Title: "Towards International Ocean Stations"

Subtitle: A network of floating laboratories for ocean open science and entrepreneurship

#Ocean #Design #Engineering #Innovation #Sustainability #Entrepreneurship #Business #Citizen Science

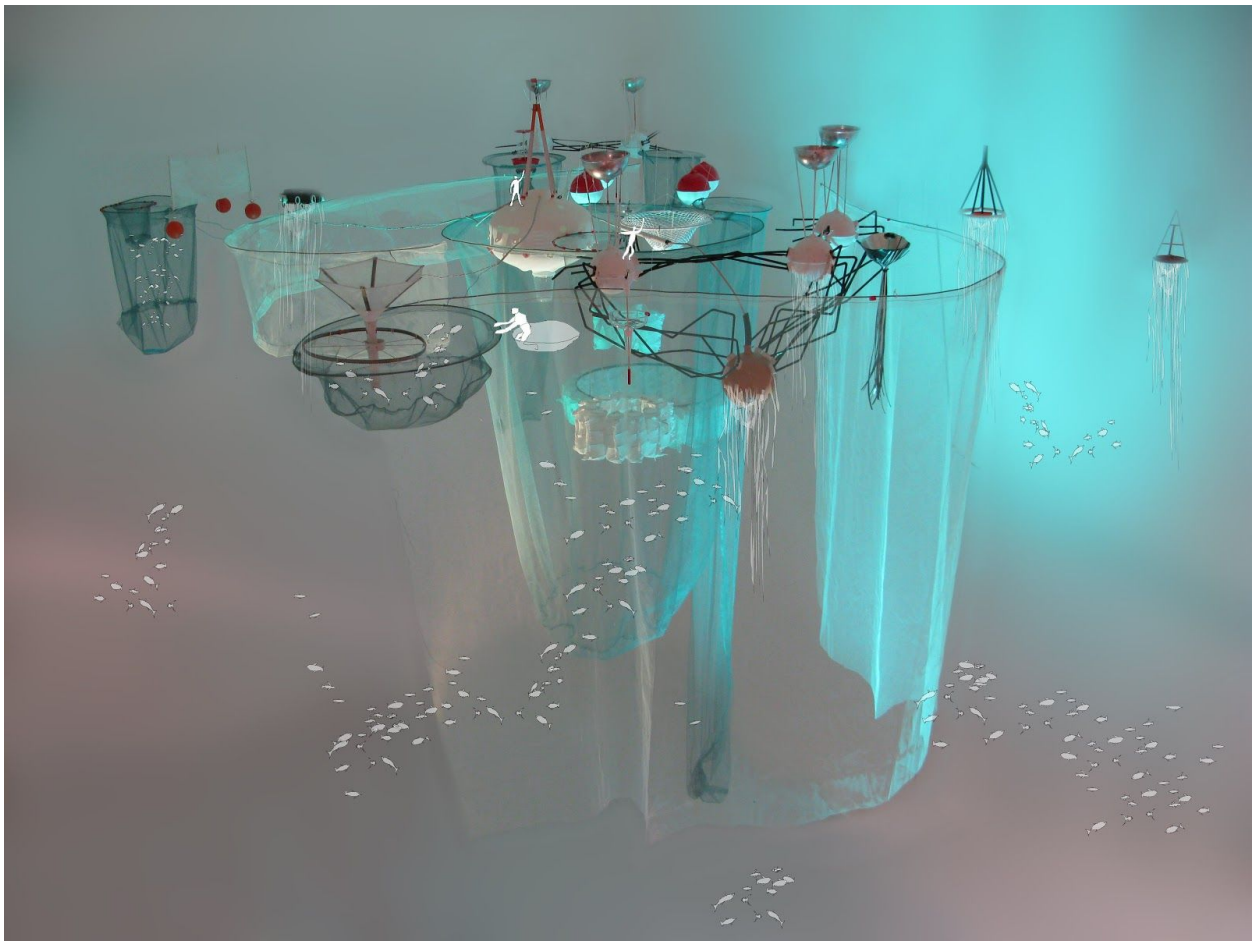

Image: "Open_Sailing" collective, lead by Cesar Jung-Harada, Feb 2009, Royal College of Art, London

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Abstract

Can we develop an inclusive infrastructure for ocean innovation to address the ocean challenges?

