

2055 Floating Data Centres

Design Engineering Futures - Final Report

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DATABERG

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Executive Summary

The rapid growth of AI, VR, smart cities, and blockchain technologies is driving an enormous increase in global data demand, but traditional land-based data centres are struggling to keep up. By 2055, these facilities will require unsustainable amounts of energy and drinking water, worsening climate change and constraining AI growth.

To address these issues, we propose Databerg, a floating data centre system. Databerg harnesses renewable energy from nearby offshore wind farms, eliminating the reliance on conventional power grids. It utilises seawater-based cooling, eliminating drinking water usage and reducing operating costs. With LEO satellite technology, it provides faster and more reliable global data transmission.

These features have been digitally prototyped with CAD and rigorously evaluated through CFD and FEA simulations, technical feasibility assessments, and expert consultations, ensuring practical implementation at scale.

An AI-driven user dashboard was designed to maximise uptime by predicting failures and scheduling robotic or human interventions in advance.

This system offers substantial benefits for governments and tech giants like Google and Microsoft, helping them stay at the forefront of AI and cloud computing while complying with environmental regulations. Additionally, it improves urban sustainability by reducing grid pressure, eliminating drinking water consumption, and mitigating noise pollution, paving the way for a greener, more resilient digital future.

Meet the Team



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Project Lead



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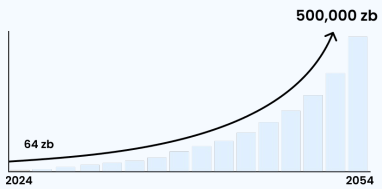
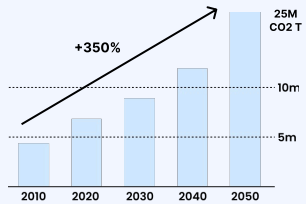
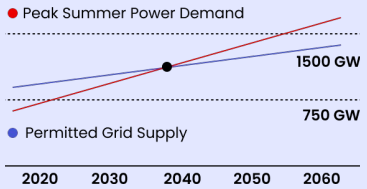
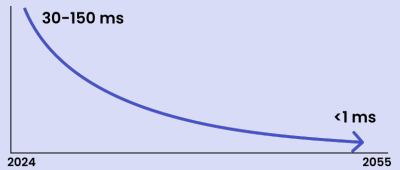
Acknowledgements

We sincerely appreciate our Tutor, Dr. Sam Cooper; our Module Leads, Maria Apud Bell and Sheraz Arif; our Assistants, Elizabeth Lee and Esther Perea; and our Industry Advisor, Xuefeng Shen, Lead Data Centre Engineer at Zhejiang Tongxing Technology, for their continuous technical expertise, time, support, and feedback.

The Problem: Signals, Trends & Drivers

Data centres are the backbone of all technology. These energy-intensive hubs store, process, and distribute vast amounts of data across the world. As AI, remote healthcare, and digital transformation accelerate, the demand for data infrastructure is set to grow at an unprecedented pace and disrupt the industry.

To anticipate these changes, the **Futures tool "Sense Making"** was used to identify key signals, trends, and drivers during the initial project definition phase.

	A. Exponential Data Growth	B. Excessive Water and Energy Usage	C. Residents Discomfort around Data Centres	D. Need for Faster Latency
PROBLEM	?			
SIGNALS	INTERNATIONAL BUSINESS TIMES Meta Is Planning a Data Center That Is So Large It Would Cover Half Of Manhattan The data-centre market is heating up but can we keep up with demand? IBTimes [1] and Construction News [2] show Big Tech's need for more data centres and concerns about the supply capacity.	The Telegraph Why thirsty data centres risk plunging the world into crisis Can Meta clean up its data centers with geothermal energy? The Telegraph [5] and The Verge [6] express concerns on the environmental impact, and how Big Tech plans to mitigate it.	AI data centers causing "distortions" in US power grid - Bloomberg The Silent Strain: Community And Health Impacts Of Data Centre Noise Bloomberg [10] explains how grid pressure leaves residents with no electricity. Tech Target [11] outlines health problems from noisy centres.	Meta: Faster Symmetrical Bandwidth, Lower Latency Among Advances Needed for the Metaverse Meta [13] outlines the changes needed in data processing and transmission for future applications such as the existence of VR worlds.
TRENDS	Data is forecast to grow from 64 zb in 2025 to 500,000 zb in 2055, a **780,000% increase.** [3] 	• US Centres use the equivalent to the **drinking water for 8M houses.** [7] • Big Tech **CO2 increase by 350%** between 2010 and 2050. [8] 	Latitude Media [12] forecasts that the grid won't keep up with the demand in 2040, causing even **more disruptions to residents.** 	Latency must be reduced to single-digit ms, from its current level of 30-150 ms through new communication systems. [13] 
DRIVERS	**VR worlds, GenAI**, Quantum Computing, IoT and Smart Cities will be the main drivers for data rise. [4]	The **data centre's inefficient AC cooling system:** it accounts for 90% of water consumption and 50% of power. [9]	• **Over-reliance on the grid** for modern AI applications. • **Poor location selection and noise measures.**	Future technology, **Low Earth Orbit (LEO) satellites** will provide faster latency than current methods, as well as global reach. [14]

KEY TAKEAWAY

To meet data growth and low latency demands for 2055, many new data centres will be built. This will threaten the abundance of natural resources, climate change, our old electricity grid, and hence the quality of the residents' life. A systemic solution must be found to satisfy all stakeholders' needs.

Our Scenario for 2055

Description

Tech Giants Google, Microsoft and Open AI are investing heavily into building new data centres to meet **soaring AI demands** of 500,000 zetabytes from VR/medical technologies.

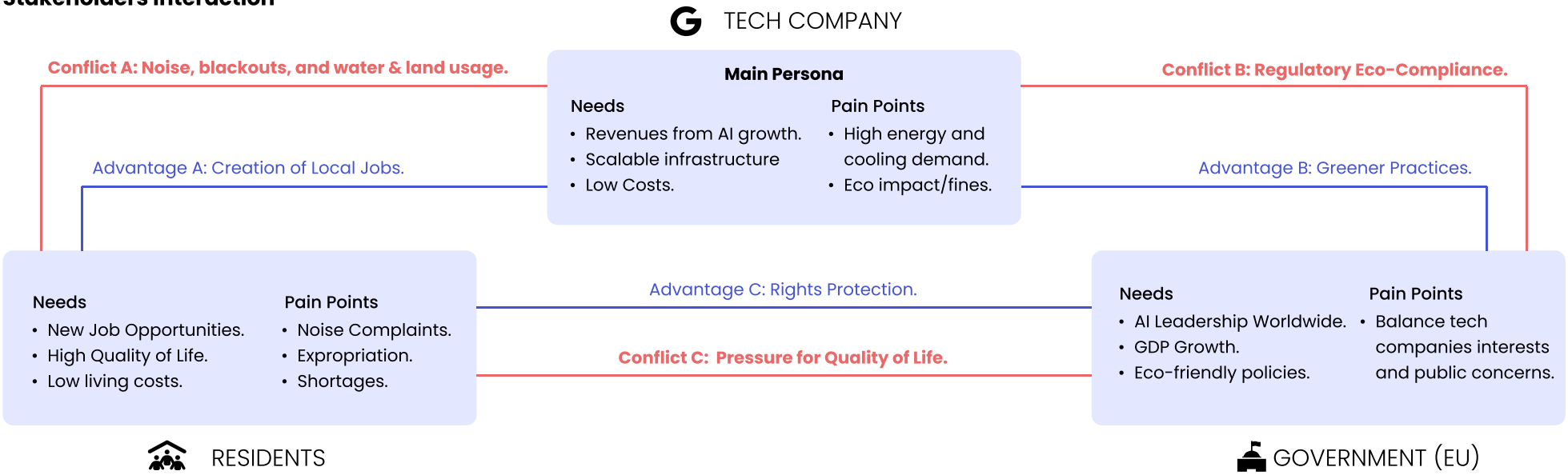
These **centres now use 20% of Europe's energy**, causing blackouts and pushing Europeans to leave their homes to make space for more data centres. To prevent this, the EU is partnering with Big Tech and offshore renewable energy firms to develop ocean-based data centres to cut water, land and energy use.



Design Engineering Opportunity

How might we design ocean-based data centres in high tech areas like Northern Europe to protect social rights and preserve natural resources while ensuring business profitability?

Stakeholders Interaction



KEY TAKEAWAY

Our main persona was chosen to be the tech companies because they have the greatest impact on the overall system. Therefore, our design process is focused on tackling its conflicts A and B with the residents and the EU, and boosting symbiotic advantages from all partnerships.

Design Process & Rationale

Design Requirements

#1 Technical Feasibility
Ensuring the design can be realised by our tech enablers in 2055.

#2 Water Usage
The design must minimise the demand for potable water.

#3 Cost
The design must minimise construction, operation & maintenance expenses.

#4 Power Usage Effectiveness (PUE)
An index defined to measure the overall energy usage. The closer to 1, the better energy efficiency.

#5 Maintainability
Simple inspection, repair, and upgrading procedures.

#6 Marine Impact
Low harm to marine life and biodiversity to ensure a sustainable future.

#7 Cybersecurity
The design should protect stored data and systems from digital and physical threats.

#8 Scalability
Adaptable for various environments and open to modular expansion.

