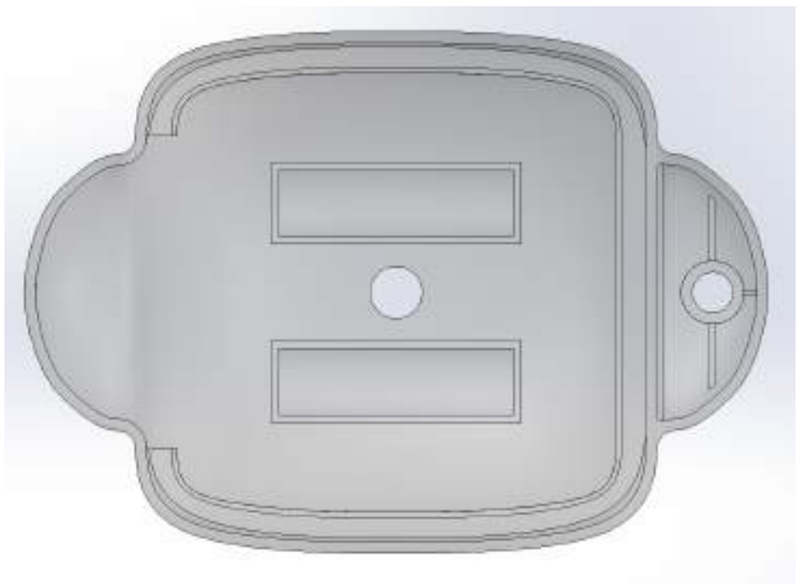
Battery slots were added next. The internal walls and subsequent ribs would be 1.5mm thick, half that of the external wall thickness for suitable injection moulding.

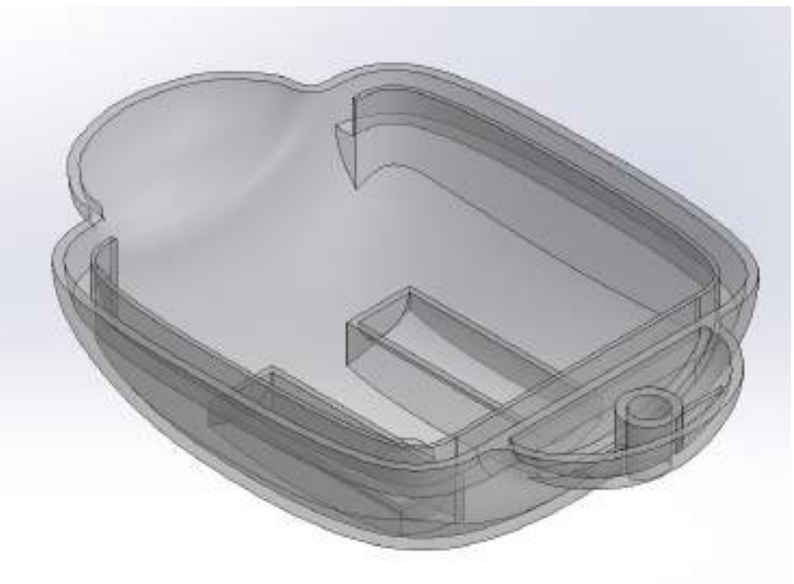
Various holes needed were also inserted at this stage to experiment with the complete assembly further.

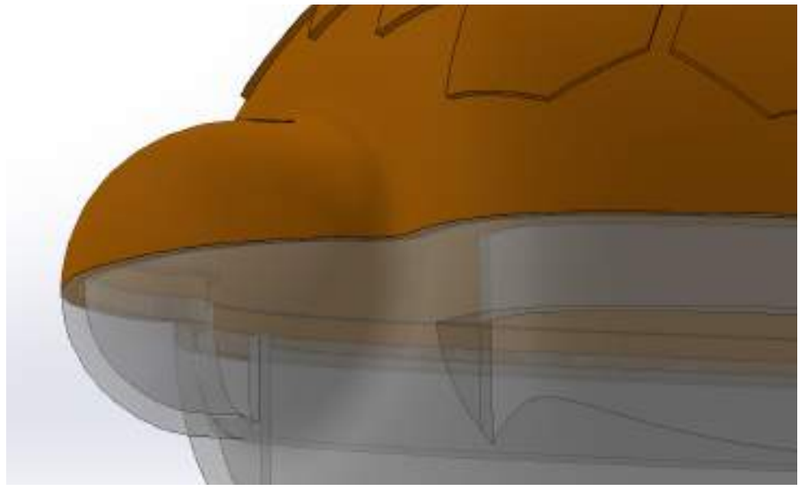


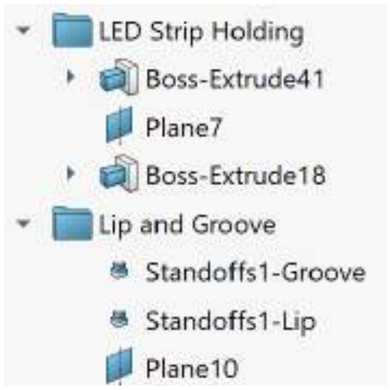
CAD Workflow | Internal Details Part 1



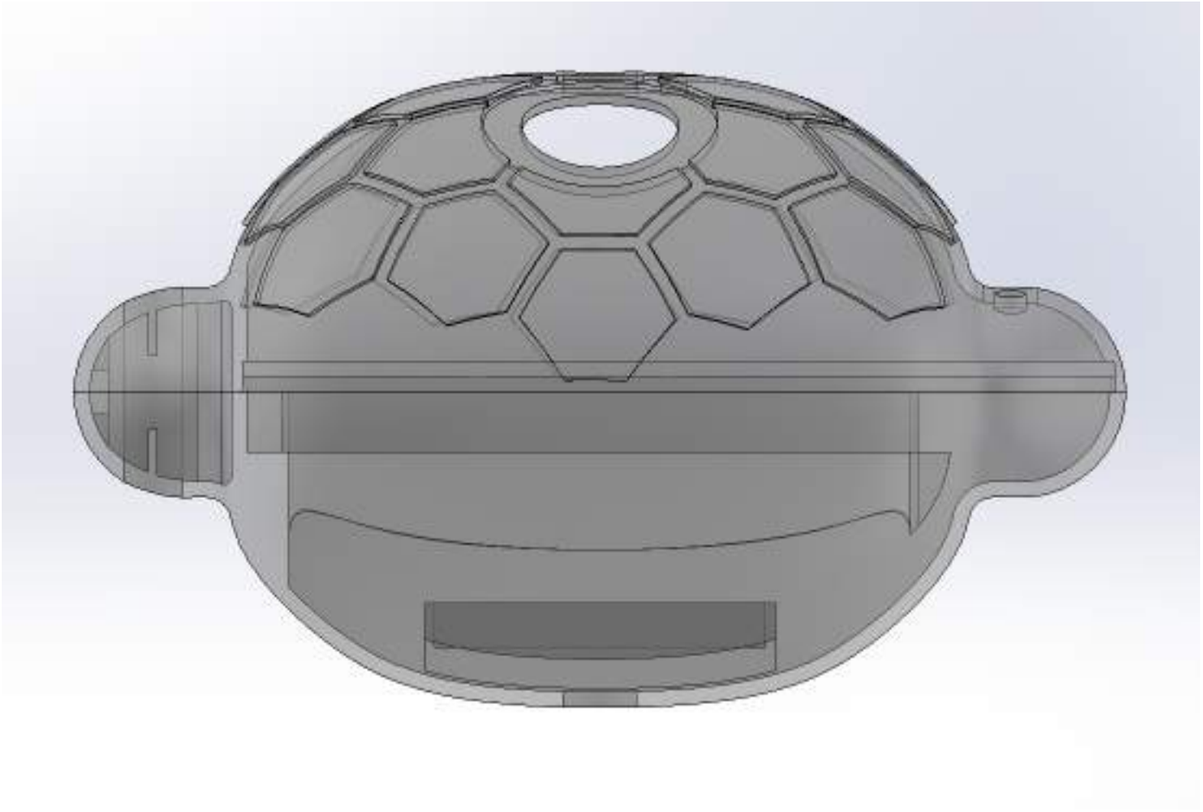




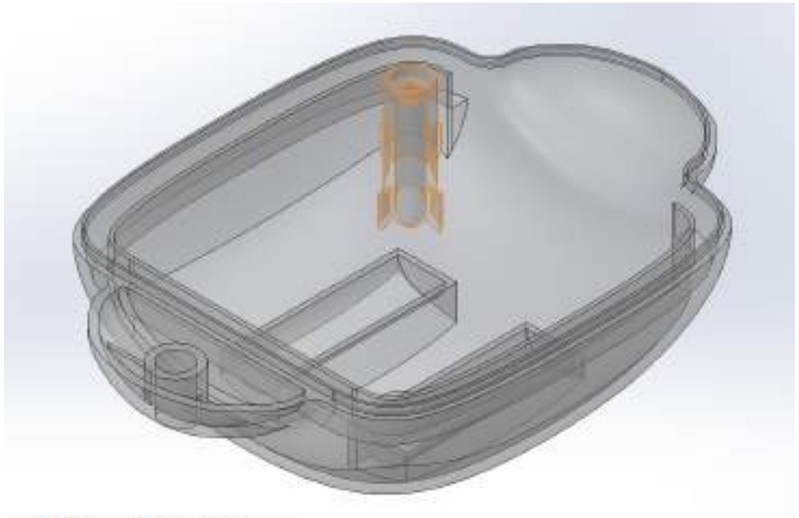


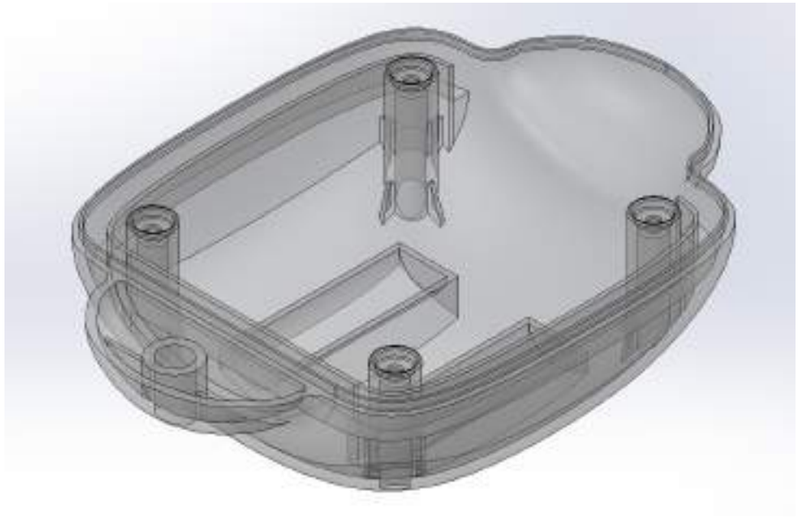


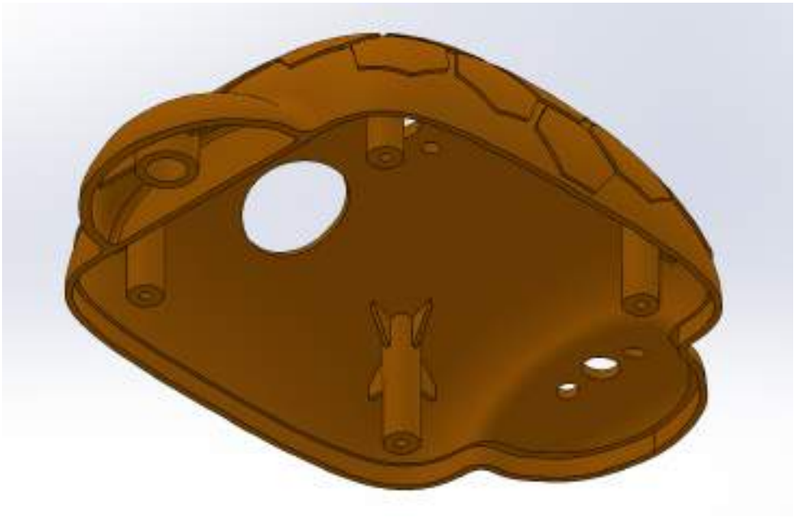
With LED strip light dimensions, I offset the internal shape of the shell to create a resting platform for the LED strip light. A lip and groove was also created for the shells to clamp together. An extra gap between the lip and groove was created to allow room for a custom washer piece to clamp between the two shells for waterproofing purposes.