The bigger problem. The ocean is where all life comes from, yet we are destroying it and compromising our future. May it be agricultural or industrial run-offs, overfishing, plastic pollution, oil spills, radioactive leaks, challenges abound. But the oceans also covers more than 70% of our planet's surface, has captured 90% of the excess heat we've produced[1] controlling our planet's climate, currently transporting about 90% of the global trade[2], having produced over 75% of the oxygen[3] we breath and could feed us all, produce more freshwater to drink and more energy we could use from wind, wave, tidal, thermal, solar, chemical and biological sources. With our mindset, our businesses, our technologies, we are damaging and depleting the ocean faster than we know how to protect or replenish it. In the coming centuries, with the human population growth, the pressure on the ocean will only increase.

The specific Problems
1. Money. Sustainability & Business: we have profited extracting form the ocean and we fail to see the short and long term benefits in developing maritime sustainable technologies and business models.
2. People. Human collaboration & Innovation: we have been collaborating poorly and too slowly, locking critical knowledge and technologies behind pay gates, slowing down the impact we could have achieved.
3. Technology: Affordable ocean laboratory: seafaring can be dangerous and current ocean research vessels are environmentally unfriendly and tend to be so expensive they exclude most coastal countries, especially the ones that need it most in the emerging world.

The questions I will investigate are: What are the ocean technologies and business models that make sustainable development possible? How can ocean stakeholders collaborate best? What sort of architecture and systems would enable research and development at sea?
The aim of this research is to elaborate and test principles to develop a network of affordable and open floating laboratories that would be equipped to do science and incubate sustainable ocean businesses. It would draw knowledge from previous small scale experiments I have conducted or participated myself, taking inspiration from some of the largest and most successful scientific projects of the last decades, and run a small-scale collaborative experiment that could become the foundation for the "International Ocean Stations", a network of connected floating laboratories.

The worsening condition of the ocean and the lack of inclusive infrastructure is an urgent and critical problem for our planet as a whole. Intergovernmental, regional, national administrations, industries, coastal communities have individually failed to protect the ocean fast enough and at a significant scale.

This research is important because it is the only integrated platform project that gets all the ocean stakeholders to work together to address the ocean challenges at scale and pace with open technology ; involving public sector, private sector and the civil society. It will also contribute to develop sustainable business models, collaboration and innovation models and a new class of affordable research vessel. If the "floating marine laboratory" experiment is successful, it will become the foundation of a mass collaboration long term project, the "International Ocean Station Network".

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[1] "Since 1955, over 90% of the excess heat trapped by greenhouse gases has been stored in the oceans" https://www.oceanscientists.org/index.php/topics/ocean-warming
[2] "Maritime transport is essential to the world's economy as over 90% of the world's trade is carried by sea" https://business.un.org/en/entities/13
[3]"It is estimated that marine plants produce between 70 and 80 percent of the oxygen in the atmosphere." https://www.ecology.com/2011/09/12/important-organism/

Introduction

What motivates this research

- General. The rate at which we lose biodiversity, accumulate toxic substances, and deplete the ocean outpaces the rate at which we innovate to heal and replenish it. It has become critical to harness technological progress, public awareness support to collaborate and address these challenges.

- **Stage of research.** In 2009, as a Design Master Student at the Royal College of Art, I proposed the initial concept of the International Ocean. In 2011, I started my PhD at Goldsmiths University on the same topic. I have spent the last 10 years working with ocean scientists, engineers, coastal communities, ocean industrialists, and building several social enterprises focused on ocean and social innovation. These experiences helped me gain confidence and I want to reflect and synthesize in this thesis, to prepare for the next phase.

