Universidade da Coruña

Doctoral Dissertation

Establishing offshore autonomous communities: current choices and their proposed evolution

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Year 2011

Doctoral Dissertation completed in Ferrol (A Coruña), on July 12, 2011

Dedicated to my daughter Sofía, who was born August 12, 2011

Figure 1: Utopia Project. Courtesy of Yacht Island Design.

Logic will take you from A to B, yet imagination will transport you to any place whatsoever
Albert Einstein.

How inadequate it is to term this planet "Earth", as it is evident that is should be called "Ocean".
Arthur C. Clarke.

If you want to build a ship, don't drum up the men to gather wood, divide the work and give orders. Instead, teach them to yearn for the vast and endless sea.
Antoine de Saint-Exupéry.
La Ciudadela

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Abstract

"Establishment of autonomous ocean communities: current options and their future evolution"

Dissertation presented as a requirement to obtain a Doctoral Degree in Naval Architecture and Ocean Engineering.

The idea of establishing floating cities in the oceans has been addressed in the past within the ambition of both science and art, though rarely with rigor or detail.

The objective of this dissertation is to provide an orderly framework around this idea as to why humanity has sought out to establish such cities. To this end, we have established a more ample definition to the term "Oceanic Colonization" which we define as "The establishment of autonomous communities in the oceans aboard artificial platforms". Additionally, we distinguish four forms of ocean colonization for four distinct purposes: 1) to expand landholdings; 2) to provide mobile settlements; 3) to allow for semi-permanent mobile settlements in order to have access to marine resources; 4) and for the creation of micronations. It is this fourth concept that will serve as a departing point to review the whole idea of oceanic colonization.

Thus, **the objective of this dissertation** is to analyze all the possible options (both present and future) permissible within the scope of Naval Architecture and Oceanic Engineering for the establishment of autonomous offshore oceanic communities which would allow for the creation of oceanic micronations. At the same time, we shall try to project the evolution of the other three forms of oceanic colonization.

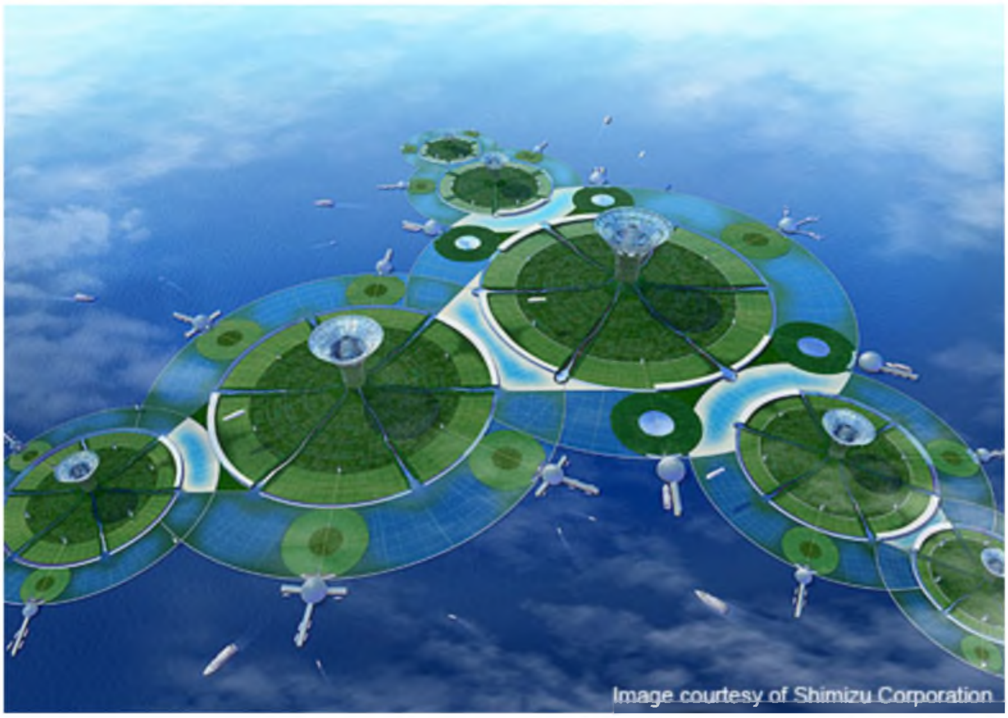


Figure 2: Floating City "Green Float". Courtesy of Shimizu Corporation.

Acknowledgements

This Dissertation has been submitted to the doctoral committee of the *Oceanic and Naval Engineering Department* of **La Escuela Politécnica Superior of Ferrol** for the conference of the Degree of Doctor in Naval and Oceanic Engineering by the Universidade da Coruña (Spain).

This investigation is the result of the collaboration of the author as an Engineering Researcher at the "Think tank" **The Seasteading Institute**[1] (Sunnyvale, California, USA) from September 2009 when he had his first contact at the Seasteading 2009 Annual Conference at the *Flotel Vessels* seminar. (1) This Dissertation has also come about through the knowledge acquired in the years employed at the two most cutting-edge-shipyards found within Spain in the last few years: **Hijos de J. Barreras S.A.** (from 2001 to 2003) and **Factorías Vulcano S.A**. (from 2003 to-date), both in Vigo, Spain.

I would like to extend my deepest appreciation to my dissertation tutor Dir. D. Luis Manuel Carral Couce, for his valuable advice and encouragement during the drafting of this dissertation; also I would like to thank all those that during my professional development have guided me with their insights and advice and at the shipyards of Barreras y Vulcano (impossible to mention all here) of whom I have elucidated such valuable knowledge about Naval and Oceanic Engineering which have been invaluable and applied, in part, through the dissertation. My appreciation is also is extended to la Escuela Politécnica Superior de Ferrol, as well as my fellow classmates throughout these years, to whom I presented this body of work as an end of degree-project on a cruise ship (2). In part, this was the trigger that led me to commence this dissertation.

- I would also like to extend my gratitude to the board of directors and community members of the Seasteading Institute for their advice and motivation, especially:
- Patri Friedman - Executive Director, Chairman of the Board
- Eelco Hoogendoorn – Engineering Researcher
- James Hogan – Senior Director
- Brad Taylor – Governor Researcher
- Eric Jacobus - Operations Manager
- Max Marty - Director of Business Strategy
- George Petri – Director of Engineering
- Jeff Chan – Community Member
- and to all of those people that have provided information about their projects, that have shared their ideas, experiences and advice, all whom have motivated me with their encouragement. I include a brief list:
- the members of the Colegio oficial de in genieros Navales y Oceánicos of Spain, for allowing me to present some of these ideas at their conferences:
    - State of the Art of the Ocanic Industry for the Establishment of autonomous Communities in open oceans (3) at the 49th Congress (2010).
    - Market segmentation and Economies of Scale in the Cruiseline Industry of the XXI Century (4) at the 50th Congres (2011)
- Mark Staunton-Lambert and Eric Tupper, Technical Director, assistants respectively of the Royal Intitution of Naval Architects (London, UK), for having provided guidance in the publication of my article titled offshore, and Coastal Floating Hotels: Flotels published in the International Journal of Maritime Engineering (5).

[1] For more information in regards to this Silicon Valley, "think tank" we shall refer the reader to chapter 2.

- Mike Simpson (Naval Architect), Marine Director of Houlder Ltd (London, UK) for his insights and information regarding nursery ships for eolic parks.
- David Foxwell, Editor Supervisor of Offshore Support Journal (London, UK) for the publication of the article Class quandary for monohull accommodation vessels (6)
- Dominique Roddier (PhD Naval Architect) of Marine Innovation & Technology (Berkeley, California-EE.UU.) for the use of the material on Clubstead and Windfloat and for his aid and comments regarding semi-submersibles.
- José Luis Lamas Rodríguez, preliminary plan Supervisor of IZAR-Fene until 2003, for sharing information regarding Flotel 9
- Robin Reeves, CEO of Marine Asset Corporation (Singapore) for the information regarding Compact SemiSubmergible, CSS.
- Rodrigo Pérez (Doctor in geniero Naval - ETSIN, Madrid, Spain), for his aid, input and support, particularly with the publication of the article Behavior of Large Floating Structures At Sea (7).
- Luciana Teperino, Architecture student at Universidade Federal de Juiz de Fora, Minas Gerais (Brasil) who has engaged in a graduation project related to floating cities concurrently with me which has allowed us to exchange information and various points of view on the topic.
- Juan Antonio Becerril (Doctor in geniero de Caminos, Canales y Puertos), Director of Revista de Obras Públicas, for his great kindness in accepting the task of proofreading my article Very Large Floating Structures (VLFS): Floating Ports and Airports (8).
- Olga Sánchez de la to rre, of Servicio de Publicaciones del CEDEX (Centro de Estudios y Experimentación de Obras Públicas, Madrid), for her kindness in accepting the task of proofreading my article on Concrete offshore Structures (9) to be published in Ingeniería Civil magazine.
- Ignacio Arroyo Martínez, president of Asociación Española de Derecho Marítmo and editor of Anuario de Derecho Marítimo, for his insights and acceptance for publication of my article Micronations in Artificial Islands and Maritime and International Law (10).
- Manuel Laranjinha, Senior Engineer, and Kristen Amundrød, Principal Lead Naval Architect of Grenland Group, (Sandefjord, Norway) for comments and teachings regarding GG4-A and in general about semisumergibles.
- Justin Back, Chartering Manager, y Elisabeth Back, Commercial Director, of Equinox Offshore Shipping Company (Singapore), for comments and information regarding accommodation vessels type ARV1 y ARV.
- Wataru Yamamoto of the Corporate Planning Division of Shimizu Corporation (Japón) for his comments and information regarding their project Green Float.
- Wilfried Ellmer of Concrete Submarines (Colombia) for exposing me to maritime concrete-structures.
- Tero Reunanen, Project Manager of Turku University of Applied Sciences (Finland) for his comments and information regarding their project Floating Ecocity.
- Rob McPherson, Director of Yatch Island Design (UK) for information regarding the project The Streets of Monaco.
- Alex Voguel, of Intership Ltd (UK) for his comments and information regarding Accommodation Work Barges.
- Santiago González Fernández organizer of II Pecha Kucha Night Ferrol, for his invitation to be a speaker and discuss ideas touched on this dissertation (11) in such a multi-disciplinary context as the various conference seminar sessions.

- Javier Osa and José Brotons, both MBAs at Stanford University (California, USA), for their support and instruction to Silicon Valley. Without their initial support, this dissertation would have not become a reality.
- Javier Armesto, chief of Editing of La Voz de Galicia, for the interview that was published on August 30, 2011 from which this dissertation has had great reach and influence.
- And to many others that have aided, advised, supported, and motivated me throughout these months including of course, my spouse, Esther, to whom I am greatly indebted for allowing me to steal away from her time and togetherness that instead was invested in the drafting of this dissertation.
- Without all these valuable people's aid, it would have been impossible to have and maintain a lively attitude and retain motivation while writing this dissertation. My deepest appreciation to each of them and to all of them.

PREFACE

The idea surrounding floating cities is a topic that has been part of the collective imagination since the nineteenth century. It has been addressed by diverse fields both in science and in the arts (engineering, architecture and literature) particularly during the twentieth century, when it was realized that the technology had been developed to take on such a challenge.

Nonetheless, in many instances, the proposals lacked realistic foundations, and appeared to be motivated simply to seek media attention for their proponents.

This dissertation seeks to address this by providing a framework on the topic regarding the concept of "floating cities" by questioning why it is that humanity has sought to establish such cities.

We avoid the media-coined term "Floating Cities" and instead use a different term with a wider context, "Oceanic Colonization", which we have defined as "the establishment of offshore autonomous communities aboard artificial platforms."

Additionally, we have distinguished four types of oceanic colonization for four different and distinct objectives:

1) expansion of landholdings; 2) mobile settlements; 3) semipermanent mobile settlements to access marine resources; 4) and the creation of micronations.

It is this fourth category that will guide the review of the whole issue of ocean colonization.

The dissertation's objective is to "analyze possible (current and future) options available to the discipline of Naval and Oceanic Engineering for the establishment of offshore autonomous communities that would allow for the creation of oceanic micronations.

At the same time, we shall attempt to explore the future evolution of the three other objectives of oceanic colonization.

In ***Part I- State of the Art,*** we seek to review the most ambitious oceanic colonization projects espoused toward the creation of oceanic micronation (such as the Principality of Sealand) as well as those proposed by professionals outside of the Naval and Oceanic disciplines with apparently media-seeking proposals (such as the "Green Float" espoused by Shimizu Corporation).

We shall point out that these vain attempts have failed as they have not taken into account a series of requirements which shall be examined in Part II of this dissertation.

In ***Part II, Set-up and Challenges,*** we develop four essential requirements that need to be fulfilled by any oceanic settlement:

1) economic and commercial, 2) technical specifications surrounding the platforms, 3) legal and external relations, and 4) self-government and internal relations.

These requirements are common to all four forms of oceanic colonization though the steps to achieving them are distinct and different for each one.

The research behind this dissertation is focused on the technical and legal requirements (requirements 2 and 3) to create a micronation in the oceans.

To this effect, we researched existing platforms.

Thus, in ***Part III-Results***, we present the review performed on the various platforms used in the three first forms of oceanic colonization identified and that best conform to the creation of oceanic micronation including the legal nuances related to them.

The platform types reviewed included cruise ships and residential offshore and inshore flotels; also those termed as Very Large Floating Structures or VLFS and the offshore concrete-based structures.

At the conclusion of this section, we shall analyze the legal and regulatory requirements of oceanic colonization from the perspective of maritime law.

In **Part IV- *Results Analysis***, we shall examine future trends of the four forms of oceanic colonization postulated.

We allocate greater detail to the review of oceanic colonization to form micronations based on the various platforms reviewed, and we provide a proposal of timelines and hypotheses as to how we see this form of colonization evolving.

Lastly, in **Part V- Conclusions**, we shall conclude that the oceanic colonization and the creation of micronations in the future is a result of the evolution of the other three forms of oceanic colonization:

1) expansion of land holdings, where the solution via VLFS appears to be a viable alternative, 2) mobile settlements (where the primary venue shall be cruise ships that will be converted into mobile-floating-ship-cities and 3) the establishment of permanent oceanic settlements to access marine resources that will require permanent floating cities in order to best extract them.

Index

ABBREVIATED INDEX

FULL INDEX

1 Introduction

1.1 An ocean of opportunities

We have chosen this title to commence this dissertation, as it is a title of a European Union (EU) document (Comisión-Europea, 2008) regarding the need of a joint effort for a positive political climate to sustainably exploit the marine resources offered by the oceans that surround the EU.

1.1.1 The Oceans

The oceans cover approximately 72% of the surface of the earth.

Life itself came from the oceans.

The oceans are not only the origins of life on earth, but they also house approximately half the life within this blue planet.

Nonetheless, this half excludes humans. Though we have a few small communities making use of the oceans (for resource extraction, to transport goods, for recreation, etc.) there are no permanent settlements in the oceans.

Thus, we have better maps relating to Mars than we do of the depths of our own oceans, which are 55 million kilometers closer.

1.1.2 The ocean and its uses

According to an Ocean Atlas of the United Nations, the uses that mankind has given the oceans have been the following (Unites Nations Atlas of Oceans, 2010):

- Fishing and aquaculture
- Tourism and recreation: sports fishing, boating, swimming, cruising
- Maritime transport
- Telecommunications: underwater cabling and infrastructure
- Human settlements along the coast: shoreline urbanization
- Mineral resource extraction: petroleum, gas and mining
- Energy: tidal, wave, thermal (Ocean Thermal Energy Conservation, OTEC) and wind
- Marine Biotechnology for the farming/extraction of pharmaceutical products and others.
- to which one could add:
- strategic military uses
- and other minor anecdotal uses such as:
- the creation of micronation taking advantage of the freedom the seas provide.

In conclusion, the oceans contribute to our lives with nourishment, energy and mineral resources; they provide means for transportation and other infrastructures. Additionally, they produce hydrocarbons through the undersoil reserves.

The oceans also play a strategic role and will continue to play a role of greater importance as it refers to recreational uses.

Definately, the oceans constitute a true **ocean of opportunities** to develop marine structures and thus an opportunity for Naval and Oceanic Engineering (NOE) as well.

Transportation

Military

Tourism

Energy

Figura 3: An “ocean” of opportunities for Oceanic and Naval Engineering[2]

In the majority of the occasions one could make use of the oceans and take advantage of the ocean of opportunities it provides, **which humanity has been force to colonize/settle in one manner or another**.

1.2 Oceanic Colonization

1.2.1 Definition

"**Oceanic Colonization**" can be defined as "the theory and practice of establishing **permanent human settlements in the oceans.**

Said settlements can float on the water's surface or be anchored to the bottom of the ocean floor, or exist in an intermediate position".

We have opted to create the following definition:

"Oceanic Colonization consists of the establishment of autonomous ocean communities aboard an artificial platform".

We make the following qualifications to the definition:

(The exchange of terms as follows): "Human Settlements" to be replaced by “Communities"; this last term providing an implicit reference to human settlements and additionally providing a notion of organization. "Permanent" is exchanged for "autonomous", it being understood that the fact of permanence does not imply colonization, but what it does confer is that they need to be "autonomous"—that they can fend for themselves.

[2] Images from left to right and top to bottom: “RN Privodino” of Factorias Vulcano, S.A.; “Juan Carlos I” of Navantia; cruise ship “Liberty of the Seas” in Ría de Ferrol; “Discovery Enterprise” of ASTANO, S.A.

Additionally, “aboard an artificial platform" will distinguish it from the colonization of a natural island, which is the meaning of colonization in its broadest definition, which is paralleled with any settlement on the continent.

For this reason we reserve the concept of "Oceanic Colonization" for those types of colonization that are born on any of the various oceanic structures such as ships, platforms, barge or any other novel concept as the newly-proposed *Very Large Floating Structures (VLFS*).

"Open ocean" is defined per the United Nations Convention on the Law of the Sea, UNCLOS III, which will be touched-on in Chapter 9 would be a part of seas/oceans specifically beyond the Exclusive Economic Zone (EEZ) and which is not under any nation’s sovereignty or jurisdiction.

In this manner, the "Establishment of autonomous regions on the high seas" that is the title of this thesis, refers to Oceanic Colonization for the creation of micronations.

Objective and forms of the Oceanic Colonization

Although many uses of the oceans exist, the objective of Oceanic Colonization is to establish communities in the oceans that would spearhead the development of those ocean uses.

That primary objective could be classified at the same time into four different sub-objectives:

1. Expansion of the vital land spaces along coastal zones with the creation of new logistical zones (such as floating ports/airports), or residential and leisure areas that replicate those already in existence on land.
2. Mobile settlements with logistical ends such as commercial, military, tourist, and residential.
3. Semi-permanent settlements to improve access to marine resources.
   These resources can be:
   - Energy: petroleum, gas, wind power, etc.
   - Biological: offshore aquaculture
   - Mining: Coastal underwater and deep (offshore) mining

- Sovereign oceanic micronations will provide the opportunity for experimentation with new forms of government or models of business that would be impossible in standard markets.

Generally, Oceanic Colonization is associated more with science fiction in the form of floating cities in the middle of the ocean.

Nevertheless, any autonomous community in the high seas already can be considered a form of Oceanic Colonization.

The crew aboard a fishing boat, an oil platform or a merchant ship would be a lesser form of Oceanic Colonization.

This is reflected in the following graphic, showing smaller to greater degrees of execution of Oceanic Colonization:

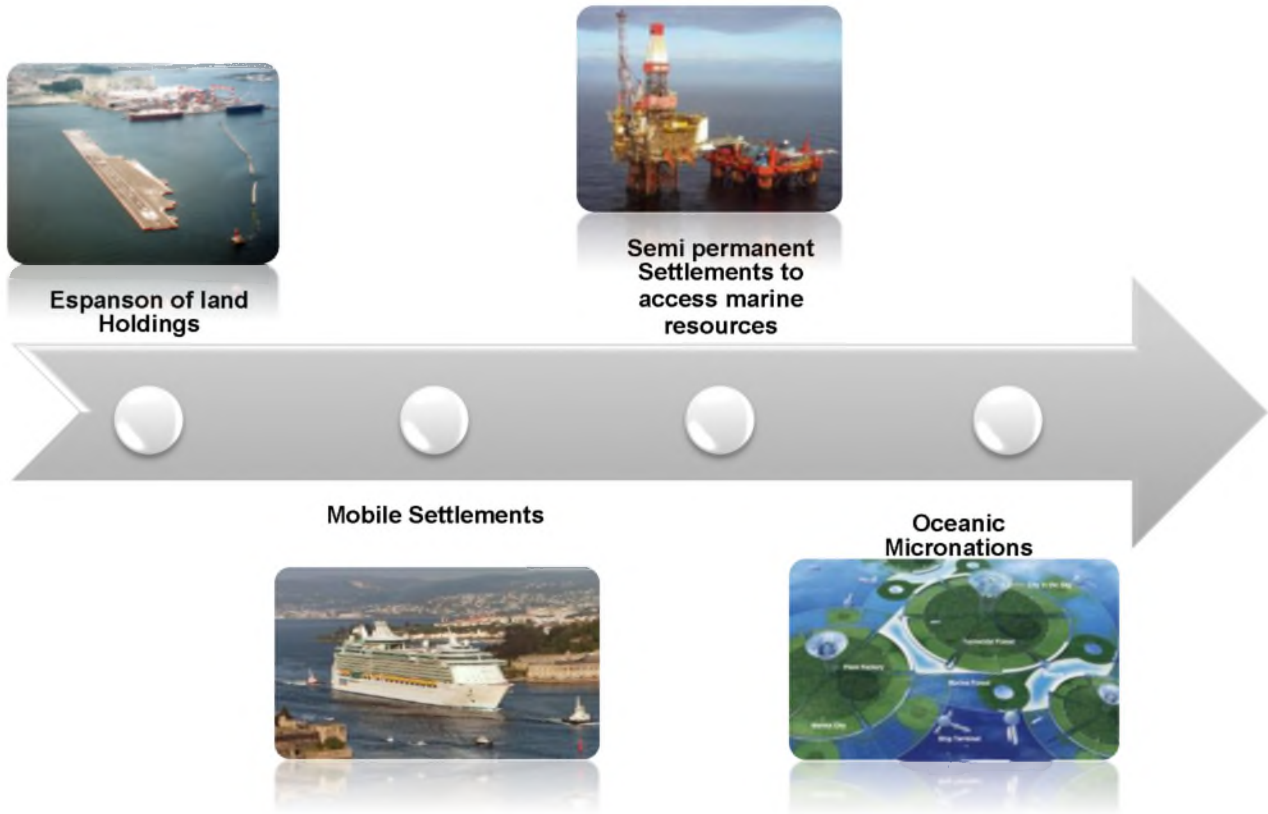


Figure 4: Forms of Oceanic Colonization from smaller to greater degrees of execution

The order present is also chronological. The ocean has been colonized for a very long time. As it occupies around 70% of the surface of the Earth, man has long been obliged to enter it:

1. Primarily by building small structures that would permit him to expand the coastal zone.
2. Subsequently aboard ships, constituting them mobile settlements.
3. Already in the 20th century with fixed settlements on the high seas with oil platforms.
4. **and the great-unknown-is, if the next step will arrive with the creation of oceanic micronations and above all, what form/s will they adopt?**

At the same time, each one of these forms of oceanic colonization has had its own evolution through time.