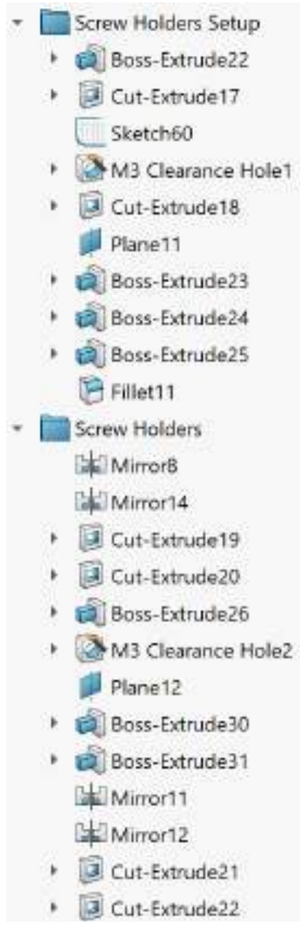


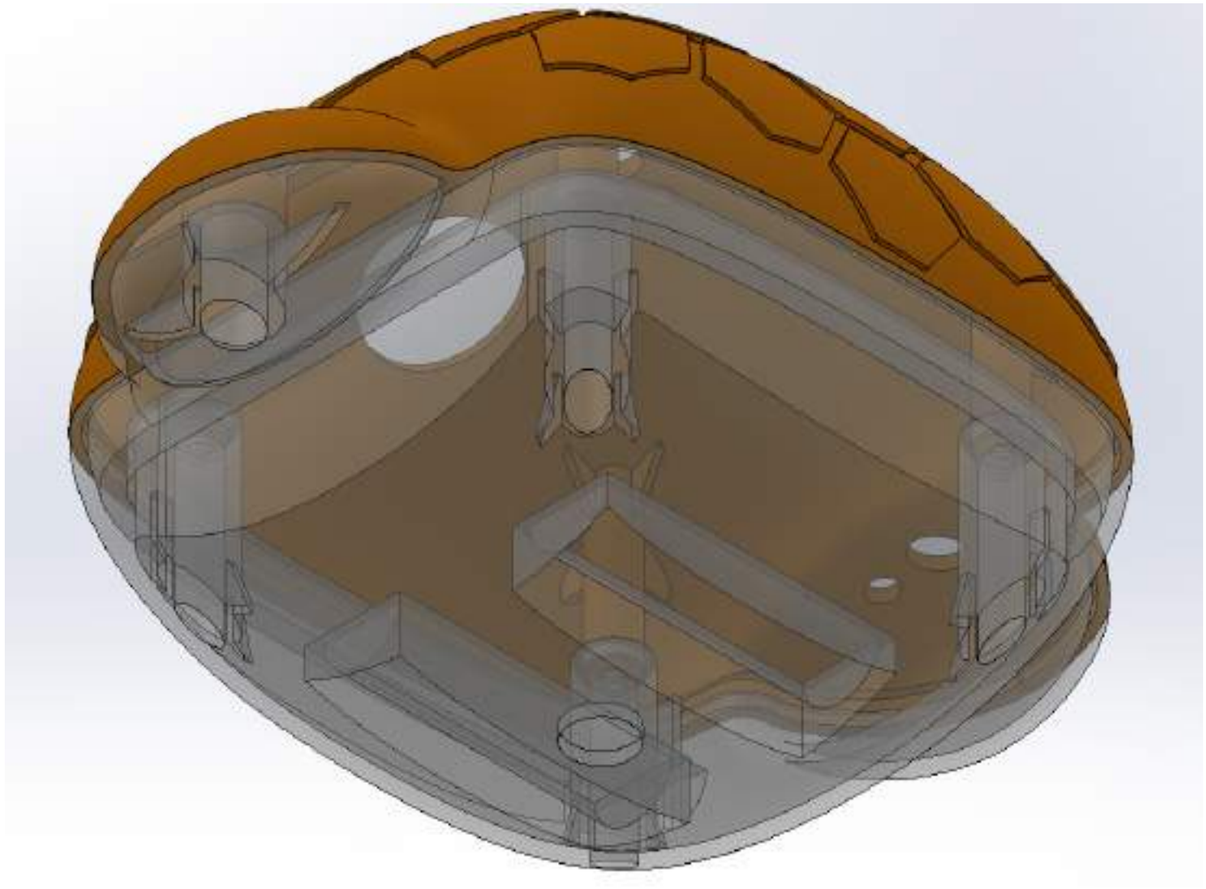
CAD Workflow | Screw Holders





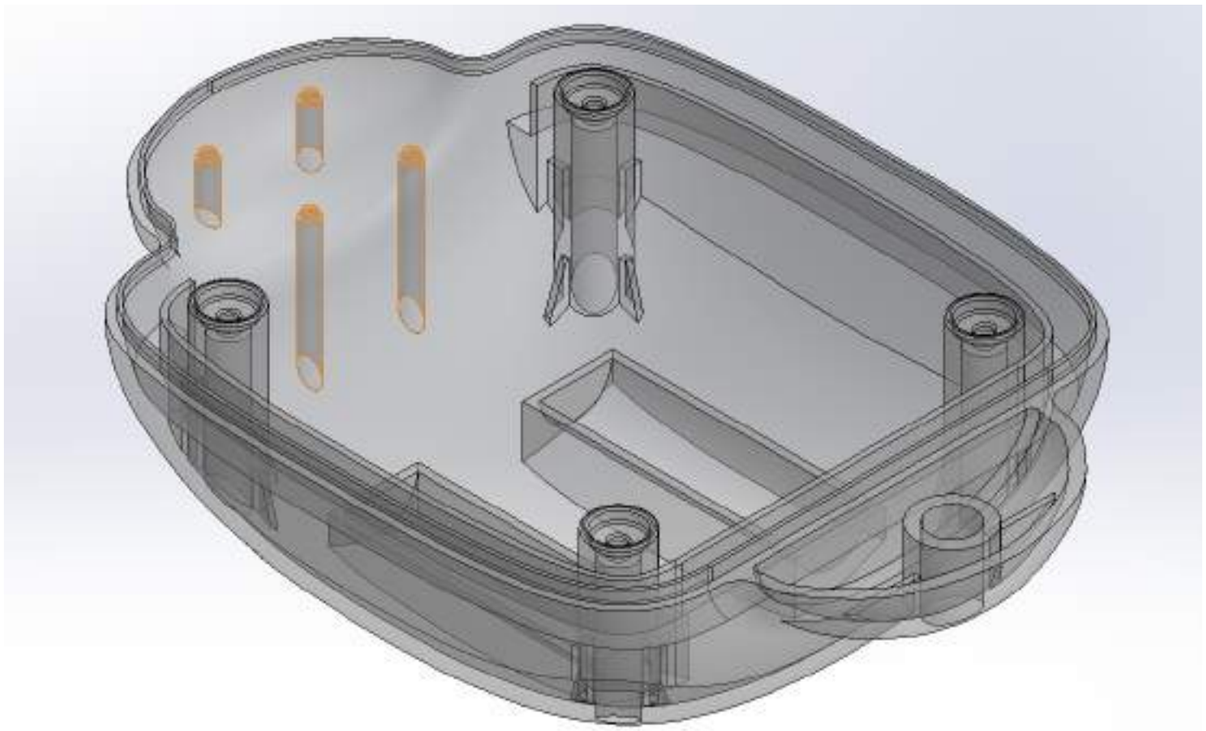


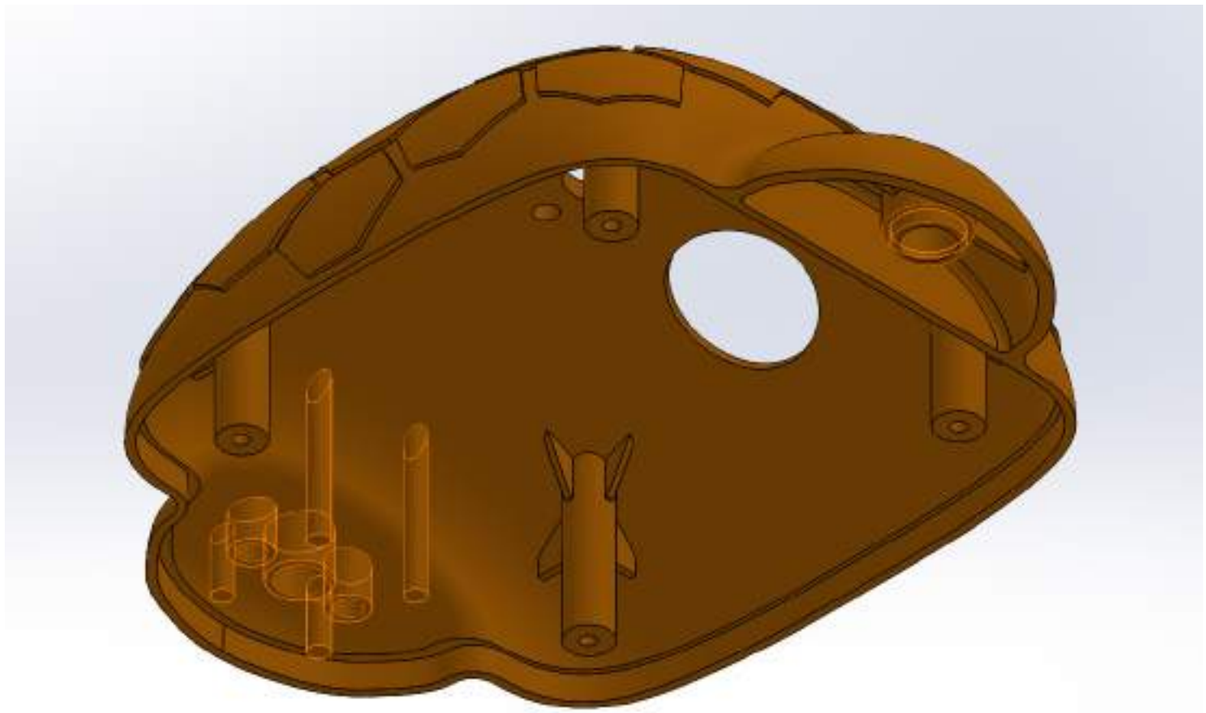


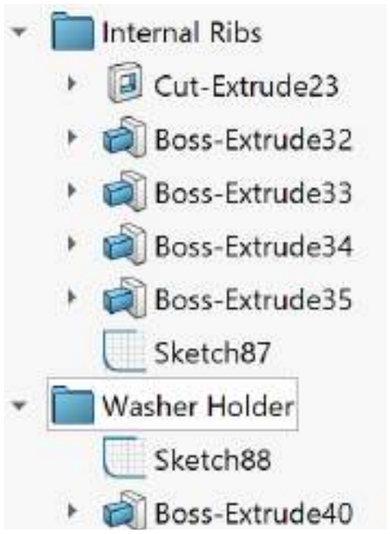


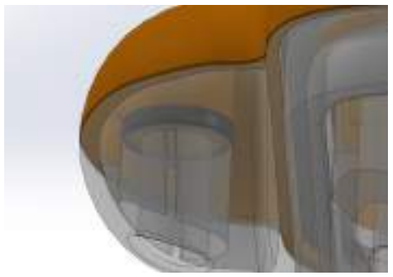
A screw holder was setup on the bottom shell, complete with ribs and cuts for the top-half to join together to. The feature was fully created on one end and mirrored across both axis. The same was done for the top half, with altered pole dimensions designed to fit snugly with the bottom poles.

CAD Workflow | Internal Details Part 2

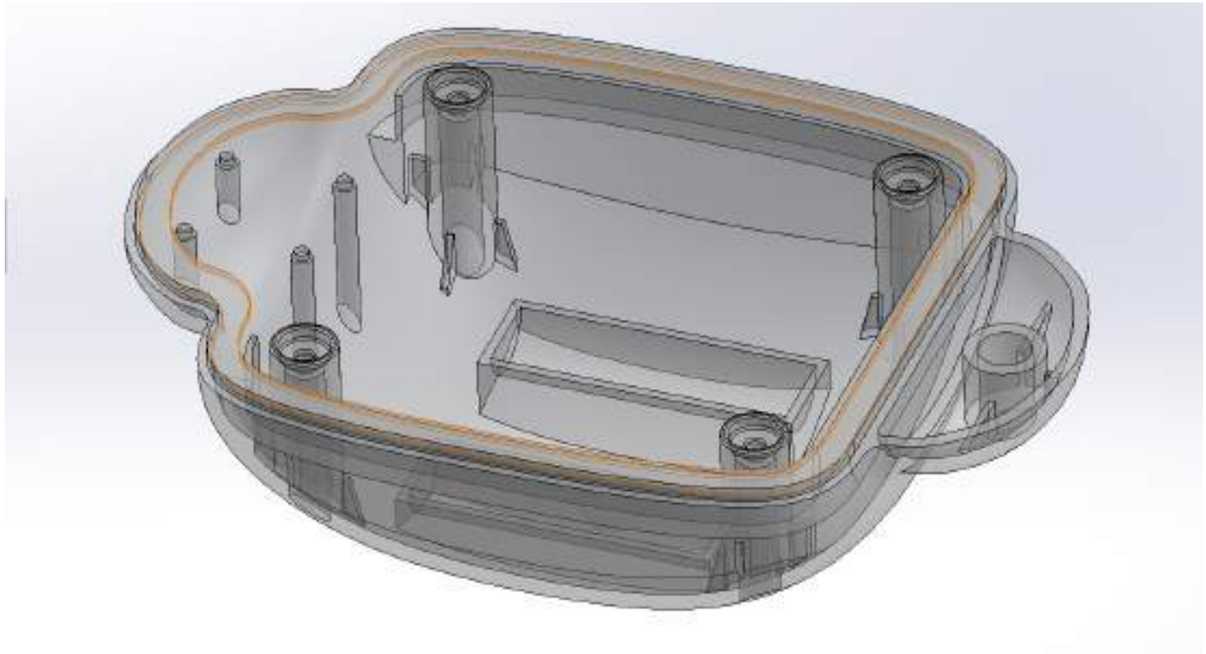




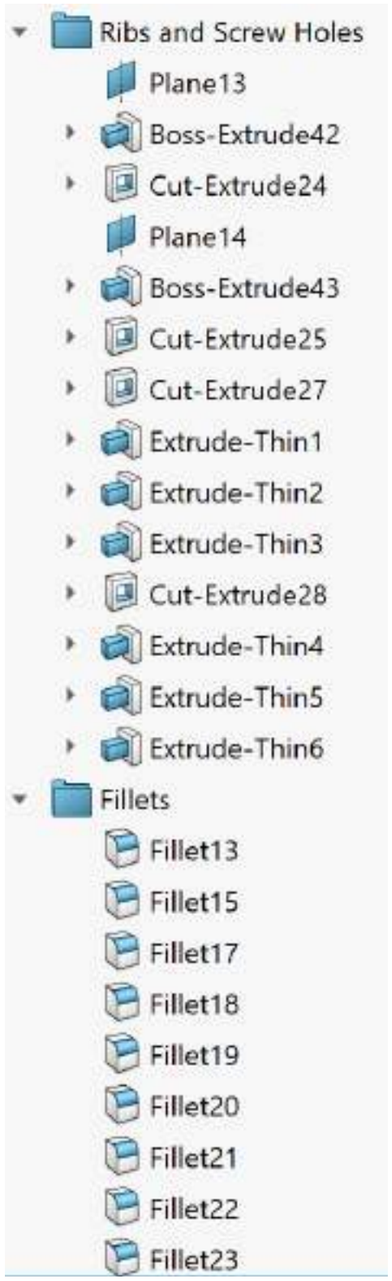


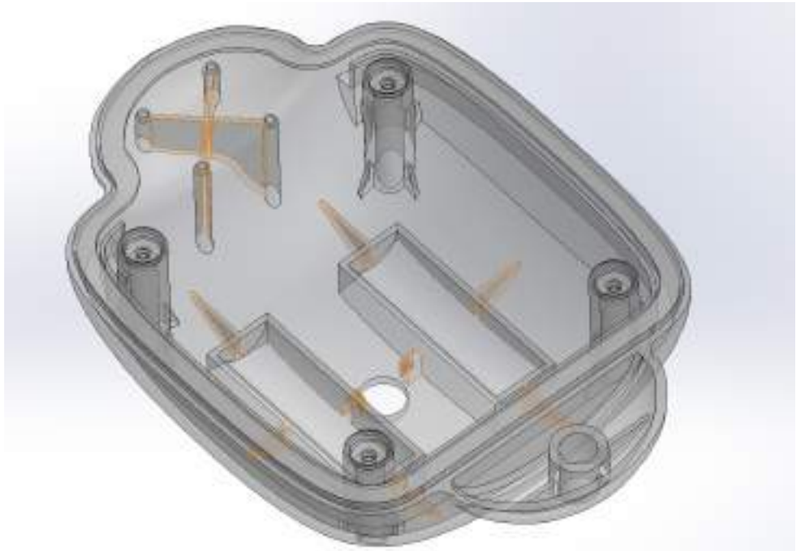


More internal ribs and other features were refined, including moulded spokes at the front head suitable for holding a PCB for the button and speaker components. A lip for the main washer piece was also added onto the bottom shell using offset entities to match the rounded shape perfectly. A 17mm O-Ring was also created to seal the rear rope hole.