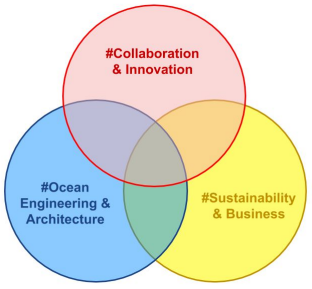
- Opportunity. I am currently a Senior Lecturer at the University of Hong Kong (HKU) in the Architecture Department and we recently formed the Ocean Research Alliance. Many of my collaborators are enthusiastic about the "Floating Laboratory" concept because it enables collaborations between marine biologists, mechanical, electrical engineers, computer and social scientists. HKU seems keen to support the development of this platform, and ASEAN provides a perfect field to develop this work at scale.

- Personal. I was born in Biarritz, grew up in Saint Malo, I now live in Hong Kong (coastal cities) and developed a deep connection with the ocean. This project allows me to combine my love for the sea with my professional work in design, technology, education, and entrepreneurship.

Research Gaps and Area of Interest

I noticed that most organisations are market, technology or hierarchy-centered ; but rarely ecosystem-centred. Without impact metrics or incentives, most ocean engineering projects do not nourish ocean ecosystems. The ocean remains a space of challenges and many untapped opportunities. These three main issues hinder the development of ocean solutions.

- **Technology: Ocean Architecture & Engineering.** Ocean research vessels are slow to build, environmentally damaging and so expensive only a few rich nations can afford them. There is no effective and affordable sea-borne innovation center design.
- **People: Collaboration & Innovation.** Despite the urgency, people and organisations don't work efficiently together. When they do, they rarely share.
- **Money: Sustainability & Business.** Too many great technologies from the lab take too long have a positive impact on our ecosystem and economy.

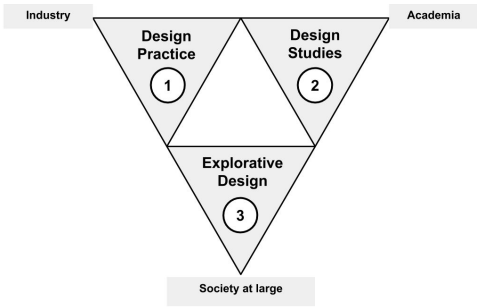


Research Questions

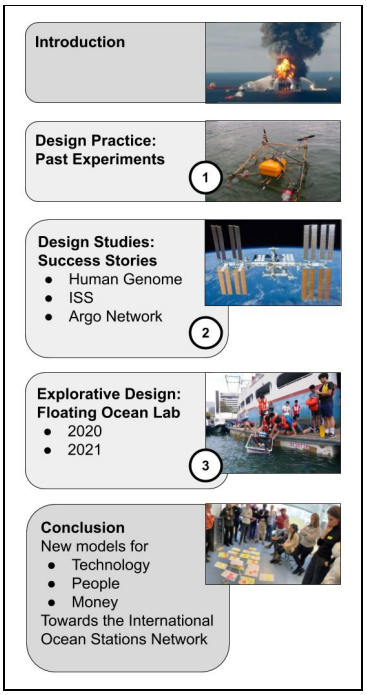
1. What sort of architecture and systems would enable research and development at sea?
2. How can ocean stakeholders collaborate best?
3. What are the ocean technologies and business models that make sustainable development possible?

Research Framework

The research is anchored in ① industry practices, ② historical case studies, ③ testing of hypothesis in a collaborative design workshop. The Fallman Triangle (2008) is a simple yet robust research framework that allows me to articulate past, current and future work in the industry, academia and society.



Outline of the Thesis



Introduction

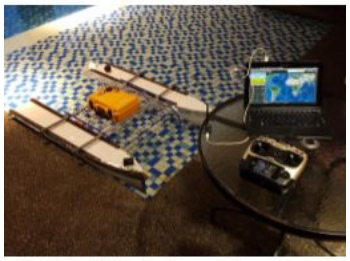
The introduction will describe the challenges and opportunities the global ocean is experiencing, detail a few specific environments and situations giving a tangible context to the research questions. The methodology will present how the research has been conducted as well as the goals for each of these different areas of enquiry.

