Group N Subcam Poster

Suitability (Justification - Mathematical Models)

Unstiffened thin-walled circular cylinder under uniform pressure

$\sigma_H = hoop\ stress = pa/t$

$\sigma_L = Longitudinal\ stress = pa/(2t)$

Where:
p is the pressure (negative if external)
a is internal radius (if p is positive) or external radius (if p is negative)
t is the wall thickness

Ring-stiffened thin-walled circular cylinder under uniform pressure

Axisymmetric Deformation

Differential Equation

$$\frac{d^4w}{dx^4} + \frac{12(1-\nu^2)w}{t^2a^2} = \frac{12(1-\nu^2)p(1-\nu/2)}{Et^3}$$

Equation

$$P_y = \frac{\sigma_{yp}(t/a)}{1-\gamma G}$$

Reference
Ross, C.T., 2011. *Pressure vessels: external pressure technology*. Elsevier.

Propellers for submersion, thruster and motion systems

- **Rv= Cv . (Re . K/L)**
- **Drag= Cd .s.(v^2/2)** Cd is relating to Reynolds number, the extrapolation to the hydrodynamics is possible..

https://www.mecaflux.com/en/hydrodynamique.htm#:~:text=The%20total%20coefficient%20of%20hydrodynamic,Ch%20%3D%20Rv%3D%20Cv.

4.3 Ship speed dynamics

The following non-linear differential equation approximates the ship speed dynamics:

$$(m - X_{\dot{U}})\dot{U} = R(U) + (1-t)T + T_{ext} \quad (7)$$
$$U_m = U + \nu_U \quad (8)$$

https://vbn.aau.dk/ws/files/169365/fulltext

http://www.mojaladja.com/upload/The-Propeller-Handbook-The-Complete-Reference-for-Choosing-Installing-and-Dave-Gerr.pdf

Ct = coefficient of thrust

$$T = f(D; n; \rho; \nu; K; u_0) = \text{constant} \times D^a n^b \rho^c \nu^d K^e u_0^f.$$

https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.32.5027&rep=rep1&type=pdf

Thrust equation for rotor and propeller

$$T_{rotor} = \rho\, v_{tip}{}^2 C_T\, A \qquad T_{propeller} = \rho\, C_T\, (n^2\, D^2)D^2$$

https://pdfs.semanticscholar.org/7e7f/1be947ba1647c5e5d142c246e49363cc965b.pdf?_ga=2.193223085.1412838247.1645021203-1352842991.1645021203

Table 11.2: Propeller Parameters and their Units

Parameter	Symbol	Units
propeller diameter	D	m
propeller speed	n	rev/s
torque	Q	Nm
thrust	T	N
fluid density	ρ	kg/m^3
fluid viscosity	μ	m^2/s
fluid bulk elasticity modulus	K	N/m2
flight velocity	u_0	m/s

https://web.mit.edu/16.unified/www/FALL/thermodynamics/notes/node86.html

Suitability of models used

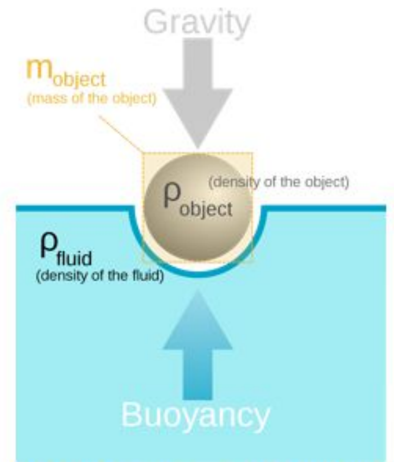
Buoyancy Force

$$F_b = -\rho g V$$

Buoyant force or upthrust is the force that is exerted upwards and opposite to immersed objects

Negative because it is opposing gravity

P = fluid density
G = gravity
V = volume



https://en.wikipedia.org/wiki/Buoyancy

Example using SUBCAM on internet

Subcam made by : https://www.gaelforcemarine.co.uk/en/GB/Chasing-M2-Underwater-Drone-ROV---200m-Package/s-7555-15410.aspx?PartnerID=618&utm_source=google&utm_medium=cpc&utm_campaign=UnitedKingdom&gclid=Cj0KCQiA09eQBhCxARIsAAYRiynPgqZnI5ZXa3NHjpTNvC1TNYnWBQNiX5R49FK2FXgHTAmIuO_PnI4aAgwxEALw_wcB

Mass = 4.5kg
Volume = 380 * 267 * 165 mm = 0.0167409m^3
F = mg = 4.5*9.81 = 44.145N

Fb = 997*9.81*0.0167409 = 163.7355N to 4d.p
for an object to not sink, the buoyancy force needs to be greater. This is what we would want because we have a submersion propeller which should immerse the SUBCAM

For Our design

if we use the design with 50cm long propellers and has a speed of 250rev/s this creates a thrust (for the submersion system) of **167.465N.** This is enough to push the system underwater if the system matches the volume.