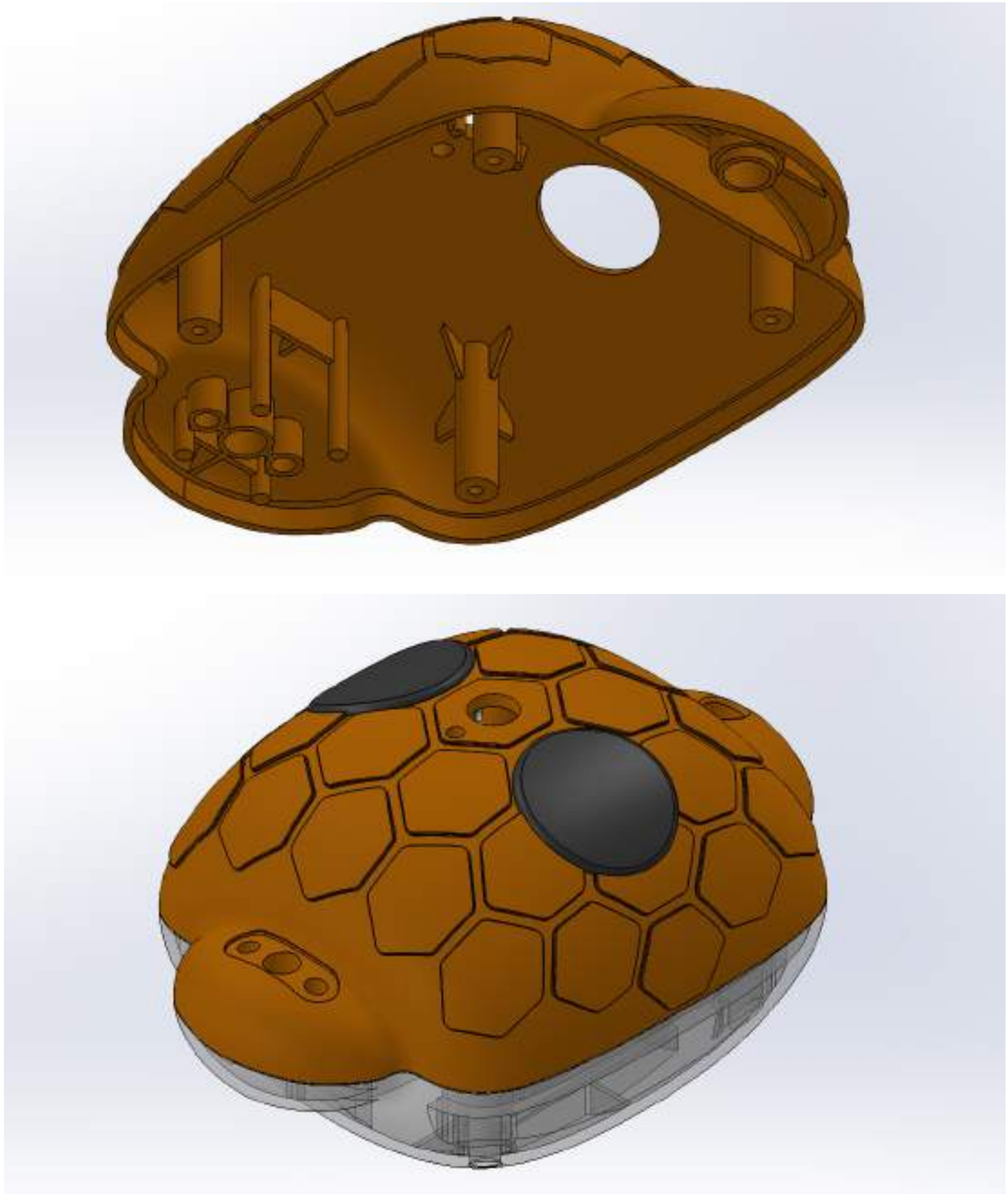
CAD Workflow | Final Resolution



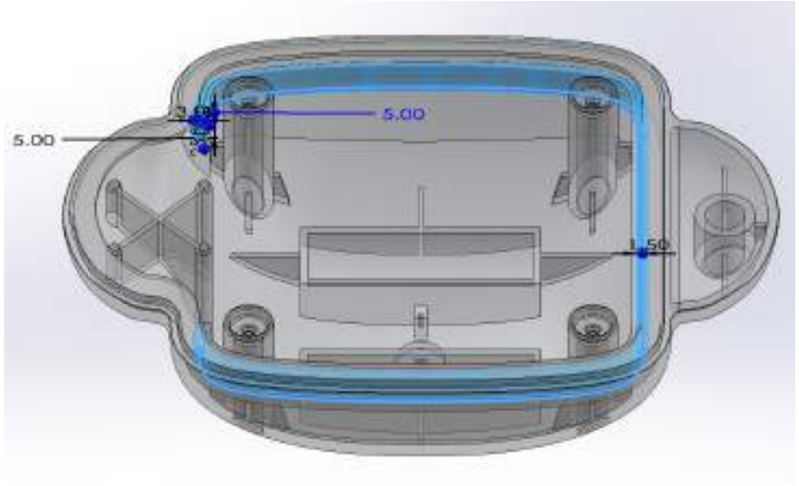


Any parts that appeared to require structural support in injection moulding were given internal ribs. Small screw holes for the camera lens holder to attach to were also included. A cutout for the buttons to rest into and fillets were included to fully resolve the shells.

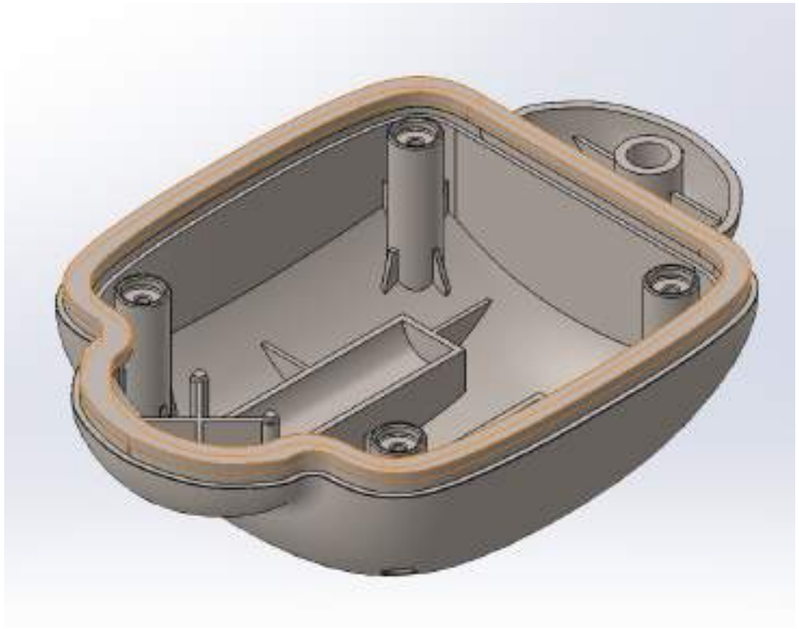
A copied file was adjusted for 3D printing, giving all cut holes and fitting components 0.5mm extra clearance to ensure the parts will have a loose enough tolerance to fit together when printed.

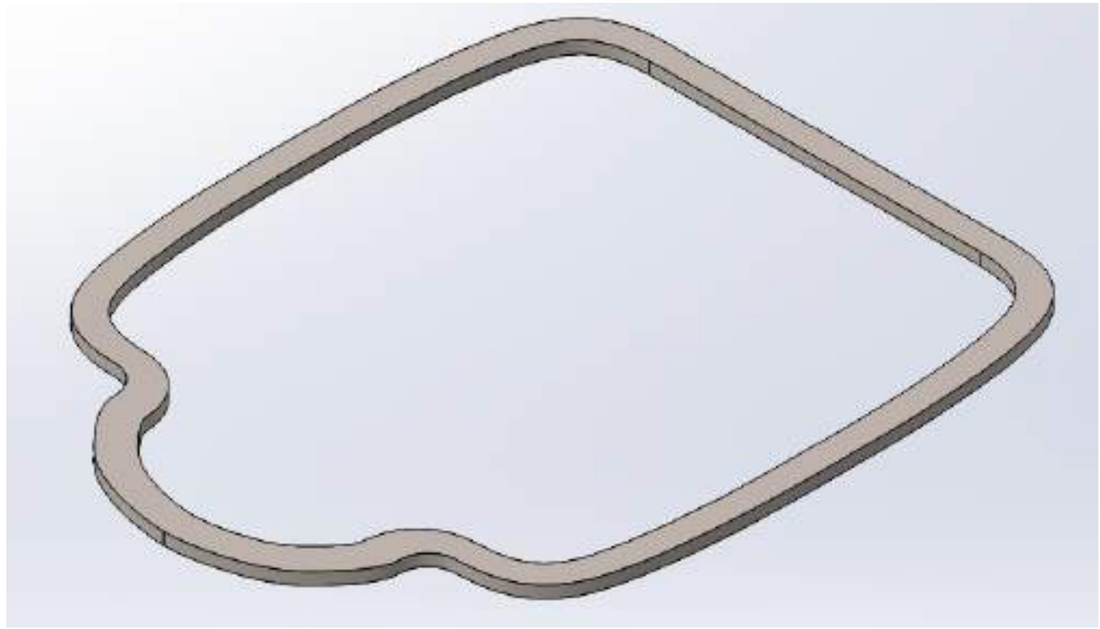


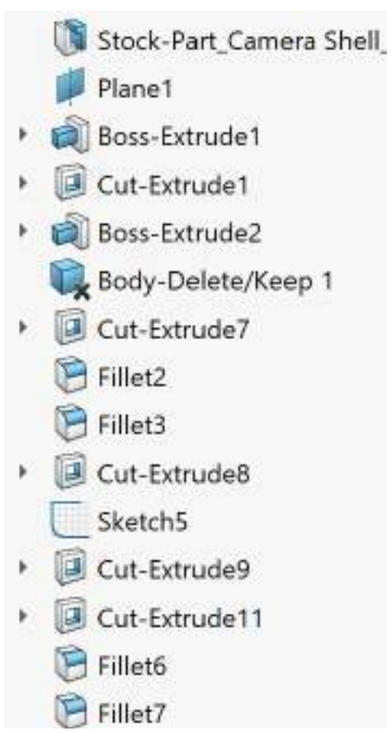
CAD Workflow | LED Strip Light Construction



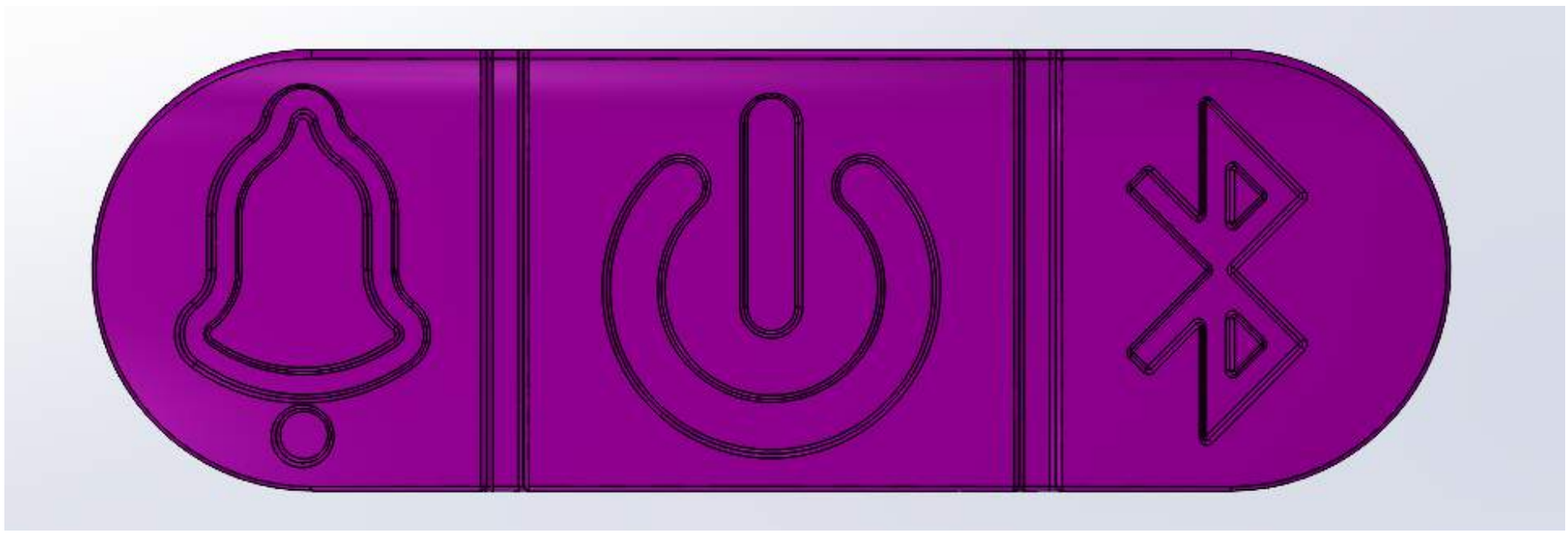
To create the LED strip light for proof-of-concept, the bottom shell was imported for geometric reference. A sweep feature created the perfect fit and appearance for the LED strip light. The washer was created in a similar manner, using converted entities to ensure the water piece would fit tightly between the two shells.



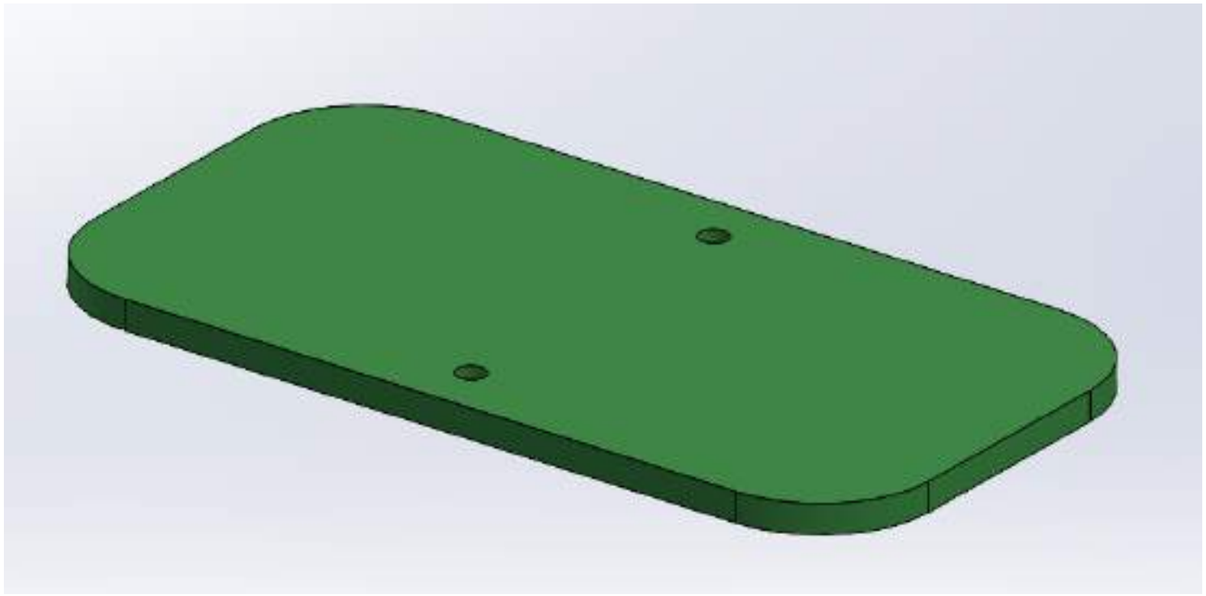


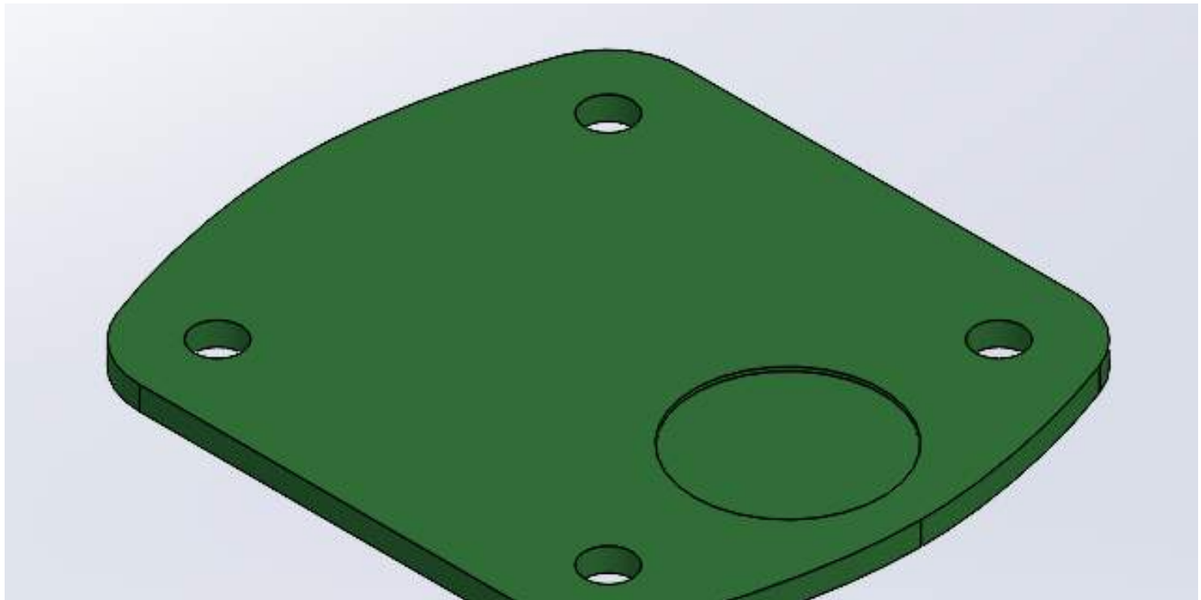


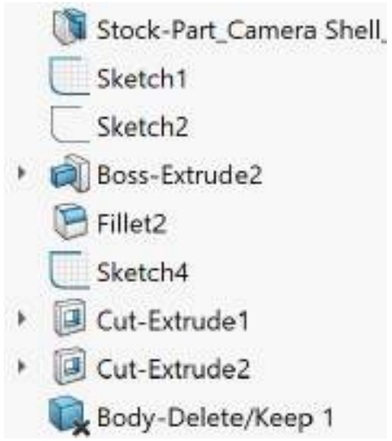
To create the buttons, a new body was created referencing the top shell and an offset cut from surface created the rounded shape. Indents separating the buttons were added and the icons are fully defined dimensions which could be reproduced in manufacturing and tooling.