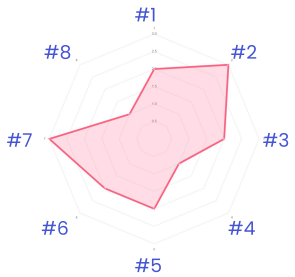
Concepts Development

Requirements Evaluation



- Term 1 Concept: Oil Rig DC

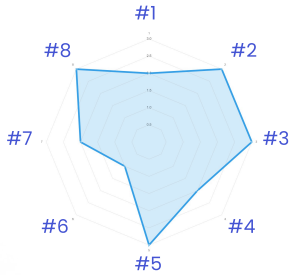
Turning decommissioned oil rigs into data centres. Reusing their foundations, we use its pipes for data transmission cables to save cost, and create artificial $CaCO_3$ reefs.





- Term 2 Concept: **Floating DC**

Utilising floating foundation technology to create scalable, modular data centres. Integrated with offshore wind. With active cooling, ensuring sustainable operations.



Design Decision 1: Why Ocean over Land-based?

Our scenario and ideation were based on the ocean to achieve the following benefits:

A. Zero Drinking Water
Sea water will be used, also avoiding the energy needed for traditional AC cooling.

B. Renewable Energy Integration
Proximity to offshore wind or tidal for sustainable power sources.

C. Faster Data Transmission
Closer to the coast, where 60% of the population will live, creating edge hubs.

D. Land Use and Scalability
Adaptable to Big Tech needs through modular design and no land constraints.

E. Access to Emerging Markets
Due to ease of deployment, it can be positioned on undeveloped areas.

Design Decision 2: Why Floating over Underwater?

Microsoft's underwater data capsule pilot set precedent, but we are improving it with futuristic tech enablers:



A. Enables Access for Maintenance
Nearly impossible for underwater, we can repair and upgrade components with simple actions.

B. Rapid Deployment
We offer easier logistics for installation, allowing larger scales at lower costs.

C. More Efficient Cooling
We use active immersion cooling rather than passive, which will be 50% more efficient.

D. Faster and Global Latency
We can use LEO satellite communications, providing 800% faster data speed.

Our Concept

Data Centres that Float on the Ocean

- **Protects Natural Resources**

Databerg saves **scarce land** and uses sea water for cooling, drastically **reducing stress on drinking water** supply. By using **offshore wind** to power our operations and the waves' energy to remove energy-intensive AC and cooling pumps, we significantly **reduce their carbon footprint**.

- **Improves Urban Environments**

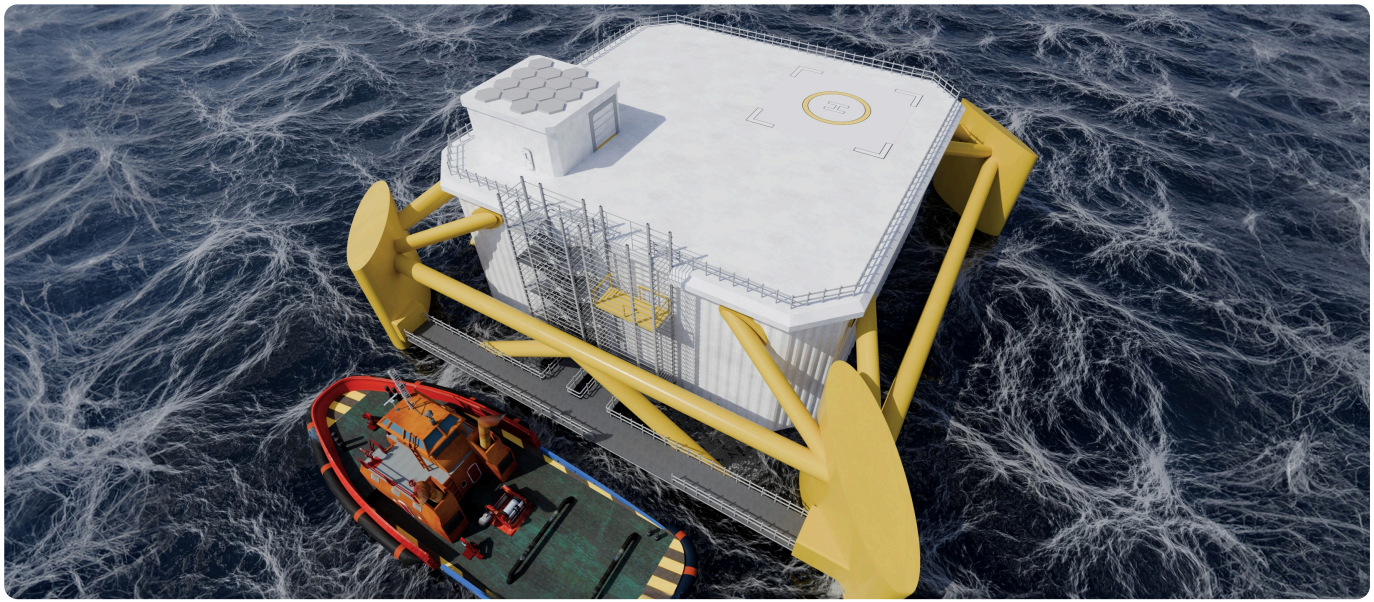
Our century-old grid cannot sustain the highly **demanding and fluctuating power levels** from land-based data centres. By taking them offshore, we **reduce grid strain, blackouts, and noise levels** that affect residents' quality of life.

- **Meets Future Data Demands**

Our sea-based immersion cooling system will allow **greater rack density at lower costs**. Moreover, the **flexible, scalable and modular nature** of Databerg will **adapt to Big Tech's growing needs**.

- **Faster AI to Underserved Areas**

With our futuristic **phased array and Low Earth Orbit** (LEO) satellite communications system, Databerg can be easily deployed to undeveloped areas to **ensure an inclusive AI growth.**





System Overview

Tech Enablers

How Does it Work? The floating data centre gets power from the offshore substation, mainly from wind, but also features grid, generator and battery back-ups. The centre receives data from a fibre cable, processes information, and rapidly transmits it globally through LEO constellations.

Offshore Wind

- Less carbon footprint and grid strain.
- Floating foundations to enable more efficient cooling at the surface.

AUV for Maintenance

- Hull-cleaning robots prevent and eliminate biofouling build-up.
- Automated robots swap damaged GPUs.

Phased Array & LEO Satellite

- Ensures low-latency, global data transmission.
- Enables multi-directional signal and resists storms.

Digital Twin (User Dashboard)

- Remote Operations: Users can deploy maintenance solutions remotely.
- AI Automation: System self-optimises load balancing, and minor repairs.
- Predictive Maintenance: Detects failures early and prevents downtime.

Anti-Biofouling Materials

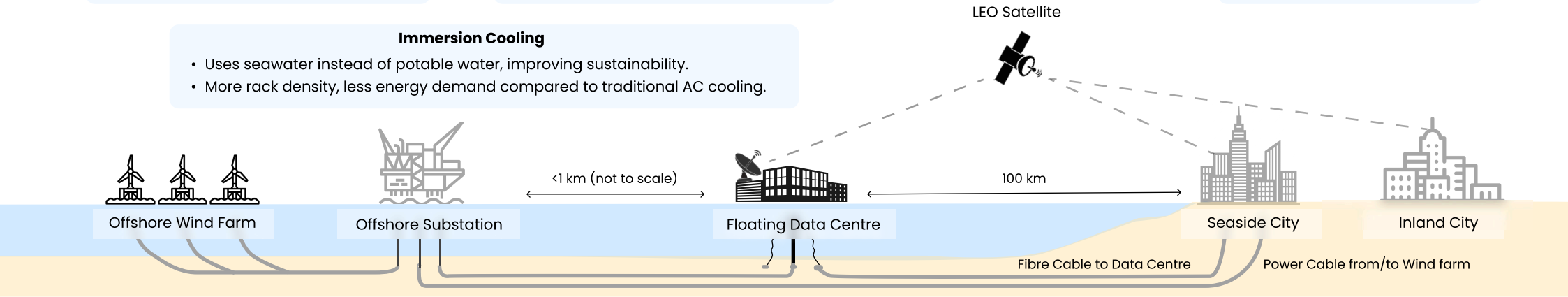
- Self-repairable & non-toxic coatings extend maintenance cycles.
- Prevents marine growth on cooling pipes.

Gyroscopic & Ballast Stabilisation

- Prevents tilting, oscillations and structural stress, increasing lifespan.
- Reduces impact of extreme weather.

Immersion Cooling

- Uses seawater instead of potable water, improving sustainability.
- More rack density, less energy demand compared to traditional AC cooling.



Impact on Stakeholders

Offshore Wind Farm Companies

- Gains a large, stable energy buyer, improving wind farm profitability.
- Encourages investment in offshore wind expansion.

Cloud & Tech Companies

- Access to scalable, sustainable cloud computing.
- Collaboration with LEO satellite providers for improved global connectivity needed for their other products.

Coastal Residents

- Chaos in city due to increased activity during construction.
- Less land used, freeing space for agriculture and business.
- More reliable grid power, reducing urban blackouts.

Technology Providers & Job Market

- New R&D opportunities in offshore data infrastructure.
- Creates skilled jobs in marine engineering for coastal towns.

Governments & Regulators

- Lower environmental impact than traditional land-based.
- Supports national renewable energy & digital policies.
- Enables regulatory compliance for big tech companies.

Maritime & Fishing Industry

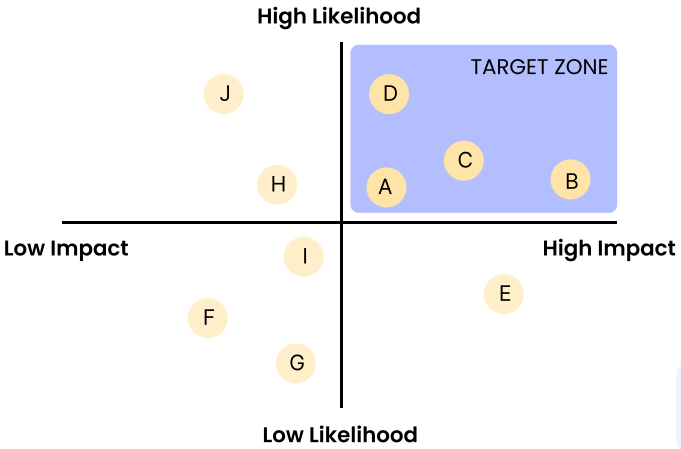
- Disruption to fishing areas.
- Lost revenues due to reduction in fish count.