Our volume = 360*240*150mm = 0.01296m^3
Estimated mass = 4.1kg
SUBCAM force = 4.1*9.81 = 40.221N

Fb= 997*9.81*0.01296 = **126.756N** to 3d.p

Subsystems	Justification
Recording camera	This system is needed to record videos for the SUBCAM and to have the data retrieved send to an above surface device.
Lighting system / search lights	This system is needed to brighten the area since underwater is much darker than surface level.
Data sender and receiver system such as Bluetooth or Wi-Fi	This is needed so that data can be transmitted and received without needing to retrieve the SUBCAM itself.
Motors/propulsion system	To allow the SUBCAM to move within the water.
Submersion system	This is needed so that the SUBCAM can go below the waters surface and alter its depth.
Thruster system	This will allow for thrust on the SUBCAM and will allow it to move faster.
Hand-held control system / RC controller	Needed to control the functions of the SUBCAM, allowing it to move, change depth, regulate pressure etc. Allows for user control.
Body shape and frame of SUBCAM	Needs to be able to contain all other systems and protect them from the water. A frame-like design for reduced weight and easier maneuverability.
Filter system/arms	Can be used to move debris that is in the water allowing for better camera vision.
Navigation/radar system	To located the SUBCAM in the water as it may not be visible to people.

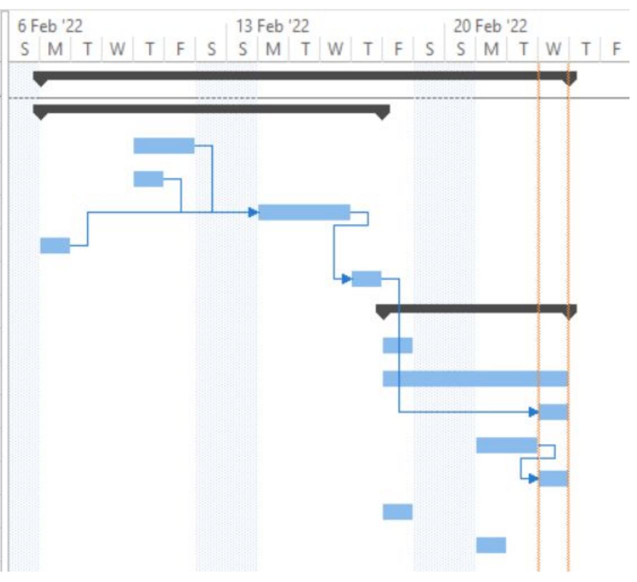
Risk Assessment

Hazard Name	Risk Involved	Severity	Likelihood	Risk	Precautions
Soldering	Respiratory tract irritation from solder fumes	2	4	8	Use a fume extractor when soldering, do not breath in fumes
	Chemical poisoning	5	2	10	Do not ingest solder or flux, make sure to wash hands after soldering
Everyone present	Transmission of COVID-19 virus	5	3	15	Take regular lateral flow tests, self isolate when tested positive, wear masks when in crowds
	Transmission of other illnesses	5	2	10	Do not show up in person when sick, get medical attention and help
Lab and workshop equipment	Electrical shock from high voltage equipment	5	4	20	Insulate live wires and connection points and disconnect equipment from mains power before moving
	Injury from mechanical equipment	5	4	20	Keep body parts away from hazardous parts of equipment, do not touch moving parts, use safety shields and goggles/glasses
	Fire and explosions from malfunctioning equipment	5	3	15	Ensure all equipment is in working order before using it
Personal items, furniture etc	Tripping over and falling, causing injury	2	3	6	Stow away lab furniture and possessions when not in use and remove them from frequently travelled paths
Underwater ROV	Injury when coming into contact with spinning propellers	3	4	12	Angle propellers away from self when testing submarine and avoid touching them when they're spinning
	Lithium battery explosion	5	2	10	Charge battery properly, store in a cool dry place and do not over-discharge the battery
	Injury or damage when ROV crashes into something	3	4	12	Ensure water is clear before testing ROV, check ship timetable to make sure no ships will come
Water	Drowning when testing ROV	5	1	5	Wear a life jacket when in deep water, make sure everyone can swim, avoid breathing in water