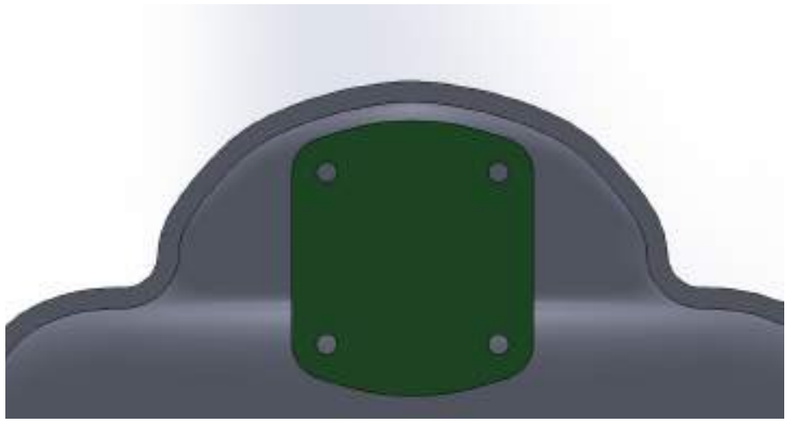


CAD Workflow | PCB Parts

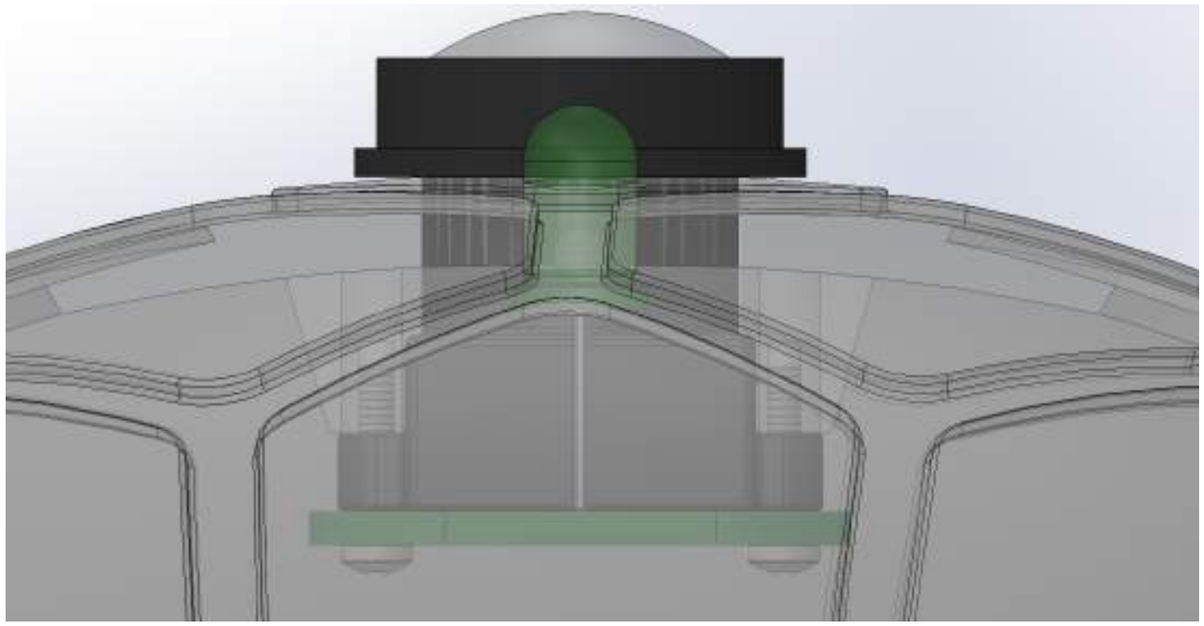




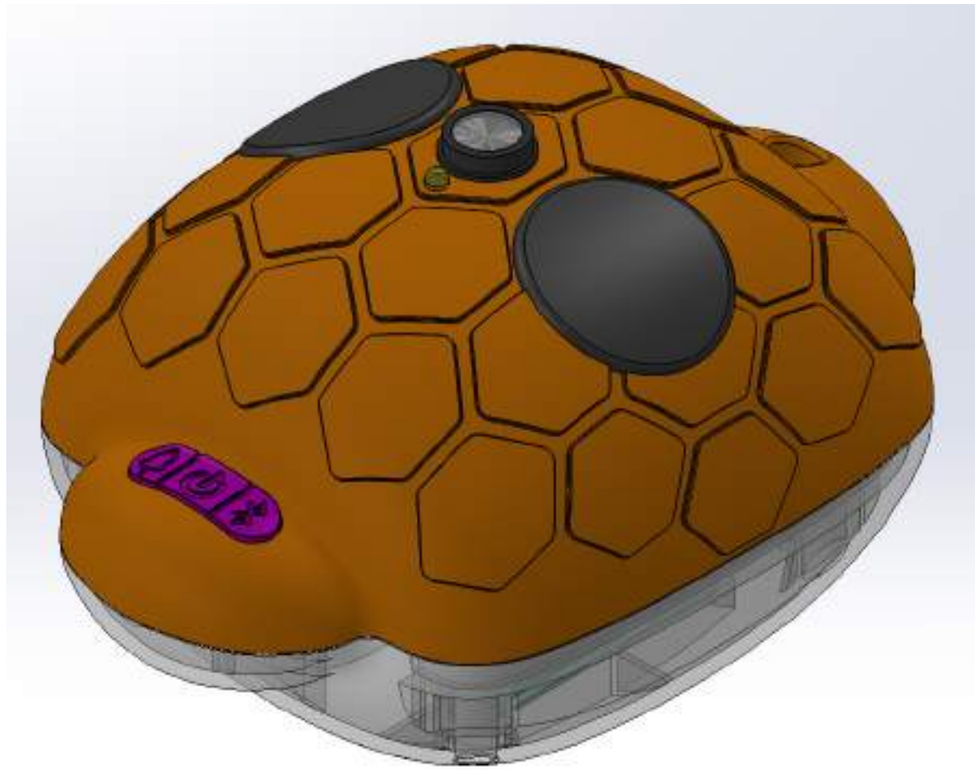


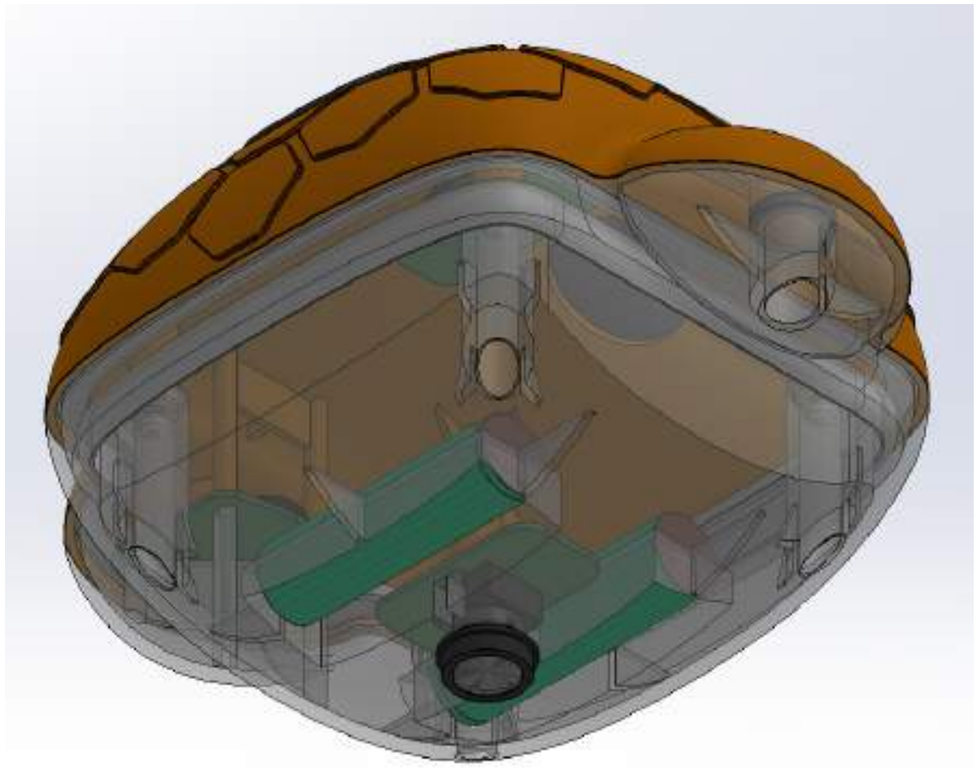


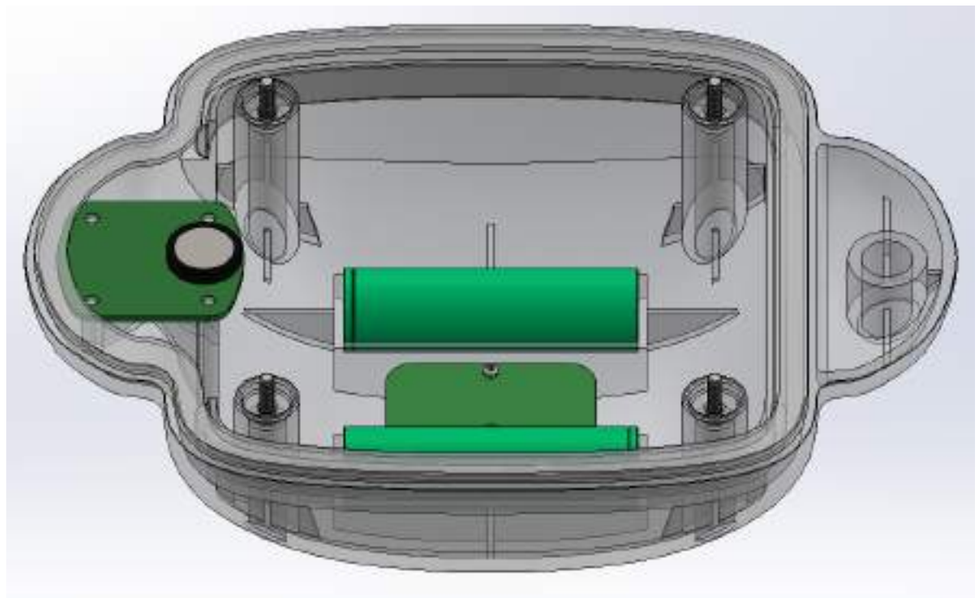
PCB components were created with inspiration from camera PCB components explored in product research. The camera PCB is a simple shape and designed to fasten with the thread holes on the camera lens holder. The interface PCB has a more organic shape to fit into the front head. A small circle was cut for the speaker component to mate to.