*Most affected. Direct benefits are explored in page 14.

Embodiment Plan

Following Phase 1 of our project, which consisted of ideation and development, a critical session was conducted with our tutors and industry expert. Here, we identified the largest uncertainties of our concept, which led to a breakdown of our concept into features, and the development of a criteria for success for these capabilities.

Identifying the Largest Uncertainties of our Concept



Feedback from Module and Industry Tutors

A. Fail to resist corrosion from sea water.

B. GPU racks damaged from wave movement.

C. Environmental impact from cooling warm water.

D. Significantly costlier than onshore data centres.

E. Over-reliance on renewables leading to power loss.

Feedback from Futures Groups in Tutorials

F. Land ownership and regulation loopholes.

G. Lack of training capacity for large AI models.

H. LEO satellite not achieving latency forecasts.

I. High disruption for local port communities.

J. Lack of best practices for marine cybersecurity.

Key Insight: Based on the feedback and 2×2 matrix, **technical feasibility** emerges as the main concern amongst our requirements, followed by **environmental impact** and **economic feasibility**. These requirements set our direction for phase 2.

Features Breakdown & Criteria for Success

FEATURE	DESCRIPTION	REQUIREMENT (Page 5)	SPECIFICATIONS CRITERIA
1: Structure	Materials and coating, shape of the outer and inner structure, stability from tech enablers to withstand tilting.	Technical Feasibility Marine Impact	• Rack tilt angle cannot exceed 11° (Industry Expert) - CFD Sim. • The centre must not surpass offshore noise limits of 135 dB [16] - Python.
2: Cooling	Design a 2-way cooling system with future immersion cooling technologies to ensure power effectiveness and minimal marine impact.	Water Usage Marine Impact	• Maximum inlet velocity cannot exceed 0.15 m/s (UK Regulations) [17] - CFD Sim. • Maximum temperature rise cannot exceed 8°C (UK Regulations) [17] - CFD Sim.
3: Data	Communication system through LEO satellites over fibre optic, redundancy and uptime predictions.	Technical Feasibility Energy Rating	• Latency for LEO Satellite should be 8x less than for fibre optic's - Matlab.
4: Deployment	Develop a plan for towing the data centre from the fabrication port to the onsite location and for the floating foundation installation.	Cost Scalability	• Cost per MW must be within +/- 10% compared to land-based data centres for this new system to be competitive.
5: User Dashboard	Develop a plan to detect, categorise and act towards a faulty component or crack. Set and simulate operations KPI with dashboard UI.	Maintenance Cybersecurity	• Design a low-fidelity Dashboard UI Figma prototype with 5 operational KPI and tracking sensors for maintenance issues.

Next Steps: Aside from features, a holistic and systemic analysis will be carried as part of concept embodiment regarding legal, cybersecurity and stakeholder implications. Moreover, the main evaluation tools for the aforementioned specifications criteria will be CFD/FEA simulations on Ansys, final validation interviews with interview experts and complementary research.

Feature 1: Structural Design

Data Centre Capacity: 300 MW

By 2055, data centre capacity will have increased heavily with **typical data centres being around 900 megawatts** and the largest being in the gigawatt scale per McKinsey & Co [18]. We have decided to reduce this by a third to 300 MW capacity for our modular floating data centre, reducing cost based risks that arise from having expensive servers in just one facility.

Roof: VTOL Access & Satellite Communication

Includes lift access, watertight entryways, a VTOL landing area for upgrades, and future wind-resistant low-profile satellites.

Top Floor: Power Backup & Human Quarters

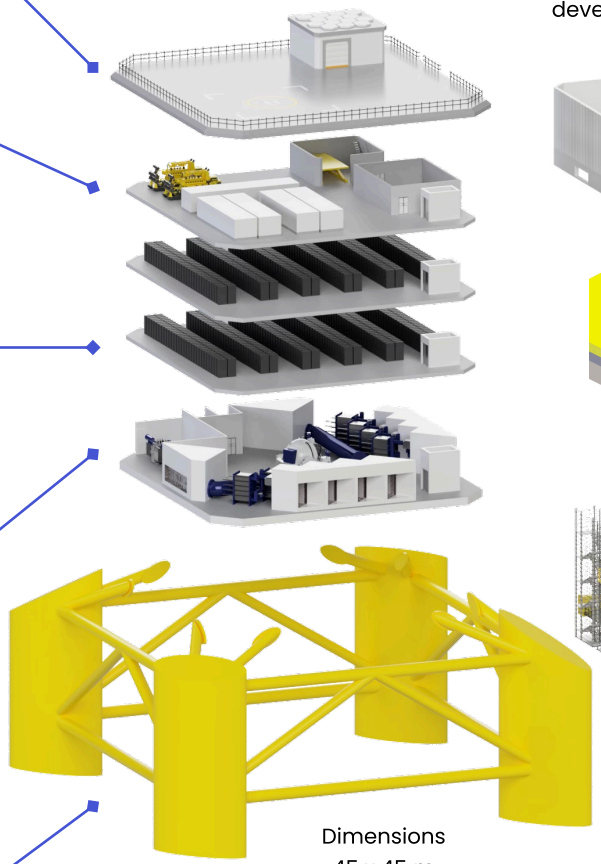
- **Power Backup:** To ensure >99.99% uptime, the data centre features battery backups.
- **Maintenance & Living Quarters:** For long missions, living quarters are provided.

Middle Floors: Servers & Immersion Cooling

With future immersion cooling technology, server rack density will reach up to 500kw [19] (4.3x higher than today), resulting in 600 racks for the 300 MW load, distributed amongst 2 floors.

Floor 0: Cooling, Power Conversion & Gyro

- **Cooling:** Seawater absorbs heat via exchangers and is discharged.
- **Power Conversion:** Voltage is stepped down from 220kV to 400V. [20]
- **Stabilisation:** Gyro stabiliser keeps the platform steady in rough seas.



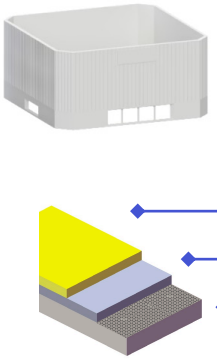
Dimensions
45 x 45 m

Structure: Floating Foundation & Mooring System

- **Power** is provided by offshore wind substations via underwater cables, and fibre connects from the shore.
- **A semi-submersible floating foundation** was chosen for low cost and ease of deployment [21], with a mooring system used to anchor the data centre to one location, while allowing flexibility for it to move and withstanding harsh conditions.

Materials: Structure and Coating

By 2055, material science will likely advance in key areas, allowing the development of stronger, lighter, and more sustainable materials and coatings.

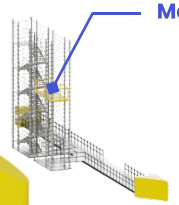


Anti-Fouling Coating: Silicone-based or PDMS: Provides a non-stick surface that reduces drag and prevents biofouling.

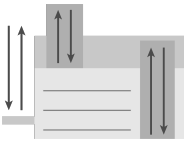
Protective Coating: Nanocapsules
Release self-repairing compounds when damaged.

Body Material: Graphene-Reinforced HEA
Excellent strength-to-weigh ratio, enhances toughness and anti-corrosion properties.

Maintenance Access: External & Internal Lifts



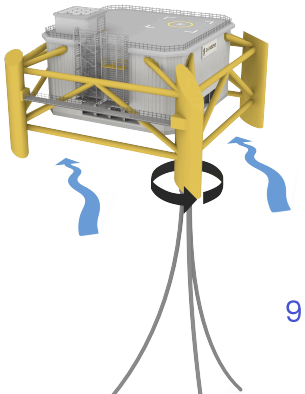
External lifts and stairways provide access to the roof from sea vessels. The roof has access to the top floor and a separate internal lift to other floors.



Hydrodynamic Design: Current Alignment

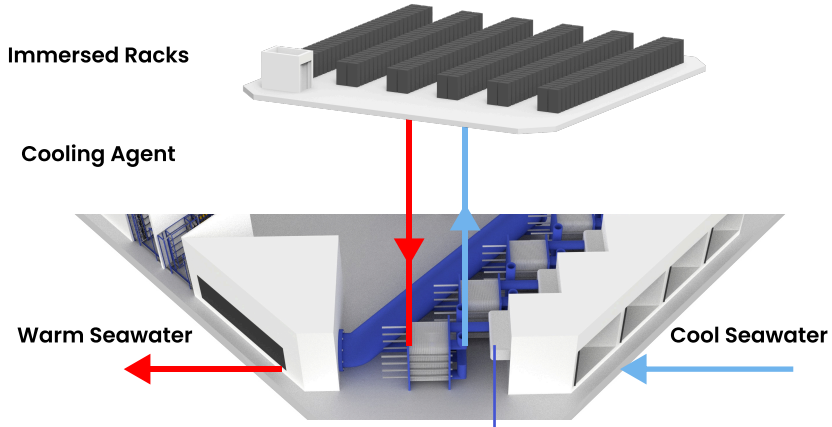
- Wave piercing columns are designed to separate water flow and align with currents.
- The water intakes are on the two sides facing the currents using wave energy to improve cooling efficiency.