We introduce subsequently each one of these forms of oceanic colonization.

1.2.1.1 **Expansion of land holdings**

These settlements along the coast (or at the bank edges of rivers, or inlets, etc.) were the initial steps taken by humanity before entering the sea with their first ships.

Once the coastal populations developed, there was the need to win land to the sea and from there the need arose to expand the coastal space, chiefly gaining ground with backfill or with steered solutions.

This form of Oceanic Colonization has two limiting aspects: they have little degree of autonomy and they are not installed in the oceans, tending to be near or united to the shore, in interior sheltered seas.

And in fact, this expansion has been addressed by disciplines other than Naval and Oceanic Engineering, chiefly by:

- Civil engineering, in the shape of backfill, and steered solutions.
- Architecture, in the shape of "houseboats", where the house rests simply on a floating pontoon, normally of concrete, instead of sitting on pilings.

Nevertheless, it has been considered that they are relevant to the study Oceanic Colonization. Towards the end of the 20th century, restlessness arose at the possibility that expansion of land holdings could be done through large floating structures that would not necessarily have to be tied to the coast. It was then that the concept of the Very Large Floating Structures (VLFS) arose, and thus land expansion became a topic of study for Oceanic and Naval Engineering.

Figure 5: **Evolution land expansion into the sea.** From floating cabins in Thailand to the floating airport known as "MegaFloat" in Tokyo.

Previous to the concept of VLFS, that so far has been experimental, floating solutions already existed to expand land spaces. They are in the shape of floating pontoons a little larger than those of "houseboats" for use as hotels and floating parking. They were addressed by the INO, but due to their limited size, they were not considered a competing solution.

Some naval engineers, not long ago, have referred to this idea as *urbanizing the sea:*

Extending urban development by means of the use of floating infrastructures (González, Salamanca, Alvarez, & Alvarez, 2005).

1.2.1.2 **Mobile settlements.**

Since the Phoenicians that utilized them for commercial ends as "mobile"[3] (La Dame Masquée, 2010) shopping centers", to the cruise ships of nowadays that are authentic "floating vacation cities", mobile settlements have evolved thanks to technological advances and economies of scale.

In the beginning, mobile settlements responded to the need to lodge the crew of the ships - mostly merchantmen, but also military, or of passengers.

The evolution of the former, the large transatlantics, toward cruise ships in the first half of the 20th century marked a new form of mobile settlements. A new concept of ship is emerging: the residential cruisers that house permanent residents who can travel the world "without leaving home".

In any case, these forms of settlements have in common that the ships do port-stops frequently.

[3] *When they disembarked at port, they left their merchandise on the beach and they returned to their ships. There they waited for the people interested in acquiring the merchandise to placd next to the product of their election the equivalent trade that the buyer considered just. Once the trade was carried out the Phoenicians returned to the beach, and if they accepted the price, they collected it and they left the merchandise. Yet, if they were dissatisfied with the offer they then returned to their ships in wait of a better offering.*

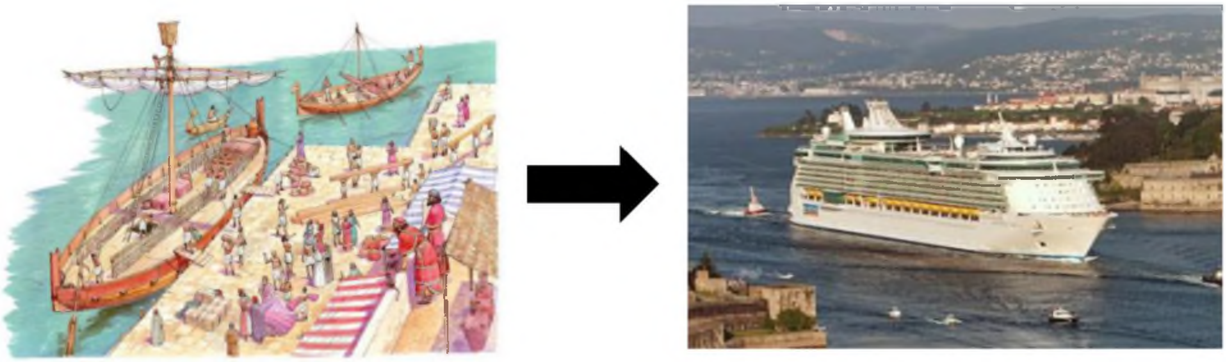


Figura 6: Evolution of mobile settlements. From a Phoenician ship that was used as a "mobile shopping center" to a mega-cruiser that is an authentic "mobile vacation city".

1.2.1.3 **Semi-permanent settlements for access to marine resources.**

- The ocean is an important source of resources:
  - It is used to extract petroleum and gas.
  - It is an important source of renewable energies: wind, waves, current, tides, thermal energy, among others
  - Minerals are extracted from it: salt, sand, gravel, and minerals such as manganese, copper, nickel, iron and cobalt.
  - It provides food such as fish and shellfish.

To permit the exploitation of these resources, the industry has had to provide lodging on the high seas to all those people responsible for its exploitation.

At first, crew were lodged aboard the platform that extracted resources. In recent years, an alternative has arisen for lodging: offshore ship hotels.

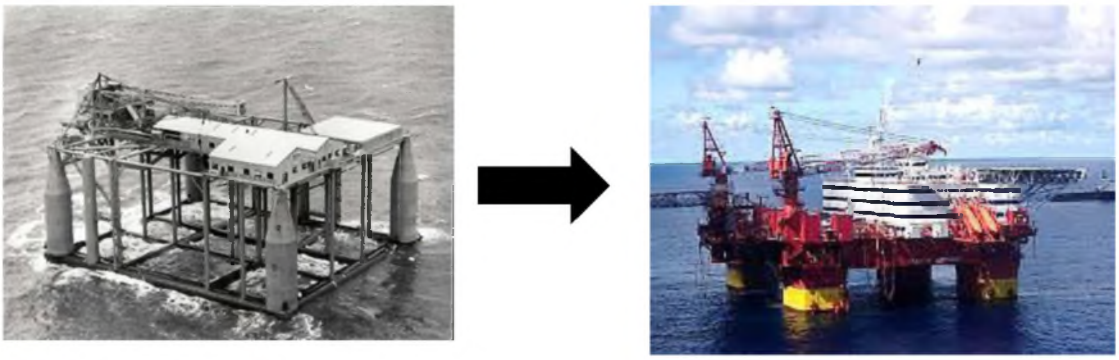


Figure 7: Evolution of semipermanent settlements from accommodations on semi-submersible platforms to modern offshore ship-hotels.

Therefore, the problem of providing lodging at sea of semi-permanent form has already been resolved.

So, in spite of the fact that up to now there have been no permanent settlements in the oceans; the oceanic industry seems prepared for the engineering challenges that will be encountered by colonization of the oceans in its more extensive sense. That is to say, the creation of oceanic micronations.

1.2.1.4 **Oceanic Micronations**

One of the first ideas of colonization of the oceans was expressed in the book *The Floating Island: The Pearl of the Pacıfic* by Jules Verne.

The plot of *The Pearl of the Pacıfic* (Verne, 1895) centers on an enormous city-ship. It navigates around the world with the mission of maintaining the political power equilibrium of the Southern Seas. But finally the savages of the Nuevo Hébridas and the forces of nature annihilate it. The social problem of the “floating island” is that its inhabitants are divided into two groups of adversaries, those of Port side and those of Starboard side.

That is to say, it had organizational and internal government problems.

Already in the second half of the 20th century, there have been several attempts to create oceanic micronations, albeit mostly failed ones. The most successful is *The Principality of Sealand*, and the most ambitious and most recent of the projects, though potentially unrealistic, is the *Green-Float* proposed by Shimizu Corporation.

Figure 8: Evolution of the micronations.
From the Principality of Sealand to the proposal of Green Float.

In principle, according to the Convention of the United Nations on the Laws of the Sea (UNCLOS III), it is not possible to exercise sovereignty on the high seas:

- *Article 89. Invalidity of claims of sovereignty over the high seas:*

  No State may validly purport to subject any part of the high seas to its sovereignty.

  But on the other hand, neither impediment to the peaceful establishment of artıficial islands is placed on the high seas:
- *Article 87 - Freedom of the high seas:*
- *[...] (d) freedom to construct artıficial islands and other installations permitted under international law, subject to Part VI;*

It also granted permission to all ships to travel unimpeded within the Exclusive Economic Zone (Article 58). The convention has not made a differentiation regarding artificial islands; thus a legal void exists which may shed some uncertainty on which efforts to create sovereign oceanic micronation are predicated.

1.3 The Evaluation and Application

Many lessons learned regarding ocean colonization can potentially be of use in space colonization.

The oceans are simpler to colonize, thus providing a consistent baseline from which a future colonization effort can be extended to outer space. For example, the adjustments to new social norms under harsh environmental conditions could be applied likewise to the colonization of outer space; additionally, many technologies can have application in these similarly adverse environments, such as in addressing habitability and energy generation.

The main discipline that addresses "Oceanic Colonization" is Naval and Oceanic Engineering. Nevertheless, of the four objectives it pursues, perhaps the best suited to oceanic engineering is the creation of oceanic micronations.

Save for a very few exceptions such as Clubstead, described later, there have been no proposals made regarding Oceanic Colonization by the discipline of Naval and Oceanic Engineering.

Other disciplines, chiefly architecture, have produced proposals to build oceanic micronations. Yet, without a sound technical base to support their vision, their primary objective often appears to be of self-promotion for the creators.

1.4 Dissertation Objectives

The objective of the investigation will be:

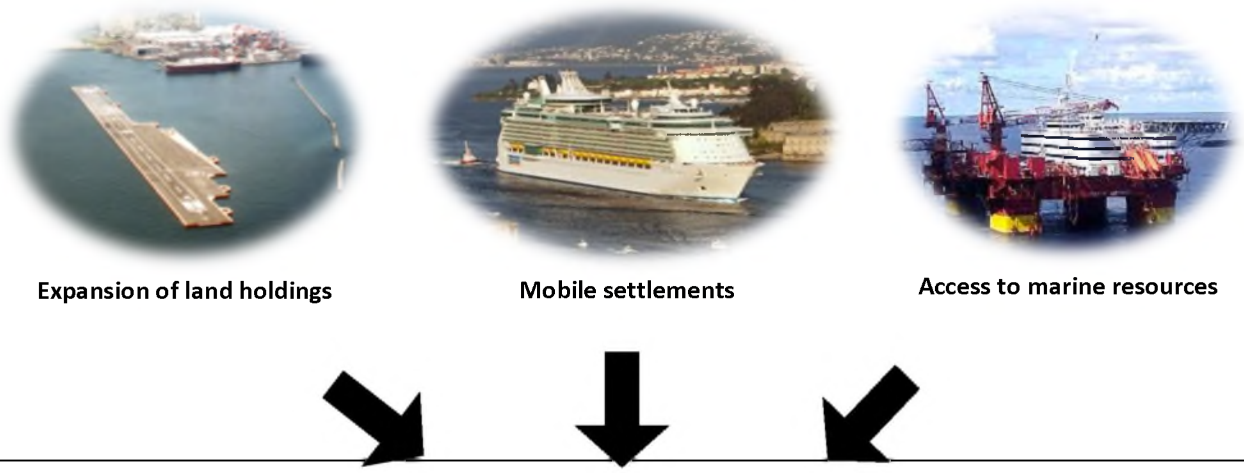
To analyze the possible options (present and future) that Oceanic and Naval Engineering can present for the establishment of autonomous communities on the high seas that would allow for the creation of oceanic micronation. At the same time, we will try to expound the future evolution of the other three forms of oceanic colonization: 1) the expansion of land holdings, 2) the establishment of mobile settlements and 3) the establishment of semipermanent settlements to access marine resources.

The work to be developed will not be so much the provision of a design detailing a specific structure, but to suggest answers to the requirements of this form of colonization (such as the price or the longevity of the platform), and from there to find the optimal solutions for this challenge.

We will study other forms of oceanic colonization, reviewing the latest technologies that could be of application to the creation of micronations.

1.5 Research methodologies

The objective of this dissertation will be to analyze the options that the oceanic industry presents for sovereign oceanic colonization. That is to say, to study other forms of colonization and to explore the results of their application to the creation of sovereign micronations, as outlined next:



Oceanic Micronations

Figure 9: From other types of colonization we will see what lessons apply to oceanic micronations.

From there, we will try to draw a possible scenario for the creation of oceanic micronations.

Before continuing, we will evaluate the various proposals that have already been made regarding micronations and why they have not succeeded.

Therefore, the steps we shall take shall be as follows:

1. **To analyze sovereign oceanic colonization**, its present and past attempts, theoretical proposals, and the motivations to build them. Also, we will see the proposals of floating cities to colonize the ocean, presented by disciplines other than Oceanic and Naval Engineering.
2. **Setting up the Scope**. We will define the requirements of a sovereign autonomous community on the high seas. That is to say, what demands are required so that a project of oceanic colonization can be successful, with particular attention to proposals aiming at sovereign communities? We will explore possible alternatives within other types of oceanic colonization and their application to oceanic colonization with sovereignty goals.
3. **Research possible alternatives** amongst other types of oceanic colonization and their application to oceanic colonization with sovereignty objectives. See prior figure.
4. **Analysis of the findings:** we will analyze the previous results and develop possible future scenarios, especially of oceanic colonization.
5. To wrap up, we will present conclusions to the analysis presented.

1.6 Dissertation structure

The previous steps will be structured in these parts and chapters:

- **Part I: State of the Art**

We will dedicate **Chapter 2** to the State of the Art of Oceanic Micronations, a review as to why someone would want to establish an oceanic nation in the seas considering the higher cost and added technical and legal difficulties that would ensue.

We will overview the most significant attempts since the conclusion of the 20th century, when technology had sufficiently developed for such attempts. We will also present a brief introduction to the concept of the micronations.

The dissertation has been drafted from the the point of view of "Oceanic and Naval Engineering", and part of the objective is therefore to show that it is this discipline that should provide a response to the challenges of oceanic colonization, as opposed to other disciplines, chiefly Architecture.

Chapter 3 is focused on the review and evaluation of those proposals. Although many of them may lack technical exactitude required for their implementation, their study is important to show that any proposal, for it to be feasible, requires that it meet basic principles of Oceanic and Naval Engineering.

- **Part II: Setup and Challenges**

In Chapter 4, we will examine the requirements a proposal should meet in order to **establish a successful autonomous community** on the high seas, and how Oceanic and Naval Engineering can provide a solution for the challenges to be encountered.

- General requirements will be established for all forms of oceanic colonization, but special emphasis will be given to the formation of oceanic micronations.

- **Part III: Results**

In this third part, we will study the three forms of oceanic colonization that broke through the realm of ideas and become reality. But as they are topics that have been addressed previously in various books, articles or in other dissertations, **we have focused the review efforts on platforms that, with the purpose of colonization, could be applied to the creation of micronations.**

Chapter 5: We will study the present situation and future trends of the cruise industry, paying special attention to the residential cruise ships and mega-cruise ships. Other mobile settlements exist, such as merchant military, fishing vessels, etc. But the cruise ships are the mobile settlements with the greatest passenger capacity, and therefore of possible application to the creation of oceanic micronations.

Chapter 6: The first section, **Chapter 6.1** focuses on the coastal floating hotels (a.k.a. Coastels).

These vessels are utilized to satisfy a variety of needs along coastal zones. Their objectives are not to provide access to energy resources, but to expand the coastal space/land holding expansion.

For pedagogical reasons, we have preferred to dedicate an entire chapter to floating hotels in general.

In part two, Chapter 6.2, we will describe the technologies utilized today in the maritime sector to give lodging to workers in a semipermanent basis on the high seas— the floating offshore **Hotels.**

This technology has been developed chiefly for petroleum and gas industry for cases where the main structure is dedicated to the exploitation of those reservoirs, and is unable to accommodate the required personnel.

Chapter 7: will be dedicated to the study of platforms proposed for the **expansion of land holdings in the form of a floating surface.** To this theme we dedicated a chapter and a half.

As we have commented, **Chapter 6.1** would fit within these objectives.

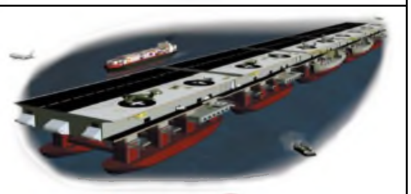
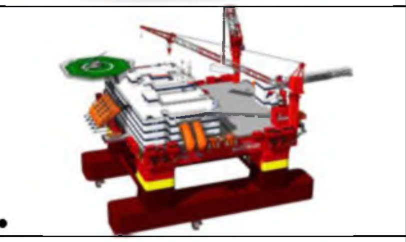
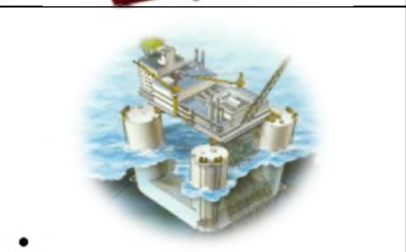
In Chapter 7, other far more ambitious structures will be analyzed. Although they are mostly theoretical, they could be good candidates for oceanic colonization if the required technology develops sufficiently to offer a competitive price: they are the **Very Large Floating Structures, VLFS.**

These experimental structures are being investigated for many purposes, such as military bases or for floating airports on the high seas. In fact, **Chapter 7.6** is dedicated to Mobile Offshore Base (MOB) that responds better to the objective of oceanic colonization in the shape of mobile settlements, specifically for military uses.

Chapter 8: We will study **Concrete Offshore Structures.** They offer great potential as structures that could provide us with a view toward the future of the oceanic colonization. Thus, It is justified to emphasize their enormous potential.

Chapter 9: We shall address the legal aspects of oceanic colonization, examining the Law of the Sea and the legal requirements any floating structure for ocean colonization should comply with. These requirements include those established by the Marine International Organization, (IMO), and those of the Classification Societies.

In the following table we show in a summary of the review.

Chapter	Platforms Reviewed		Forms of Oceanic colonization
7	Very Large Floating Structures - VLFS		Expansion of land holdings
6.1	Coastal floating hotels - Coastels		
5	Mega-cruisers and residential cruisers		Mobile settlements for residential, tourist, military or commercial use with logistical aims.
7.6	VLFS as MOB – Mobile Offshore Bases		
6.2	Floating offshore hotels - Floatels		Semi-permanent settlements to improve access to marine resources
8	Concrete Offshore Structures		All

• 9	Regulation and legal aspects to establish platforms in the oceans		All

Table 1: Summary of the review of platforms for the establishment of oceanic micronations.

Part IV: Analysis of results and proposals.

Chapter 10: We will analyze the results, and examine the future trends of each of the forms of oceanic colonization.

We will allocate a larger segment to the review of sovereign oceanic colonization based on the discussed platforms, and a timeline shall be proposed as to how each of those platforms might develop towards their use as colonizing tools.

Part V: Conclusions

Chapter 11: We will gather all the conclusions, review them based on parameters common to all dissertations such as originality, methodology, relevance of the findings, and evaluate the results, conclusions and suggestions as well as recommendations for future work.

Part VI: Appendices

During the execution of the dissertation, prominent aspects have been studied to better understand the idea of oceanic colonization: parting from dynamic systems aimed at maintaining the platform's position and anti-rolling, anchoring and hitch systems, and the review of basic principles for semisubmersible platforms. They are topics beyond the scope of this dissertation, so they have not been incorporated into the final document.

Nevertheless, we have considered them topics of interest so we include each in a separate chapter. They address the primary engineering challenge of colonization of the oceans: how the platforms and floating structures behave in open ocean. It will be a simple overview to this segment of naval architecture.

Chapter 12: The behavior at sea of floating structures. We have also left for the appendix other research performed in parallel during the drafting of this dissertation.

Chapter 13: proposals for locales and structure types best suited to the creation of micronations.

In Chapter 10 we discussed possible scenarios for the future evolution of oceanic micronations, but without exploring concrete details.

We have left to the appendix some of those concrete proposals for locales and platforms types that would best fit such a scenario.

As neither the locales nor the platforms are a reality, they are only presented as proposals. We have decided not to present them as viable solutions to the challenge that we formulated, but have decided to present them as examples within the appendix.

PART I: STATE OF THE ART

2 Oceanic colonization with sovereignty aspirations: Oceanic Micronations

2.1 Introduction

City-states (or microstates) have always been one of the main economic, cultural and social hubs for humanity: from the Greek city-states (Athens, Sparta), or Italian (Venice, Florence), to their newest forms such as Singapore or Hong Kong. Many economists, like Paul Romer[7] with his concept of Charter Cities[8], maintain that it is the liberty for self-government that facilitates such a high degree of development.

On several occasions, people have attempted the creation of sovereign "micronations" on artificial islands, but so far, these attempts have failed to achieve international recognition or attract many citizens. The best-known example is the *Principality of Sealand*. In general, these attempts fail not only as it pertains to engineering, but especially in those requirements of a commercial, political and legal nature (Lamas Pardo & Carral Couce, Estado del Arte de la Industria Oceánica para el Establecimiento de Comunidades Autónomas en Alta Mar, 2010). Engineering requirements have been neglected or not approached in a rigorous and thorough manner. As we pointed out in the prior chapter in reference to the four objectives that any oceanic colonization attempt should follow in the establishment of oceanic micronations, the least known and developed is that of Oceanic and Naval Engineering. Yet it this colonization type that has been addressed on many occasions by other disciplines.

In this chapter we shall discuss oceanic colonization with aims at sovereignty (the creation of micronations on artificial islands), and review past attempts, their motivation, types of platforms proposed, and the reasons for which these attempts have failed or not prospered. We shall also provide a small introduction to microstates and to micronations, attempting to discern their differences, as the term "microstate" which has a connotation of an independent state, which should not be confused with "micronation" which is neither a state nor independent.