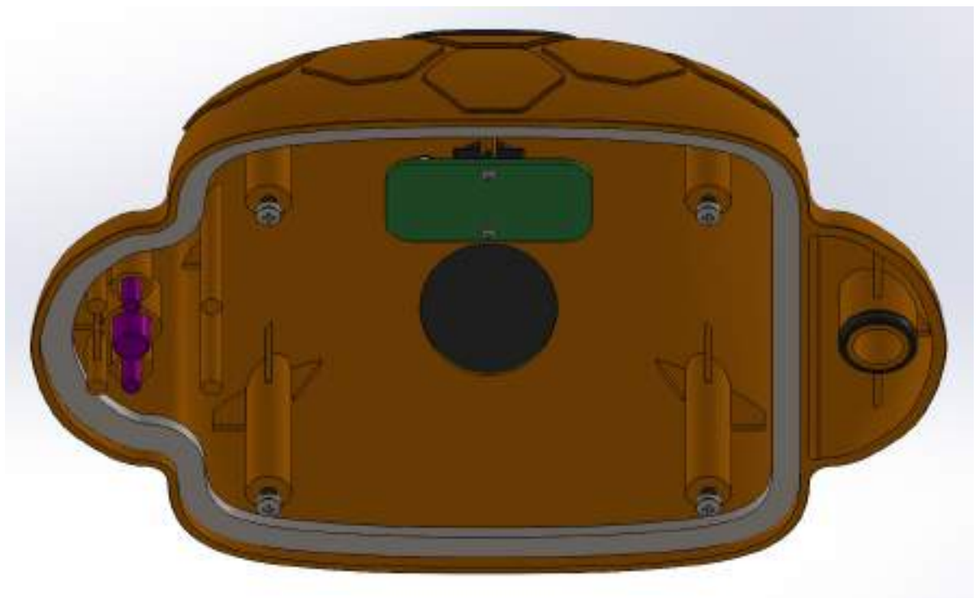


CAD Workflow | Final Assembly

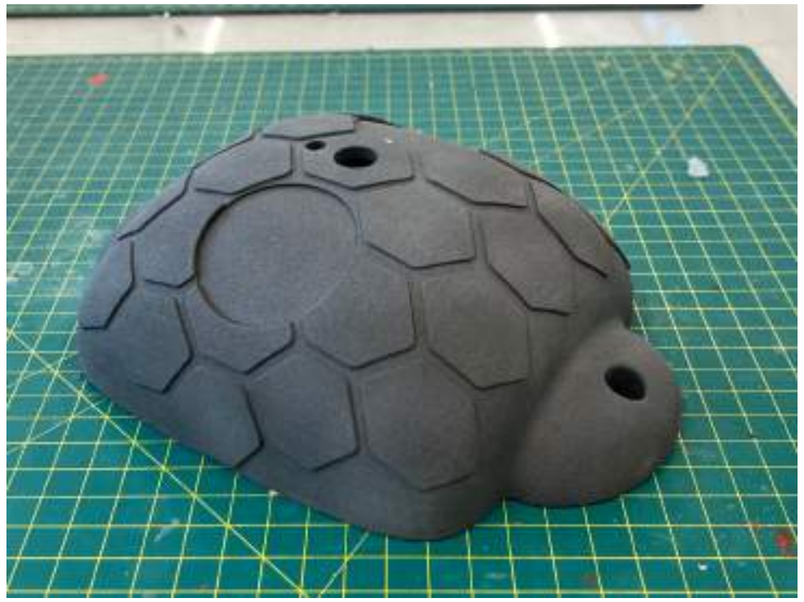


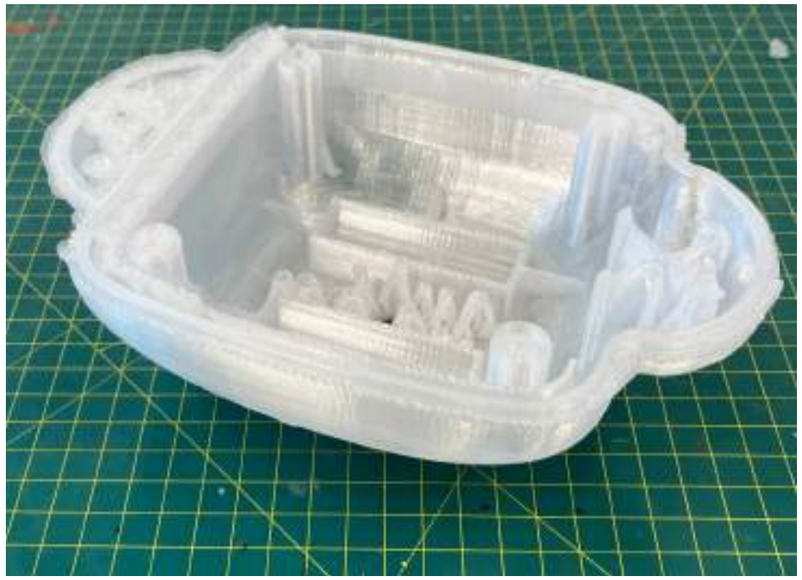


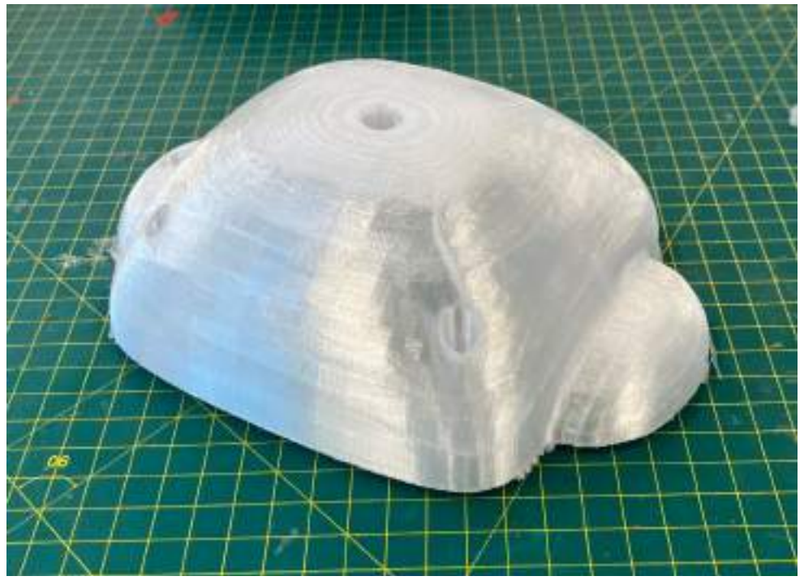




Physical Model | 3D Print Collection



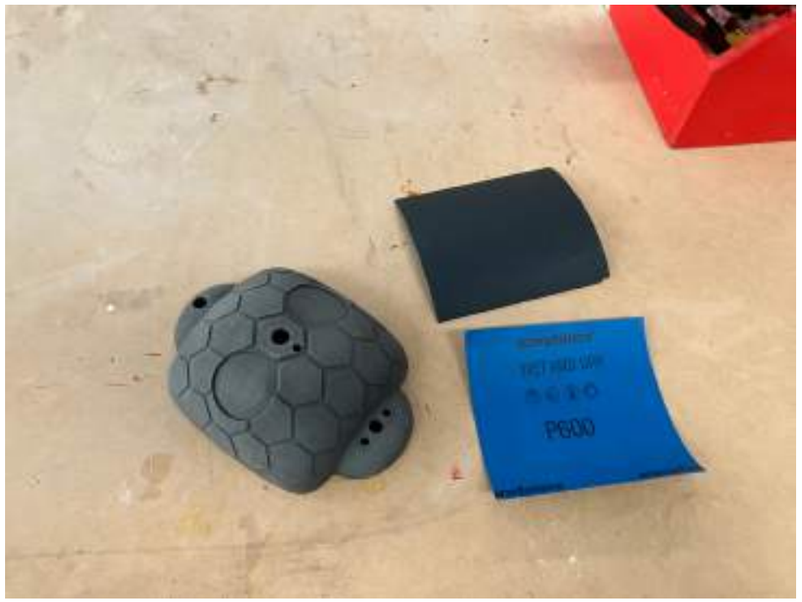




The 3D printed parts came back looking and fitting excellently. The top shell was printed with nylon fliament for a good finish from the get go. The bottom shell was printed with transparent PETG to be accurate as a transparent piece.

The buttons were printed from SLS elastic resin to feel accurate as silicone rubber buttons. The print unfortunately tore, and Digifab were no longer running elastic resin prints after my part. They were kind to lend a hand in repairing the part by curing it (top right).

Physical Model | Shell Priming



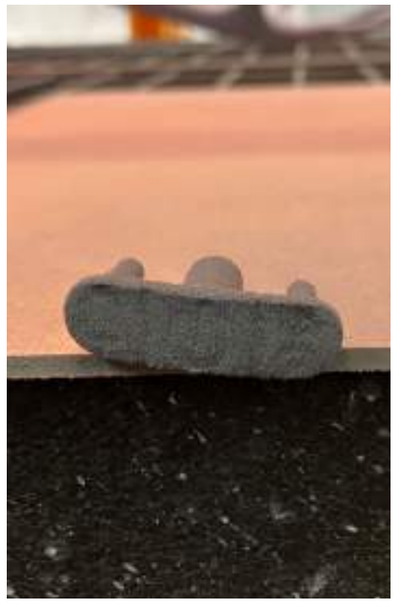
Plastic filler primer was used to help address any small dimples that were on the model. As the model already looked great, very fine sandpaper was used between coats. The primer resolved the print nicely with even coverage after three coats.

Physical Model | Shell Spray Painting

Rust-oleum 2X Ultra Cover Gloss Orange spray paint was used to give the shell its characteristic bright orange appearance. The shell needed five coats of paint to achieve full resolution. The stages of coats are shown in order from top left to bottom right.

Physical Model | Button Spray Painting




The Digifab workshop staff also gave me the button piece reprinted in TPU as an alternate option. The finish is good, but I could not get the button icons to show no matter what I did. The above was as clear as I could get it. I decided I would spray paint both button prints to see how they resolve, though I aim to still use the elastic resin print as I feel it is important to show the button icons. Plus, the elastic resin is also closer to the intended manufacturing material.

The buttons themselves are very small for spray painting. I had to apply four coats of primer and four coats of fluorescent pink spray paint to achieve a good resolution. The elastic resin worked well with the paint and made the colour really stand out, which was my intended effect.



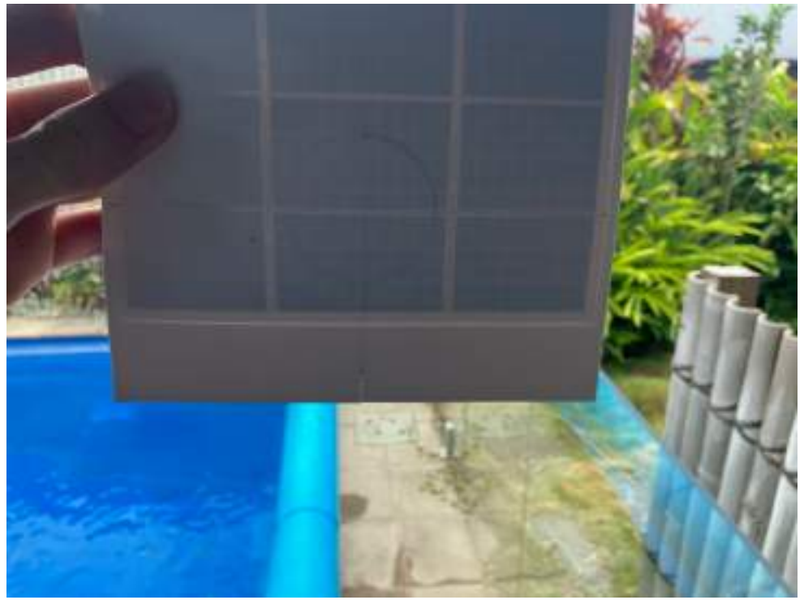

Physical Model | External Electronic Attachments

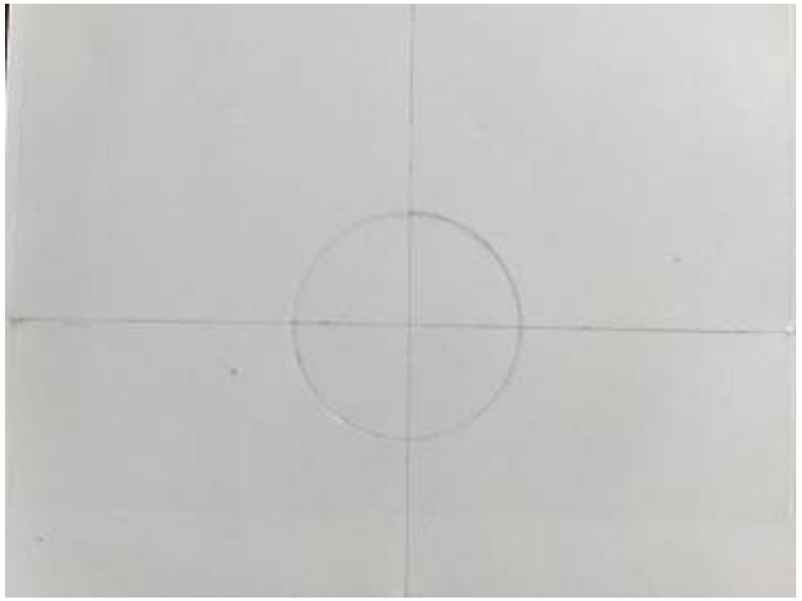
The custom-made external parts look great, so now it is just a matter of including the off-the-shelf components needed to make the exterior look 100% accurate. Surprisingly, the bottom camera lens screws in naturally. Regardless, it was still supported with silicone caulk. The top camera and LED were taped as it was the most discrete solution available.

Physical Model | LED Strip Lights

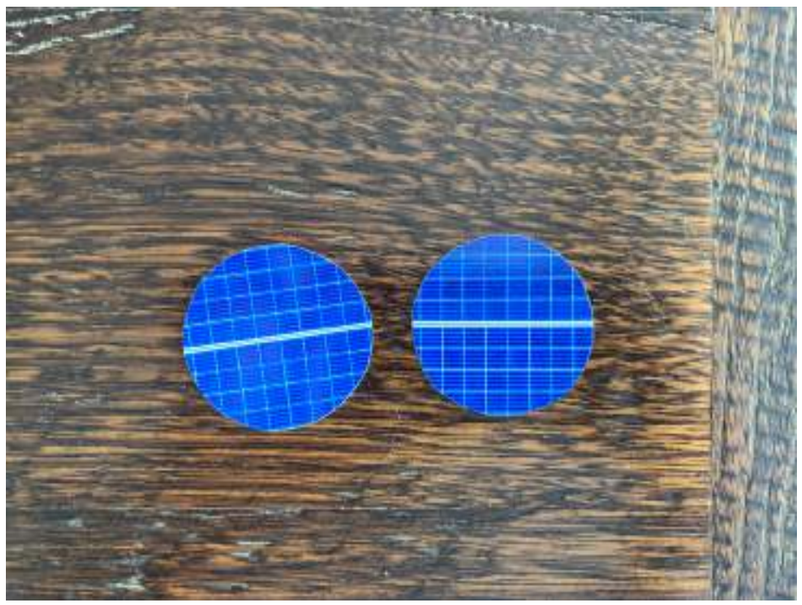
LED strip lights were also inserted into the model for demonstration purposes. The blinking motion achieves a close effect to how the final model would work.