① Design Practice: Past Experiments

This is a list of projects I have either led, contributed to, or simply participated in. Some are related to ocean technology, open hardware, citizen science, innovation in STEAM/maker education, incubation and social business models. I have consistently documented the work, but not systematically studied it. This is an opportunity to organise, reflect, articulate the value and learning from these relevant experiences:

1. 2006 "Micro Trimaran" ENSAD, ENSCI, France
2. 2007 "Scattered House" as assistant of Usman Haque
3. 2008 "Urban Space Station" as assistant of Usman Haque
4. 2009 "Natural Fuse" as assistant of Usman Haque
5. 2009 "The International Ocean Station" Royal College of Arts, UK. Ars Electronica Golden Nica, Linz Austria.
6. 2009 "Anaconda Wave Power" Southampton University, UK
7. 2010 "Seaswarm" MIT, MA, USA. Researcher and Project Leader
8. 2010 _iHub* Nairobi, Kenya. As Construction Site Manager
9. 2010 "Grassroots Mapping" with the Louisiana Bucket Brigade, New Orleans, LA, USA
10. 2010 "Protei: Shape-shifting sailing robot" Scoutbots, TED Talk
11. 2013 "Protei in Hawaii most polluted beach" Unreasonable at Sea, Hawaii, USA
12. 2013 "Fishing in Axium" Unreasonable at Sea, Ghana
13. 2013 "Protei Hackathon" Unreasonable at Sea, Morocco
14. 2013 "Protei testing in Vietnam", Unreasonable at Sea, Vietnam
15. 2015 "Ocean Plastic Optical Sensor" Scoutbots/MakerBay, HK. Jane Goodall Roots & Shoot Prize"
16. 2015 "Oil Spill spectrometer" for the Harbour School, HK - after the Public Lab
17. 2015 "How I teach kids to love science", TED Talk, Los Angeles, USA
18. 2016 "Ocean Sediment Radioactivity Collector" with Safecast, Japan [Link 1, Link 2, Link 3]
19. 2016 "Laser Quadrat for Coral reef Survey" with Harbour School, HK
20. 2016 "COP21, Action Day" Cesar presentation in front of many heads of states
21. 2017 "Marine Litter Detective I, wax balls" for WWF, with Scoutbots/MakerBay, HK
22. 2018 "Mindorobot, Coral Reef Mapping Robot" Abra de Ilog, Philippines, Scoutbots/MakerBay, HKU
23. 2018 "Stitch and glue rowing boats", Stamford American Int'l School, Makerbay, HK
24. 2018 "Bioreactor & Plankton Net for Red Tides Study", Harbour School Int'l School, Makerbay, HK
25. 2018 "Coral Reef Mapping Robot" in Sarawak, Malaysia, with Scoutbots/MakerBay, HK. 5th International Marine Conservation Congress Silver Prize
26. 2018 "Harbour Cleaning robots" with Canadian International School, HK
27. 2019 Feb: "Marine Spatial Planning Workshop", University of Bergen