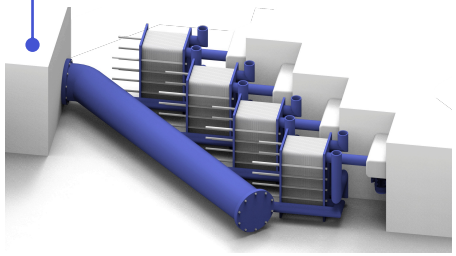
Feature 2: Cooling System

Cooling Design



Assumptions

- Heat Transfer Coefficient (k) = 8 kW/m²·°C [22]
- Exchanger flow rate: 5,000 m3/h = 1.39 m3/s [22]
- **Max seawater intake Velocity = 0.15 m/s** [23]
- **Max Temperature Rise = 8°C** [24]
- North Sea Temperature = 15°C [25]
- **Total Heat Dissipation = 300 MW**
- **Cooling Loop Temps: 25°C - 45°C** [26]



Heat Exchanger Calculations

Log Mean Temperature Difference (LMTD) = **15.22°C**

Total Required Heat Exchanger Surface Area:
A = 300,000,000 / (8,000 * 15.22) = **2,467 m²**

Number of heat exchangers:
mass flow = 300,000,000 / (4180 * 8) = 8,971 kg/s
volume flow = 8,971 / 1025 = **8.75 m³/s**
8.75 / 1.39 = 6.29 **(8 for redundancy)**

Heat Exchangers Dimensions: (2 m² per plate)
Depth = (308.38/2) × 0.005 = **0.77 m**

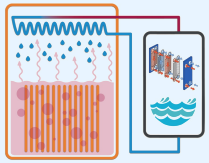
Plate Heat Exchangers

High-efficiency marine heat exchangers transfer heat from the immersion cooling loop to seawater. Using future heat exchanger design specifications, calculations were conducted to determine the system's scale, design, and layout. The final design features eight plate heat exchangers that leverage wave energy to reduce pumping needs.

Why Immersion Cooling?

Servers are cooled using immersion technology. A cooling agent absorbs the heat from GPUs and then transports it to a heat exchanger, where the heat is transferred to seawater. Once cooled, the agent flows back to the racks to repeat the cooling cycle.

Why Two-Phase?
It submerges servers in a dielectric fluid that absorbs heat and vaporises, it is condensed back to liquid by a sea-cooled condenser avoiding energy-intensive AC. This **improves cooling efficiency**, power usage effectiveness (PUE), and **minimises noise**. **The coolant never mixes with seawater.**

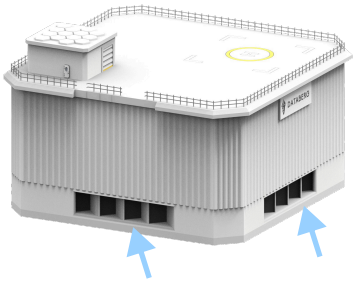


Seawater Intakes

- **Size Calculations:**

Total = 8.75 / 0.15 = 58.3 m²
One Intake = Total / 8 = **7.29 m²**

The design consists of 8 intakes, one for each heat exchanger. Calculations ensured a low intake speed of 0.15m/s to **avoid trapping fish**. These intakes align with currents to use wave energy for smaller pumps.

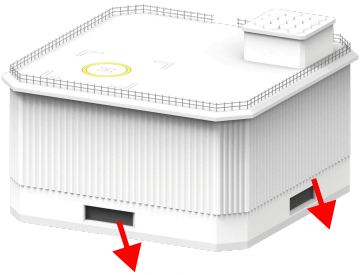


- **Intake Filters**

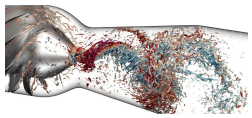
To **avoid debris build-up** and maintenance issues for the cooling system, a four stage filtering system is implemented to filter particles up to 0.02 microns. The filters are maintained and cleaned constantly using future robotic technology.

Seawater Exhaust

The hot water from the cooling system is exhausted on the rear side of the structure. They are **aligned with the currents** to allow the heat to be dissipated rapidly.



- **Minimising thermal impact to the ocean**



Downwards facing swirling flow turbines were designed to **enhance heat dissipation** and decrease local temperature rise.

Feature 3: Data Transmission

A. Our Proposal: LEO Satellite Hybrid Communications

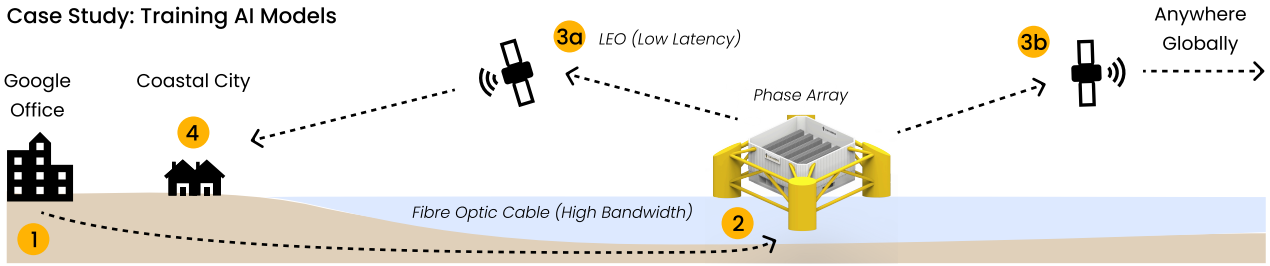
LEO (Low Earth Orbit) satellites are a futuristic technology that will closely orbit the Earth at altitudes around 1000 km, compared to 35000 km for traditional satellites, providing ultra-low latency for future applications like AR/VR or remote surgeries. [27]

Key Market Players

STARLINK AIRBUS amazon

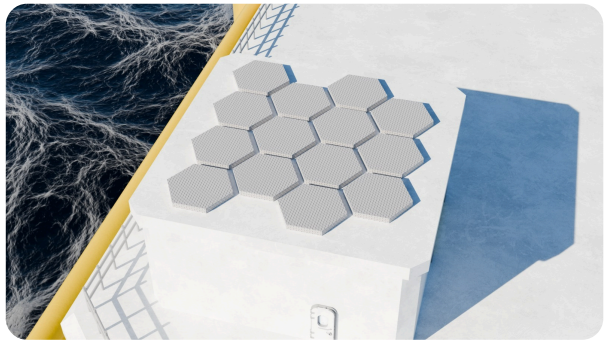
Key Insight: LEO will provide faster latency and reliability than transoceanic fibre cables. However, fibre will have much greater bandwidth. For redundancy (see below) and to get the best of both, we will implement them together:

Case Study: Training AI Models



1. **Google** is training their AI Model Gemini. Fibre optic cable can carry large data because of its high bandwidth.
2. **Databerg's servers** process all data. Gemini receives an AI prompt from a metaverse user, generating an answer.
3. **LEO Satellites** send the answer to the coastal city (a) or anywhere globally (b) with the LEO constellation.
4. **The user** receives the answer in less than 1 ms, benefiting from their high-tech edge hub.

Why Phased Array over Traditional Antennas?



#1 Reliability in Harsh Environments: no moving parts, not affected by wind or rain, less maintenance.

#2 Connectivity: can connect to multiple satellites at once, keeping up with the fast latency.

#3 Beam Steering: instant and precise.

#4 Form: flat, low-profile, scalable and easy installation.

When? Tech matured by 2050.

B. Uptime and Redundancy

Uptime refers to the amount of time a system remains operational without disruptions. It is a key measure of reliability and availability for data centres.

Tier	Uptime	Yearly Downtime
1 (min)	99.671%	29 hours
4 (max)	99.995%	26 minutes

To achieve the maximum uptime (Tier 4), our industry expert stated the importance of redundancy design.

Data Centre engineers use **"N+1" redundancy** to ensure key subsystems have backups; this also happens on other applications such as aircrafts for safety. We have implemented the following features to enable uninterrupted service:

Power	Electronics Tilting	Cooling	Data Transmission
Offshore wind can be unpredictable. Battery pack and Grid backup will solve this issue.	Ballast protect against long waves, whilst gyro against sharper ones.	Instead of having a large inlet and exchanger, we designed multiple, smaller ones.	LEO will provide faster latency, whilst fibre a larger and more resistant bandwidth.

Insight from Expert: Companies are willing to take higher upfront costs for redundancy to avoid long-term losses.

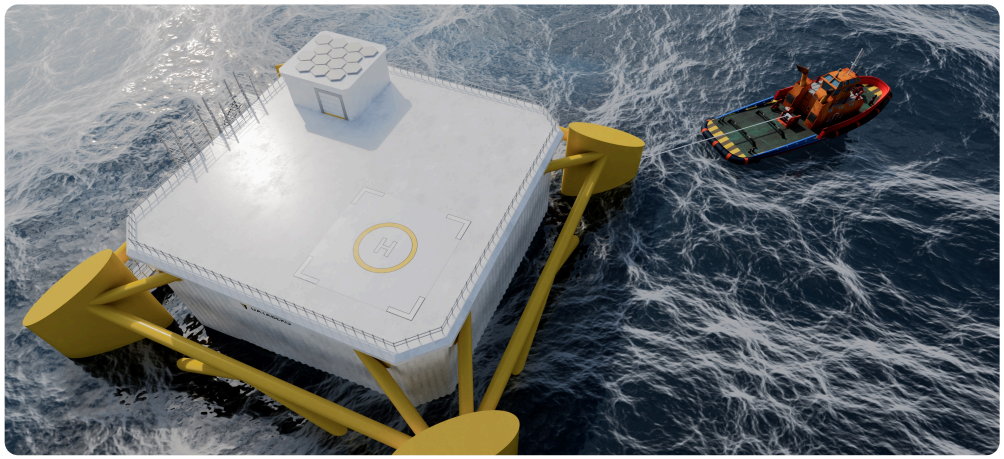
Feature 4: Deployment Process

1 Onshore Fabrication

- The floating modules and the main body of the data centre are **manufactured separately onshore.**
- These modules are then **assembled and tested at fabrication ports** for existing offshore infrastructure.