2.2 MICROSTATES AND MICRONATIONS

These are two concepts frequently confused. As a mode of introduction one can say that a "microstate" is a community with a small delimited territory that has been recognized as sovereign by the international community and at the same level as the larger "nation-states" and thus the microstate participates and forms part of international organizations, such as the United Nations (UN). When such an entity has not yet achieved recognition, it is termed a "micronation". As such, any community that aspires to receive the designation of "microstate" has to be previously designated a "micronation" Additionally, there is a third designation of "special territories" which are an interim stage between a microstate and a micronation, as they are independent territories yet have not attained presence at the UN and generally are still under the management of a macrostate.

The following table summarizes the three conceptual minor national entities (both in population and/or territory) and their equivalents in major national entities.

7 Paul Romer (1955) is an economist, enterprising and activist from the University of Chicago. At present he works at the University of Stanford (EE.UU.).

8 A *Charter City* is a city whose system of government is defined by the city itself and not by state, province, regional or national laws. Examples of these Charter Cities can be found in California at the *League of California Cities*: http://www.cacities.org/chartercities/

Extent and population	Without International Recognition	Without a UN presence, yet with International recognition	With presence in the UN
> 1000 km^2 and > 500,000 residents	-	**States without full recognition:** Abkhazia, Ossetia of the South, Turkish Republic of Northern Cyprus, Sahrawi Arab Democratic Republic	**Macrostates or Nation-States** Spain, USA, France, China, Holland, etc.
< 1000 km^2 or < 500,000 inhabitants	**Micronations** i.e: Seborga, Hutt River, Sealand	**Special Territories** Isle de Man, Channel Islands, Gibraltar, Macao, Hong Kong	**Microstates** Singapore, The Vatican, San Marino, Monaco, The Republic of Nauru
	• **Minimum**	**SOVEREIGNTY LEVEL**	**Maximum** →

Table 2: Micronations and Microstates

2.2.1 Montevideo convention

The *Montevideo Convention* on the Rights and Duties of States[9] establishes in Article 1 the criteria as to how to define a "state". It reads:

"The state as a person of international law should possess the following qualifications:

I. permanent population

II. a defined territory

III. government

IV. capacity to enter into relations with the other states".

Additionally, Article 3 states: *"The political existence of the state is independent of recognition by the other states".*

Under these guidelines, any entity that satisfies these criteria could be considered a sovereign state as per international law, whether it be recognized by other states or not[10]. As such, nations and territories that have not been able to satisfy all criteria are not considered states, the fourth requirement generally being not met as is the case of large territories such as Occidental Sahara or

[9] The **Montevideo Convention on the Rights and Duties of States** was a treaty signed at Montevideo, Uruguay, on December 26, 1933, during the Seventh International Conference of American States. The Convention codified the declarative theory of statehood as accepted as part of customary international law. At the conference, United States President Franklin D. Roosevelt and Secretary of State Cordell Hull declared the Good Neighbor Policy, which opposed U.S. armed intervention in inter-American affairs. This was a diplomatic attempt by Roosevelt to revert the perception of "Yankee Imperialism" sowed by the policies instituted by his predecessor, Theodore Roosevelt. The convention was signed by 19 states. The acceptance of three of the signatories was subject to minor reservations. Those states were Brazil, Peru and the United States. The European Union is the primary affirmation of its Bdinter Committee. It follows the Montevideo Convention in its definition of state: for holding land, have a population and a political authority. The committee as well has concluded that the existence of a state was a matter of fact, while the recognition of those was only a factor of a declaratory scope that does not determine statehood.

[10] Some have questioned whether the criteria set forth are sufficient, as to allow statehood of entities not universally recognized such as the Republic of China or even such states without statehood recognition such as the Principality of Sealand. According to the alternative theory of statehood, a state exists in as much as it is recognized by others as such.

Ossetia of the south, or of the special territories of Isle of Man or Hong Kong. In the case of micronations, in most cases, none of the requirements are met[11].

We shall explain with greater detail and with examples the difference between "microstates", "special territories", and "micronations".

2.2.2 MicroStates

A microstate (or ministate or city-state) is a sovereign state that has a small population of less than 500,000 people; it is a sovereign state with a very small area of less than 1000km^2 or both. Andorra, Monaco, Bahrain, Singapore, San Marino, Liechtenstein, Nauru, Palau, Tuvalu (a.k.a Ellice Islands), Saint Kitts and Nevis and the Vatican are examples of microstates. Microstates have an important influence role in the General Assembly of the United Nations (UN) due to its organizational structure which allots each state a vote.

2.2.2.1 The Republic of Nauru

The Republic of Nauru is a Micronesian state situated in the Central Pacific Ocean and is composed of a single island, an oval-shaped atoll, just south of the Equator. It has a surface of 21.3 KM2 and a population of about 13,770. It is the smallest island nation of the world and the smallest Independent Republic and the smallest UN member nation with the smallest population.

Figure 10: Republic of Nauru.

The Republic of Nauru had great phosphate deposits which had been exploited since the 20th Century by foreign enterprises. In 1968, the founder of the new republic, "Hammer" Deroburt, had won the Independence from Australia (even if it never became a part of the UN until 1999) and with it to fulfill his promise to nationalize phosphate. So through the 70s and 80s this little island became one of the nations with the greatest per capita income in the world. However, once the resources were exhausted during the 90s it has reverted to great poverty and the majority of their inhabitants find their daily sustenance by going out to fish. So its greatest economic development failure was to

[11] There have also been attempts to widen the definition espoused by the original Montevideo Convention, though they have received little support. The founders of micronations, without territories, generally promote the idea that the requirement of having a defined territory ought to be removed. Some entities without territories, of which the Order of Malta is its most notable exponent, are considered an independent subject of international law, but they do not aspire to statehood.

depend on only one resource without developing other sources of income and activities. Today, their aim is to diversify their economy, primarily as a financial center.

Despite this, the example of Nauru, a little island with great resources, has obtained its independence. This has served as an example and encouragement to other micronations that aspire to receive a microstate designation.

2.2.3 Special Territories

These are territories that though they have not yet reached full sovereignty and thus have no UN representation, they are bestowed with certain level of independence from the macrostates that manage them.

- These are some examples of special territories:
- The *British* Overseas Territories like Gibraltar, Holland, France, Norway, etc.
- The three Crown *Dependencies* are British possessions of the Crown, amongst them Isle of Man, and Channel Islands
- China's administrative regions of Hong Kong and Macao.

2.2.3.1 Isle of Man

Isle of Man is a Crown dependency of the British Crown that has had autonomous government since 1786. It is formed by the main island and islets located within the Irish sea (between Ireland and Great Britain). The island expands across 572 km^2 (221 square miles), has a population of about 80,000, and issues their own money, the manx pound.

Per British law, Isle of Man is not part of the United Kingdom (UK). However, the UK is responsible for its foreign relations, defense, and to some degree, it legislates it.

Today, the most important political party on the island, Liberal Vannin Party promotes greater Manx independence and greater responsibility by their government. Others, like *Mec Vannin* - The Manx Nationalist Party, seek complete independence from the UK and establishing a sovereign republic on the isle.

Figure 11: Isle of Man

2.2.4 Micronations

A "micronation" is an entity that claims the right to be an independent and sovereign nation or state, but lacks recognition from international bodies, such as the UN. They differ from small states with minimal official recognition but in practice are independent, and may have some type of recognition, as is the case Abkhazia, Ossetia of the South, Turkish Republic of the North of Cyprus, as well as special territories under the administration of other macronations. They are also referred to as "new nation projects" and new model nations

The micronations are formed by small aggregations or communities than do not exceed a hundred people, and most do not have more than one or two active participants. However, there are a few such as Seborga and Hutt River, which hold significant territory and have a population of over 10,000.

A common characteristic of these type of micronations is that they issue their own passports, seals and currency, but are rarely are recognized outside of their sphere of influence.

The aspirations that have motivated these communities to seek and create a micronation, could be summarized in the following list:

1. Social, economic and political simulations.
2. Entertainment.
3. For fantasy or creative fiction.
4. As an advancement of a cause.
5. Fraud.
6. For historic anomalies and aspiring states.
7. New nation projects.
8. Historic revisionism.

The project known as The Seasteading Institute, which we shall discuss more in chapters ahead, appears to be motivated by reasons 1 and 7. They favor the creation of a new nation (motive 7) to create experimental opportunities in the economical, social and political realms.

In contrast to imaginary nations and other social groups such as ecovillages, clans, or sects, The Seasteading Institute aspires to a certain level of sovereignty over a specific land holding. For this reason, these "nations" exist only in reduced realms, in small physical spaces or simply as theoretical projects only find a virtual window of expression via the internet. Physical spaces that are claimed can be continental territories, natural islands or artificial islands. We shall examine some examples.

2.2.4.1 Micronations within Continental Territories: Principality of Seborga.

Seborga is an Italian municipality with 362 people which inhabit the province of Imperia, near the border to France. Based on historical documents, in the 1960s the leader of an agricultural local cooperative named Giorgio Carbone, has a vision of an independent Seborga. In 1963 he was elected as chief of state and later named Prince Giorgio I of Seborga. In 1995 the population voted in favor of a Constitution for the principality. Naturally, these claims have not been recognized by Italy nor by the international community. Giorgio Carbone died in his small kingdom on November 25, 2009 without progeny, and with him this micronation found also its demise.

2.2.4.2 Micronations in Natural Islands. The Principality of Outer Baldonia.

An example of a micronation is the natural island of the principality of Outer Baldonia, a rock (the isle of "Outer Bald Tusket") of about 16 acres near the coast of New Scotland and has been founded by Russell Arundell, Executive Director of Pepsi Co, in 1945, and it consists of a population of about 69 fishermen. Today, with the passing of his founder, this principality is no longer active.

2.2.4.3 Micronations on artificial islands

This dissertation is centered on this type of specific "micronations": those that have been established on artificial islands, and which differentiate themselves from those established on natural territories either continental, or virtual. The following sections will be dedicated to their analysis.

2.3 Micronations in artificial islands

2.3.1 Introduction

The primary reason to promote oceanic micronations on artificial islands is that there are no vacant places on land that has not been claimed by a nation. To claim any part of existing land would create a conflict with the nation that holds sovereignty over said territory. Though the open ocean beyond the Exclusive Economic Zone (EEZ) has certain restrictions, there exists a legal void that would allow for the creation of a micronation, though obviously it would be more of a technically challenging proposition than it would be on emergent land.

2.3.2 Legal voids for the creation of Micronations in open oceans

Outside of the EEZ, beyond 200 nautical miles (370 km) from land, the nation would not be subject to any law of any sovereign nation, only to the laws under which the would wish to sail whether it be a ship or a platform. An example of an organization that already makes use of this freedom is *Women on Waves*[12], which provides abortions to women from countries where laws ban abortion or are stricter as it refers to that allowance. Another is *Radio Veronica*[13] a pirate radio station that sailed the North Seas with transmissions to the Netherlands during the 1960s. Similar to these organizations, an autonomous community in open ocean could benefit from the more flexible laws and rules in international waters and thus in aspire to be mostly self-governed.

However, The United Nations Convention of the Law of the Seas III (UNCLOS) does not provide a provision to exert sovereignty over any portion of the ocean while at high seas.

- *Article 89 – No state may validly purport to subject any part of the high seas to its sovereignty.*

Although, on the other hand, there is not an overt impediment to the peaceful establishment of artificial islands in open oceans:

- *Article 87 – The high seas are open to all States whether coastal or landlocked Freedom to construct artificial islands or other installations permitted per international law.*

Moreover, once inside of the EEZ there is also allowance for unhindered navigation with vessels (Article 58). The convention has not exhaustively differentiated artificial islands. **As such, there is a legal void in which the attempts at establishing oceanic micronations are based.**

2.3.3 Micronations and oceanic communities

Though nowadays there are communities or oceanic colonies as we have seen in Chapter 1, there have been few instances in which said communities have made a claim of independence. Each of them constitutes a form of oceanic colonization upon whose experience one can draw knowledge for the creation of micronations:

- Floating hotels
- Marine investigation stations
- Houseboats
- Stilted homes over seafloor
- Lowlands below the sea level behind dikes
- Cruise ships
- Oil platforms
- Merchant vessels

[12] More information www.womenonwaves.org
[13] More information: http://es.wikipedia.org/wiki/Radio_Ver%C3%B3nica

- Etc.

Moreover, the scattering of humanity across little islands across the world has occurred for thousands of years and continues today. Utilizing modern technology to actually create artificial islands is only an incremental step towards continued expansion of civilization.

We shall see following the attempts in some oceanic colonies to reclaim their Independence or sovereignty.

2.4 Real attempts to create micronations on artificial islands

As mentioned, there have been several attempts at oceanic colonization on artificial islands for the creation of a micronation. We shall present the most successful attempts:

2.4.1 Sealand

The *Principality of Sealand* is probably the most successful oceanic micronation effort to date. *Sealand* was founded in 1967 by Roy Bates, an operator of a pirate radio station that was relocated to an abandoned antiaircraft platform during the Second World War known as *Rough's Tower*. The platform was located about 7 miles off the British coast and thus was within international waters.

Figure 12: *Sealand* Site Map showing its location along the British coast.

Sealand has not been recognized officially as a sovereign State by any other State nor by the UN, though Roy Bates claimed that it had been recognized by Germany as they had sent a diplomatic delegation to the micronation, and by the United Kingdom once their court had dictated that they had no jurisdiction over *Sealand.*

More Recently, Prince Roy has retired, and *Sealand* has been transferred to *HavenCo* which did business from it as *Haven Data*[14] for several years. In 2008, this venture ceased operations without explanation. In January 2009, the *Kingdom of Marduk* claimed the property of *Sealand,* asserting that the property had not been noted in the post-Second World War inventory and as such could be claimed by anyone. Michael Bates, son of Roy Bates rejected the claim as new Prince of *Sealand*. To date, *Sealand* is inactive.

[14] A **data haven**, like a corporate haven or tax haven, is a refuge for uninterrupted or unregulated data.

Figure 13: The platform on which *Sealand* was founded and its code of arms.

2.4.2 The Republic of Rose Island

The Republic of Rose Island (Respubliko de la Insulo de la Rozoj, esperanto) was a short-lived artificial structure constructed in the Adriatic Sea about 11 km of the coast of Rímini, Italy. The platform on this micronation was established consisted of 9 pilings and a surface of 400 m^2. It was built in 1967 by its president; the Italian Engineer Giorgio Rosa and it contained a restaurant, a bar, a club, a souvenir store, a post office and its own radio station. On June 24, 1968, the artificial island declared its Independence and printed its own seals and declared its own currency. A short time after this declaration, a group of Italian Carabineers (Italian Police) and inspectors seized the island. The active government of the occupation sent out a telegram in protest, but it was ignored. Quickly after seizure, the island was destroyed by the Italian Armada.

Figure 14: The platform on which the micronation was founded and its flag.

2.4.3 Republic of Minerva

The Republic of Minerva was an idea of a Nevadan entrepreneur named Michael Oliver, who at the beginning of the decade of the 1970s announced his plans to claim land in the southern Pacific Ocean and build a city-state inspired by liberalism, and able to sustain a population of 30,000 inhabitants.

The chosen location was the Minerva Reef, a group of underwater reefs, to this day unclaimed, situated 400 miles south of Fiji and 260 miles west of Tonga. In 1971, some barges filled with sand came from Australia bringing the level of the reef to above sea level thus allowing the construction of a small tower and the placement of a flag. *The Republic of Minerva* declared its Independence on January 19, 1972. Unfortunately, the only nation that acknowledged *Minerva* was Tonga, and only to claim jurisdiction of the reef. On June 21 1972 an expedition from Tonga was sent to make the reclamation effective and the Tonga flag was raised. Eventually, the atoll was claimed officially by the Republic of Tonga. *The Republic of Minerva* did not produce mail seals or currency during its short existence. Its only currency was recorded as a bi-metal simple coin.

Figure 15: Location map to the Minerva Reefs and Republic

Figure 16: Minerva Reefs

2.4.4 REM Island

REM Island was a platform built in Ireland and towed to Dutch shores in 1964 and achieving its final destination 6 miles off Noordwijk, from which a pirate Radio and Television station known as Noordzee attempted to transmit radio and television signals to Holland. At the time, the location was beyond the territorial waters of Holland. The structure was anchored via stilts to the ocean floor. Later that year, in December, the seafloor at that location was claimed as Dutch Territory and the station was dismantled.

Figure 17: REM Island

2.5 Theoretical proposals for the creations of micronations on artificial islands

As seen in the prior section, there have been real proposals for the creation of micronation in the oceans--all with similar objectives. These attempts were unsuccessful as each failed to take into account critical factors for success, including platform requirements, commercial, legal and self-government considerations.

In addition to the former attempts, there have also been intellectual or theoretical proposals that have not reached any level of becoming concrete realities. One of the more recent proposals is that of *The Seasteading Institute*. Before launching a physical attempt to establish a micronation, they are undergoing a rigorous study to determine the critical factors to succeed in the proposed enterprise, that we have previously alluded to. As we shall make reference to them throughout the dissertation, we shall provide a brief introduction along with other minor projects.

2.5.1 OCEANIA – The Atlantis Project

2.5.1.1 Description

In February of 1993, *The Atlantis Project* proposed the creation of a floating city in the ocean to be called *Oceanía*[15], receiving attention in magazines like *The Art Bell Show*, *Details Magazine*, *The Miami Herald*, *Boating Magazine*, as well as global publicity in Canada, New Zealand, Hong Kong, England, and Belgium. Within a year, the project lost popularity and saw its demise by April 1994. This is what its proponent Eric Klein's wrote at the beginning of 1994:

> *The Atlantis Project is dedicated to the goal of establishing a new country named Oceania. This country will be devoted to the value of freedom, and will first exist as a sea city in the Caribbean. As no collectivist nation is likely to sell us the land they need, we will build an island out of concrete and steel. At this point, the organization behind this new country, The Atlantis Project, is building the necessary financial resources to pay off past debts and to pay for the completed model of Oceania. Once this task is completed, The Atlantis Project will go into full gear and go well beyond its peak reached in early 1994 when it was covered by media across the U.S. and the world -- including the BBC, the Miami Herald, the Art Bell Show, Boating magazine, and Details magazine.*

These are the reasons the founder gave as to the project's cancellation (April 1994):

> *In retrospect, the biggest problem concerning The Atlantis Project was lack of interest. Lack of interest and the fact that its precepts were based in Libertarian politics. The Libertarian party is small in numbers and too few members have the financial resources to bankroll their beliefs. The poor performance of Libertarian candidates throughout the nation is reflective of these sad facts.*

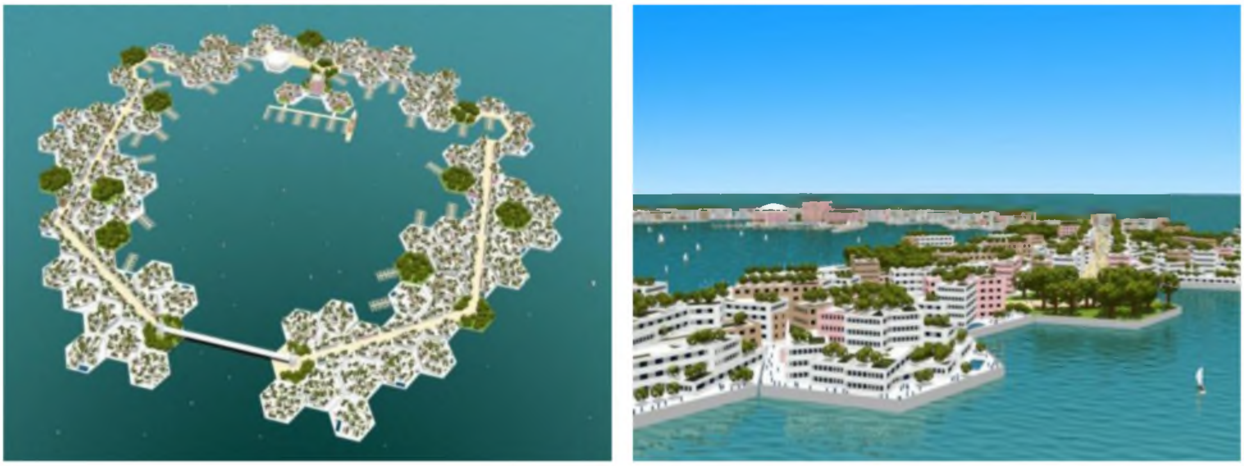


Figure 18: Images created by Jim Albea for the Project Atlantis

[15] http://www.oceania.org/

2.5.1.2 Analysis

Thanks to interactions with direct collaborators on the Project, we have gleaned the real causes as to why the Project was terminated so abruptly - poor investments or mishandling of funds donated by the sympathizers of the Project by its proponent. This is far from the official reason given.

The design was based on a technology called *Seacells*, something like cylindrical polyethylene floaters that were vaguely described.

To this end the project was little more than a declaration of intentions and fancy 3D sketches that never saw fruition.

2.5.2 The Principality of New Utopia

2.5.2.1 Description

The principality is a proposal for a micronation involving the construction of an artificial island to be located at the Misteriosa Banks, about 160 miles west of the Caiman Islands in the Caribbean Ocean. The ambition is the establishment of a fiscal paradise with about 50,000 to 100,000 permanent residents. It is to be the "Venice of the Caribbean" according to its proponent Lazarus Long (a.k.a. Howard Turney).

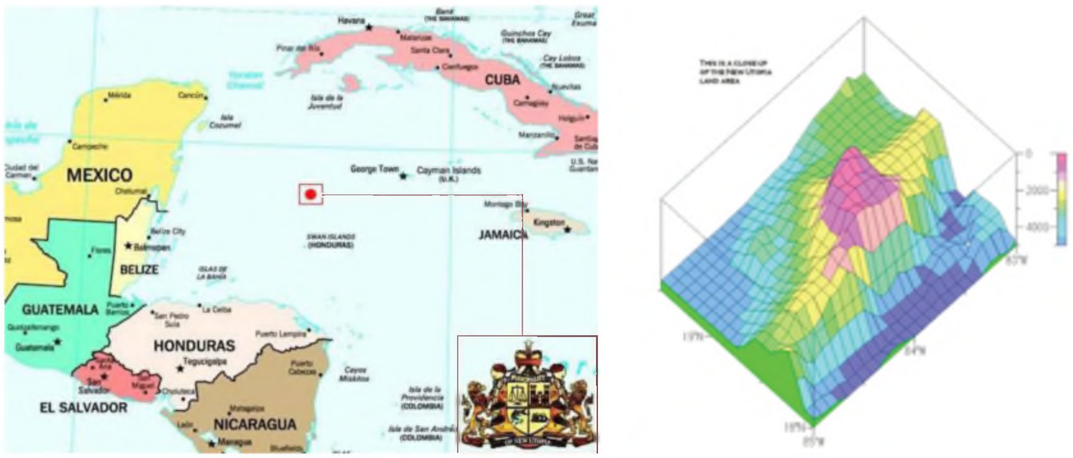


Figure 19: Principality of New Utopia (PNU), site map and the Misteriosa Banks

2.5.2.2 Analysis

Details of the artificial platform were not even mentioned. Their proposal only included rendered images.