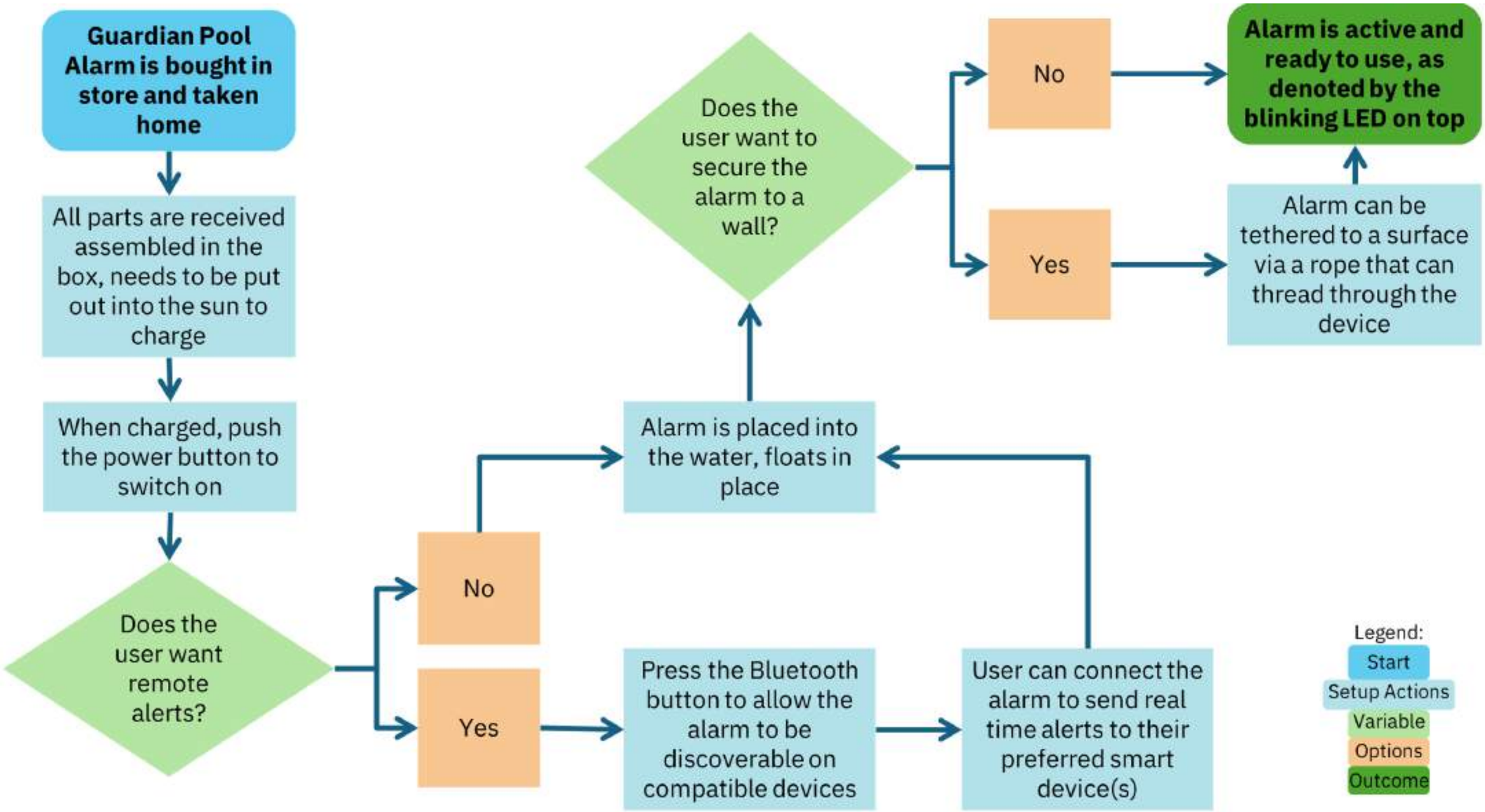
Physical Model | Solar Panel Decals



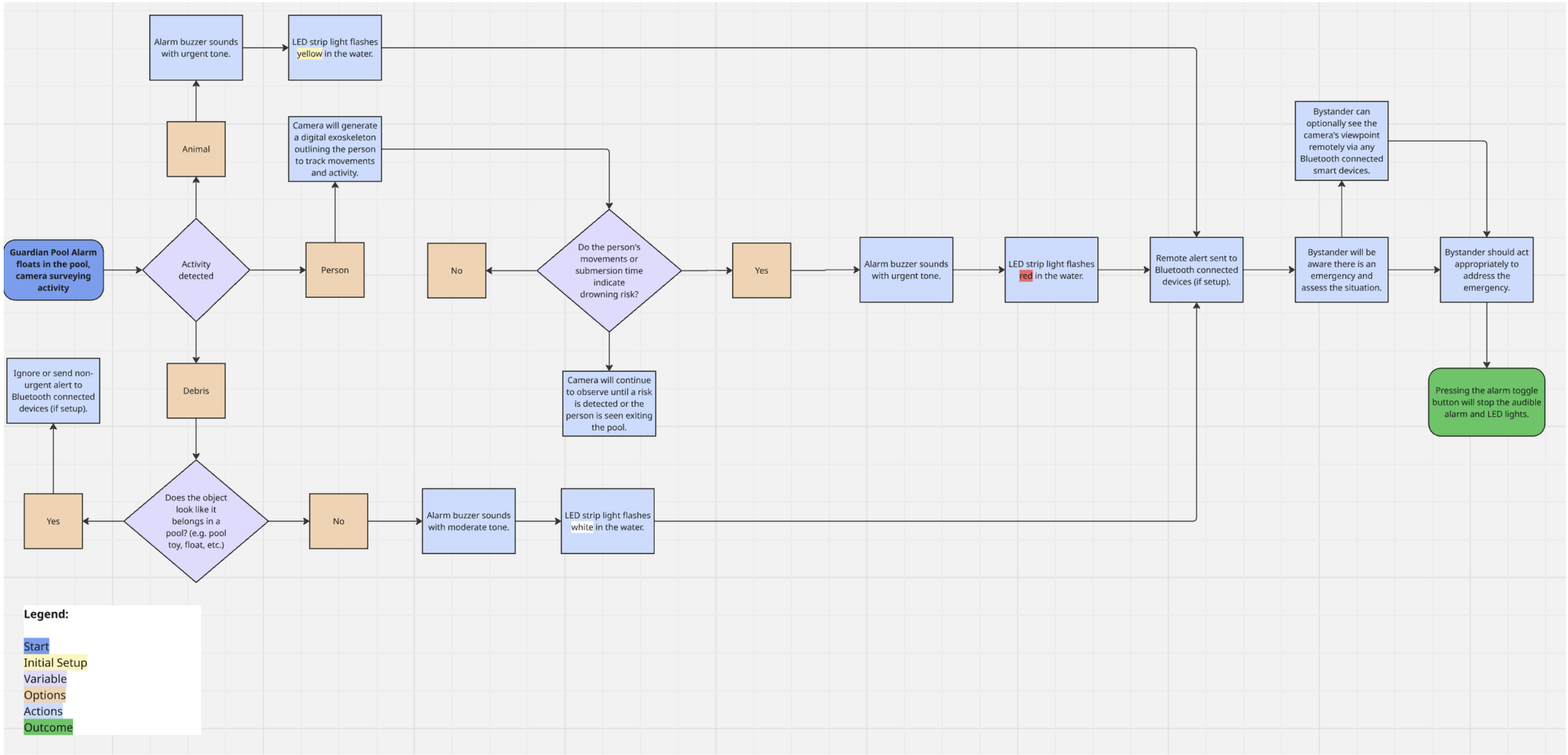


A solar panel decal was purchased to create visual representations for the prototype model. A big sheet was purchased when size and shape of the panels was still being explored. A circle diameter of 45mm was measured and cut twice on the sheet to get two clean identical solar panel decals.




Guardian Pool Alarm is bought in store and taken home
All parts are received assembled in the box, needs to be put out into the sun to charge
When charged, push the power button to switch on
Does the user want remote alerts?
No
Yes
Alarm is placed into the water, floats in place
Press the Bluetooth button to allow the alarm to be discoverable on compatible devices
User can connect the alarm to send real time alerts to their preferred smart device(s)
Does the user want to secure the alarm to a wall?
No
Yes
Alarm is active and ready to use, as denoted by the blinking LED on top
Alarm can be tethered to a surface via a rope that can thread through the device
Legend:
Start
Setup Actions
Variable
Options
Outcome

User Experience | Regular Use-Case Flowchart



Manufacturing Package | HDPE Bottom Shell Costing

Quantity*
20000

Material
High Density Polyethylene (HDPE), Inj...

Envelope X 6.35 - 914.4* 200 mm
Envelope Y 6.35 - 914.4* 62.9 mm
Envelope Z 0.508 - 381* 139.9 mm

Max Wall Thickness 0.508 - 6.35* 3.35 mm

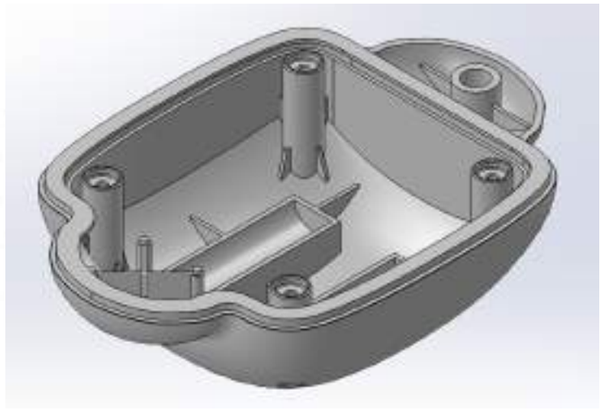
AREA

Projected Area 0.258064 - 645160* 9171.344674 mm²
Projected % Envelope 72.90 %

Projected Holes

VOLUME

Volume 0 - 21303.1* 194.945 cm³
Volume % Envelope 11.08 %



Tolerance (mm)
Low precision (≤ 0.5)

Surface Roughness (µm)
Smooth (Ra ≤ 0.8)

Complexity
Custom

Advanced Complexity Options

Advanced Mold Complexity

Feature Count
<100 features

Side Action Directions
0

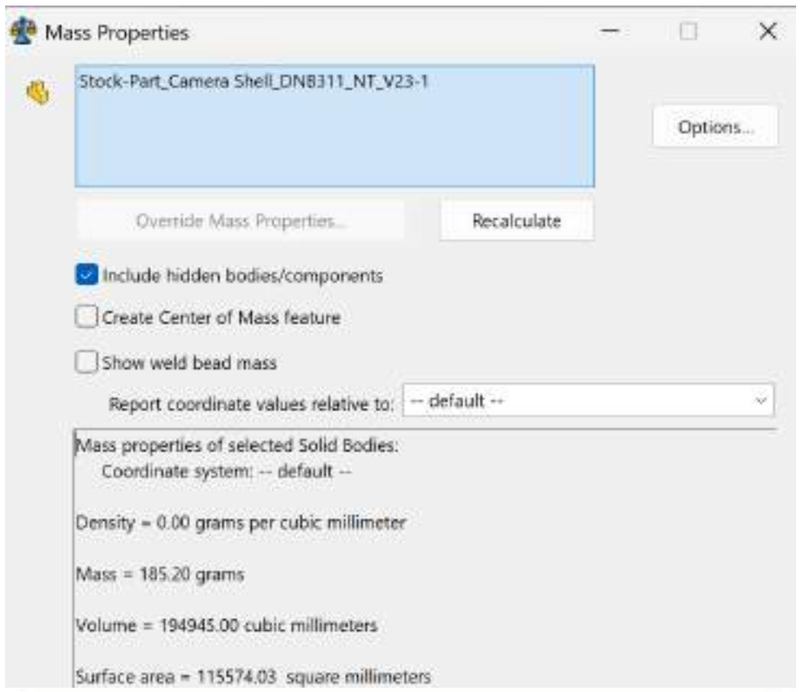
Side Cores
0

Lifters
0

Unscrewing Devices
0

Parting Surface
Complex curved surface

For initial production, 20000 units will be projected to be manufactured and distributed. This should reasonably cover the costs of tooling and other associated costs without going overboard in investment. Future production runs can be organised once supply, demand and consumer reviews are assessed.



Material	$10,122.533
Production	$4,992.575
Tooling	$36,195.589
Total	$51,310.698
Cost Per Part	$2.566

Manufacturing Package | HDPE Top Shell Costing

Quantity*
20000

Material
High Density Polyethylene (HDPE), Inj...

Envelope X 6.35 - 914.4* 200 mm

Envelope Y 6.35 - 914.4* 60.9 mm

Envelope Z 0.508 - 381* 141.9 mm

Max Wall Thickness 0.508 - 6.35* 3 mm

AREA

Projected Area 0.258064 - 645160* 85875.22 mm²

Projected % Envelope 705.05 %

Projected Holes

VOLUME

Volume 0 - 21303.1* 132.136 cm³

Volume % Envelope 7.65 %

Tolerance (mm)
Low precision (≤ 0.5)

Surface Roughness (µm)
Smooth (Ra ≤ 0.8)

Complexity
Custom

Advanced Complexity Options

Advanced Mold Complexity

Feature Count
<100 features

Side Action Directions
0

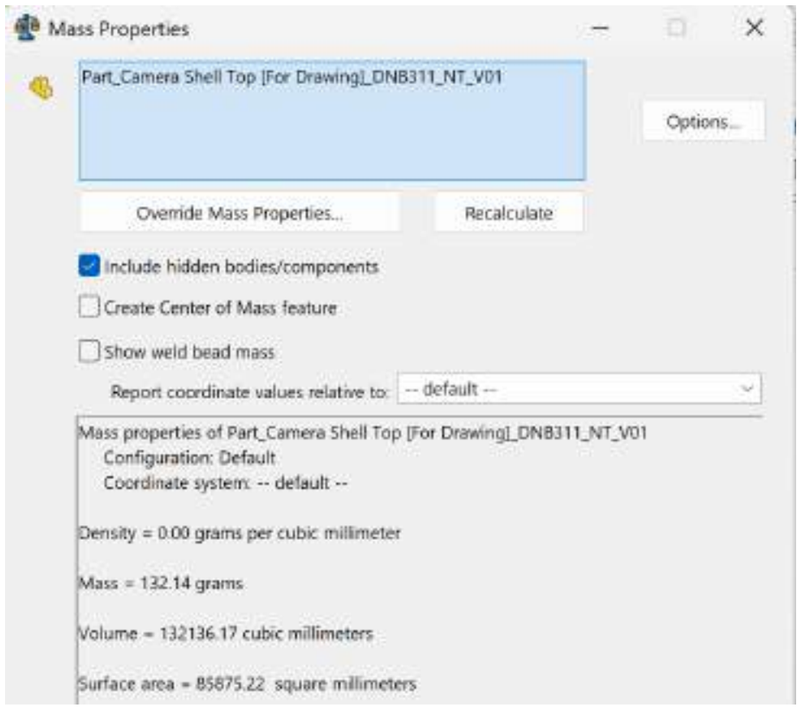
Side Cores
0

Lifters
0

Unscrewing Devices
0

Parting Surface
Complex curved surface

The top shell appears to cost twice as much to manufacture. The complex hexagonal pattern is likely causing this uptake in cost, as well as the other complex curved features.

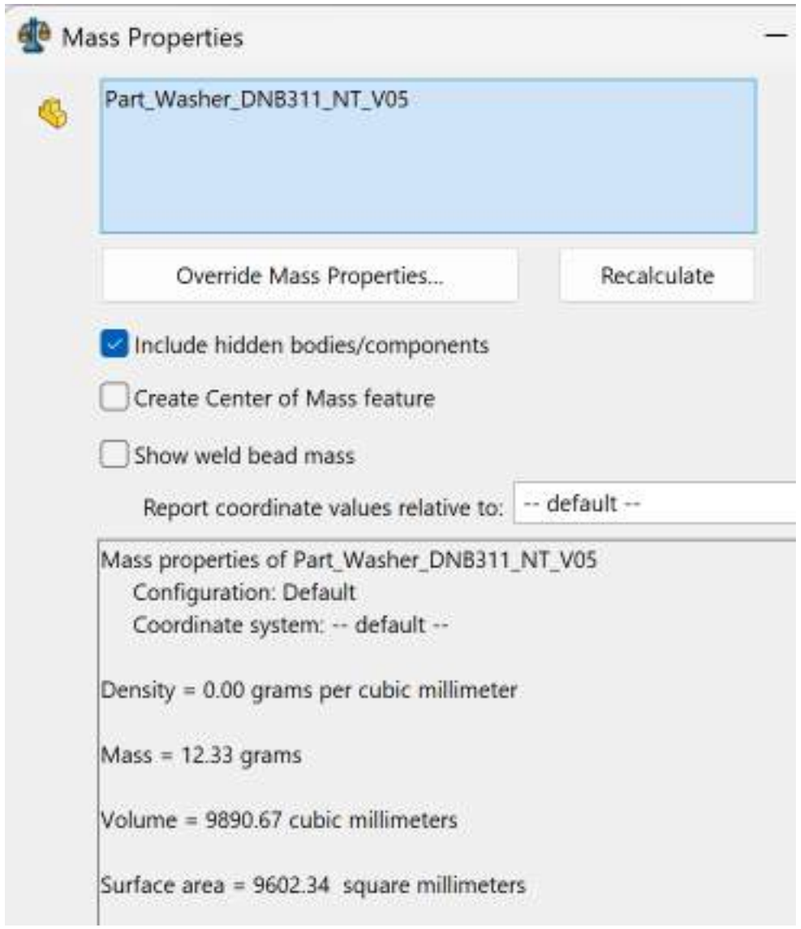


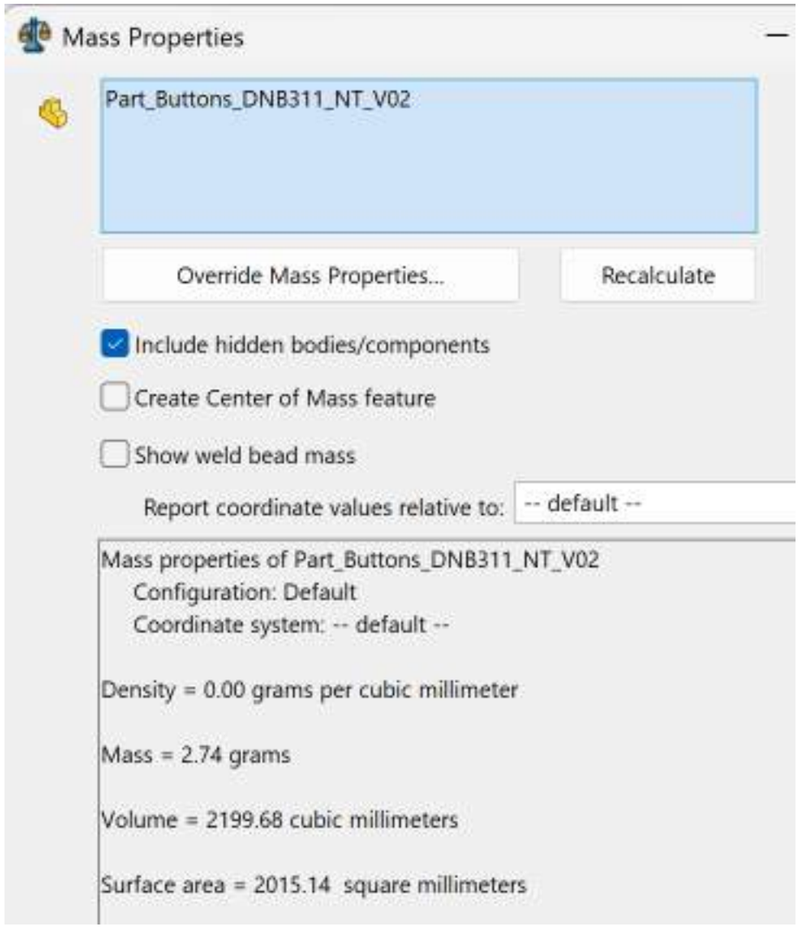
Material	$12,862.067
Production	$10,521.923
Tooling	$82,242.844
Total	$105,626.834
Cost Per Part	$5.281

Manufacturing Package | Silicone Rubber Costing

The average global price for silicone rubber is $2.02USD, or $3.12AUD per kilogram (https://www.statista.com/statistics/727582/price-of-rubber-per-pound/). This cost was multiplied by the weight of the washer (12.33g) to an estimated cost of $0.04AUD per unit. Considering additional costs needed to produce the part in-house, a production cost of $0.20AUD should cover this.