2 Flexible Transportation

- Benefiting from being semi-submersible, our data centres can be **easily towed** by powerful tugboats.
- The towing speed is maintained slow (4 -6 knots) to reduce stress on the structure.



3 Installation

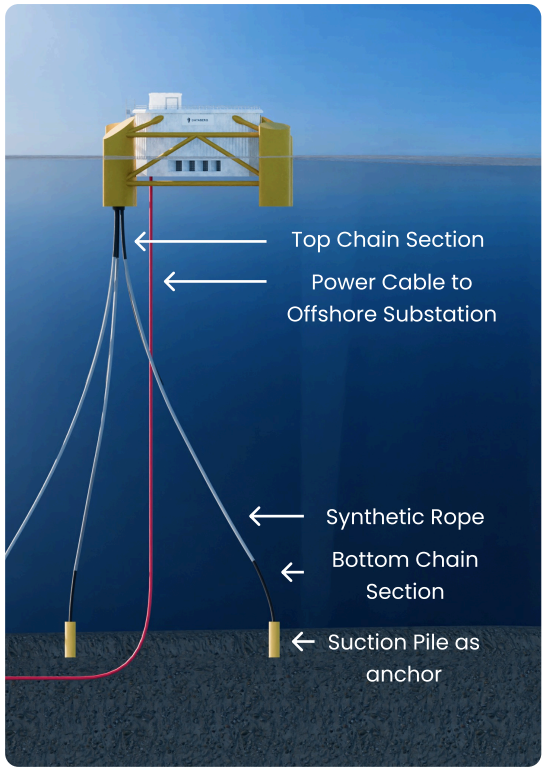
A. Before the data centres arrive, suctions piles are pre-laid inside the seabed. They will serve as the anchors of the data centres.

B. After arriving at the offshore site, the data centres will be connected to the seabed through the mooring system.

C. Mooring lines consist of chains and synthetic ropes, which are deployed and connected to the suction piles.

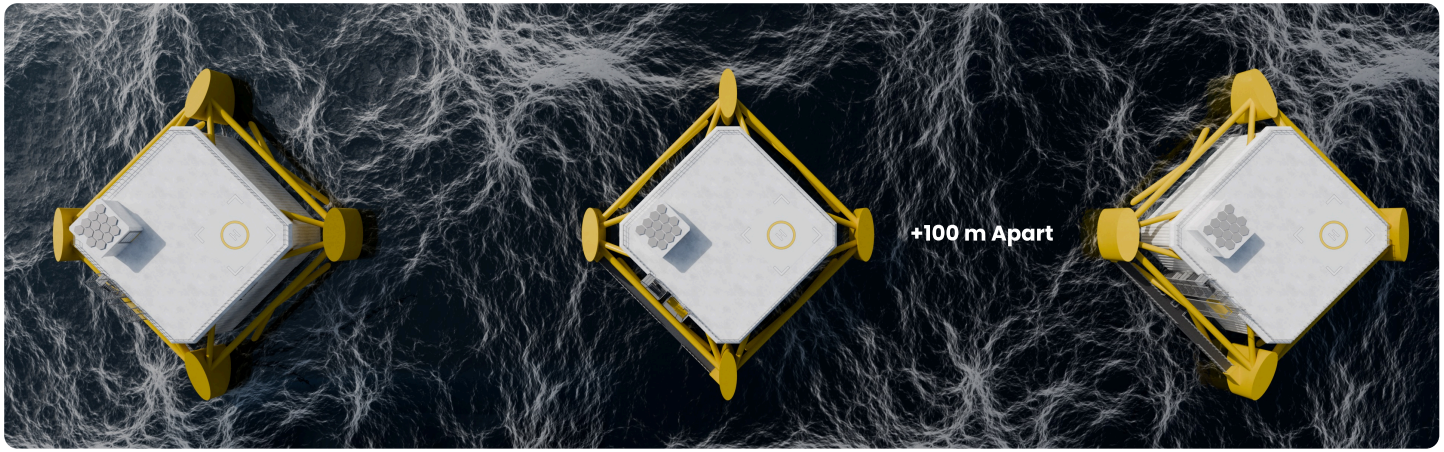
D. Ballast tanks are filled with water to partially submerge the platform.

E. Cables are connected to offshore wind substation.



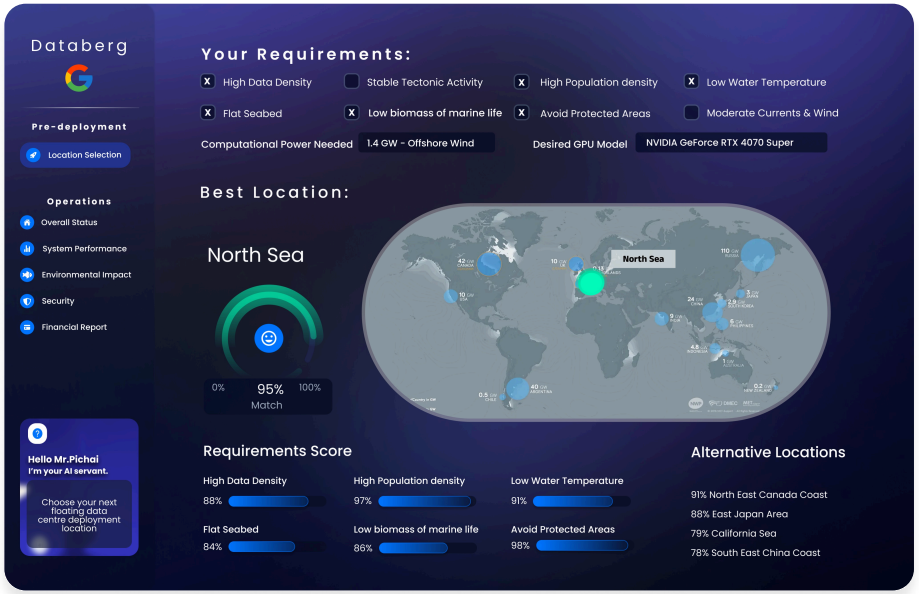
4 Modular Design

- To achieve a similar capacity to onshore data centres in 2055 (estimated at 900 MW), our system allows for multiple 300 MW data centres to be **grouped into a modular array.**
- The ideal layout was found to be a **straight line, with centres +100 metres apart** to ensure cold water intake and no collisions.
- Modularity helps the system maintain operations even in the event of a failure, **reducing uptime risk and financial losses.**



Feature 5: User Dashboard

The dashboard provides a real-time digital twin interface for floating data centres, including 3D models and live feed, enabling remote monitoring, security oversight, and eco-tracking.



Pre-deployment: Location Selection

Why Location Matters?

- **Performance Optimisation**: Crucial for maximising renewable energy use, optimising latency for client needs and reducing risk during installation.
- **Reduced Risk**: Long-term durability by selecting stable, low-risk waters for reliable operations.

Selection Rationale: Parameters

1. **High Data & Population Density:** ensures high-demand regions with low-latency.
2. **Low Tectonic Activity**: avoids active zones to minimise disaster risk.
3. **Low Water Temperature:** improves cooling.
4. **Flat Seabed:** facilitates installation.
5. **Low Biodiversity:** minimises environmental impact from heat and noise.
6. **Offshore Infrastructure**: decreases costs by leveraging existing technologies.
7. **Protected Areas:** eco-compliance.
8. **Mild Currents:** prevents failures.

Post-Deployment: Operations & Maintenance

Preventing Downtime

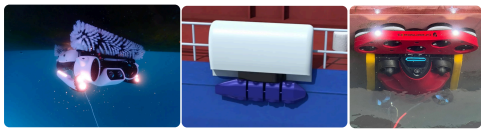
- **When Minor issues** arise, the system self-optimises by re-routing workloads, cooling down components, or adjusting power flow.
- **Potential failures** are detected, AI-driven predictions recommend maintenance schedules and suggest technician interventions.
- **Critical situations**, the system issues immediate alerts and provides emergency response options, allowing users to take action as needed.

Proactive Maintenance Methods

External Maintenance: Robots equipped with ultrasonic sensors and photogrammetry perform inspection, cleaning, and coating repairs on the submerged infrastructure, preventing biofouling and corrosion.

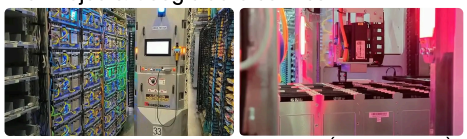
Internal Maintenance: Robots manage hardware replacements, liquid filtration, coolant circulation, sediment removal, and cable maintenance, to ensure optimal performance and longevity.