Protei: Shape-Shifting Sailing robot, Open Hardware and crowd funded



Coral Reef Mapping Drone: AI, Semi-Autonomous imaging robot

"Sea Nettler" biomorphic Ocean Drifter

28. 2019 "Katapult Ocean" as a startup mentor, in Oslo, Norway
29. 2019 April "Aquathon", Paris & Brest with CRI, ifremer, University of Bretagne Occidentale, CRI, France
30. "Ghost Net Tagger" with Eddie Yung, Ken Chew and Jacky Chu, for WWF with MakerBay, HK
31. 2019 "Marine Litter Detective II, Sea Nettle" for WWF, with Scoutbots/MakerBay, HK
32. 2019 "Ocean Plastic Mapping", Lingnan University, Hong Kong, with MakerBay, HK
33. 2019 "Air Quality Sensor Hacking", Makerbay, HK
34. 2019 "Mapping Environmental Radioactivity", University of Macau with MakerBay, Macau
35. 2015 - 2020 MakerBay 1 Yau Tong, Makerbay 2 Tsuen Wan, MakerBay Foundation with 6 youth centres. Social Entrepreneurship, coworking, education, R&D services: a complex business model
36. 2020 "Design for a Multiplanetary Specie", "Mobility on Mars", "3D Printing Mars Habitats", "Everyday Martian Objects", University of Hong Kong

② Design Studies: Success Stories

I will study three large international collaboration projects that have a lasting impact:

1. The Human Genome Project #biology - 1990[4]
2. The International Ocean Station #space - 1998[5]
3. The Argo Ocean Drifter Network #ocean - 2000[6]

To compare these projects fairly, I will start by collecting data such as goals, methodologies, technologies, scale, size, duration, people and organisations involved, governance model, decision-making process, management, legal structure, intellectual property, dissemination, financials. I will also look at scientific, financial, environmental, social and cultural output.

I will also briefly mention relevant projects such as the Polar Pod by explorer Jean-Louis Etienne, Sea Orbiter by architect Jacques Rougerie, the Aquarius Reef Base, Andrew Quitmeyer floating makerspace, the Ocean Cleanup led by Boyan Slat, the Dolphin Embassy by Ant farm, BIG and MIT OceaniX floating city, the Seasteading Institute, the Makoko floating school, the extreme environment experimentator Lloyd Godson, the research of Etienne Gernez, the artist Angelo Vermeulen, some more traditional ocean science vessels, ocean activists vessels, floating communities, large fish farms by Salmar, and more traditional fish farming enterprises in Asia.

Overall, I will analyze these projects focused on my three areas of study: Architecture & Engineering, Collaboration & Innovation, Sustainability & Business. I will pay special attention to the praise and criticism the projects have received, identify the characteristics and traits I would like to incorporate in the development of the international Ocean Station Networks.

③ Explorative Design: Floating Ocean Laboratory

The final phase of applied research will be two design workshops with 15 Architecture Master students from the University of Hong Kong who will a) interview the floating laboratory stakeholders, b) propose several floating laboratory designs, and c) build one floating prototype in Hong Kong waters to support the research of the local scientists. The experiment will be focused on architecture for research and development primarily, but the students will also explore the other aspects of having such infrastructure operate: safety, usability, scalability, operations, maintenance and longevity, impact measurements, documentation, replicability. The students will collaborate using Github as the primary collaboration platform, where they can share 2D and 3D files, source code, data, document interviews in a wiki, project and task manage, track, license and share their work openly. The course description can be found here[7].

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[4] The Human Genome Project: https://www.genome.gov/human-genome-project

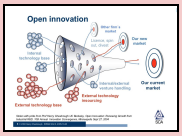
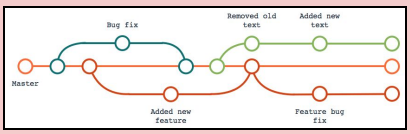
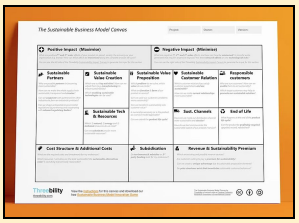
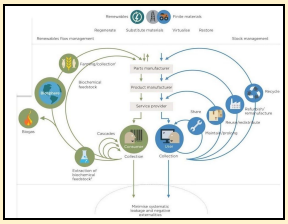
[5] International Space Station: https://www.nasa.gov/mission_pages/station/structure/elements/zarya-cargo-module

[6] Argo ocean sensing network: http://www.argo.ucsd.edu/About_Argo.html

[7] *"Floating Marine Laboratory", Master of Architecture course brief, University of Hong Kong: https://docs.google.com/document/d/1DHAoRQx--HyJ6n4gOVN_LMBXvwADXu-VNbrKdRWz-CQ/edit?usp=sharing*

Conclusion

The conclusion will evaluate ① how my many experimentations (Design Practice, Industry), informed by ② great success stories (Design Studies, Academia), culminate into ③ a final experiment (Explorative Design, Society at large). Of course, this culminating experiment isn't devoid of influences and ambitions to improve the best existing technologies, practices, and models.