The proposed geographic location is within the Exclusive Economic Zone of the Government of Honduras, which makes it impossible to establish an artificial island without the consent of said government; even though the proponents of PNU claim in a legal document (18) that this would not be an impediment to achieve this project.

The majority of the media that have covered it have declared it a fraudulent project similar to that of Atlantis, geared to lure enthusiasts of oceanic micronations to invest. Despite the many warnings by the US Government that this is a fraud, the website remains operational and able to solicit funds.

2.5.3 The Seasteading Institute

2.5.3.1 Description

The Seasteading Institute [16](TSI), with its headquarters in Oakland, California, is a non-governmental organization founded in 2008 with the mission of promoting the establishment of autonomous communities in international waters. By opening a new frontier, the Institute attempts to revolutionize the nature of government by allowing a new space for innovation and competition among political and social systems. The book *Seasteading: A Practical Guide to Homesteading the High Seas* (Friedman & Gramlich, Seasteading: A Practical Guide to Homesteading the High Seas, June 2009), is the first publication by the Institute and it responds to questions as to why to establish new nations in the ocean and why prior attempts have failed.

Figure 20: *The Seasteading Institute's logo*

The Institute synthesizes its mission and vision in its long term and short term strategy, which is exemplified below in its original text:

> ***Our Mission***
>
> *The Seasteading Institute's mission is to further the establishment and growth of permanent, autonomous ocean communities, enabling innovation by promoting new political and social systems.*
>
> ***Our Vision***
>
> *The Seasteading Institute believes innovative political systems could serve humanity far better than our governments do today.*
>
> *That's why we work to enable "seasteads"—floating cities—which will give people the opportunity to peacefully test new ideas about how to live together. The most successful will become thriving new societies—inspiring change around the world.*
>
> *We're creating this future because our governments profoundly affect every aspect of our lives, and improving them would unlock enormous human potential.*
>
> *Before the end of this century millions of people will inhabit seasteads. They will choose seastead life because of the positive effects of advanced innovative governments, including better job markets and higher standards of living.*

2.5.3.2 The Seasteading concept or marine appropriation.

Seasteading is a coined word that is formed by the combination of two terms, sea and homestead, implying a form of oceanic colonization with the purpose of creating new forms of government. Permanent habitable residences on the ocean, located outside of the jurisdiction of any existing government, are called *seasteads*. To date, two persons have coined the idea in an independent form through their writing: Ken Neumeyer in his book "*Sailing the Farm*" (1981) and Wayne Gramlich in his article "*Seasteading: The Homestead of the High Seas*" (1998).

[16]Official website: www.seasteading.org

Thus one can say that the term *seasteading* is an expression of *oceanic colonization with a sovereignty objective.* As such it can be the term that we could use when referring to the four objectives that need satisfaction in order to achieve viable oceanic colonization: the creation of oceanic micronations.

2.5.3.3 Dynamic Geography

Should these oceanic colonies be static or free-floating/mobile? TSI foresees that these islands will be free-floating and modular - modular in the sense that they will be able to take advantage of their capacity to float in the ocean and thus be able to join or not join other pods/modules as they see fit. This is a key concept – to have the freedom to come and go, to be or not part of a particular government. If *seasteaders* are content with their government, then they shall remain; if not, they can abandon their pod/module and take their personal module to another colony and join it or even create their own colony with their own choice of governance that may attract other sympathizers and grow their colony. It will be a "Government Market" where only effective governments will persist and grow as they attract members to themselves, while those that are not will vanish as their members will leave – just as in other markets. This is the essence of Dynamic Geography.

However, stationary colonies can also provide valuable benefits. There can be a mix of stationary *seasteads* and free-floating/mobile ones that can achieve a desirable balance.

Therefore, the central thesis of TSI regarding why ocean societies can function better than their land counterparts, is that the oceanic societies can have the capacity for movement of their individual members, per their own volition have the capacity to join or not a certain community, and that entirely new societies can be built from scratch. **There is freedom to form and shape societies.**

Property along the coastal zone in the third world is less expensive and thus attractive, but there is a reason as to why the people that could live there, do not, choosing to remain in the first world. Institutions, whether political or social, are of great importance. If one could provide an innovative society that could provide governmental services in an efficient manner, TSI believes, then people would be more productive, and productive and entrepreneurial people will congregate there to live, work and/or vacation.

2.5.3.4 Clubstead

This is the first of the proposals by TSI for a seastead. It was designed in 2009 by the naval engineering firm *Marine Innovation & Technology* (Berkeley, California) as a 270-person occupancy hotel/resort capable of withstanding the international open ocean waves common beyond the EEZ of California. The base of the platform is taken from traditional designs of offshore oil platforms such as semisubmersible platforms that will be described in the section regarding *flotels* (Chapter 6.2), but modified by adding a suspended covering from steel cables inspired by the concepts of *Tensegrity* [17], which reduce material costs.

The dwelling's upper portion was designed under the rules included in *API RP 2A-WSD Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design* of the *American Petroleum Institute, API*.

[17] **Tensegrity** is a structural principle based on the use of isolated components that are compressed into a continuous tensile network, so that the compressed members (usually bars) do not touch each other and are united only by means of tensile components (usually cables) which are spatially delimiting the system. The term **Tensegrity** is an architectural term coined by Buckminster Fuller as a contraction of *tensional integrity* **(tensional integrity).** Source: http://www.tensegridad.es/

The submerged columns and bases that provide hydrodynamic stability to the structure are designed per the standards of the American Bureau of Shipping (ABS): *Rules for Building and Classing Mobile Offshore Drilling Units (2006, American Bureau of Shipping).*

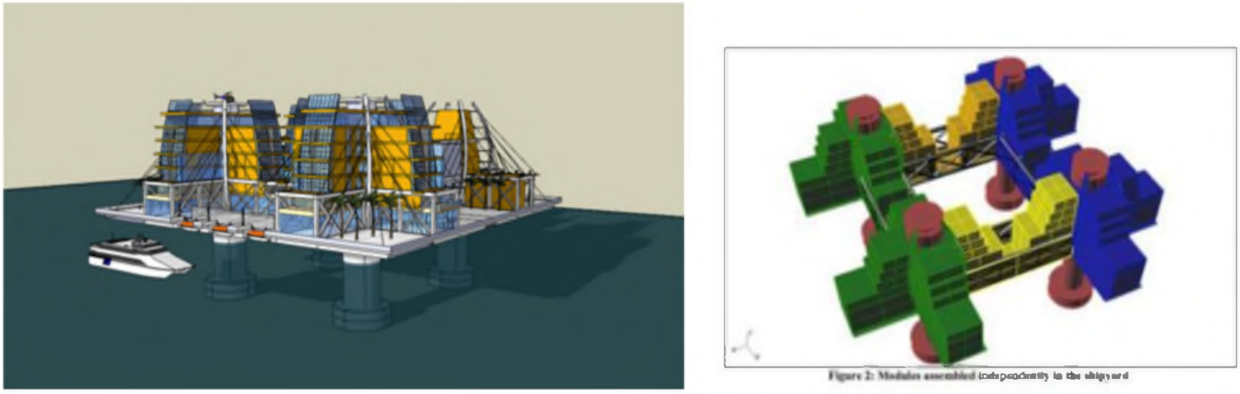


Figure 21: Clubstead: Virtual rendering and structural model. Source: The Seasteading Institute

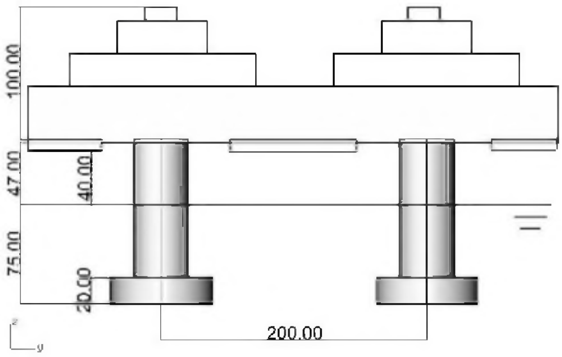


Figure 22: Dimensions for the Base and Supports (Clubstead). Source: The Seasteading Institute

- This design was patented by TSI, but was put aside for the short term due to the high estimated initial cost. The exercise was simply geared toward finding and/or demonstrating that it was technically feasible to establish a *seastead* that met the requirements of comfort and livability mid ocean. One can find the description of this design in *Feasibility and Design of the Clubstead: a cable-stayed floating structure for offshore dwellings* (Aubault, Sitler-Roddier, Roddier, Friedman, & Gramlich, 2010).

Figure 23: Two artistic interpretations of Clubstead. Source: The Seasteading Institute

2.5.3.5 Analysis

Unlike other offshore colonization attempts dicussed, The Seasteading Institute's efforts are geared towards making ocean colonization with sovereignty aims a reality and is focusing on three long term projects:

1. Working on the inherent legal and engineering challenges of life at sea.
2. Developing business models that can work on seasteads, with the goal of attracting investors and capital to the sector.
3. Developing a community around this idea and becoming aware of how the success of this movement can impact humanity.

For each of these projects, this institute has surrounded itself with specialists that advise them and research regarding each of the requirements needed to establish an autonomous community in the high seas. Said requirements are the ones to be addressed in Chapter 4.

Therefore it is a sound and professional attempt to bring oceanic micronations to reality. The legal strategy we can find in *Charting the Course: Toward a Seasteading Legal Strategy* (Mutabdzija & Borders, 2011).

2.5.4 Project Utopia. yacht island design

Although this project is not aimed specifically at the creation of a micronation, but geared to the promotion of luxury yachts that could harbor a micronation, we consider it sufficiently interesting to include here and not in other sections, such as the section for cruise ships.

Conceived by the designers of yachts, *Yacht Island Design* and the office of naval engineering BMT NIgel GEE (both in the UK), the central idea behind this project is that it is not viewed as a vessel in which to travel, but rather an established island so anyone can have the vision of creating their own private island. With dimensions of 109.3 yds x 109.3 yds, and 11 decks equivalent to a modern cruise ship, there is sufficient space to create a complete "micronation". The design is based on four columns using principles for designing small floating areas to minimize its movements, even under extreme conditions (just as the *Clubstead* or offshore floating hotels with submersible platforms that we shall discuss in sections ahead. Each column supports an azimutal 360^{o} propulsor and with each of the four propulsors, it is capable of moving at low speeds. A large central structure divides the water surface in two, acting as a conduit for the anchoring system, which is the key idea in the design, as well as to harbor a dock for ease of access by boats. Additionally, the design includes a heliport.

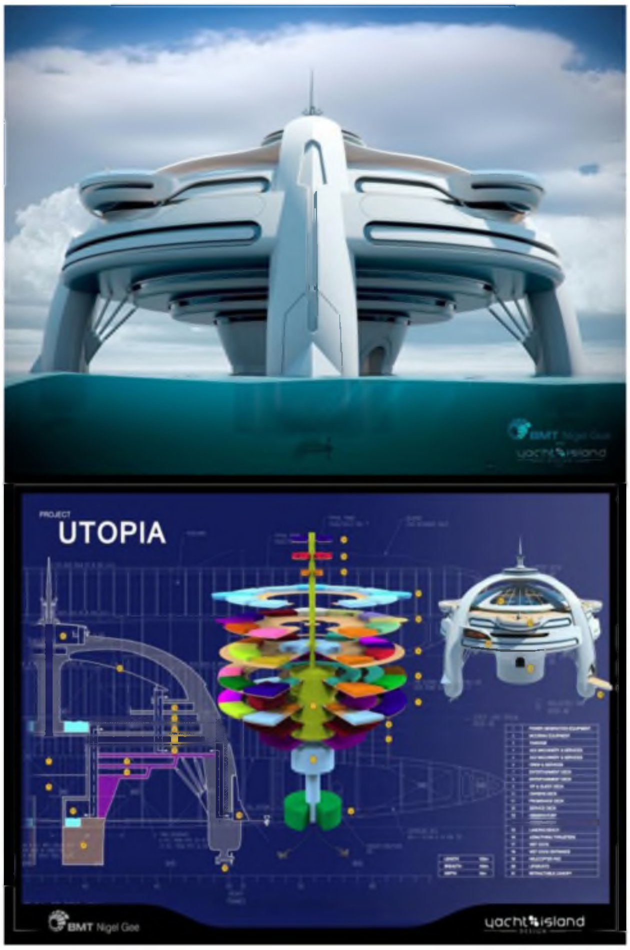


Figure 24: Project Utopia Schematic and Artistic Rendering. Source: Yacht Island Design

2.5.5 Other Proposals

In the book *Seasteading: A Practical Guide to Homesteading the High Seas* (Friedman & Gramlich, Seasteading: A Practical Guide to Homesteading the High Seas, June 2009) there are a compilation of a group of proposals for oceanic micronations, that we simply list as their concepts have been previously addressed:

- 120 Acre City.
- Alexandisle.
- The Pelagic Project.
- The Venus Project.
- Spar Buoy.
- Ballard's Ocean Watch Tower.
- Reed Ship.
- Seascape.
- Triton City.
- Ocean Base One.
- Poseidon Undersea Resort.

Most of these, like the Atlantis Project or the principality of New Utopia, do not amount to much more than their web page and are without any technical, commercial, nor legal basis.

2.6 CONCLUSIONS

The attempts to create of micronations on artificial islands have remained mere attempts. They fail to address the requirements of the *Montevideo Convention* which are:

I. Permanent Population
II. Predetermined territory.
III. Government
IV. Capacity to enter in relations with other states.

However, they set out from a disadvantage regarding those micronations founded on existing land, though the legal void of international waters provides for the establishment of artificial islands with peaceful objectives, and as such one would have a territory that no other sovereign nation can claim.

The requirements set forth by the Montevideo Convention are the requirements we have conveniently adopted as requirements for the establishment of autonomous communities in high seas, as we shall see in Part III of this dissertation, Chapter 4.

3 Oceanic Colonization Per Other Disciplines Not Related to Oceanic and Naval Engineering

The term "Oceanic Colonization" is rarely employed within the ambit of "Oceanic and Naval Engineering (ONE) it is used by other disciplines to express the creation of "Floating Cities". The idea of floating cities has been part of the collective imagination since the 19th century and being addressed by many disciplines both in science and in the arts (Engineering, architecture, literature) particularly since the later part of the 20th century, when technological advances could make the challenge possible. However, due to disregarding the basic principles of ONE, the majority are infeasible proposals. The ones that do take into account said principles can be made a reality but under limited conditions such as close to the coast and at shallow depths. **As such, these proposals made by disciplines outside of ONE do not constitute a viable option for the creation of Oceanic Micronations.** This is what we will address in this chapter.

3.1 Introduction

We will analyze the various proposals for oceanic colonization from disciplines other than ONE. In Chapter 1, we introduced how the maritime industry, and specifically ONE, has offered several proposals to this ample and complex theme of oceanic colonization. In the last few years it has seen various proposals with questionable technical viability, and therefore doubtful economic viability, yet they are interesting to the extent that they provide ideas that, if addressed through ONE, could become viable options. Most of these proposals have been presented by architects to achieve media attention and boost their professional careers, often presenting sketches which, though very inviting to those not versed in ONE, have no technical basis. They limit themselves to generate appealing images with bold statements regarding aspects of sustainability, ecology, energy efficiency, etc. that provide no cost analysis nor have a sound engineering foundation. Nonetheless, the architects have their name cited and their ideas discussed by the media, **yet they provide a false sense that these ideas that they present are feasible.**

One of the proposals for a floating city that as of late has received that media attention/hype is the project "Green Float" espoused by the Japanese corporation Shimizu. One of the notable characteristics of this Project is that it is espoused by a real corporation from within the heavy industry compared to the majority of the conceptual designs proposed which are made by architects, as we have formerly noted. Still, it is just another image exercise, in this case a corporate image one. As we shall see, the proposal lacks technical basis.

However, there are real floating homes projects carried-out by Architecture without them being exceedingly ambitious or showy, that have been successfully constructed in sheltered areas.

We shall review those projects, plus a few more purported by architects, as we have noted.

3.2 Architecture and the Expansion of Land Spaces

We shall review proposals and real projects made within the realm of Architecture for the construction of floating settlements with the objective of providing land expansion.

3.2.1 Waterstudio Projects

Waterstudio is a Dutch architectural firm that claims to develop solutions for the problems imposed on by urbanization and climate change. They work on floating urban enterprises for bays and interior waters, a form of oceanic colonization included in the objective of terrestrial expansion, but with the added vision that within 50 years they could be feasible in waters beyond the coastal zones. Following, we shall review some of the more notable projects by this Dutch firm and that without a doubt is ones of the more attractive as it refers to the design of floating urban structures, some of which have been implemented while others remain a concept.

3.2.1.1 "New Water" and the Floating Complex "Citadel"

New Water is a reference project amongst the many Dutch developments relating to land gained to the sea. The sea level is maintained artificially in this ancient polder[29] that should be raised to the level of the sea and would not only act as a water containment area for emergencies, but would also harbor water based/related developments including 1,200 residences. Construction was to commence in 2009, but the project has been delayed.

Figure 25: Urban Project New Water. Source: Waterstudio

The first urban project for *New Water* would be *Citadel*, an urban complex of **60 floating apartments**. The ecological, recreational and residential requirements are integrated into the organized and thematic units. Each one of these units offers a specific building type and a series of diverse habitats. Each unit will contain "palafitos" which are stilted residences, and for this project will be free-floating, eliminating this ecological impact on the area.

Figure 26: Floating Apartments at *Citadel*. Source: *Waterstudio*

3.2.1.1.1 Analysis

Even if this project is geared to inland water zones, it is interesting to observe how the establishment of floating cities in no way appears impossible in countries like Holland, which has a strong tradition of using this type of construction. The layout of *New Water* is very similar to the floating homes in Camboya discussed in Chapter 1.

[29] A "polder" is a tract of low land (as in the Netherlands) reclaimed from a body of water (as the sea) and by extension it is applied to any wetlands (marshes/swamps, lakes, and pluvial plains) that have been desiccated and have been claimed for land with agricultural, industrial or port uses.

3.2.2 Projects By +31 Architects

3.2.2.1 Description

This is another example of a floating villa from a Dutch architectural firm, +31 Architect. The firm explains: ”Living on the water has become more and more popular in Holland. The clients/proprietors that come to our offices love the charm and typical characteristics of life on the water, but do not like the ‘caravan’ look of existing houseboats. More and more people wish to live on a floating house that is contemporary in its look, designed for their specific needs; the floating house at the *Omaval* is a clear example of this”.

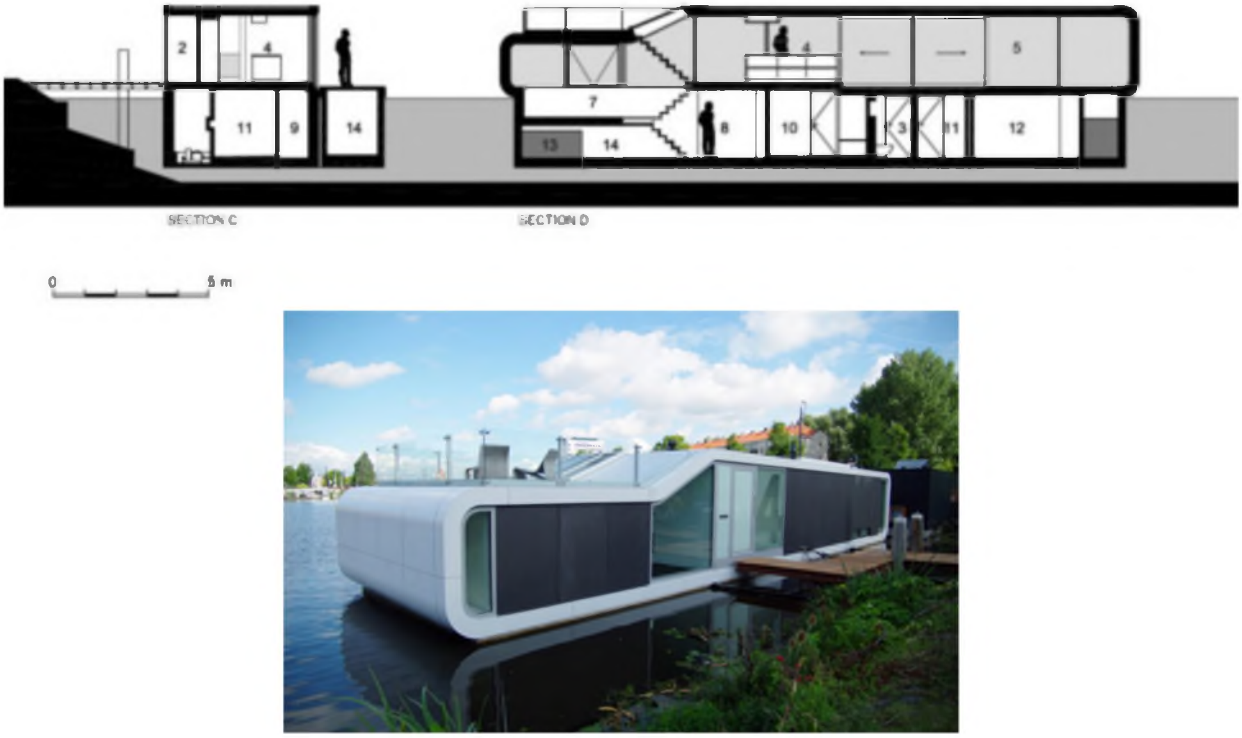


Figure 27: Cross-section and real image of the Omaval Aquatic Villa. Source: +31 Architects

3.2.2.2 Analysis

With most of Holland’s territory being land gained from the sea, it does not seem odd at all to have floating residences. But in any case, they are limited to the tranquil and shallow waters like lakes and canals.

3.2.3 Projects By Aquabase [Construction Limited]

3.2.3.1 Description

Here is a company that already provides floating residences on a commercial basis. They are made of concrete pontoons. *AquaBase*[30] are designers and builders located in England that specialize in concrete products, form small prefab structures to large pontoons that can withstand floating residences, floating docks, walkways, wave attenuators and many other types of floating structures.

[30] http://aqua-base.co.uk/index.html

Their specialty is crafting laminated concrete and super-reinforced concrete to be used in marine environments, which includes lakes, rivers, channels/canals as well as estuaries or even for those off-shore locations.


Figure 28: Construction of a Concrete Pontoon and floating ferro-cement structure along the river Thames. Source AquaBase.

3.2.3.2 Analysis

Traditionally, steel is used for marine constructions. But steel is not as cost-effective compared to concrete for certain marine applications. Marinas will be discussed in Chapter 8.