Severity/Likelihood	Likelihood of occurrence	Consequence of occurrence	Risk rating	Risk level
1	Very unlikely	Insignificant injury	1-3	Insignificant risk
2	Unlikely	Minor injury	4-10	Low risk
3	Fairly likely	Moderate injury	11-15	Medium risk
4	Likely	Major injury	16-20	High risk
5	Very likely	Permanent injury or death	20-25	Very high risk

Project Planning- Gantt Chart

ID	Task Name		Duration	Start	Due	Finish	Predecessors
1	**XE521 Group N**		**13 days**	**07/02/2022**		**23/02/2022**	
2	**Pin up**		**9 days**	**07/02/2022**		**17/02/2022**	
3	Background Research	- All Members	2 days	10/02/2022	17/02/2022	11/02/2022	
4	Identifying Design Specifications	- Tariq	1 day	10/02/2022	17/02/2022	10/02/2022	
5	Concepts	- Aria and Tariq	3 days	14/02/2022	17/02/2022	16/02/2022	3, 4, 6
6	Project Planning	- Scott	1 day	07/02/2022	17/02/2022	07/02/2022	
7	Justification of Subsystem Choices	- Iain	1 day	17/02/2022	17/02/2022	17/02/2022	5
8	**Poster**		**4 days**	**18/02/2022**		**23/02/2022**	
9	Appropriate Design	- Tariq	1 day	18/02/2022	24/02/2022	18/02/2022	
10	Communication for the Client	- Tariq	4 days	18/02/2022	24/02/2022	23/02/2022	
11	Justifications of Systems	- Iain	1 day	23/02/2022	24/02/2022	23/02/2022	7
12	Suitable Models (Mathematical and CAD)	Tariq - Scott and Iain	2 days	19/02/2022	24/02/2022	22/02/2022	
13	Ease of Construction/Assembly/Installation	- Khalid	1 day	23/02/2022	24/02/2022	23/02/2022	12
14	Likelihood of a Successful Outcome	- Scott	1 day	18/02/2022	24/02/2022	18/02/2022	
15	Risk Assessment	- Aria	1 day	21/02/2022	24/02/2022	21/02/2022	



References

Ross, C.T., 2011. *Pressure vessels: external pressure technology*. Elsevier.

Background Research

http://rainbow-doc.irisa.fr/pdf/2001_cviu_cretual.pdf

https://www.dpreview.com/articles/1561165185/ttrobotix-introduces-ttr-sb-seawolf-submarine-for-gopro-cameras

https://wetpixel.com/articles/anglerfish-announces-deep-housing-for-panasonic-bhg1

https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=406981

Appropriateness of design

There are two main reasons why Subcams are useful and why we chose to create one first reason is because they are fascinating creations allowing one to explore the wonders of the ocean/lakes. The more educational reason is to explore the different forms of life under water and see how they look and act in the wild.