Using the same calculations for the washer, the silicone buttons should cost even less in terms of material (2.74g). The indented buttons are much more complex in shape however, so an estimated production cost of $0.20AUD should cover overall production costing.

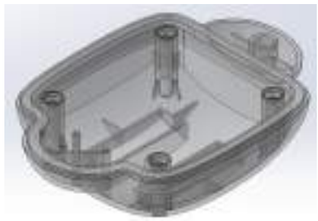




IMPORTANT: The non-off-the-shelf electronic components cannot be accurately cost estimated as there is a lack of information about these components. Especially the AI software technology, which currently costs over $1000AUD on a monthly subscription model.

With this in mind, it would be good to aim for a manufacturing cost under $250.00AUD to aim for a retail price under $750.00AUD. This will allow the product to compete neck-in-neck with existing competitors discovered in benchmarking. For a product using developing AI technology, this may not be achievable until the technology is more widely adopted and more affordable, which may be the case within 5 to 10 years time.

Manufacturing Package | Bill of Materials Part 1

Part Name	Part Image	Quantity	Colour	Finish	Manufacturer	Material(s) Used	Estimated Unit Cost (AUD)	Total Parts Cost (AUD)
Bottom Shell Half		x1	Clear (White)	Translucent Frosted	In-House	HDPE	$2.57	$2.57
Top Shell Half		x1	Pantone #FF9900 (Orange)	Glossy	In-House	HDPE	$5.28	$5.28
Circular Solar Panel (45mm)		x2	Pantone #000000 (Solid Black)	Epoxy Coated	External	Epoxy Resin	$0.69	$1.38
Custom Washer		x1	Clear (White)	Matte	In-House	Silicone Rubber	$0.20	$0.20
17mm O-Ring		x1	Pantone #000000 (Solid Black)	Smooth Silicone	External	Silicone Rubber	$0.08	$0.08

https://www.alibaba.com/product-detail/Custom-Molded-FKM-NBR-EPDM-Silicone_1601504728060.html

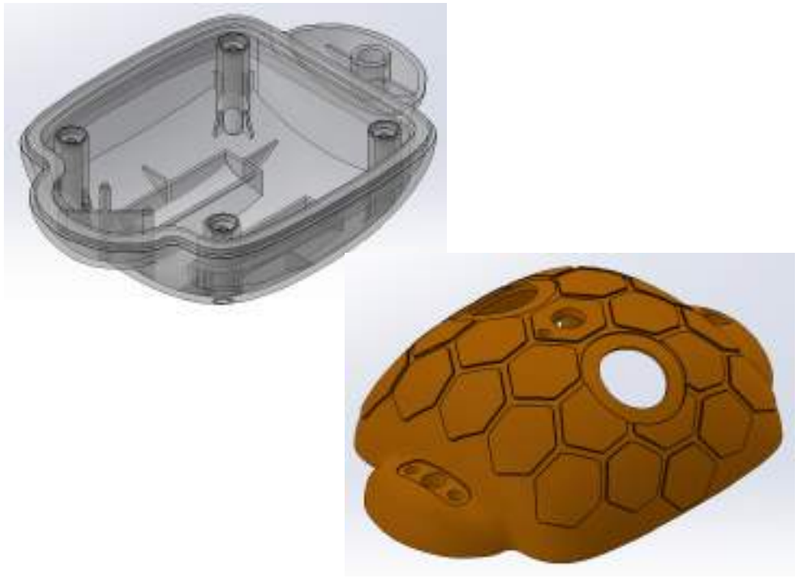
Manufacturing Package | Bill of Materials Part 2

Part Name	Part Image	Quantity	Colour	Finish	Manufacturer	Material(s) Used	Estimated Unit Cost (AUD)	Total Parts Cost (AUD)
Interface Buttons		x1	Pantone #CC33CC (Bright Pink)	Bump Textured	In-House	Silicone Rubber	$0.20	$0.20
Interface PCB (Sound Chip included)		x1	Pantone #229344 (Medium Green)	Solder Masked	In-House	Primarily FR-4 (fiberglass-reinforced epoxy resin)	$TBD	$TBD
Camera PCB		x2	Pantone #229344 (Medium Green)	Solder Masked	In-House	Primarily FR-4 (fiberglass-reinforced epoxy resin)	$TBD	$TBD
Lens Holder		x2	Pantone #000000 (Black)	Anodised	External	Aluminium 304	$0.25	$0.25
Camera Lens		x2	Pantone #000000 (Black)	Optical Glass Lens	External	HDPE (Outer Housing) Optical Glass (Lens) Aluminium 304 (Thread)	$5.27	$10.54

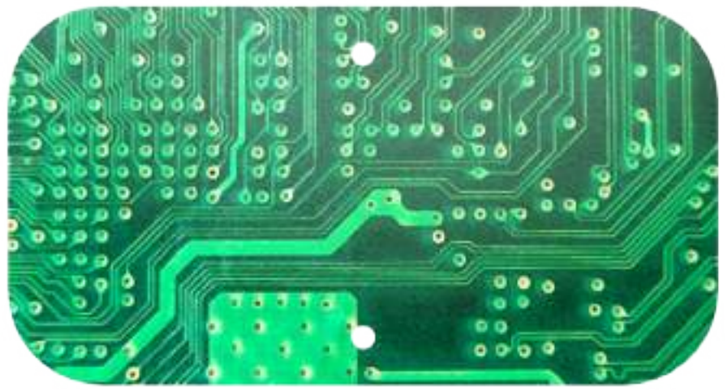
Manufacturing Package | Bill of Materials Part 3

Part Name	Part Image	Quantity	Colour	Finish	Manufacturer	Material(s) Used	Estimated Unit Cost (AUD)	Total Parts Cost (AUD)
LED Diode		x1	Standard Green LED	Epoxy Coated	External	Epoxy and Indium Gallium Nitride	$0.02	$0.02
Speaker		x1	Pantone #000000 (Black)	Matte	External	HDPE and Aluminium 304	$0.34	$0.34
LED Strip Light		x1	RGB	Epoxy Coated	External	Primarily FR-4 (fiberglass-reinforced epoxy resin)	$0.26	$0.26
Battery		x2	Pantone #50D086 (Bright Green)	Glossy	External	Lithium-ion	$1.37	$2.74
Pan Head Phillips Screw ISO 7045 - M1.6 x 8 - Z - 8S		x4	Natural Material (Silver)	Stainless Steel 304	External	Stainless Steel 304	$0.09	$0.52
Pan Head Phillips Screw ISO 7045 - M3 x 12 - Z - 12S		x4	Natural Material (Silver)	Stainless Steel 304	External	Stainless Steel 304	$0.09	$0.52

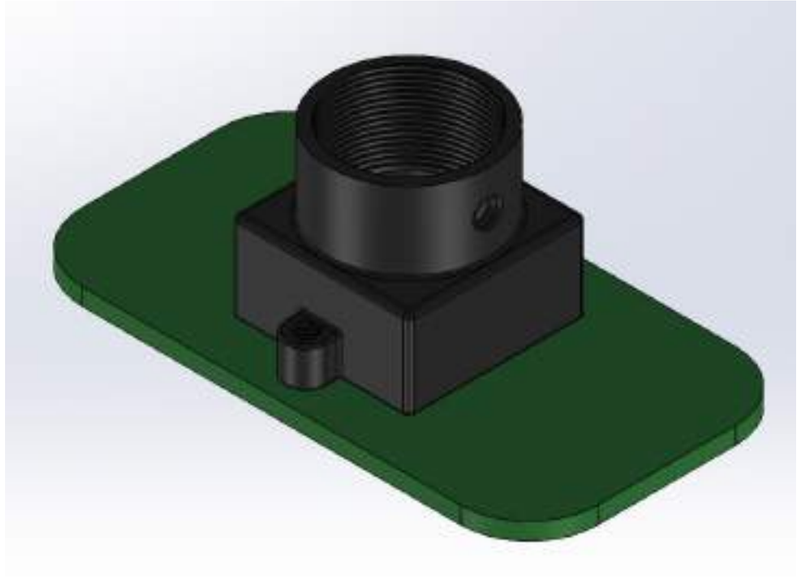
Manufacturing Package | Assembly Process Part 1



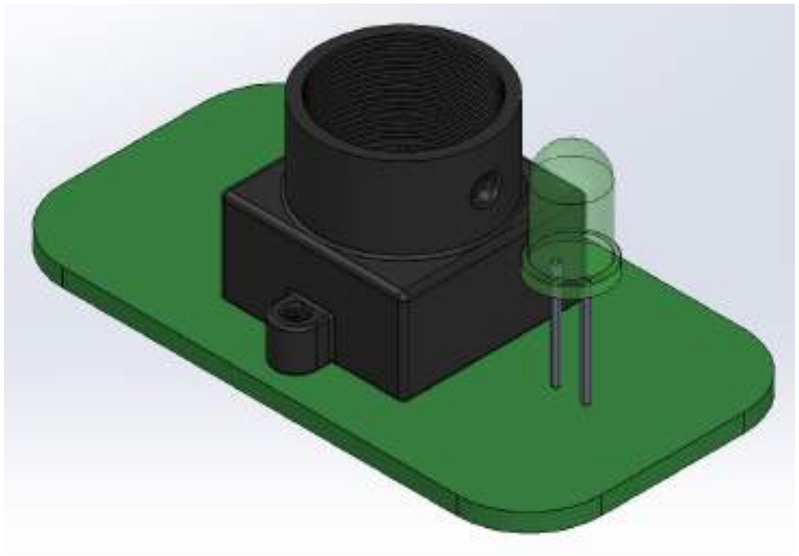
1. Shells are formed via an injection moulding tool.



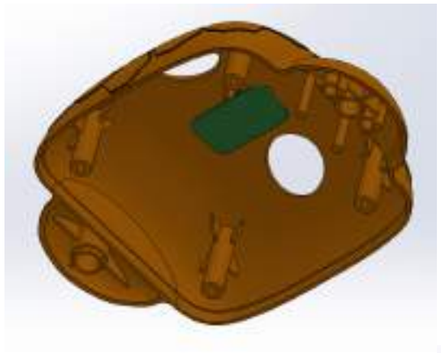
2. The camera PCB's are manufactured in-house.

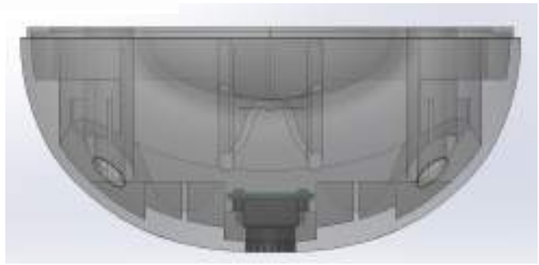


3. Align a lens holder on the PCB. Repeat twice.

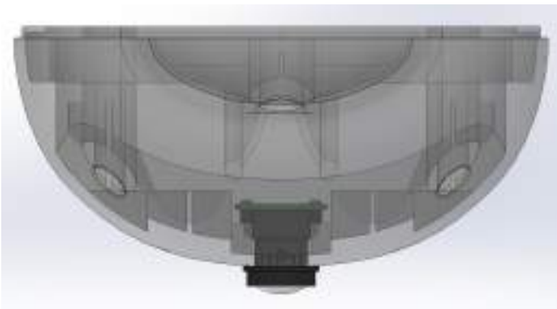


4. On ONE PCB assembly, solder an LED diode on to dimension with the top shell opening (14mm from centre).





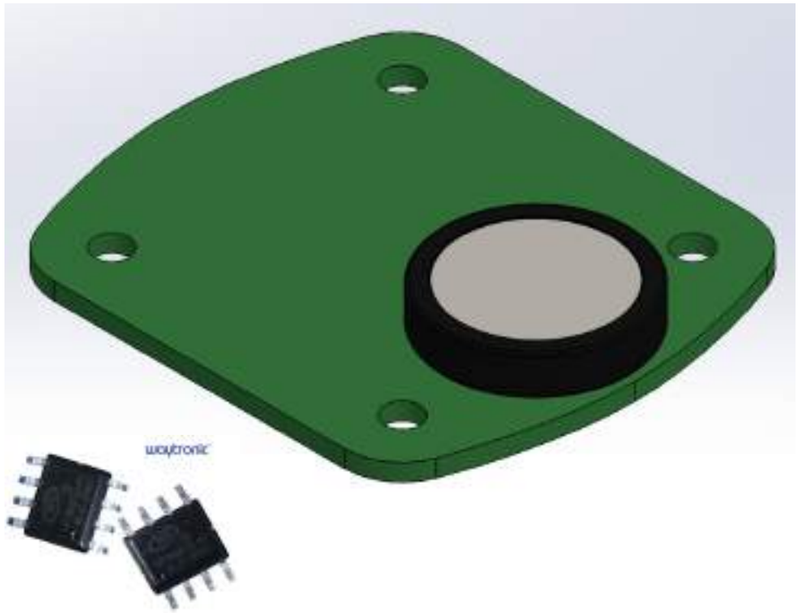
5. Screw the PCB assemblies into the corresponding shell half.



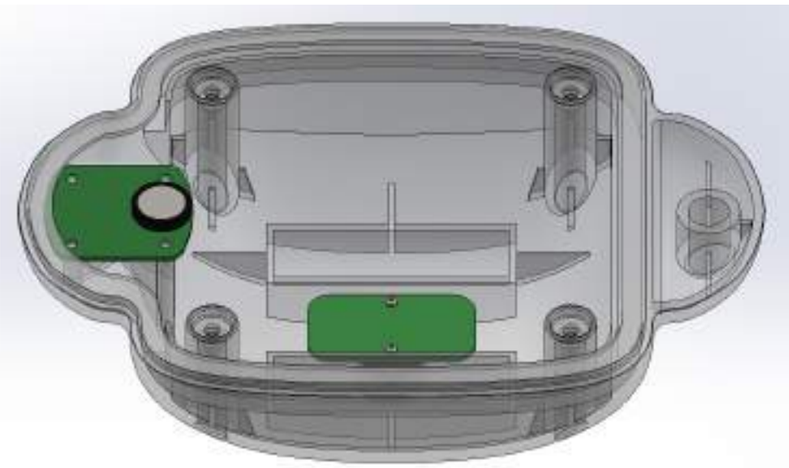
6. Screw the camera lens into both holders.

Manufacturing Package | Assembly Process Part 2

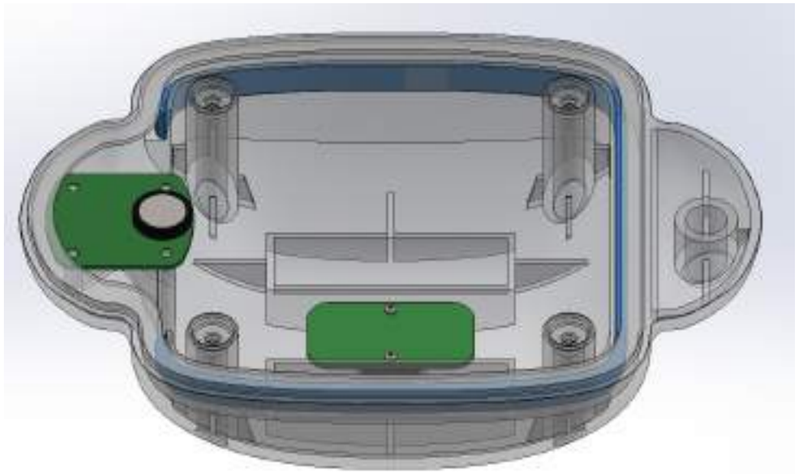
7. The interface PCB's are manufactured in-house.