Concrete	Steel
- Useful life: 100 years or more - Condensation: none - Initial cost: 7-8% more than steel, but greater economies of scale for multiple hulls - Maintenance cost: much lower than steel - Reduced down-time due to less frequent inspection - Excellent fatigue life - Resistance to impact - High mass moment of inertia and low centre of gravity means good station keeping behaviour and reduced motions - Slower thermal response/better insulation - Resistance to fatigue and crack propagation •	- Useful life: up to 30 years - Condensation corrodes the hull from within - Initial cost: 7-8% less than concrete; traditional engineering and manufacturing at existing shipyards - Maintenance cost: much higher than concrete - Greater down-time due to more frequent inspection - More steel designers and fabricators are available

Table 3: Comparison between concrete and steel. Source: *AquaBase*.

3.3 Architecture and Oceanic Cities

This section is dedicated to Architecture. The majority of floating projects engaged by Architects tend to be primarily publicity-seeking pursuits. They are generally aware of the impossibility of realizing said projects, and are used as attention gabbers to showcase other real projects, as is the case of the Dutch architectural firm *Waterstudio*. At the same time that they engage in projects for floating residences, they market floating terminals for cruise ships. This is why this architectural firm is included in both sections.

3.3.1 Lily Pad

3.3.1.1 Description

Global warming is expected to cause a rise in sea level and with that, a large number of people will need to relocate from coastal cities to other places. In this context, *Lily Pad*, by *Vincent Callebaut*, is a concept of a floating city geared to be completely self sufficient and provide refuge to the future climate change refugees: it is an urban solution designed to provide living quarters to refugees.

Biomimetics is clearly the source of inspiration for this design. *Lily Pad* was designed to imitate a water lily and was conceived as a zero emissions floating city via the use of a series of technologies (solar, wind, biomass, and tidal). It is being proposed that the project would not only be energy self-sufficient but that it could also have the capacity of processing atmospheric CO_2 and SO via its skin/coating of titanium dioxide.

Each of these floating cites was intended to harbor 50,000 people. It contains a mixture of an artificial terrestrial landscape that is provided with an artificial lagoon and three mountain ranges to provide diversity to its inhabitants. *Lily Pad* is destined to be near shore or be free floating in the ocean, traveling from the equator to the north seas, the currents may take it by the Gulf Stream.

Figure 29: Lily Pad. Source: Vincent Callebaut, 2008

3.3.1.2 Analysis

The development of this concept in itself is laudable and the spectacular design by *Callebaut* has been able to capture attention by many; which is what the author was really after, as the concept did not provide a technical solution to a concrete issue. Though it opens up discussion to novel solutions to climate change, it is understood that solutions will come in a simpler form than the one presented.

3.3.2 Recycled Plastic Floating Island By WHIM Architecture

3.3.2.1 Description

There are million tons of plastic forming a type of gyre in the North Pacific Ocean known as *the North Pacific Garbage Patch (NPGP)*[31] In early 2010, *WHIM Architecture* (Holland) proposed to recycle it with their Project known as Recycled Island: to gather the plastic, classify it and then recycle it in construction blocks to create a new floating city rivaling Hawaii (approximately 10,000 km^2 (3861 mi^2) depending how much plastic could be gathered.

[31] The North Pacific Garbage Patch is an area of the ocean covered with marine debris in the center of the North Pacific Ocean, located between the coordinates 135° to 155°W and 35° to 42°N. It is estimated that it has a size of 1,400,000 km^2. This Ocean dump is characterized by having concentrations exceptionally high in suspended plastic and other debris that have been trapped by the currents of the rotation of the North Pacific (formed by a vortex of ocean currents). Source: Wikipedia

As climate change occurs, many people, especially those residing on insular nations as the Maldives, shall be forced to abandon their homes and become refugees. This new island of plastic could be situated somewhere between San Francisco and Hawaii and would be made available to these refugees.

The island would be self sufficient, capable of producing its own food, processing its waste and producing renewable energy. Part of the island would be residential, while other parts would include commercial and recreational spaces. Beaches would be situated near the homes so people could relax, enjoy and have fun.

The remainder of the island would be destined to raise food/algae that obviously could be obtained readily in high seas. Algae could be used as nourishment, bio-fuel, fertilizer, and medicine. Other organic matters would be composted and reutilized as fertilizer for farming. Renewable energy used would include solar, tidal and wind.

To date, the Recycled Island is merely a concept and their proponents are currently seeking technical assistance to develop the idea further with the aid of experts in various fields such as chemistry, oceanography and engineering.

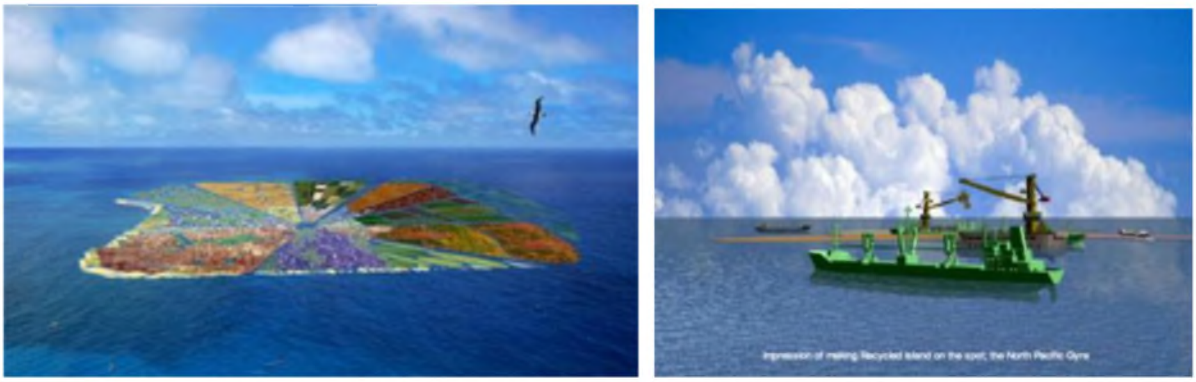


Figure 30: Island Made of Recycled Plastic. Source: WHIM Architecture

3.3.2.2 Analysis

The suggestion of utilizing the *NPGP* to obtain materials for construction has been made several times.

Although it is a creative and elegant solution, with a small analysis one can demonstrate the lack of economic viability. Additionally, there is still plentiful land where one could harbor refugees.

Let's suppose that one could convert trash into raw materials for construction in an economically viable manner. The most efficient form to do it would be to recycle plastic that is already on land and transport it to the ocean. On the contrary, *WHIM Architecture* proposal presents both impediments and disadvantages:

1. Operations at sea are of higher cost than on land.
2. The NPGP marine litter is very fine (without density) it is not a solid uniform pile, but a large area that borders the ocean here and there. Thus in order to gather such great amounts of materials over such a large expanse would not only be difficult but also costly which would elevate the costs of operation at sea.
3. Plastic is resistant enough to sea water, but it is not to the sun. [Plastic] degrades rapidly, so the NPGP materials are of lower quality than those found on land.

•

- It is true that the recycling of certain material on land can be done with a small profit, but the gains are minimal. Tosupport the added burden of the significant costs of marine operations, the whole equation would waste resources.

Add the impractical cost of transporting the population to the floating city in the event that the sea level would rise, when it would be more logical and practical to transport the refugees inland.

3.3.3 Turbine City by On Office

3.3.3.1 Description

Norway is considered to have both one of the most advantageous conditions in the world as it refers to exploitation of marine wind energy and a strong offshore oil industry. Under this notion the Portuguese architectural firm *On Office*[32] proposed *Turbine City* in 2009 to utilize offshore wind generators to propel tourism. The proposal consists of the integration of a spa/hotel and

[32] *On Office* is an inactive architectural firm as of 2010

museum within an aero generator in an offshore park; with only 1MW of the total 8MW needed to provide the total energetic resources to maintain the complex. The proposal is expected to attract tourism, mariners, and workers as well as cruise ships to this region so people could experience firsthand the advantages and the spectacle of the aero generators augmenting consciousness and support for this type of energy.

Figure 31: Images of islands proposed for Turbine City. Source: On Office

3.3.3.2 Analysis

Although *Turbine City* is another conceptual project that has not become a reality, the proposal of integrating tourism and wind energy seems appealing for those regions where wind energy is rejected for the perceived impacts it could have on tourism. Along the coast of the Mediterranean both in France and Spain, wind parks have been rejected based on arguments that it would negatively impact tourism. *On Office* flips the argument round indicating that instead of it being a detriment, it would be a benefit and be a magnet for tourism.

3.3.4 Floating Eco-City, FEC

3.3.4.1 Description

The concept of *Floating Eco-City (FEC)* has been developed by an architectural firm known as *Aaro Söderlund Oy* for a competition on ideas for ecological cities organized by Turku *University of Applied Sciences* (Finland) in the spring of 2009. The objective was to satisfy the demands surrounding Bohai Bay in Tianjin, China. According to the promoters, the advantages of the new concept in urbanization are multiple as it allows for a new way of ecological life aboard a platform designed around green technologies:

- It offers flexible solutions for the challenges associated with overpopulation, pollution and climate change.
- It reaches lofty environmental goals by allowing emergent areas to be earmarked for other uses.
- It has positive energetic fingerprint and ample utilization of green energy sources.
- It creates a biosphere that is protected by a structure (Megatent) with vegetation specially selected for shade and cooling of buildings, air, water, soil purification as well as producing oxygen and maintaining humidity equilibrium. The structure is ranked as a zero emissions structure and has no negative CO_2 impacts.

- The services available for the community and the opportunities for work are all located within the same structure, thus minimizing the need for travel and traffic.

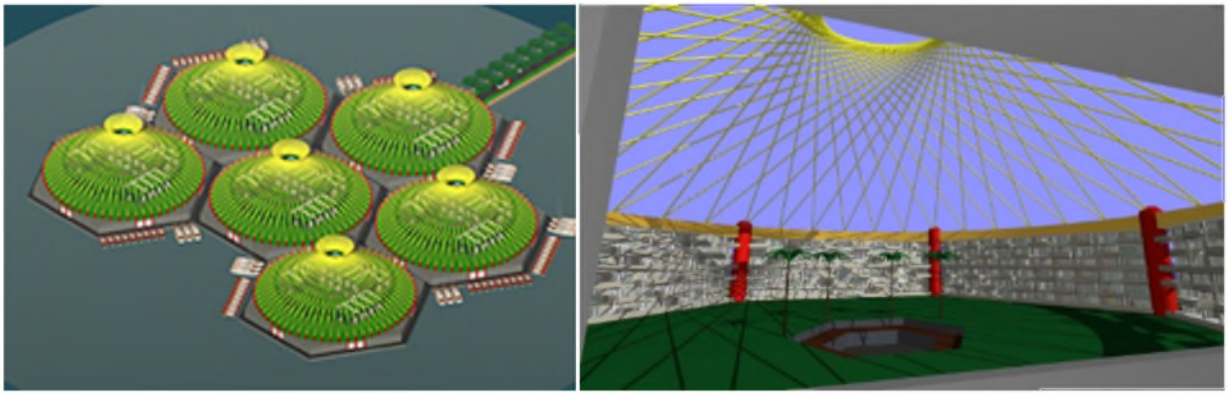


Figure 32: "Floating Eco-City" and structure "Megatent". Source: Aaro Sȍderlund Oy

The main floating unit or "EcoFlo Quarters" with a hexagonal shape is formed through the combination of box platforms that have been surrounded by vessels that protect the platforms. The "Megatent" structure will cover all the hexagonal platforms and vessels to protect them from extreme temperatures, acid rain, sand storms or other type of pollution. The figure below depicts an urban unit with 6 vessels and 26 platforms extending about 1km (0.62 mi) and having an occupancy capacity of 50,000 residents, which could be joined to form even larger urban centers.

Figure 33: "EcoFlo Quarters", boxes surrounded by vessels. Source: Aaro Sȍderlund Oy

3.3.4.2 Analysis

Again, we come back to solutions for global warming and sea level rise.

During the drafting of this dissertation, promoters of this idea have been contacted; but at this stage, it remains a 3D schematic awaiting a market for its development at a commercial level. The design continues to lack technical development as well. Though the vessels are described as converted vessels, there is no mention as to how they are to remain in place, their anchoring systems or even which type of vessel they would be. They do not describe the platforms, materials, dimensions, stability, etc. Nor they provide details for the "Megatent" that would encase the "EcoFlo Quarters".

3.3.5 Floating Cruise Ship Terminal By Waterstudio

3.3.5.1 Description

This is a proposal for a floating cruise ship terminal by the Dutch firm *Waterstudio* and its objective is to decongest land ports by attracting vessels to this platform. This cruise ship terminal triangular shape is expansive enough to allow for the simultaneous mooring of up to three of the largest cruise ships the world has to offer. The highest point of the terminal acts as the entryway to the interior basin and dockage to be utilized by smaller vessels and water taxis that would convoy passengers to the coast. Within the terminal there will be 165,000 m^2 of retail space for shops, conference rooms, movie theatres, hotels and more.

Figure 34: Floating cruise terminal. Source: Waterstudio

3.3.5.1.1 Analysis

As we shall discuss in Chapter 7 referring to the VLFS, this idea of pulling traffic away from the coast to floating mooring structures is not new, and has been explored by experts on the matter who have made proposals that are more or less achievable. This one presented by *Waterstudio* is being conceived from an architectural view point. It lacks technical rigor that other proposals made from a Civil engineering perspective have, as we shall see in Chapter 7.

3.3.6 Autopia Ampere

3.3.6.1 Description

This project has been envisioned by the German architect *Wolf Hilbertz* (1938-2007) utilizing the process of electroplating to construct a self-assembly city to be deployed from the sea bottom and named *Autopia Ampere*, as it would be located over the submerged Mount Ampere, situated between Madeira and Portugal[33]. *Autopia Ampere* would start with a series of armored cables anchored over the mount's submerged face. Once set, they would be connected to a low voltage electrical source powered by solar panels. With time the electrochemical reactions would extract minerals from the sea forming calcium carbonate walls, colloquially known as limestone.

[33] This submerged mount will be referenced at the conclusion of this dissertation as one of the ideal locations on which to establish a sovereign oceanic colony.

Figure 35: Autopia Ampere schematic and electroplating principles. Source: Wolf Hilbertz

3.3.6.2 Analysis

Although the physical principle of electroplating was demonstrated by in 1979 (22), the challenge lies in the time it will take to construct this city. **During the drafting of this dissertation, a contact was made with collaborators and family members of the recently diseased Wolf Hilbertz, but unfortunately, the majority of the notes and studies appear to have been lost.**

3.3.7 Walking City

3.3.7.1 Description

This idea of floating cities can be thought of as an avant-garde proposal *Walking City* circa 1964 of the British architect Ron Herron, of the *Archigram Group*[34]. It is not precisely a floating city, but it shares the idea of a mobile city.

In the article of the architectural magazine *Archigram* circa 1964, Ron Herron proposed the construction of sapient-mobile robotic structures that could move about freely amongst the ruins of the post-nuclear-apocalyptic world and their mobility would bring them to where their resources or building ability would be needed. Many cities could be interconnected and form even larger cities when needed, and later disperse when the need ceased. The individual buildings or structures could also be mobile, relocating to wherever the owners wished them to move to or necessity dictated.

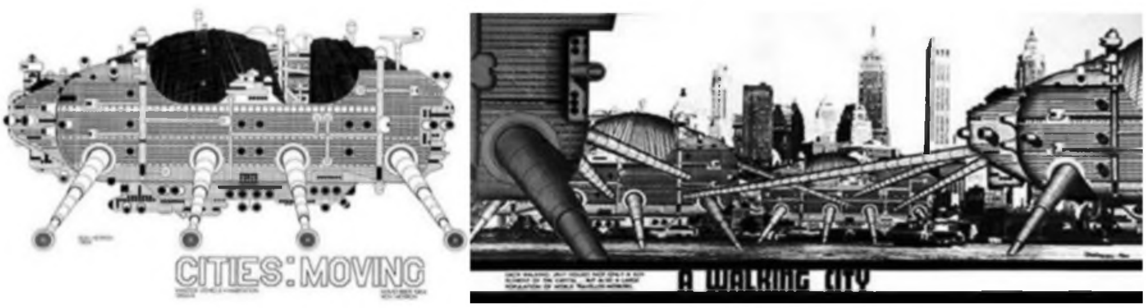


Figure 36: Walking City. Source: Archigram

[34] Archigram was an architectural vanguard firm created in the 60s and part of the London Association of Architecture.

3.3.7.2 Analysis

Although it is not a proposal for a floating city, it shares the same philosophy found in the concept of "Dynamic Geography", thus the reason to have included it in this project. The backdrop to this proposal is a nuclear disaster — not very believable, as well as lacking technical viability, as with other such projects as have been discussed previously.

3.4 Engineering and Oceanic Colonization

In this second segment of Chapter 3 (dedicated to analyze proposals of oceanic colonization outside of Naval and Oceanic Engineering) the focus will be to analyze proposals made from within other sub-disciplines of engineering discipline far more developed than those presented by proponents from the world of architecture and although they may appear as part of science fiction, the proposals have certain technical rigor.

3.4.1 Shimuzu Mega-City Pyramid

3.4.1.1 Description

Shimizu TRY 2004 Mega-City Pyramid was a proposal by *Shimizu Corporation* (Japan) in the year 2004 for the construction of an enormous pyramid over Tokyo Bay. the structure will be around 14 times bigger than the great pyramids of Giza, and will house about 750,000 people, and will reach 730m (2,395 feet) over sea level, including 5 piled frames, each with dimensions similar to those of the Giza pyramid. This pyramid would alleviate the lack of space in Tokyo, although the project would only handle 1/47 times the living area of Great Tokyo.

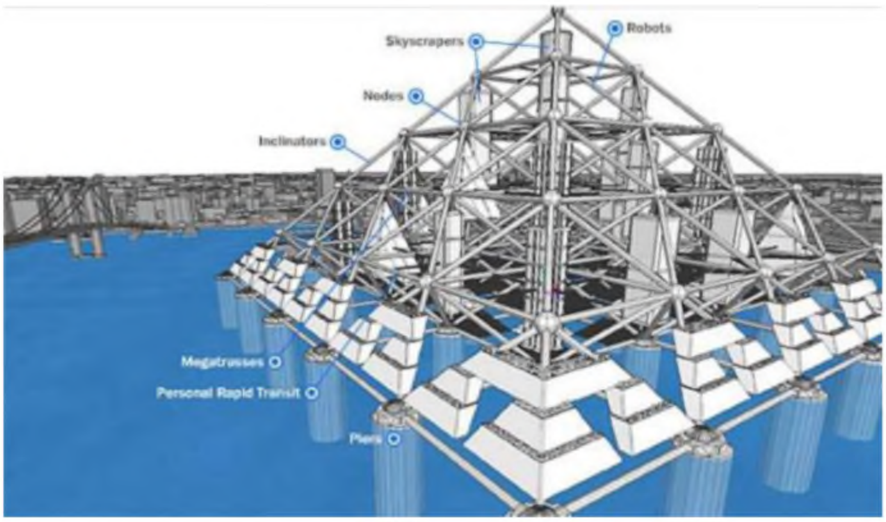


Figure37: Shimuzu Mega-City Pyramid. Source: Shimizu Corporation

3.4.1.2 Analysis

The idea stems of the fictitious and architectural marvel of *Tyrell Corporation*, which appears in the science fiction film Blade Runner (1982) as dual futuristic pyramids. It would simply be supported on the seafloor over pillars of gargantuan dimensions, and the advantage of this is to lessen the ecological impact on the bay, compared to completely filling it. And although it is described well at a technical level, its economical viability is very questionable. Thus it appears to be more an exercise in promotion by the *Shimizu Corporation* than a real proposal.

3.4.2 Floating Mid-Ocean City

3.4.2.1 Description

"When the continents of the world become overpopulated, and transatlantic travel (by plane) becomes common fare, maybe then the establishment of an oceanic community would be possible". This is what the French designer and engineer Leon Feoquinos said in Modern Mechanix, March 1931 (23), presenting the design of a floating city. The main objective was to offer a landing platform for planes traveling from the Americas to Europe that, at that time, would not have the capacity to make the full trip.

The base of the structure would be a lattice of steel fixed by cables to act like a dike against the waves. At the same time, a breakwater would surround the structure to attenuate the waves of the Atlantic Ocean. At its center there would be a closed port that would serve as a place for landing of hydroplanes and port for vessels. Then there could be additions to the installations such as hotels, casinos and so forth.

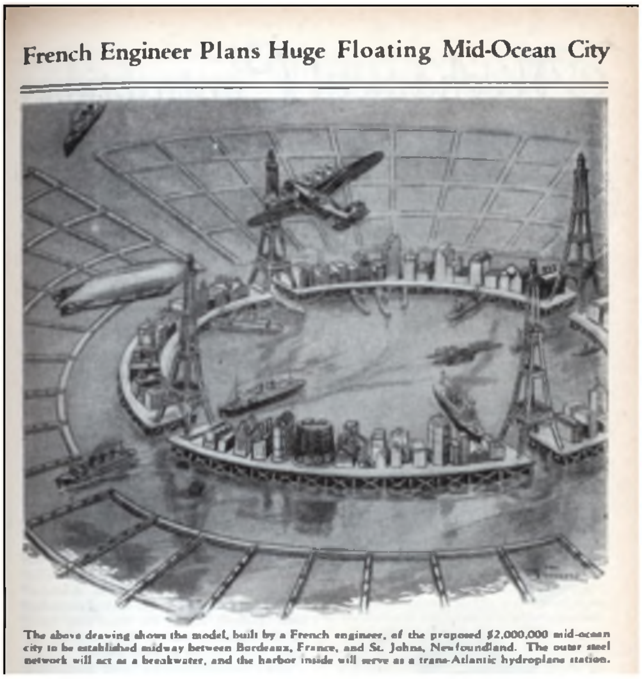


Figure 38: Original illustration March 1931 of *Modern Mechanix*

3.4.2.2 Analysis

It is difficult to envision that the technology of the day would have been capable of sustaining such a structure in a stable manner in the sea, given that it still would be difficult today. The key to all these would be the breakwater to attenuate the impact of the waves in the principal structure that supports the city. In this respect, this solution shows certain similarity to the project of the Green Float, which we shall see next.

As it pertains to its objectives, a floating airport for transatlantic flights would be similar to that of the Seadorme which will be presented later in chapter 7.

3.4.3 Green Float: a Self-Sufficient, Carbon-Negative Floating Biotic City

3.4.3.1 Description

"Green Float" is a very ambitious project involving the construction of numerous artificial islands to create an enormous floating city, and at the same time support the tallest building of the world—a tower rising 1,000m (3,281 feet) high. It is part of a futuristic vision of the giant engineering firm Shimuzu Corporation, Japan. A team of scientists, engineers and financiers commenced working on the project in 2010, forecasting that by 2025, the technology necessary for its implementation would be available.