Pilot Projects: hull bot industry

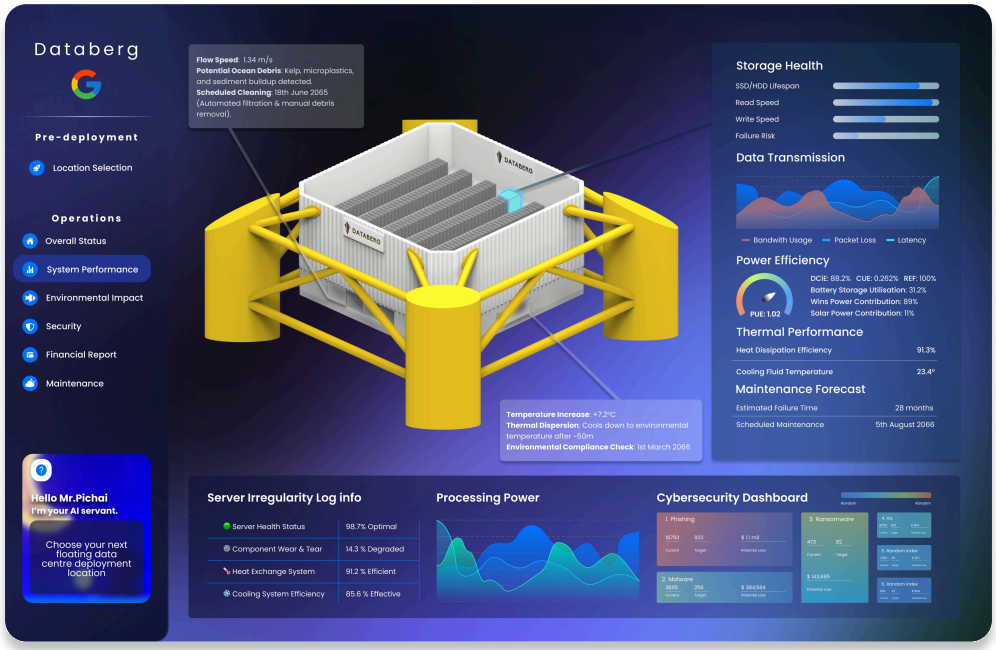


Hullbot NakAI Everclean

Pilot Projects: Google data centres



Disc Repair Automation & Material Movement (OCP'24 spotlight)



Holistic View: Legal, Cyber & Stakeholders

Legal Loopholes with Seabed Ownership

- **Who owns the seabed where floating data centres would be located at?**

The United Nations Convention on the Law of the Sea (UNCLOS) arose in 1994 to act on resource conflicts, for instance, oil extraction, fishing and deep-sea mining. This treaty divided the oceans based on distance to coast: [28]



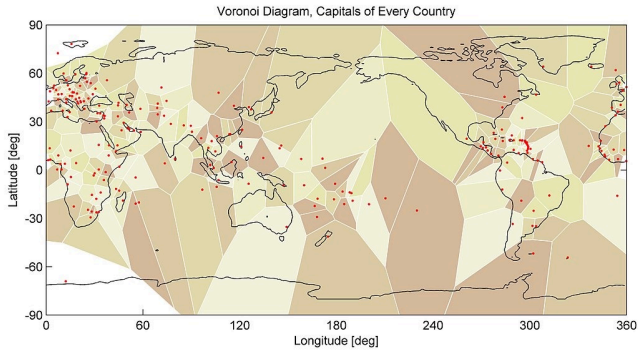
✓ 99% of current oil rigs and wind farms sit on their country's EZZ [29], setting precedent for our operations and avoiding legal risks.

✗ If floating data centres were to expand to international waters, they could face a blockage from a lack of regulations in UNCLOS.

- **How can we deal with operations on international waters?**

Databerg proposes 2 strategies that the UNCLOS could implement in 2055 to regulate this case:

1) **Voronoi Regions:** a mathematical model that grows zones from a seed node (main city or port in country) until all the space (international waters) is divided. If finely tuned, this would ensure a fair split between countries, who would just control a few activities to ensure the preservation of commons.



2) **Revenue-Sharing Fund (Global Equity Model):** the UNCLOS was signed by 161 countries. If any floating data centre wanted to operate within their Voronoi region, the revenues associated with it would be shared amongst all countries based on GDP, debt level, need, etc...

Impact on Local Communities

- **Who will we affect, and what direct benefits can we provide?**

Coastal Residents: disrupting roads and resource availability

Offered Benefits: taking reference from offshore windfarms, we could provide discounted high-speed AI access and cheaper electricity through our renewables contractors. Indirectly, we will create long term jobs for residents, and provide infrastructure upgrades to support our operations.

Fishers: altering the ecosystem and reduce fish count

Offered Benefits: involve them in the design process to avoid their zones, provide them with our expert marine data to enhance their operations, subsidised fuel or gear, fishing permits on alternative locations, and create off-season jobs in maintenance or marine monitoring.

Cybersecurity Implications in Offshore Applications

Our design decision of moving the data centre from the seabed to a floating platform improved maintenance but led to a higher risk of cyber-physical attacks. We will follow the IMO MSC.428(98) marine guidelines [30] and add extra layers of security through the following strategies:

Threat (ranked by likelihood)	Mitigation
Onboard Intrusion	Controlled by biometric access. Racks become sealed during AI-detected intrusions. Fake entrances as decoy.
Subsea Intrusion	Sonar-based detection system. Temperature monitoring sensors will also be used for this.
Tampering	Concrete encasing for key cable attachments. Redundancy design. Dummy cables.

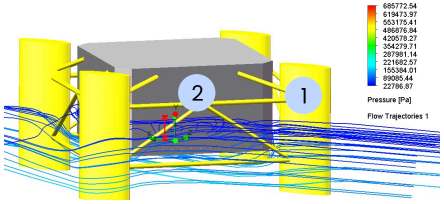
*The threat alerts and mitigation success will be tracked on our dashboard, alerting staff.

Features Evaluation: Structure & Cooling

Feature 1: Structural Design - Stabilisation

*Criteria: Maximum tilting angle cannot exceed **11.2°** to protect GPUs (Industry Expert).*

A. Passive Stabilisation with External Shape Design



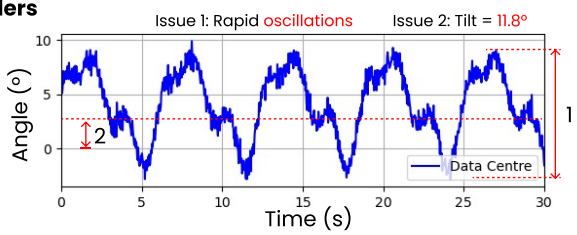
Assumptions (North Sea) - CFD Method
Wave height = 2 m; wave speed = 0.15 m/s

1. Ballast cuts the waves to reduce impact.
2. Centre of buoyancy 3.8 m higher than centre of gravity -> 42% less instability.

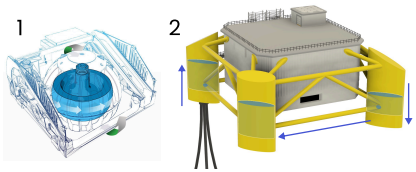
Result 3.8°C	Max. Tilting. The structural design withstands waves in average weather without active stabilisers, boosting energy efficiency (PUE)

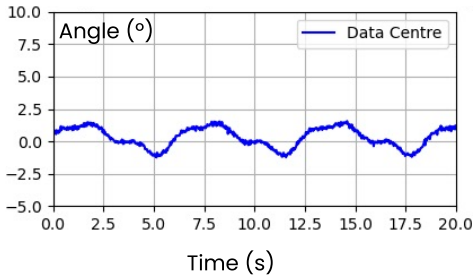
B. Active Stabilisation with Tech Enablers

In extreme weather (5m, sharp waves), our centre surpasses the tilt and frequency limit. Our proposal used the following tech to solve it:



1. **Gyro-stabiliser:** Dampens high frequency vibrations, highly damaging for electronic components.
2. **Dynamic Ballast:** Adjusting the level of water in the columns to reduce tilt.





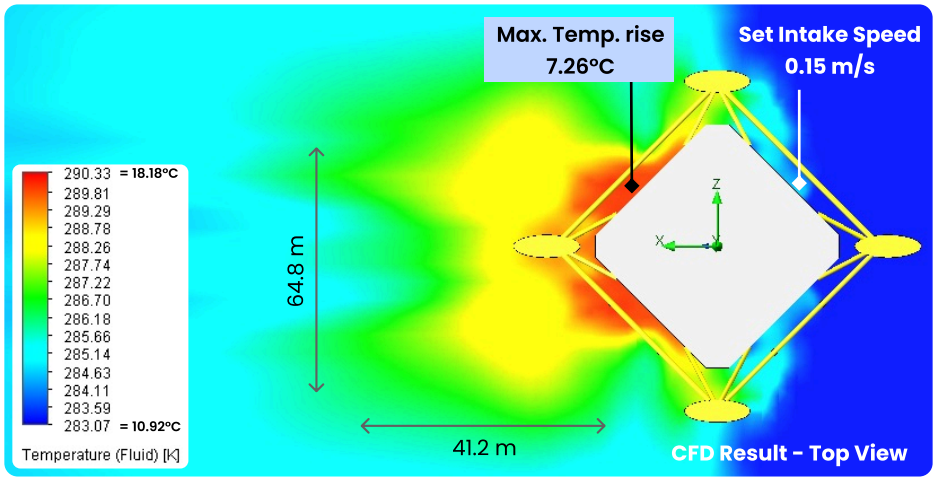
Final Result: Successful ✓

With Stabilisers		*Expert Value*
Max. Tilt	0.4°	< 11.2°
Max. Vibration	5.2°	

Feature 2: Cooling System - Environmental Impact

*Criteria: Maximum temperature rise cannot exceed **8°C** to protect ecosystem, and intake speed cannot exceed 0.15 m/s to avoid fish getting stuck (UK Regulations).*

A. Thermal Pollution with CFD



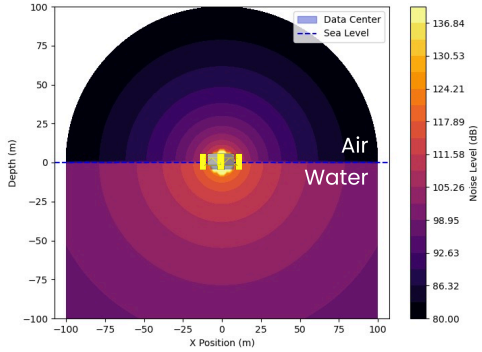
Risk: Accumulation of warm water might lead to algae bloom.
Solution: Designed turbine outlet creates a swirling flow that dissipates heat effectively.