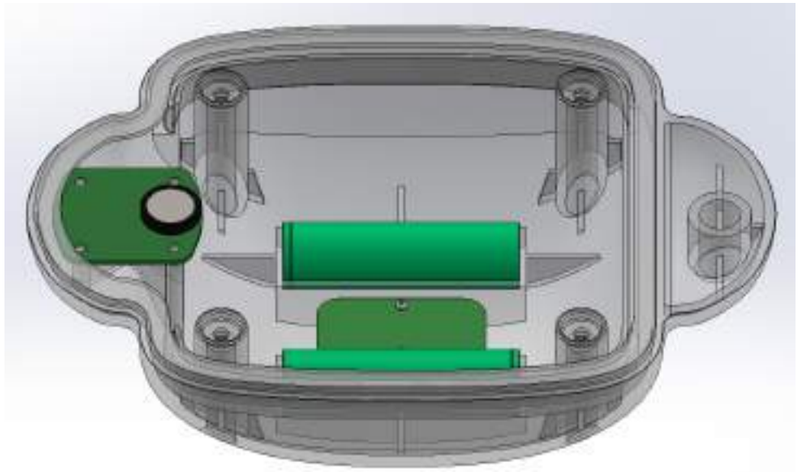
8. Sound chip and speaker are soldered to the PCB.



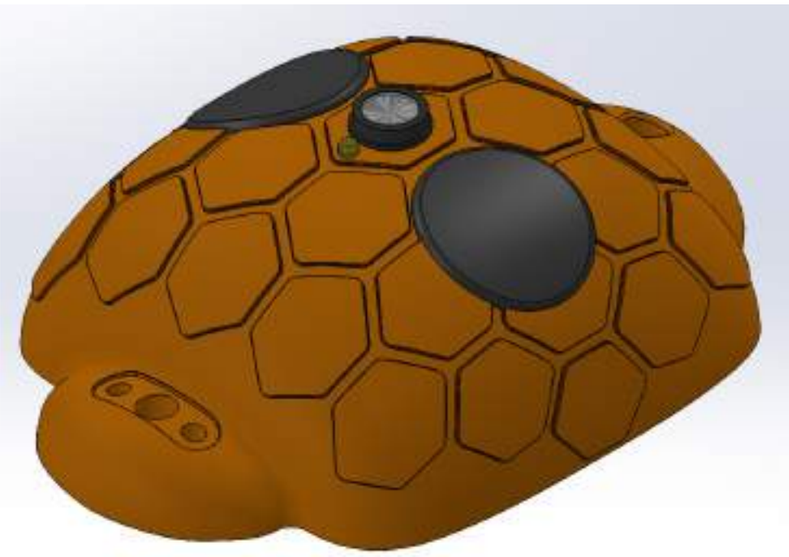
9. PCB Assembly slots into the bottom shell.



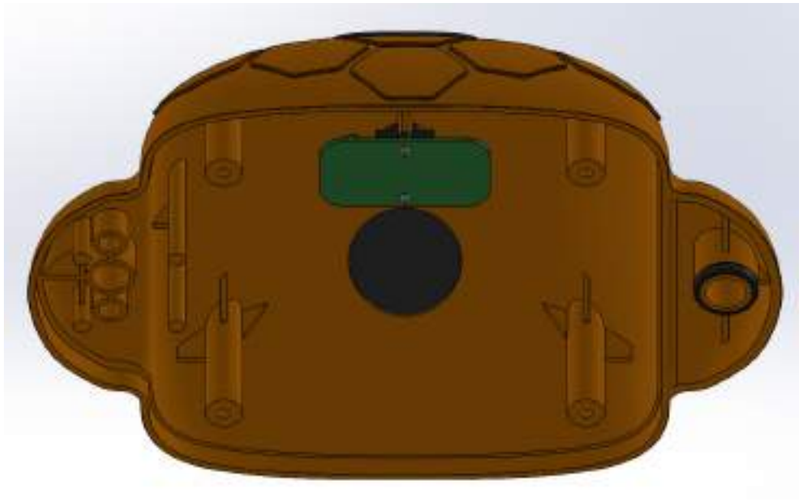
10. The LED strip light is threaded through the bottom shell housing and wires to the interface PCB.



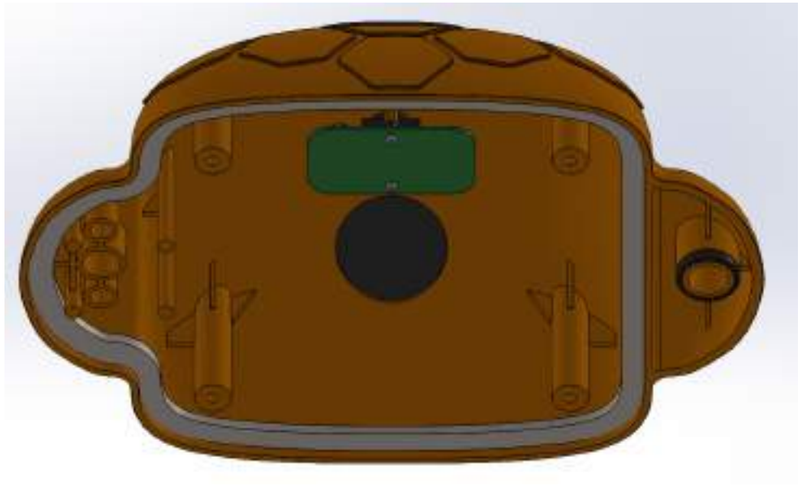
11. Batteries are placed in the bottom shell and wires connect to all PCB's.



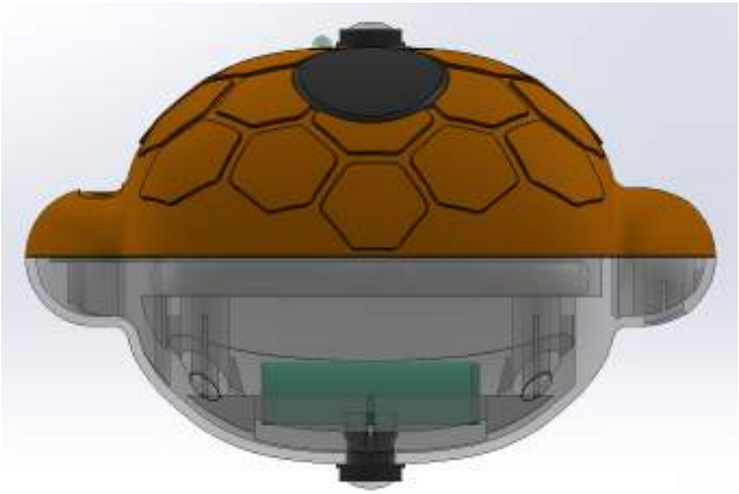
12. Solar panels wrap onto the top shell, supported with marine epoxy adhesive. These wire to the batteries.



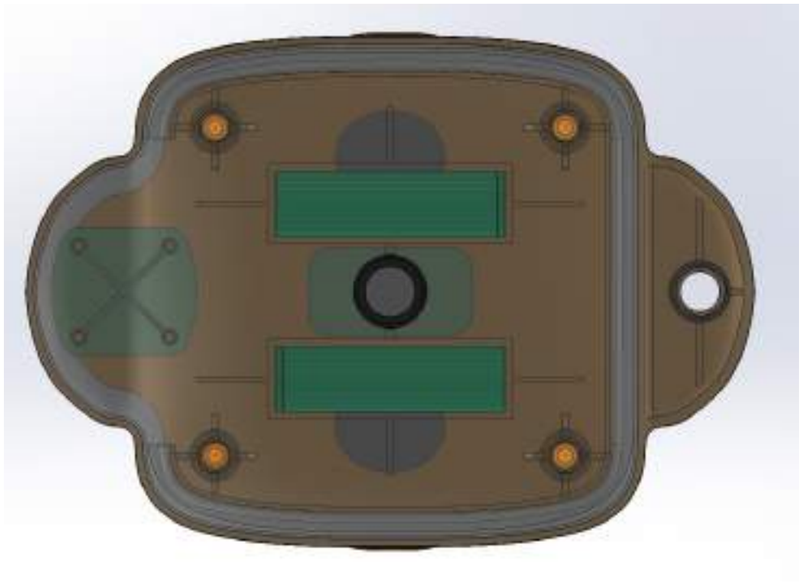
13. O-ring is fitted around the rear hole.



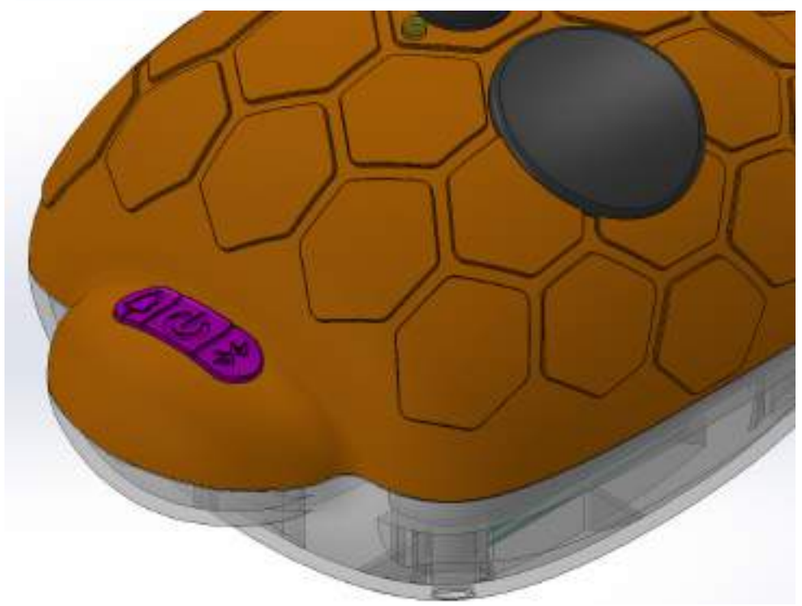
14. Custom washer is fitted into the top shell.



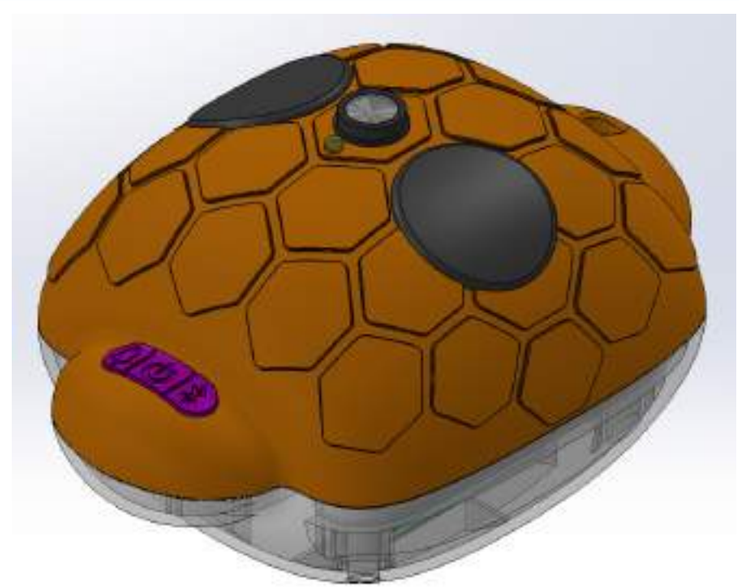
15. Fit both shell assemblies together. The washer and o-ring will clamp to create a watertight fit.



16. Screw both halves together.

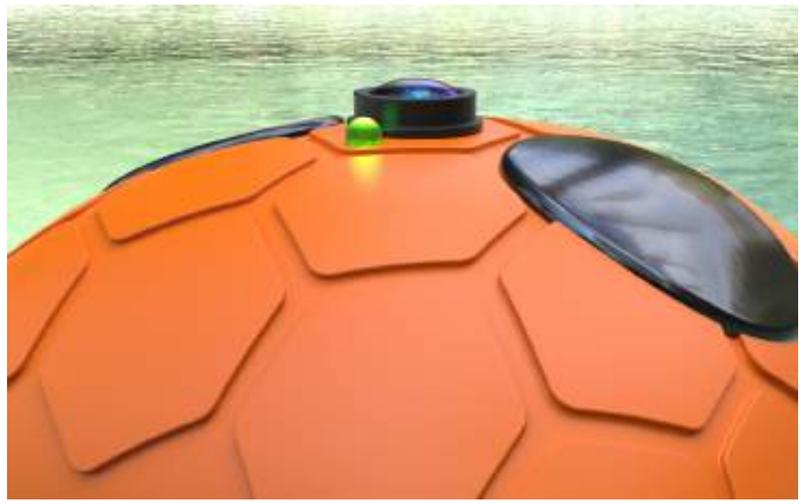


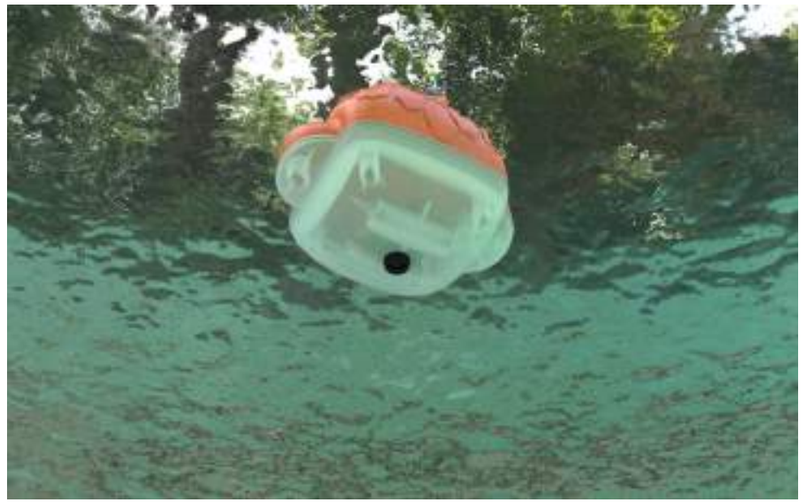
17. Interface buttons are slotted in aligning with the interface PCB, fastened with marine epoxy adhesive.



18. Complete unit made. To disassemble, unscrew from the bottom and follow steps in reverse order.

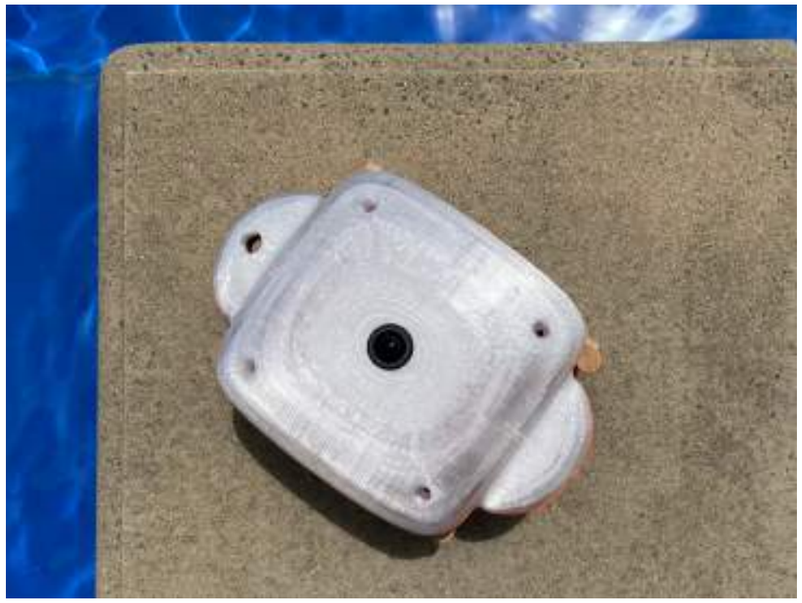
Key Imagery | In-Context Renders





Key Imagery | Internal Renders

Key Imagery | In-Context Photographs



Key Imagery | Ergonomic Photographs