Designed to organically expand, the project Green Float follows the Water Lily model and floats on the surface of the ocean and would include almost all that a community would need to live in a sustainable manner. The project contemplates the construction of various platforms or artificial islands with a diameter 3 km (6 miles) that were never constructed to this scale. The city would be established in an equatorial region where the sun is abundant and hurricane effects minimal.

The platform is divided into 3 distinct zones:

High tower: the residential and office zone that with a capacity of 30,000 inhabitants without high winds and at a temperature of about 26-28 °C (7-8°F)

The enormous circular base would be dedicated to the plantation of mangroves, fields of cereals and large extensions for livestock to feed the inhabitants of the city. A type of resort at the skirt of the circular base will provide housing for about 10,000 people in low-rise homes.

Mid tower: will contain vertical farms that would provide work for about 10,000 workers who would reside at the lower portion of the structure.

The tower would be constructed by super light alloys derived from magnesium obtained from seawater. Once the island is created, each new level in the tower will be fabricated at floor level and then pushed downward to the sea floor. When the 1000m mark is reached, the tower will rise to its final height. The enormous circular base will be constructed forming a pontoon lattice in the form of a beehive weighing 7,000.

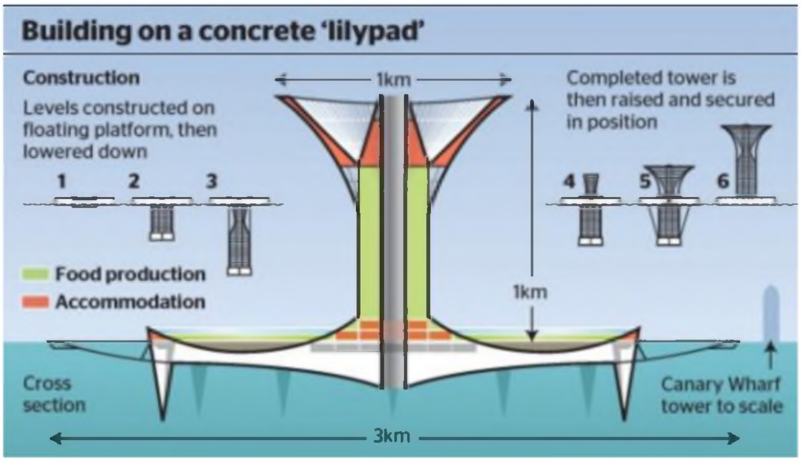


Figure 39: Schematic view of Green Float. Source: Shimizu Corporation

The CO2 emissions will be minimized with the use of efficient transports. Energy would be generated utilizing renewable sources such as tidal, wind, solar energies, Ocean Thermal Energy Connection (OTEC) and an innovative system of special solar satellites.

Each floating city will provide residence to 50,000 people. The idea would be to concatenate more units, creating a fleet of artificial islands capable of sustaining a population of one million people, as can be seen in the following image.

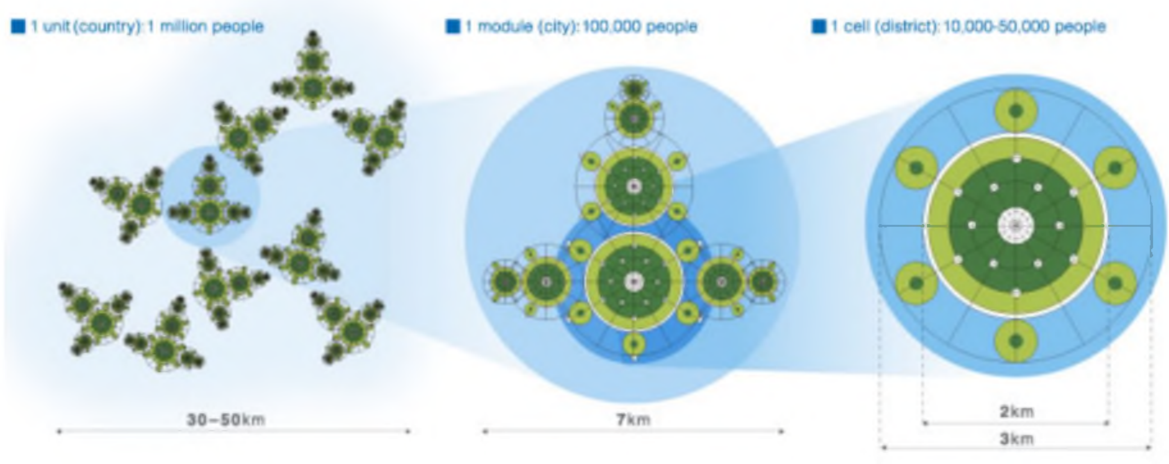


Figure 40: Green Float Island Fleet Float. Source: Shimizu Corporation

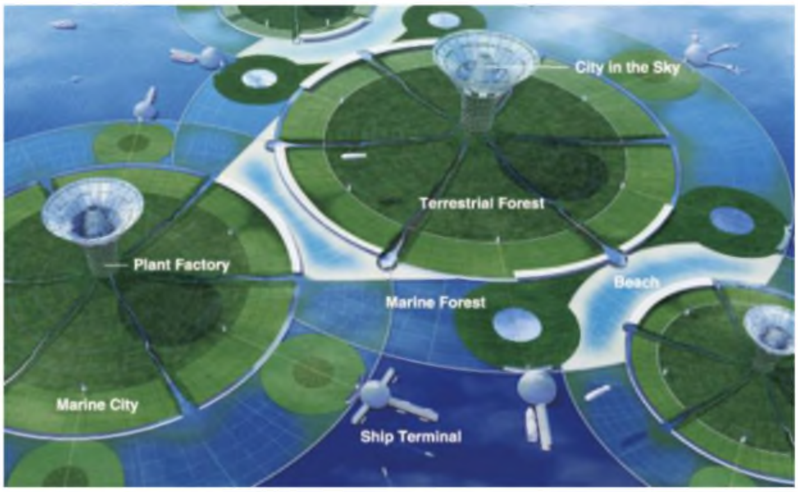


Figure 41: Aerial view of a Green Float Fleet. Source: Shimizu Corporation

The platform, rather than remaining fixed in one place, will be allowed to float free throughout the equatorial zone. The propulsion system is based on electromagnetic induction but is to be used only to maintain position within the current flow .

Figure 42: Green Float Movement along the Equator. Source: Shimizu Corporation

The construction of the base structure will be using the lattice with beehive firm, which incorporates hexagonal cells that can be joined. The material would be magnesium for the tower. Amply used in cutting edge construction and aerospace engineering, this structure is 90% air, making it not only light but resistant. The process of construction is depicted in the following figure:

• **Step 1:** the individual blocks produce a wave resistant barge equipped with construction plants. Approximately 20m (6 feet) wide, 50m (164 feet) high and a weight of 5,000-7,000 tons, that rotate at the end of it and brought afloat by a crane located at the end of the barge. •	
• **Step 2:** Water is injected in the blocks until they reach a position of stability. The units are joined to other square groups with other blocks with rubber moldings, utilizing water pressure to join them by removing interstitial water via pressure.	
• **Step 3:** Once the 50m (164 feet) high floating substructure is coupled and extended to create on it an artificial floor, commence the work over the floor itself.	

Figure 43: Construction of the base platform. Source: Shimizu Corporation

3.4.3.2 Analysis

The “Green Float” may appear to be fairly improbable, particularly because the artificial islands have never been built at that scale, and thus it would be unlikely that it would support a building 1km high. But also, there are other aspects that make this project improbable not only short-term but also in the medium term.

Their sources of energy include solar energy satellites, and they say that investigating these systems are part of their plan.

Their materials include "magnesium alloy structural materials refined from seawater". To refine materials from seawater is a very laborious, inefficient, and fairly expensive process relative to simply obtaining the source materials from the earth. An example of such an attempt is Autopia Ampere.

The investment bank Nomura, that is the main agent in this project, has not given an amount as to how much this Project is estimated to cost.

3.5 Summary and Conclusions

We have seen in this Chapter that the most significant proposals for oceanic colonization have been made from perspectives foreign to Oceanic and Naval Engineering. Some of them more modest and real like the “AquaBase” projects, while others more ambitious but with certain technical merit as the Project “Green Float”. However the field is dominated by proposals made by architects without engineering qualifications presenting floating artifacts that lack technical merit. Two basic aspects of any offshore floating structures are the way a structure behaves in the ocean, and how they maintain their position. These are not mentioned in such proposals, and without mentioning at least these two aspects it is impossible to seriously offer any type of proposal of a floating artifact, whether it be a floating island with kilometric dimensions or a modest vessel. For this reason it is easy to discount these proposals. Their primary objective is often publicity-seeking as, in the case of architects, or even large corporations such as Shimizu, which seek to reinforce their corporate image.

On another note, it is interesting to observe how far-future projects like *Floating Mid-Ocean City* and *Green Float* share the same idea to situate the habitable portion of the colony in the center of a structure with a breakwater as a border. This idea has been adopted by The Seasteading Institute. As such, even though they are unrealizable projects today, their ideas are interesting and could become a reality when the technology so permits it.

Thus, entering into the reasons that justify Oceanic Colonization, one finds that the dominant **objective is the expansion of terrestrial and coastal space**. Many times this is to address the consequences of global warming, but nothing we have discussed has a feasible technical basis.

However, we have seen projects of a more real and modest nature such as floating homes where the **objective of expansion of terrestrial** space has been made viable for certain projects, as seen in Holland.

PART II: APPROACH AND CHALLENGES

4 MANDATORY REQUIREMENTS TO ESTABLISH AN AUTONOMOUS OFF-SHORE COMMUNITY

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4.1 INTRODUCTION

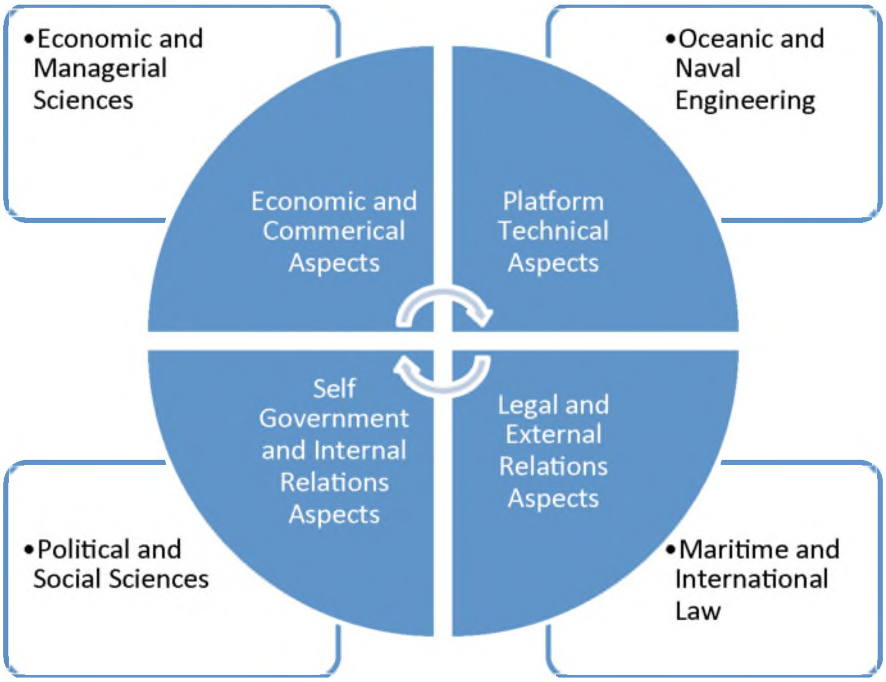
As we have seen, attempts to build new sovereign societies on the ocean that have not taken into account Oceanic and Naval Engineering have failed. This part of the dissertation will list and evaluate the requirements applicable to any oceanic colony, regardless of objectives, but will pay special attention to those requirements needed for a sovereign oceanic colony.

4.2 The four types of requirements

The mandatory requirements for an autonomous oceanic colony encompass the following four principal aspects:

1. **Economic and commercial**
2. **Platform technical requirements: oceanography, naval architecture, marine structures, etc**
3. **Legal or external relations**
4. **Self-government or internal relations**

Each of these four aspects is paired with a specific discipline that has the tools to study it, as seen in the following graphic:



Graphic 1: Mandatory requirements for an oceanic colony and the disciplines that study them.

These requirements are common to any type of oceanic colonization regardless of its aim; what differs is how these requirements will be met.

4.2.1 PARALLELISM WITH the Montevideo Convention

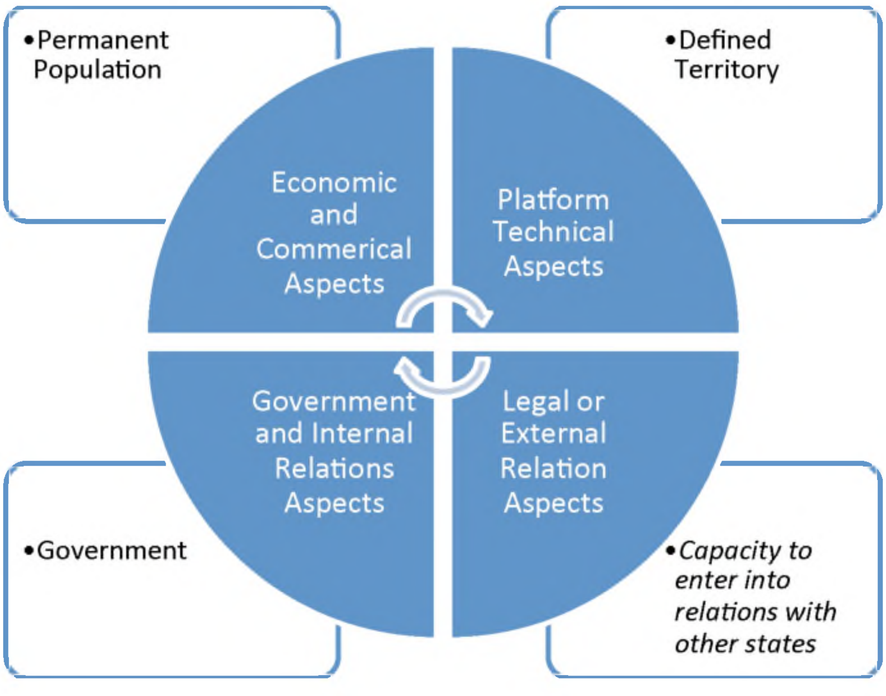
The Montevideo Convention on Rights and Duties of States establishes criteria for the definition for "State" in its Article 1:

> *"The state as a person of international law should possess the following qualifications:*
> *I. Permanent Population.*
> *II. Defined Territory.*
> *III. Government*
> *IV. Capacity to enter into relations with other states".*

The first paragraph of Article 3 explicitly states: *The political existence of the state is independent of recognition by the other states."*

Under these parameters, any entity that meets these criteria could be considered a sovereign state under international law, whether or not it is recognized by other states. Nations or territories not meeting these criteria are not considered states, the fourth requirement being the one most commonly not met, as is the case for Western Sahara or South Ossetia, or in special territories such as the Isle of Man or Hong Kong. For the majority of micronations, none of the requirements are met.

This has been addressed in Chapter 2.2.1 but merits revisiting as we draw parallels with the requirements of an aspiring oceanic colony as demonstrated in the following graphic:



Graphic 2: Mandatory Requirements for an Oceanic Colony and their parallels to the criteria set forth by the *Montevideo Convention*

4.3 Economic and commercial requirements

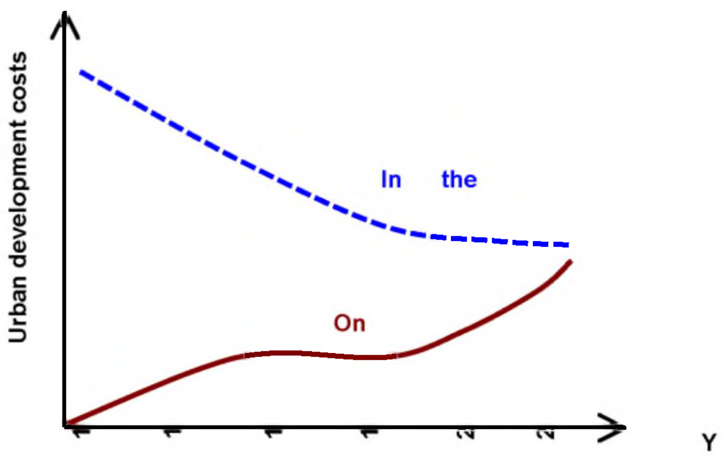
4.3.1 Costs on land vs. costs on the ocean

A colony must provide products or services that offer a competitive advantage in being produced on the ocean. Though the territory is free, the construction of the floating structure is costly. However, the cost of land is increasing while the cost of floating structures is decreasing. One example is a floating Liquified Natural Gas plant: some studies (Méndez-Díaz, 2004) placed the cost in 2004 far beyond a similar land plant, but in 2011, Petronas and Shell both announced plans to build the world's first floating LNG plants.

We examine the costs for each of the forms of oceanic colonization.

4.3.1.1 Cost of expansion of terrestrial land holdings

Oceanfront real estate often has a very high value, especially in tax-free countries, so the construction and sale of floating spaces could be lucrative. According to Project Euphlotea (25), a proposed project to build an airport off the coast of San Diego, between the years of 1984-2004, the median price of a house in San Diego increased 528%. During that time, new technologies and economies of scale have substantially reduced the cost of construction on the ocean. According to a study in 2004 the cost of certain activities on land had exceeded or was about to exceed the cost on land. One such activity was airports.



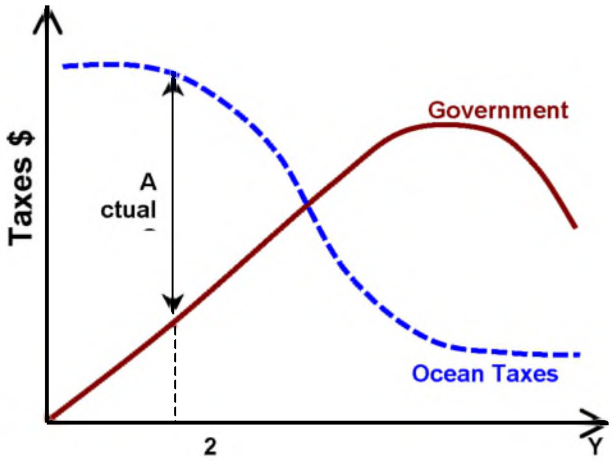
Graphic 3: Activity development cost comparison of land vs. ocean

4.3.1.2 Costs for the creation of oceanic micronations

In the case of sovereign oceanic micronations, the costs of living in a nation with high taxes ("government taxes") will be compared to the costs that citizens would have living on the ocean ("ocean taxes") without government taxes, outside of the jurisdiction of any state.

Joe Lonsdale gave a speech at the 2009 Seasteading Conference about the creation of value in the ocean and compared the cost of living on land and living on the ocean (see the graph below):

- Along the X axis, time in years. Along the Y axis, taxation in dollars ($).
- A line along the graph, government taxes increases rapidly. Given the current state situation, the people will likely accept more government intervention due to the government deficits and thus taxes be expected to increase.
- The other line on the graph, ocean taxes, decreases rapidly. At the moment, the cost for living in the harsh oceanic environments is high. But in the measure that oceanic and marine is more affordable, the knowledge in engineering will grow, and economies of scale will emerge and the ocean taxes will continue to decrease.



Graphic 4: Taxes imposed by government by living on land vs. "Taxes" for living on the ocean.

Today, the "ocean tax" is greater than "government tax", but if the trend continues, the lines will cross and living in the ocean will be less expensive than living on land. The time at which this occurs will depend on the technology and what oceanic engineering will be capable of to decrease "ocean tax" rapidly, as shown in the figure presented.

On the right side of the graph, that is to say on a far away future, the state tax that has been growing will start to lessen. As oceanic micronations (the seasteading movement among them) becomes a viable option for sovereignty, jurisdictional arbitration, and the discovery of optimum rules, governments on land will need to adapt to and change their policies or they will lose citizens to seasteads. It would be a "government market" ruled by the laws of offer and demand.

4.3.1.3 Mobile Settlements Costs

It has been mentioned that cruise ships constitute, nowadays, the principal example of mobile settlements. As cruise ships have been, for many years, an alternative to tourism on land, one can imagine that the graph lines described for other forms of oceanic colonization have crossed the cost effectiveness threshold years ago. The economies of scale are bringing down the cost of renting out a cabin in a cruise ship, almost to the same price as a hotel on land.

The same is happening to other mobile settlements in merchant vessels: the costs of marine transportation are competing with the costs of transportation via land, and at times are even less.

4.3.1.4 Cost of access to marine resources

The graphical comparison for this parameter have also crossed years ago as it pertains to the oil industry, where it is profitable to pump oil out of the subsoil miles deep and hundreds of miles from shore, competing with oil fields on land.

In the case of other resources, the fishing industry competes with the land-based food industry, and ultimately, aquaculture in the ocean is starting to be presented as a viable cost alternative to aquaculture on land.

About a decade ago, sea-based wind energy began without there being a need to establish an autonomous offshore community, as the first developments have been near shore. But as we shall see, here too one will observe the need for oceanic colonization within this sector, as the wind parks are set up more and more away from the shore.

4.3.2 The business plan and the platform design

Regardless of the objective for oceanic colonization, it will require heavy investment to construct a structure on which a colony can settle. For this reason, even before one can think of the platform one should ask oneself a fundamental question: what is the business plan? Which leads to more questions:

- What would be a viable business proposal?
- Which is the best technical solution for the platform?
- How many platforms?
- What functionalities will the platform(s) have?
- What cost range is being considered?

These considerations are normally based on individual experience, knowledge and a good hunch. The process takes time, months, or even years. Frequently, the lack of rigor and formality leads to an immature investment plan. Even then, these ideas not yet refined can be presented to naval engineers so they can make a sketch of a technical solution that will be presented to the general public. This sparks a great deal of technical design work without the benefit of a true and clear understanding of the general commercial and operative requirements and their consequences. The end result can be high costs, poor quality and a project that consumes time without a clear business plan.

The prior chapters have seen a few failed projects of floating cities because they have been created without a mature business plan. As such it is critical that before the design work of the structure to colonize the ocean starts, the business plan must be developed.

4.3.2.1 **The Business Development in the Platform's Life Cycle.**

The next figure shows how the business process of the first stage prior to the design of the platform it in its life cycle. Let's say that the process of engendering and creating that precisely gives life to the platform.