Final Result: Successful ✓

Temp. Rise	7.3°C	<	8.0°C
Intake Speed	0.15m/s	=	0.15m/s

B. Noise Pollution with Python

- Land Data Centre Noise = 135 dB (overestimation for safety).
- 0-5m from Data centre: 120 dB [31]
  Fish perform minor behaviour change (changing direction/schooling pattern).
- >5m from Data centre: < 120 dB
  No impact on fish.



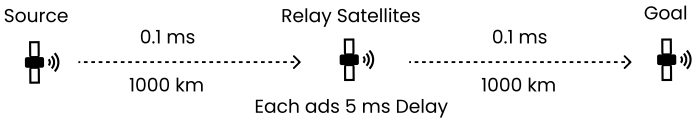
Features Evaluation: Data & Deployment

Feature 3: Data

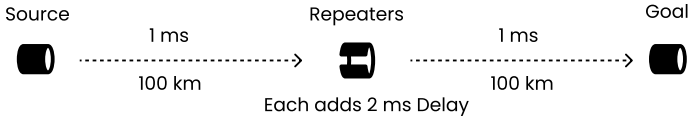
*Latency for LEO Satellite should be **8x** less than for fibre optic cables.*

Assumptions (Forecasts):

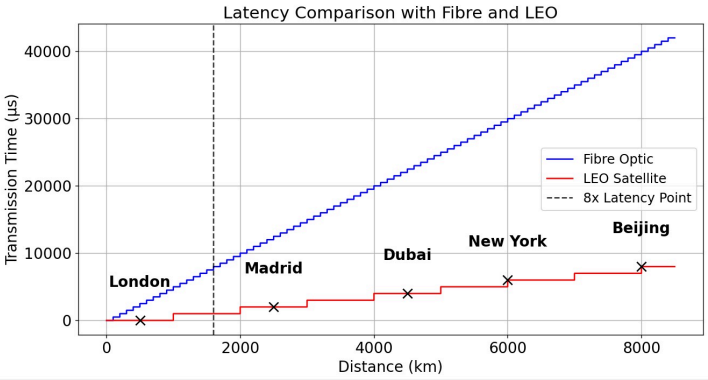
Every 1000km, a satellite handoff is done to ensure a large coverage.



Fibre cables are each 100km long, and are connected by repeaters.



Matlab was used to compare latencies at different distances from the North Sea, highlighting key cities and turning points:



Final Result: Successful ✓

The graph show that from 1800 km away from Databerg, data will travel more than 8x faster than with fibre optic. However, this comes with the limitation of having less bandwidth.

Feature 4: Deployment Costs

To estimate the costs for construction and installation, we referenced future cost projections for floating wind turbines and sub-stations as well as research into underwater power and data cable costs. We also estimated the total cost of our cooling system.



Costs Breakdown: (Link to spreadsheet) [32-35]

Floating Foundations: **£15.1M**

Mooring System: **£2.7M**

Data centre Structure: **£31.5M**

Power Infrastructure: **£25.7M**

Cooling System: **£81.9M**

Internal Systems: **£307M**

Data centre installation: **£1.8M**

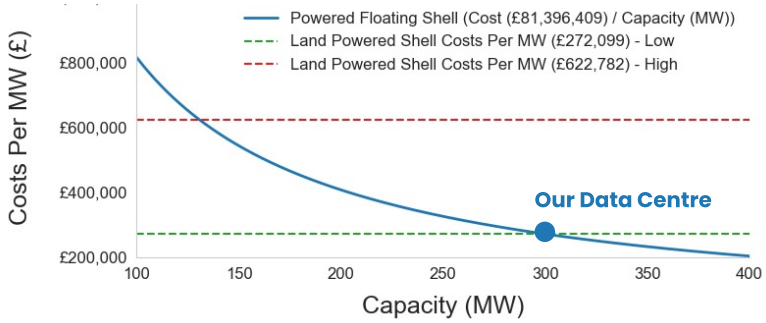
Data & Fibre Cables (With Installation): **£4.3M**

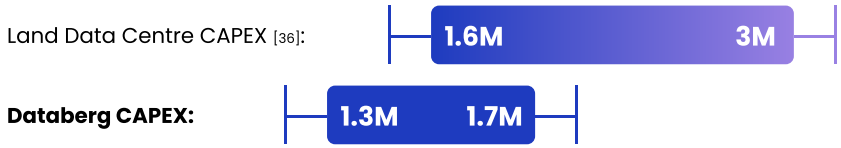
Total Databerg Capex (300 MW) **- £470M**

Databerg Capacity Validation

After estimating the total cost of construction and deployment, we explored how changing the data centre capacity would affect the cost per megawatt in order to compare the costs with land-based data centres. Validating our designed capacity of 300 MW.

Cost Per MW - **£1,5M/MW**





By saving costs on land, the deployment costs of our floating data centre concept are at the lower boundary compared to land-based.

Final Result: Successful ✓

The results show that Databerg would be highly competitive with land-based data centres, especially because land costs will likely increase, while floating foundation costs will decrease.

Scenario Evaluation with Industry Expert

To validate the viability of our tech enablers and stakeholder benefits, we organised a co-design workshop with **Xuefang Shen, lead data centre engineer at Tongxing Technologies.**

Roadmap for 2055

2025	2035	2045	2055
Funding & Research Secure grants and partnerships to build small-scale prototypes.	**Mature Technology** Floating wind, LEO communications, nanomaterials, and gyro start commercialising separately.	**Development & Rollout** Big Tech builds functional prototypes near the cost and launches its first floating data centre.	

Societal Trends

AI and Data Surge: The rapid adoption of AI in industries and consumer applications increases the demand for computational power from all Big Tech companies.

Offshore Wind Expansion: The rise of floating offshore wind farms creates new opportunities for ocean-based infrastructure such as floating data centres.

Electricity & Water Crisis: Traditional land-based data centres consume excessive power and water, leading to sustainability concerns.

Tech Enablers

Advancements in **cost-efficient immersion cooling** enable wider adoption in industry.

Dynamic Ballast & Gyroscopic Stabilisation (TRL 8)
Advanced motion stabilisation systems improve structural integrity and reliability for floating data centres.

European Digital Twin of the Ocean (EDTO) (TRL 8-9)
Provides high-resolution, multi-dimensional ocean forecasts, enabling better response to environmental conditions.

Anti-Biofouling Coatings & Hull-Cleaning ROVs (TRL 9)
Matured non-toxic coatings and autonomous cleaning robots extend maintenance cycles for ocean-based data centres.

LEO Satellite for Data Centre-Grade Transmission (TRL 7-8)
Advancements in beamforming phased array technology achieve high-bandwidth, low-latency satellite connectivity.

Adoption Barriers

Regulatory Challenges
Maritime laws and environmental restrictions may limit deployment.

Industry & Security Concerns
Traditional data centres may resist adoption due to cybersecurity risks, physical accessibility challenges, and uncertainty about floating infrastructure reliability.

Severe Climate Events
Extreme weather patterns, rising sea levels, or stronger ocean currents could make long-term deployment unsustainable.

Lack of Investment in R&D
Given its futuristic and innovative nature, funding will be needed from public and private institutions to develop the tech enablers needed.

Stakeholders Interaction

We revisited our stakeholder diagram from our scenario (page 4) and asked our expert about the symbiotic benefits that emerge from our concept.



Critical Analysis of Project Outcome

Limitations, Risks & Mitigation Strategies

	Tech-enabler		System		Scenario
Limitation	The LEO satellite system is vulnerable to space-related hazards such as solar radiation.	Materials and coatings are insufficient to prevent cracking under significant impact.	Floating wind farms may encounter power fluctuations.	Ocean facilities could face extreme weather conditions.	The cost of future data centre structures may not be economically viable.
Risk	Data transmission capabilities could be lost in the event of large-scale satellite failures.	Leaking and sinking caused by large fish or ship crash.	No stable power supply during certain weather conditions.	Threat to the structural integrity and risks interrupting the continuity of services provided.	Slow market adoption, investors concerned over long-term ROI.
Mitigation Plan	Multiple LEO satellite systems will be used; seabed fibre-optic cables add redundancy.	Protective coating releasing self-repairing compounds. The deck features a platform for helicopter to provide intensive quick fix.	Onboard battery packs supply power during less windy conditions; substations providing grid power when batteries are depleted.	Active stabilisers turns on autonomously. In tsunami, people get warned and can tow the structure to somewhere else.	Cost reduced by off-shore wind infrastructure development; government subsidises development for environmental benefits. [37]

System Impact

Environmental Impact

- **100% reduction in potable water consumption;** land-based centres can use enough water for 8M households in the U.S.
- **≤8°C temperature rise** (marine regulatory limit), preserving aquatic ecosystems.
- **Under 135 dB Noise,** meeting offshore standards.