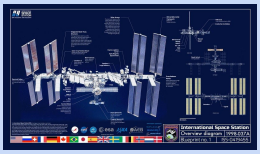
Technology: Stability, Mobility and Modularity The architecture of the vessel is currently influenced by the stability of the Givens Buoy life raft, the extreme mobility of the foil-powered sailing yachts such as the Hydroptere, the modularity of Chinese fish farms.	
People: Governance & Decision Making The governance model is currently influenced by theories such as Open Innovation, Design Thinking, and practices from software development with branches and version control, meritocracy, holacracy, consensus.	 
Money: Sustainable Business I am very interested to test models such as the Sustainable Business Model Canvas, test some assumptions of Jeremy Rifkin's "Zero Marginal Cost Society", circular economy principles and propose a New Structure of Scientific Revolution (Khun) based on intensive collaboration.	 

The goal is to lay the foundations for building a network of affordable floating laboratories for open research and development.

Aims and Objectives

Primary objectives

The primary objective of this research is to explore how we might develop an inclusive infrastructure for ocean innovation to address the ocean challenges.
From experience, knowledge and experimentation, I will produce specific deliverables:

		
"What the system will be". Blueprint of structure and systems	"How it will be run". Governance and Operations Models.	"How we are going to make this happen". Sustainable Business Model and Roadmap.

Secondary objectives

- Build the human connections and the expert network to build this project beyond the Ph.D.
- Build the actual online infrastructure that will serve for further development
- Contribute to Design Research as a field

Research outcomes and dissemination

Beyond the benefit of designing the International Ocean Station Network itself, I hope elements of this research will contribute to the broad fields of:

- Design of Complex Systems
- Naval Architecture, Ocean Engineering
- Management Science, Innovation Methodology
- Sustainable Development & Business
- History and Philosophy of Science

What is the research output / what will the research enable?

I hope that this research

- (Inwardly) will enable the actual development of safe, open, affordable, floating laboratories to do research and development around the world ocean. I have a particular interest in enable the global south to study, exploit and protect their natural maritime resources.
- (Outwardly) to inform and contribute to other ambitious endeavours to sustain life on this blue planet.

Scope and depths

The scope of this research is broad and interdisciplinary in nature. Designers and architects are uniquely trained to organise large scale projects that have environmental, social, technological and cultural complexity, work with a great number of stakeholders, high parts count, tight budget and timeline. Beyond attempting to answer a very specific ocean engineering question, this research also investigates the role of designers in science and society. Can a designer be mandated to articulate environmental, social, technological, economic complexity and propose integrated solutions? When there is a global scientific consensus about global warming, paired with an utterly insufficient response, who is actually trained and in a position to affect change at the necessary scale and pace?

Timeline of Research Activities

- 2020 January - May: "Floating Ocean Laboratory" workshop with 15 Master students in Architecture, University of Hong Kong. First iteration of the "Culminating Experiment"
- 2020 June - August: "Coral Reef Mapping Robot" expedition with multiple coral reef mapping robots and 36 students in the Philippines.
- 2020 Sept: Re-enroll as a Ph.D. candidate.
- 2020 Oct - Dec: Complete missing interviews, especially for the 3 case studies (the Human Genome Project, the International Space Station, The Argo Drifter Network).
- 2021 Jan - May:"Floating Ocean Laboratory" workshop with 15 Master students in Architecture, University of Hong Kong. Second iteration of the "Culminating Experiment".
  Complete first draft for feedback and review
- June - Aug: Complete manuscript
- Aug - Dec: Peer review, final edits
- 2022 Jan: Public defense

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