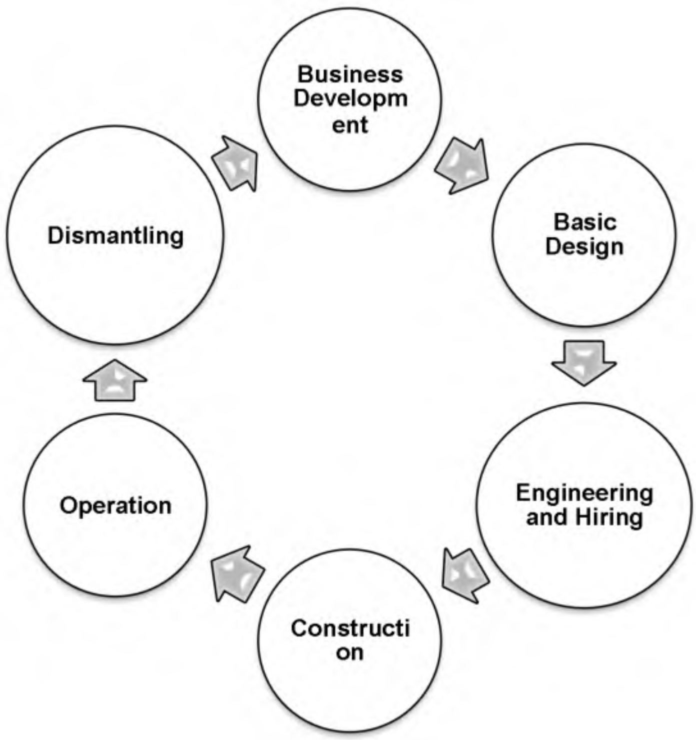


Figure 44: Life Cycle for an Oceanic Colonization Platform

However, within the process of Business Development, three parallel aspects need to be taken into consideration: Commercial, Technical and Operative.

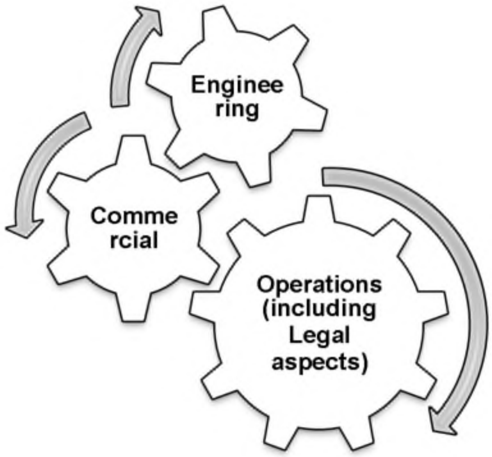


Figure 45: Business Development Aspects

Therefore, business development should be the first stage in the life cycle of the platform, even before its design. It is also the most critical stage and needs to be done in an iterative manner combined with Commercial, Operational and Technical (Engineering) aspects. In the case of oceanic colonization with sovereignty objectives, legal and political aspects also will have to be taken into account within the operations of the platform.

4.3.2.2 Agents in Business Development

During this process, a series of external agents (stakeholders) need to be taken into consideration and their participation in the platform's concept. They are shown in the following figure:

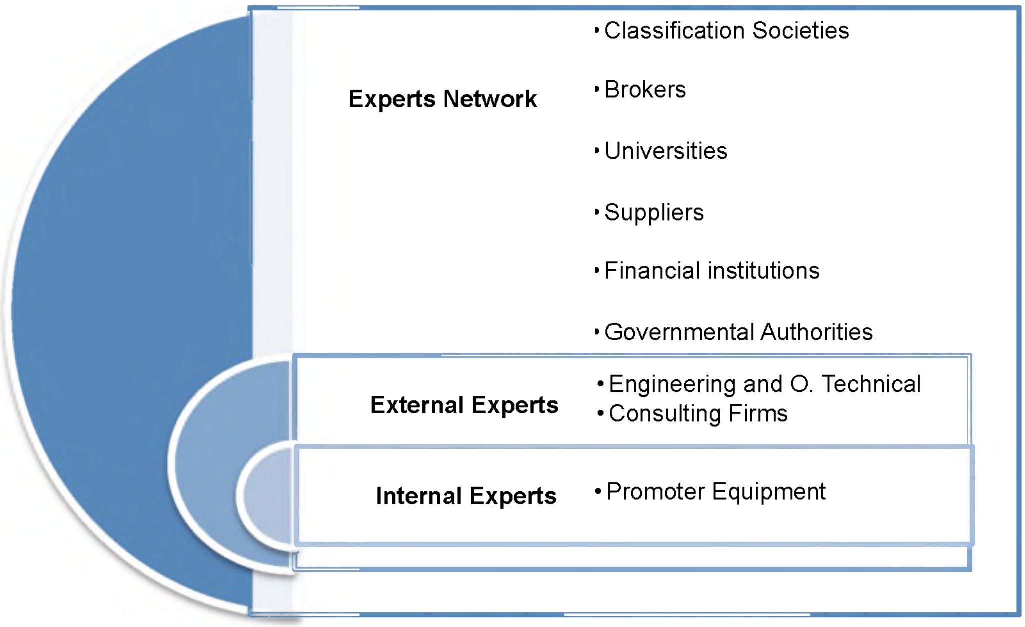


Figure 46: Agents (Stakeholders) In the Business Development of an Oceanic Platform.

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1. **Internal Experts:** are the team of engineers, economists, etc. within the the organization. The promoter is to make a simple analysis of the business idea that will explore the idea of the platform. They have the original idea and crunch the first numbers.

2. **External Experts:** are hired by the promoter to help internal experts to sketch out the ideas or even to develop them, depending on the capacity of the team of internal experts. It includes consulting firms and/or independent technical offices.
3. **Net of specialized experts:** these are experts of different fields that perform a deep analysis en themes that require great knowledge:
   a. Preliminary technical approval of the vessel and the applicable rules: Classification Societies and Governmental Authorities.
   b. Financial Viability: Financial Institutions, banks.
   c. Market feedback on the business idea: brokers.
   d. Consulting on the latest research applicable to the vessel: universities and technical centers.
   e. Consulting the market on the latest available systems that are available to install in the vessel: suppliers.

In this matter, the process to obtain a business plan will be:

- **Stage 1:** Business analysis by the promoter's internal experts.
- **Stage 2:** Technical and economical conceptual design of the platform along with external experts.
- **Stage 3:** Business development with the net of specialized experts.

The final business plan and the conceptual solution of the platform is to be presented and submitted for approval:

- Administration counsel (or any other organization in charge of deciding investments) by the promoter.
- Financial Institutions.
- Investors interested in the idea

The process is shown next:

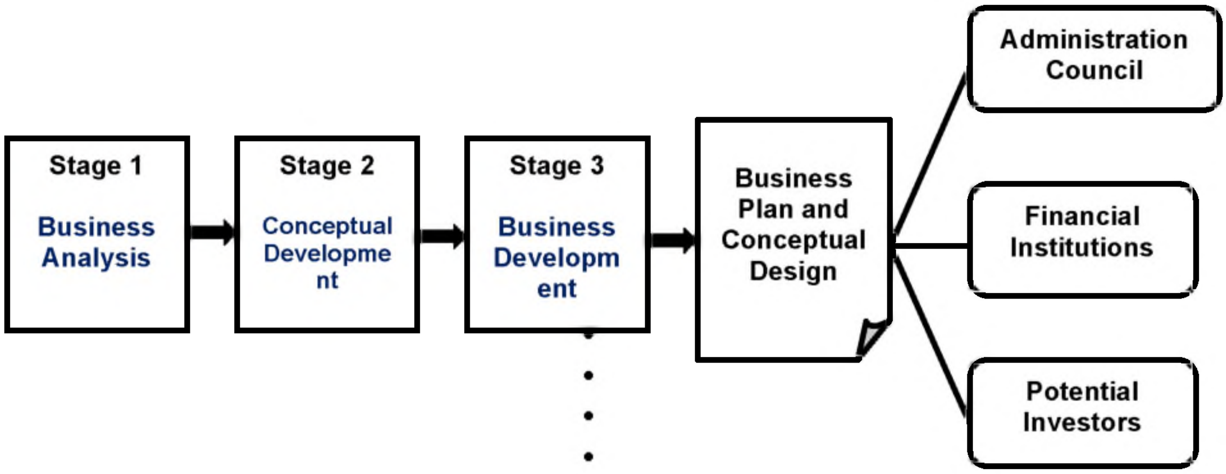

Figure 47: Simplified development process of the business development of an oceanic platform.

4.3.2.3 Business model for the creation of a micronation

As we have mentioned, one must leverage the advantages of the oceans in order to have a competitive edge that would make oceanic colonization profitable. Examples of resource exploitation and recreational activities already exist. In the same manner, expansion of terrestrial space only replicates business models on land.

Potential businesses for sovereign micronations follow:

Type of Business	Name	Requirements	Description
Medicine	*Drugs R Us* Medical Clinic	Near the U.S.	Provide medical services, treatments and medicines that are not yet approved by the FDA or that have strict regulations in the US.
Retail products	Big Brother is not looking	Near a country where there are restrictions for certain merchandise.	Sell unapproved products such as films, books, etc.
Humanitarian Aid	Safe & Sound	Would need a strict control of who comes and goes within the colony.	Would offer secure and anonymous asylums to artists, writers, political activists, and others who would need residency or work while they disseminate their work.
Residential	Oceanic Real estate promoter	Near a large city with high land costs along the shore.	Sell or lease oceanfront real estate and oceanfront property and lease space to providers of services. Residents would live sufficiently close to the large metropolis which implies shorter and easier day trips, while saving the expense of the property and possible income taxes.
Aquaculture	Caviarmar	It will need to be the right oceanic environment.	Cultivate specific species such as surgeon to obtain Caviar.
Entertainment	Water Party	Needs to be near a city.	Will celebrate various festivities along the year.
Information	Global Library	Requires follow-up to ensure information safeguarding.	Haven for open source information of every kind. Researchers can study and learn from the data and files on board.
Scientific Research	Innova-ocean	It must be situated in an area of significant environmental value.	Performs long term environmental impact studies within a specific oceanic region.
Biotechnology	CelularMar	Must be close to a country that imposes strict restrictions on treatments	Stem cell research with therapy and treatment.

Type of Business	Name	Requirements	Description
		and/or research with stem cells.	
Energy Reserch	Enermar	Must be situated in an area that allows for anchoring of energy-generating devises.	Research and test ocean renewable energy

Tabl5 4: Business examples for oceanic micronations

4.3.3 Economic independence

While food imports and fishing can be thought of as the largest part of the food consumption in oceanic settlements, other possibilities exist that include hydroponics and open water aquaculture. In this manner an oceanic settlement can be both an importer and exporter of food.

Oceanic colonies will import diesel for conventional energy plants, as is done nowadays in any vessel or small island. However, other possibilities exist such as marine renewable energy plants. There are even some studies (26) that show that renewable resources could provide all the energy necessary to service the people at the hotel aboard vessels. The same could be applied to any oceanic colony.

4.3.4 Summary and conclusions

There are already communities situated on locations such as oil rigs, offshore floating hotels, research stations, cruise ships, etc. So, from a commercial point of view, it is not preposterous to engage in oceanic colonizations with sovereignty objectives, or the creation of oceanic micronations. Success or failure will depend on having a good business plan (or plans) to sustain the colony. Examples have been presented of such potential businesses. In summary, the great freedom of the ocean ought to be used to **create profitable business models** that justify the establishment of a colony. These business models have to be searched-out with care in traditional markets based on urbanistic developments or innovative markets as a future research market of social and political systems.

The costs of development on land ought to exceed those at sea, so an activity can be profitable and relocated offshore.

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4.4 Platform technical requirements

4.4.1 Introduction

In principle, living on the ocean is a solved problem, as we shall see in Part III. F**loating forms of oceanic colonization are already a reality:**

- Houseboats and shore-based floating hotels, *coastels*, constitute real estate at a competitive price compared to similar solutions on land.
- Cruise ships provide accommodations both basic and luxury with affordable prices while they navigate from port to port.

- Offshore floating hotels, *flotels,* provide accommodations for the offshore oil industry in Open Ocean.

Ultimately, any floating artifact (merchant vessels, military or offshore platforms) has accommodation modules for those that operate them. **However, these structures are not of direct application to oceanic colonization with sovereignty objectives because:**

- coastels and houseboats are not for use outside of the sheltered waters of bays.
- Cruise ships cannot withstand a 100-year storm in mid ocean.
- Flotels are much more expensive than hotels on land.
- Modules and accommodation vessels and platforms do not attain the levels of comfort and convenience available on land.

Other novel concepts are the Very Large Floating Structures (VLFS) or other concrete offshore structures are a more viable option for the creation of micronations, though they have other disadvantages, primarily in costs and viability. The consideration of cost is of prime importance: **the technical problem of oceanic colonization with sovereignty objectives consists of identifying the optimal point between cost and functionality.**

This is one of several technical challenges that oceanic colonization phases, but it is not the only one.

In broad strokes, **the two research lines regarding the technical platform requirements:**

1. **Platform Engineering:** for security and comfort of the residents.
2. **Oceanic Environmental Conditions:** for the selection of the most appropriate location to situate the platform.

The objective is the identification of conceptual structures (there is not a single solution) that best adapts to the creation of an oceanic micronation. The purpose is not to provide a detailed design for a specific structure, but to research all the possible options (present and future) and find a response to general questions as are the cost of construction and operation, habitability, mobility, applied rules or the real short-term possibility of construction a sovereign oceanic colony.

4.4.2 Engineering of the micronation platform

Following are presented the challenges that have been identified as critical for the engineering of the platform.

4.4.2.1 Cost

The offshore industry handles hundreds of millions of dollars for the construction of its platforms, as does the cruise ship industry. A platform for oceanic colonization with sovereignty objectives should be less expensive in cost per unit area than land.

4.4.2.2 Security and Comfort

As the ocean is a harsh and unusual environment, the **engineering and comfort of the** platform is one of the greatest challenges for oceanic colonization.

4.4.2.3 Scalability, Modularity and Dynamism

Any community on land grows in a staggered pattern. There are different engineering solutions to having one family live comfortably and to scaling that to a floating city of a million inhabitants.

It is important that floating cities be modular: that there be a unit size (whether it be a single apartment/flat or an apartment/flat block) that can be **physically relocated and regrouped**, whether it be to change the internal structure of the city or to move the module to another city. This is also important for scalability: an oceanic colony of large scale will need to be constructed in an incremental manner, as it would be difficult obtain the financing or the inhabitants to create a city for 10,000 people at once.

The ocean's fluid nature makes the movement of the structure relatively simple. Restructuring the nation presents a challenge of relative situational control, as adjacent units would have to agree to be separated and this may be challenging in large agglomerations.

4.4.2.4 Necessities and requirements of the population

- In addition to the platform's structural requirements (security, comfort, scalability, modularity and dynamism), it must also have auxiliary systems for, among other things, the following needs:

- **Food Production:** as there will be no land to farm, options will include vertical farms, aquaculture and fishing.
- **Washrooms/Toilets:** treatment and reutilization of wastes, residual waters and recycling, water treatment (desalinization) and water reuse.
- **Sustainable Energy Production:** wind, solar, photovoltaic, geothermic, tidal, marine currents, OTEC (Ocean Thermal Energy Conversion, which produces fresh water as a by-product). These sources can be located on the platform itself or on "satellite" platforms around the colony.
- **Transportation:** From land to the micronation and back, and or amongst micronations. Options include helicopters, ferries or hydrofoils.

4.4.2.5 Summary and Comments

These platform requirements are common to all offshore platforms:

- **Salability, modularity and dynamism:** these would be the self-evident requirements of any sovereign oceanic colony for organic growth.
- **Population needs and requirements.** Although one could depend on food and energy imports, ideally, the colony may be self-sufficient, as discussed in section 4.3.3. Energy independence is possible, and offshore aquaculture developments also make food independence possible.

4.4.3 Oceanic environmental conditions for the creation of a micronation

There are many oceanic environmental conditions that will influence the design of any offshore platform.

4.4.3.1 Water depth

Water depth is one of the most important conditions addressed in Oceanic Engineering. In shallow waters, structures can be fixed to the seabed. In deep waters, anchoring and/or dynamic positioning are the only feasible alternatives. Additionally, water depth has effects on the materials used for anchoring due to weight reduction.

4.4.3.2 Seabed

The type of seabed has a strong influence over the type of anchoring systems to be used or the type of support it will give to the structure being installed when they are resting on the bottom. As an example, a jack-up platform is easier to install on rocky ground, which provides certain measure of stability, than on clay which is more unstable.

4.4.3.3 Wind and Waves

Unless the structure is mobile, the structure has to be designed for the worst possible wave and wind conditions – the 100 year storms. This will be expensive.

Extreme conditions live in a spectrum of period and frequency that change with time. Gigantic waves (a.k.a. rogue waves or freak waves) need to be taken into account.

4.4.3.4 Special Conditions

Earthquakes, tsunamis and other natural disasters vary across the globe in frequency and intensity. If a structure is to be in a geographic area where one of these phenomenons may occur, then they need to be considered. Tsunamis are dangerous to coastal land and shallow water, but are insignificant as they pass through deep water.

4.4.3.5 Currents

Two types of currents affect oceanic structures: large scale, such as oceanic currents, and small scale, such as water circulation patterns at various depths and tidal currents. These tto types of currents can have a significant impact on a structure.

4.4.3.6 Corrosion

Corrosion as a result of the marine environment imposes material lifespans and maintenance costs for the marine structure. Vessels have to be dry-docked regularly, while offshore platforms corrode in a few decades. Within 30 years, damage is irreversible, making the structure obsolete. An oceanic colony aims to be low-cost long term. An oceanic colony seeks to have low costs, a long lifespan, and not need to be drydocked. Corrosion thus presents a significant challenge for engineering.

4.4.3.7 Summary and commentaries

The requirements of the oceanic environment to establish a sovereign oceanic colony are similar to the problems encountered for the establishment of an offshore platform.

4.5 Legal or external relations requirements

Political stability is as important as physical stability. As was discussed in the failed attempts for the creation of oceanic micronations, it is not physical integrity and structural aspects of the platforms that have been the problem, but that of the relations of the oceanic state.

Finding an adequate location for the colony requires an oceanic study, but as well a legal study. Just as research in engineering will provide the best physically stable location, diplomacy is the key for the longevity of the colony.

Explosive growth of countries like Hong Kong and Singapore show that people and capital are attracted to societies with appropriate legal environments. As such, legal and political research should discover what makes a good legal regime, and identify the obstacles that said regime will encounter in its road to prosperity as an oceanic colony.

National and international laws affection oceanic micronations will be complex. Applicable laws will depend on the citizenship of the residents of the colony, their geographic location and the country under the vessel is registered (flagged), as well as being influenced by international maritime treaties.

These complexities raise questions:

- Under what conditions will the oceanic colony's internal matters experience outside interference from other countries?
- What legal considerations give rise to unique business opportunities?

- What laws and taxes will be applied to residents of an oceanic colony?

4.6 Self-government and internal relations requirements

In any society of any size, there are rules for government: capitalism, communism, liberalism, republics, monarchies, federalism, etc.

One of the motivations for oceanic colonization with sovereignty objectives is to establish colonies in such a way that each can experiment with new political and social systems. This is The Seasteading Institute's project. We shall not expand within this dissertation on the possible options of self-government, as they do not fall within the scope of Oceanic and Naval Engineering. In case there is interest in deepening the understanding on this topic, the bibliography has been expanded to include document references to this topic: (Taylor, 2010), (Friedman & Taylor, Seasteading: Institutional Innovation on the Open Ocean, 2010), (Friedman & Taylor, Seasteading and Institutional Evolution, 2011), (Friedman & Taylor, Barriers to Entry and Institutional Evolution, 2011), (Balloun, 2010), (Lamas Pardo & Carral Couce, Offshore and Coastal Floating Hotels: Flotels, 2011).

At any rate, small oceanic colonies established thus far follow the rules of the Merchant Marine Act for their organization: There are a series of officers (Captain, Chief Machinist, etc), subordinates, crewmates, etc. That is to say, that they are already organized in their own hierarchy and own form of self-government. As increasingly large oceanic communities flourish, these existing systems shall be insufficient.

4.7 Areas of Research

We shall examine the possible options (present and future) afforded by Oceanic and Naval Engineering for the establishment of oceanic micronations. At the same time, we shall present the possible evolution of three other forms of oceanic colonization: expansion of land holdings, mobile settlements and semi-permanent settlements to access marine resources.

As such, the focus of our research will be on the options presented by the other forms of oceanic colonization to analyze whether they address the following concerns:

4.7.1 Research of platform requirements

The requirements of the platform mentioned earlier lead to the following areas of research with several questions to address.

4.7.1.1 General Aspects:

- **Review of the Oceanic Industry's State of the Art.** To understand the basic principles of Oceanic Engineering.
- Design criteria for a platform aimed at oceanic colonization; for example, comfort and habitability.

4.7.1.2 Staggered Growth:

- What approach would one take to scale the platform's growth from a capacity of 50 to 100,000 persons? What would be the structure for each stage of growth?
- What would the cost vs. size curve look like? What designs work best at each of the ranges? How would the curve be when comparing structure vs. size?

4.7.1.3 Structure Type:

- Vessels/Barge. In what oceanic conditions can they operate? How would stability and comfort be achieved? Are there any good antirolling systems and antiheeling? How could their cost be reduced? How could platforms be made modular? What subtypes could be helpful (Small Waterplane Area Twin Hull, etc.)?
- Semi-submersibles. How do they stack against vessels? In what conditions or sizes are they superior? How can they be made more affordable? Could they be made modular?
- Breakwaters. How do they work? Do they require anchoring? What are their costs and rules of scalability? At what size do they become feasible? Could they include energy generation and what is the marginal cost per energy unit?
- Other innovative options. What other structures could be considered? What has been attempted/considered as VLFS? Mega-Float, Mobile Offshore Base, PSP, etc.

4.7.1.4 Challenges

- Materials: better quality (durability, maintenance) – concrete, steel, are there other possibilities?
- Size: What is its residential capacity? How much weight can it support?
- Concept: semi-submersible and submergible
- Location: At what distance to the coast? Will need understanding of international law.
- Mobility: anchored (fixed) or free-floating. What are the best locations for necessities such as: import/export, sun, wind, protection against bad weather – waves, tsunamis, and strong winds. If free floating, what is the power source for propulsion and navigation.
- Forces that act upon the platforms: the natural forces that act upon the platform: waves, wind, earthquakes, tsunamis, hurricanes, storms, flotation and stability. Security.
- Urbanism: Working on the concept of a new space. How would the city be developed? What would be their future needs? Limited Space.
- Architecture: ideas for recycling of containers such as buildings? Green concrete for the construction work. Futuristic and deconstructive architecture for the moment, to bring order to chaos, the power of technology.