Energy & Efficiency

- 1.01 PUE, **reducing power usage by approximately 8.2%.** [19]
- Each 300 MW module is powered by off-shore wind, **eliminating pressures on the grid.**

Economic Impact

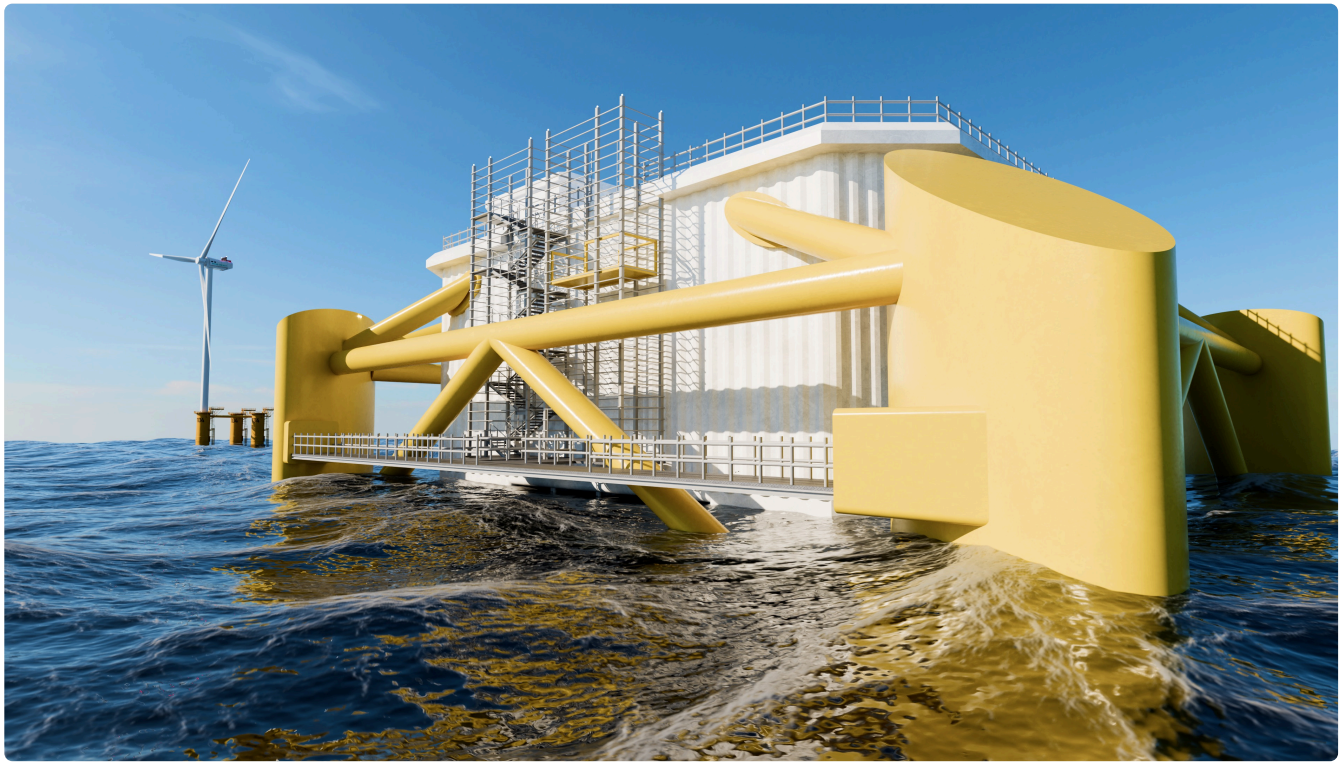
- **~£1.5M per MW** in capital costs—~36% lower onshore builds at £1.7M–3.0M per MW.
- Each 300 MW module can **save ~10 acres of land.** [38]

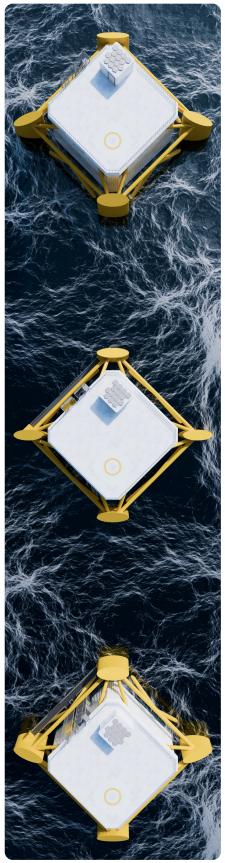
Performance

- LEO satellite systems provide up to **8x lower latency** than fibre.
- Modular design allows fabrication onshore and towing for installation.

Conclusion: The system is designed to significantly reduce environmental and operational impacts by eliminating the need for potable water and minimising thermal and noise pollution. It harnesses renewable offshore wind energy to boost efficiency and lower operational costs. Its modular architecture allows for rapid, scalable deployment while advanced data transmission technology ensures exceptional performance.

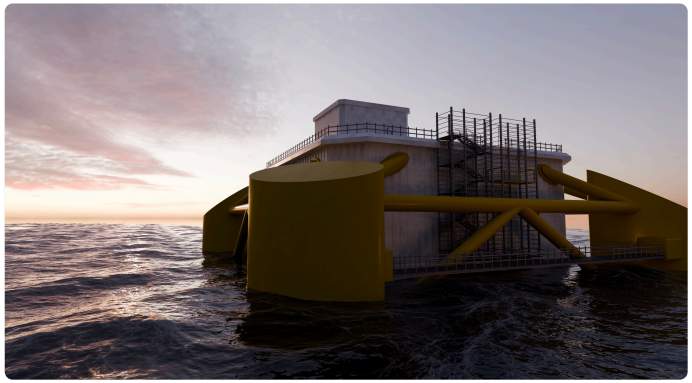
Final Concept Renders







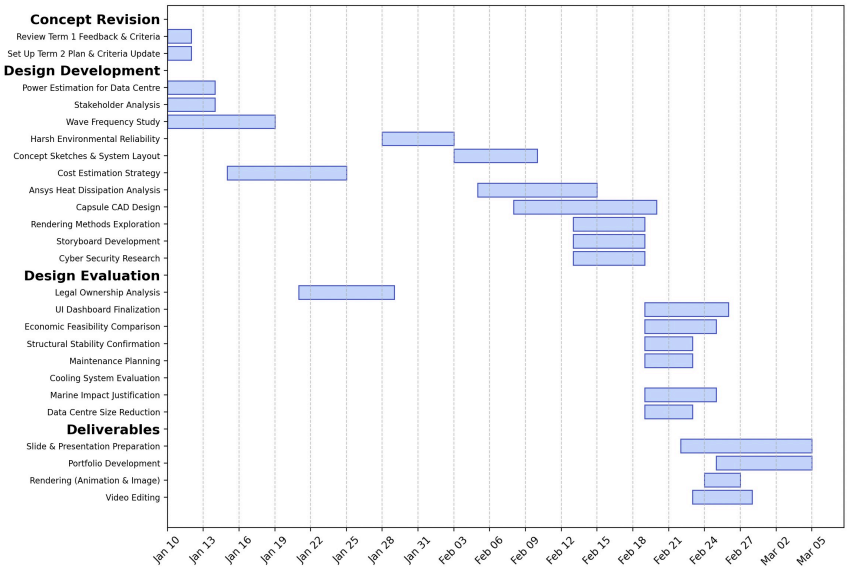




Project Management Reflection

Term 2 GANTT CHART

Meeting Minutes *(Link)*



Project Planning

- Schedule all group activities on weekdays, avoiding occupying weekends.
- Hold weekly tutorials on a fixed date for consistency and timely delivery.
- Dedicate more time to discussing findings in meetings and assign individual research tasks for better efficiency.
- Use online meetings when needed to avoid delays due to absence.

Improvements from Term 1

- Enhanced our minutes by expanding the Any Other Business sections.
- Improved the breakdown of tasks based on each teammate's skills.
- Invested more time on ideation to foster creativity.
- Crafted better plans with specific questions before tutorial session.
- More ideation and concept development.

Group work limitations

- Communication between group members could be more efficient.
- More industry expert input could strengthen insights and feedback.
- More backup strategies should be prepared for unexpected issues.

Individual Reflection



Javier de la Fuente
Project Lead

Role: Created the scenario and set direction for features development. Main contributor to presentation and portfolio work.

Reflection: I struggled with "Future" thinking, usually coming up with present solutions. I refined my system thinking skills, considering the broader picture with stakeholders rather than just our concept.

Improvement from Term 1: I was more open-minded when iterating on features and improved open communication with my peers.



Hongyi (Henry) Hu
Technology Lead

Role: Evaluations through simulations & expert interviews.

Reflection: I invested lots of time learning and applying theoretical knowledge and software skills for this intense project. However, I realised that I sometimes focus too much on certain details, leading to unnecessary time wastage.

Improvement from Term 1: I learned to communicate concepts using professional language and became more efficient in group work.



Gexing Fang
Design Lead

Role: Produced the renderings in the portfolio and presentation. Storyboard production. Produced all the animations in the demonstration video. Initial research about data centre cooling systems.

Reflection: Sometimes I focus on my own current work and did not communicate with my teammates to report my progress in time, which led to unnecessary concerns.

Improvement from Term 1: I am able to do more timely and comprehensive research on target areas quickly.



Danyaal Hussain
Engineering Lead

Role: Designed the structural, cooling and stabilisation systems. Developed the Databerg CAD model. Performed the engineering and financial calculations.

Reflection: Spent lots of time engineering small details, which were not necessary for designing something so conceptual. I refined my skills in full systems design and development.

Improvement from Term 1: Was more willing to take on aspects of the project I was less confident in such as project planning.



Qinxuan Li
Research Lead

Role: Dashboard & Maintenance, stakeholder & roadmap analysis, Video Editing, Organising Minutes.

Reflection: I focused too much on feature development and should have collaborated more on structuring deliverables and ensuring logistical cohesion, while also stepping back to identify gaps and refine the project for a more comprehensive system.

Improvement from Term 1: My efficiency in conducting research and preparing presentations has been greatly improved.

Video, Meeting Minutes & References

CLICK TO WATCH PROJECT VIDEO	https://youtu.be/Xwkxkof3_wQ
CLICK FOR MEETING MINUTES NOTION PAGE	https://plausible-foxtail-976.notion.site/Underwater-Data-Centre-Group-13-179756c8c8c3819993a0d224ea822e94?pvs=4

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