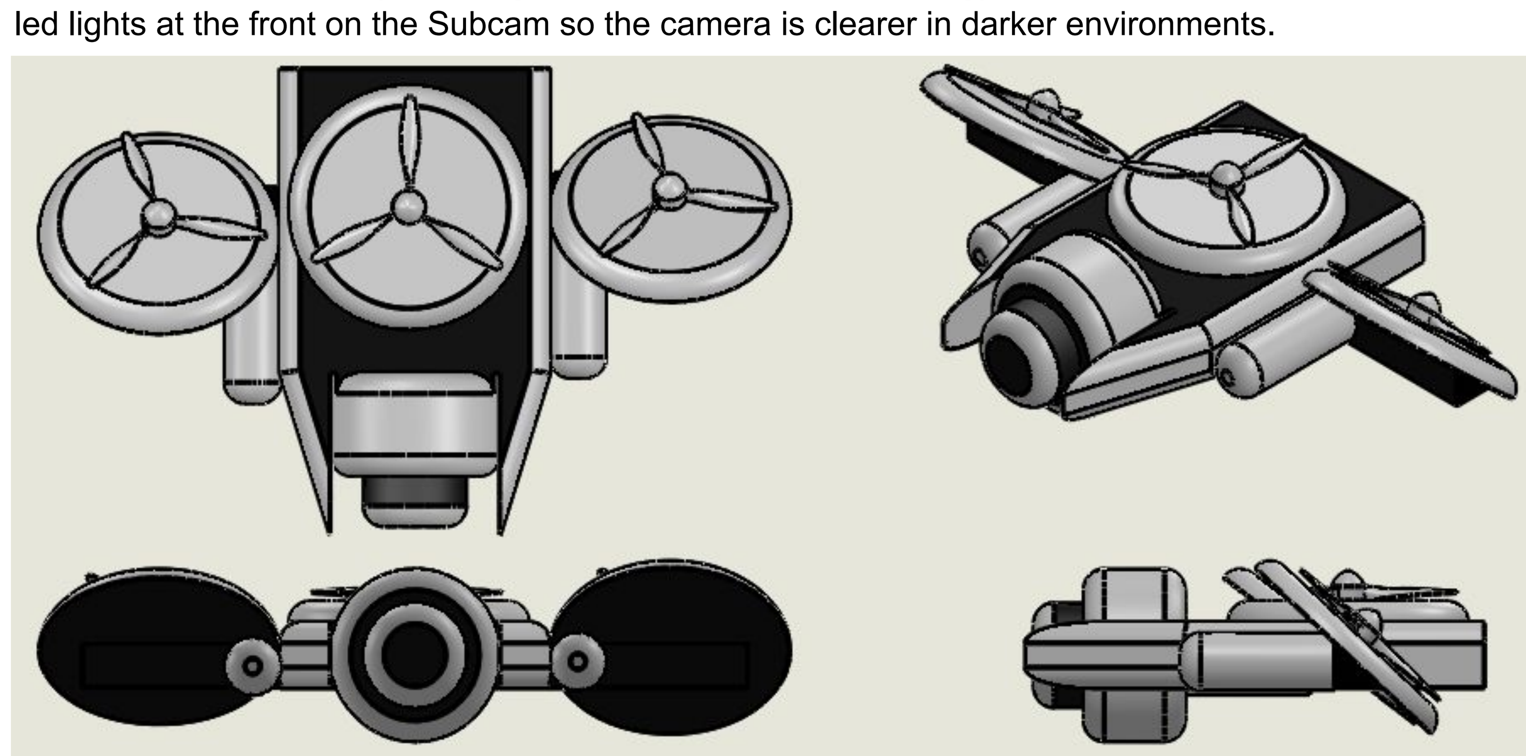
Design a remote underwater vehicle with a suitable camera that is both affordable and practical with a motor that is strong enough to move freely underwater.

Remote control - The remote would need to have a strong wireless connection that can reach the Subcam when submerged into the ocean this would be appropriate to ensure the Subcam does not get lost in the ocean or the river when travelling this will help to explore the sea's further

Shape/ capabilities – The Subcam that we create will have sensors around the perimeter of the body so it can be aware of hazards that are nearby and wildlife when submerged into water.

Mass – The SubCam should not be too heavy, or it will sink when submerged into water, must be a suitable size for the user so transportation is easy.

Dimension and constraints – must be even in weight so it can manoeuvre freely in the water, it should looks aesthetically pleasing with water resistant technology and a clear camera. Will have led lights at the front on the Subcam so the camera is clearer in darker environments.



Ease of construction/assembly/installation

The main chassis of the SUBCAM will be 3d printed out of ABS plastic; mainly because of its resistance to most common solvents and chemicals that may be found in different bodies of water. ABS is also cheap, easy to print with and is widely available. This makes its selection for the chassis/frame great, as it is very easy to construct. The material will be strong enough to support the low mass of the SUBCAM components whilst still retaining a low overall mass to aid with manoeuvrability.

Most components will be attached to the chassis using mounting brackets as seen in Figure 1. Motors, cameras and lights can all be attached in this manner through use of different size mounting brackets that are 3d printed. Holes can be drilled into the chassis to determine placement of the components and nuts and bolts will be used to attach the bracket down onto the chassis, retaining the component onto the frame. This makes our SUBCAM easy to construct and assemble.

Figure 1
https://grabcad.com/library/bracket-n20-1

Most components will be off the shelf parts; this adds to the ease of manufacture. The lights will be readily available and rated to be highly waterproof. Motors are available off the shelf at the IP68 rating and cameras such as Gopros can be used under water too. Most of these systems can be operated independently to each other. This helps with useability, ease of construction and manufacturing cost.

PCB's can easily be prototyped and manufactured through ordering them online; the main issue will be waterproofing these electronics. An easy, yet effective solution for this will be acrylic insulating varnish. It is sprayed in layers onto the PCB and will create a hard, waterproof coating over the board.