Many of these issues are common to any other objective of oceanic colonization, whether they have a sovereignty objective or not.

4.7.2 Research regarding legal requirements

The legal segment described earlier encompasses Naval and Oceanic Engineering. Considerations include International Maritime Law, as well as the rules and international regulations that must be met by any marine platform, whether a vessel or barge, oil rig, or artificial island; we refer to the regulations of the IMO and classification societies.

These themes shall be discussed in Chapter 9:

- **Artificial Islands in Maritime Law.**

1. **The Maritime regulations that would need to be met by Artificial Islands**

4.7.3 Research Structure

We will study the platforms of other forms of oceanic colonization that would be best suited to the creation of micronations, and the legal ramifications of them.

We reproduce the table presented at the introduction of this dissertation with the platforms we shall analyze to respond to the questions posed.

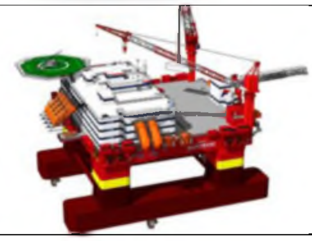
Chapter	Platforms Reviewed		Forms of Oceanic colonization
7	Very Large Floating Structures - VLFS		Expansion of land holdings
6.1	Coastal floating hotels - Coastels		
5	Mega-cruisers and residential cruisers		Mobile settlements for residential, tourist, military or commercial use with logistical aims.
7.6	VLFS as MOB – Mobile Offshore Bases		
6.2	Floating offshore hotels - Floatels		Semi-permanent settlements to improve access to marine resources
8	Concrete Offshore Structures		All
9	Regulation and legal aspects to establish platforms in the oceans		All

Table 5: Review of platforms for oceanic micronations.

On another note, both **commercial requirements and those for self-governance or internal relations are outside of the scope of Oceanic and Naval Engineering, and as such <u>are not</u> part of this dissertation.** Legal aspects have been included, as any platform must abide by rules, and their classification depends on whether it can be situated in one maritime zone or another, as it will be addressed in Chapter 9.

PARTE III: RESULTS

5 Cruisers and Residential Cruise Ships

This chapter is an adapted version of the lecture given at the 50th Congress of Naval Architecture and Marine Industry: *Market segmentation and economies of scale in the cruise industry in the 21st* century. (4)

5.1 Introduction

We will examine how the cruise ship industry increasingly offers customers diverse opportunities (recreational and residential) onboard these ships that have already become genuine **floating cities**. The concept of *"The Nation of Why Not*" of Royal Caribbean or the residential ships such as *"The World*" are the realization of this trend.

We brief review the cruise ship origins, regulations, and market segmentation to reach the final **mega-cruise** and the **residential cruise, the concepts that are closest to the floating city idea:** the first by its size and the second for its concept.

5.1.1 From the Transatlantic to the Residential Cruise Ship

The transatlantic ship is one of the largest mega man-made structures, especially in the greatest period of its history: from the 1930s century forward. These ships were striking during those days because they were as great as a skyscraper. At speeds of up to 30 knots, they were the great monsters and kings of the ocean, and were truly **floating cities**.

In the nineteenth and twentieth century, the pre-established transatlantic routes were the ideal way to travel: for the first time it allowed people to travel long distances between countries and continents on a regular basis. In the '60s and '70s this role of the transatlantic had declined due to the advantage of air travel. In the late 20th century, the transatlantic was adapted for leisure travel and became the cruise ship as we know it today. Nowadays it is more than a means of transportation; cruises are a destination in themselves and have become floating resorts.

The cruise industry has grown rapidly over these past decades. There are many companies that offer onboard cruise vacation packages for one or two weeks, with meals and entertainment included in cabins ranging from the most popular cruise Spartan to the most elite luxury cruises. Many cruise ships have casinos on board so that customers can bet (an example of taking advantage of the freedom of international waters, an objective of sovereign ocean colonization).

Transatlantic and cruise liners have been the seed of the concept of a **floating city**: at the beginning of the twentieth century we have seen the emergence of the first residential vessels, marking the next stage in the continuing evolution of oceanic travel.

5.1.2 Cruise Ships in SOLAS and Classification Societies

As defined by the International Convention for the Safety Of Life At Sea (SOLAS) and the classification societies, a cruise ship is a passenger ship used for recreational and pleasure travel. The trip itself and the amenities, attractions, activities and entertainment on board are an integral part of the experience of the cruise ship. This is what the Det Norske Veritas (32) says, for example, about the passenger ship class notation:

There are two main categories of passenger ships:

- A Passenger Ship is designed primarily for carriage of passengers.

- Car and Train Ferry is a Roll-on/roll-off ship designed for regular transport of passengers and vehicles (these may also be pure car ferry or pure train ferry, in both cases also carrying passengers).

Today, we find only cruise ships in the first category because, as mentioned in the introduction, the old liners have become obsolete by the use of aircraft for transoceanic voyages, while passenger ships are used only for recreational purposes. In the table below we present the typical class notations of the Det Norske Veritas (DNV) the Norwegian acronym for passenger ships. The notation ensures that transportation of passengers and cars are in compliance with SOLAS rules for passenger ships and steel vessels.

		Coastal Express	Cruise Ship	Ferry	Ropax
Main Class	✠				
	1A1				
Service-, Type- and Additional Notations	Passenger Ship				
	Car Ferry A				
	Car Ferry B				
	Train Ferry a				
	Train Ferry B				
	General Cargo Carrier				
	RM	I			
	COMF-C	I	I	I	
	COMF-V	I	I	I	
	ICE-05	I	I	I	I
	ICE-10	I	I	I	I
	ICE-15	I	I	I	I
	ICE-1A	I	I	I	I
	ICE-1A*	I	I	I	I
	ICE-1A*F	I	I	I	I
	ICE-1B	I	I	I	I
	ICE-1C	I	I	I	I
	ICE-C	I	I	I	I
	ICE-E	I	I	I	I
	RO/RO				
	DG-B			I	
	DG-P			I	
	MCDK			I	
Equipment and Systems Notations	E0	I	I	I	I
	RP	I	I	I	I
	RPS	I	I	I	I
	F-A		I		
	F-C		I		
	F-M		I		
	NAUT-AW	I	I	I	I
	NAUT-OC	I	I	I	I
	NAUT-OSV (A)	I	I	I	I
	DYNPOS-AUT		I		

		Coastal Express	Cruise Ship	Ferry	Ropax
	DYNPOS-AUTR		I		
	DYNPOS-AUTRO		I		
	DYNPOS-AUTS		I		
	HMON		I		
	CLEAN	I	I	I	
	CLEAN DESIGN	I	I	I	
	ECO			I	I
	HELDK		I		
	HELDK-F		I		
	HELDK-H		I		
	HELDK-S		I		
	SBM		I		
	LCS-DC		I		
Special Feature Notations	TMON	I	I	I	I
	PWDK			I	

(green)	Mandatory
(yellow)	Not Applicable
(blue)	Voluntary
I	Voluntary, frequently used

Table 6: Classification of passenger ships under DNV rules

5.1.3 Cruise Ship as a Platform For the Creation of Micronations

As we shall see later in this chapter, residential cruise ships are also included in this category of passenger ships. They offer property ownership on board a ship such as *The World* of ResidenSea or Utopia Residences. They are also the only real venue by which to own the property legally. In principle, therefore, the Class Notation seems more suitable for use for any structure that is intended for oceanic colonization because cruise ships are designed to accommodate passengers. However, this notation would also be applied to different structures and semisubmersibles or other innovative structures that are not a "ship" as it is defined in DNV regulations.

Consequently, cruise ships can be considered as early stage candidates to colonize the oceans. However, they have the following disadvantages:

- Cruise ships are expensive.
- They are designed to navigate between ports in benign conditions rather than to remain in a permanent location on the ocean in all kinds of inclement weather (wind, waves and currents).

However, the cruise market offers interesting figures and business opportunities that would be very useful for colonization at sea. This market is experiencing incredible growth, even amid the current global financial crisis.

5.2 Brief Review of the Cruise Industry Market

The cruise industry, along with the market for offshore accommodation vessels (discussed in Chapter 6.2), represents the "natural" market to offer accommodation on a ship. While an offshore accommodation vessel is located for long periods of time at one position (usually near an oil rig), a cruise ship sails from one port to another. Therefore, cruise ships do not seem to be the perfect offshore structure for the establishment of autonomous regions on the ocean.

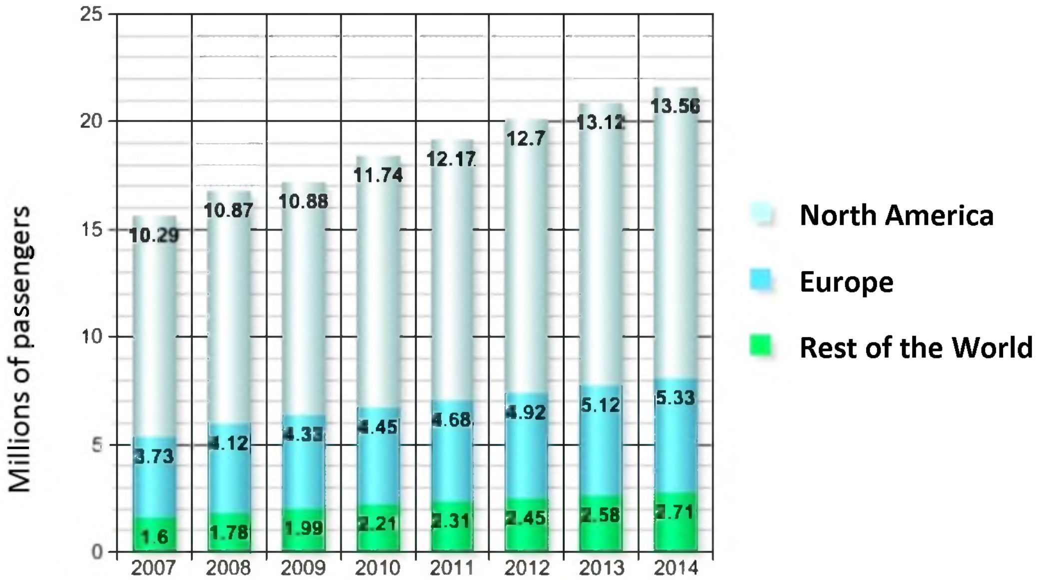
But on the other hand, they are shaped in the form of excellent ocean colonization mobile settlements. The study of the cost of cruise ships, both capital costs (CAPEX[36]) and operating costs (OPEX[37]), and market segmentation is useful for for the creation of micronations.

5.2.1 Growth Estimates of the Cruise Industry

In recent decades, the cruise industry has responded to extensive market research and consumer requirements by developing innovative designs, greater length, more exotic destinations around the world, and new activities both on board and on land, and themed environments, which are developed to provide a vacation option that best meets consumer expectations.

North America, the largest cruise market, the cruise ship industry has had a passenger growth rate of 7.2% annually from 1990 to 2011. Growth strategies to date have been driven by shorter cruises, local ports, more destinations and new activities on board/on land. The industry is also expanding rapidly internationally and has yet to reach its full potential in the U.S. or Europe. The construction of "mega-ships" is generating much interest in the consumers of cruises. The ongoing increase in the number of beds available, with lower costs per sailing passenger, is a by-product of economies of scale of the larger vessels. These activities help to increase penetration in the heart of the North American market that still has growth potential: only 45% of the target market of North America has ever taken a cruise; this may rise to 70-80%. The market in Europe and the rest of the world, though still a small market, is also growing, as shown in the chart below[38], and has further growth potential than North America.

[36] CAPEX: Capital Expeditures
[37] OPEX: Operational Expeditures
[38] Fuente: Cruise Market Watch



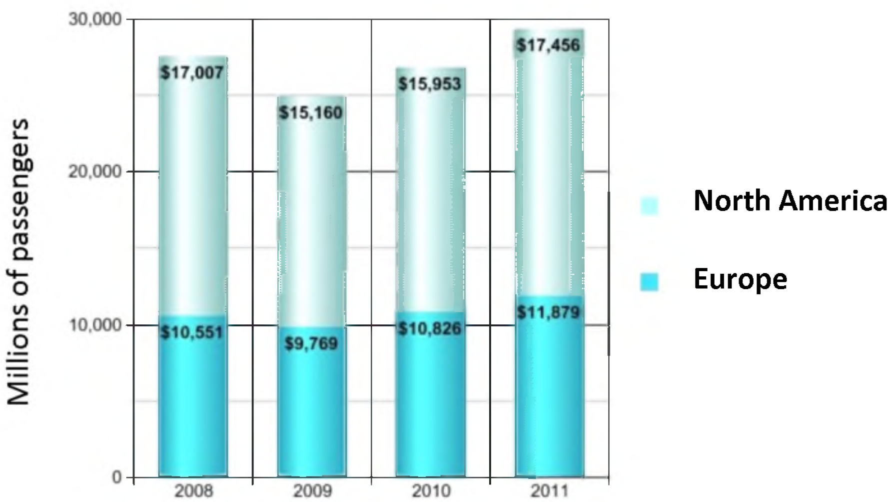
Graph 5: Projection of cruisers worldwide

Capitalization of the cruise industries growth capacity will be based on market testing strategies and diversification of brands using a market segmentation model, identifying the correct segments and then communicating appropriate value propositions to potential customers. These and other strategies continue to drive growth for the cruise industry in the future.

Sovereign oceanic colonization could obtain certain benefits of growth potential in the cruise industry to create new business models that create a demand for ocean real estate aboard a cruise ship, as discussed below.

5.2.2 Cruise Ship Fleet and Pricing

A total of 13 new ships were added in 2010. In 2011 and 2012, 13 new ships will be added. Following is a graph obtained from Cruise Market Watch:



Graph 6: Income from the cruise industry worldwide

From the same source we can obtain data regarding all cruise ships that will enter the market through the coming years, along with their costs:

Cruise Ship Companies	Name of Ship	Passenger Capacity	Cost of Construction mill $	Cost of Construction mill €	Cost of Construction per Passenger in $
AIDA Cruises	AIDAblu	2,17	513	398	$235,971
Costa Cruises	Costa	2,26	548	425	$242,478
MSC Cruises	MSC	2,55	548	425	$214,902
Celebrity	Celebrity	2,85	698	542	$244,912
P&O Cruises	Azura	3,07	535	415	$173,927
Ponant	Le Boreal	264	150	116	$568,182
Seabourn	Seabourn	450	250	194	$555,556
Holland	Nieuw	2,10	567	440	$270,000
Oceania	Marina	1,26	530	411	$420,635
Cunard Line	Queen	2,09	708	549	$338,432
Carnival	Carnival	3,65	738	573	$202,081
Disney Cruise	Disney	2,50	899	697	$359,600
Costa Cruises	Costa	3,01	726	563	$241,036
Ponant	L'Austral	264	150	116	$568,182
Seabourn	unnamed	450	290	225	$644,444
MSC Cruises	MSC	2,55	548	425	$214,902
Oceania	unnamed	1,26	530	411	$420,635
Celebrity	unnamed	2,85	798	619	$280,000
Costa Cruises	Costa	3,01	726	563	$241,036
Disney Cruise	Disney	2,50	899	697	$359,600
AIDA Cruises	unnamed	2,17	565	438	$259,890
Celebrity	unnamed	2,85	768	596	$269,474

Table 7: Cruise ships in portfolio at the end of 2011. Source: Cruise Market Watch

We can also analyze the costs of construction by country. The table below[39] shows the location of the order book for the period of 2009-2012 itemized by country of construction. Four counties dominate the market (Finland, France, Germany and Italy), while it is other countries like Spain, USA and Canada are building small cruise ships.

[39] These figures are based on orders made at the end of 200GT (Gross Tonnage), LB (Lower Berths), Pax (Passenger). There were no additional orders during 2009 due to the financial crisis. Source: G. P. Wild (International) Limited.

Country of Construction	No.	GT	Pax (LB)	Pax/per ship	Cost €m	Cost € per pax	Cost $ per pax
Finland	2	440,000	10,800	5,400	4	15000 €	$199,779
France	5	552,600	15,150	3,030	22	170 €	$231,576
Germany	10	1,013,500	24,972	2,49	07	196 €	$248,107
Italy	18	1,363,000	33,084	1,838	79	2003 €	$264,099
Spain[40]	1	5,000	136	136	78	5729 €	$739,221
USA & Canada	2	12,700	318	159	67	22 €	$271,560

Change 17-08-2010=	0.7759	$1

Table 8: Cruise ships in the portfolio in late 2009

5.2.3 Economic Breakdown of a Typical Cruise Ship

As we have seen from the above market figures, the price per passenger is very high compared to the price of an apartment on land. The challenge for ocean colonization aboard these ships to be competitive is to lower the CAPEX to a level at which the price of a cabin could be competitive to an apartment on land.

The breakdown of costs of a typical cruise ship is shown in the following table:

Concept	Description	% cost
Labor	Hours of cutting, steel erection, pipe assembly, tests, etc.	14%
Steel materials and paint	Plates, profiles, poles, paint	17%
Machinery and propulsion	Main engines and auxiliaries, thrusters	7%
Auxiliary systems	Pipes, pumps, purification, treatment plants	8%
Special equipment	Air conditioning, stabilization systems, elevators, etc.	9%
Accommodation	Supply and installation of furniture, decorative bulkheads, doors, gates, etc.	27%
Electrical installation	Supply and installation of electrical panels, transformers, cables, etc.	8%
Other costs	General costs, financial costs, etc.	10%

Table 9: Cost breakdown of a typical cruise ship

The following table shows a breakdown of revenues and expenses for a typical cruise passenger. Total average costs per passenger are $1,454 per cruise. This figure is an average for all types of cruises from luxury cruise ships to the more conventional. The typical cruise lasts days, so projecting that figure per passenger per day is an expense of $205 per day with $150 per day in the ticket price (7%) and $50.10 per day in expenses on board (2%). For the cruise line, about 7% of revenues are fuel costs, salaries and payroll 11%, 11% agent's commission and 6% food.

As with CAPEX, the challenge for colonization is to lower the OPEX to a competitive level compared to an accommodation on land. for example, corporate costs represent 38% of the OPEX for a cruise ship. On a platform that aims to accommodate a micronation, these costs would not exist. The same goes for port costs and forwarding agents, and other costs such as fuel, which could be lowered. Although more research is needed, perhaps the costs of a ship in which one micronation is housed would be less than 50% of expenditures for a similar cruise ship.

5.2.4 Agents of the Cruise Ship Industry

Business models in the cruise industry have four types of agents (33):

1. **Shipyards.** They function as the main suppliers in the value chain. The shipyards build and repair cruise ships that meet the requirements of ship owners (cruise lines) that are service providers.
2. **Ship owners.** They make most of the strategic decisions such as choosing the target market, investment and *consumer branding*[42].
3. **Service companies.** Owners of cruise ships have outsourced services in the operation of the cruise to service companies operating some of the individual services on board (shows, shops, etc.) or nearby port itineraries (tours, baggage handling, etc.).
4. **Passengers.** Cruise passenger companies are looking for customers, as customers serve as the ultimate goal of the value chain.

[42] Branding es un anglicismo empleado en mercadotecnia que hace referencia al proceso de hacer y construir una marca (en inglés, brand equity) mediante la administración estratégica del conjunto total de activos vinculados en forma directa o indirecta al nombre y/o símbolo (icono) que identifican a la marca influyendo en el valor de la marca, tanto para el cliente como para la empresa propietaria de la marca. Wikipedia.

5.3 Market Segmentation and Cruise Ship Types

As mentioned, the rapid growth and specialization experienced by the cruise industry in recent decades has affected the design, overall aesthetic, material, size, equipment and entertainment of modern cruise ships and recreational vessels of all kinds, while also responding to growing concern about the environmental impact of cruises in the communities and marine and coastal ecosystems.

Today, every continent and region of the earth can be visited in a cruise or recreational ship, including more exotic destinations and distant and isolated places.

Similarly, in recent years an increasing number of companies and organizations previously detached from the cruise industry have come to offer cruise passengers seeking unconventional experiences.

This section will describe the different types of ships designed to provide services to cruise the seas and oceans of the world, with special attention to residential cruise ship (sometimes called English cruise condo[43], a way to have a property (real estate) on board a ship.

5.3.1 Conventional Cruise Ships

This is the most known and popular cruise ship and is sold by most companies in the sector as floating resorts designed and equipped to meet the needs of the majority of cruise passengers. These ships have a capacity of 850 to 3,000 passengers, and include all the features of a resort, such as restaurants, bars and pubs, clubs and discos, malls, theaters and cinemas, galleries and museums, libraries, casinos, personal care areas with gyms and spas, swimming pools and other sports facilities.

5.3.1.1 Serenade of the Seas

This Royal Caribbean ship is an example of a conventional cruise ship. It features:

- Passenger capacity: 2,500. Length: 294m. Breadth: 32m. Draft: 8.5m. Speed: 25 knots.
-

Figure 48: Serenade of the Seas. Source: Royal Caribbean

[43] Condo =abreviación de Condominio, se refiere a un piso o apartamento, en este caso, en un buque crucero.

5.3.2 Small Specialized Cruise Ships

There are also a number of smaller cruise ships ranging from motor and sailing yachts to mid-size classic cruise ships with a capacity up to hundreds of passengers. This type of cruise ship offers a more intimate and relaxing experience than the larger ships and they normally navigate to less familiar places, provide specific services (conventions at sea, water sports, cruises for singles, cruises for seniors, cruises to encourage businesses, etc.), and sail across waters, small bays, harbors or islands, which could not support larger vessels. They usually provide the same level of comfort and basic amenities of larger cruise ships.

5.3.2.1 Ms Europa

The *MS Europa* belongs to *Hapag Lloyd Cruises* and has capacity for up to 408 passengers and is intended for specialized cruises and private events, family gatherings, musicals and conferences.

Figure 49: MS Europa. Source: Hapag Lloyd Cruises

5.3.3 Luxury Cruise Ships

These motor and sailing cruise ships are equipped with more sophisticated and technologically advanced systems, high standard features and luxury amenities to meet the special demands of an exclusive clientele in search of more exotic itineraries and destinations worldwide.

5.3.3.1 Sea Cloud II

The *Sea Cloud II*, built in *Gondan Shipyards* (Spain) for *Sea Cloud* Cruises (Germany) is a good example of a luxury cruise ship.

Figure 50: Sea Cloud II. Source: Sea Cloud Cruises

5.3.4 Adventure Cruise Ships

The adventure cruise ships are designed and equipped to visit remote destinations not normally frequented by commercial lines, or inaccessible to larger ships. They are marketed to a specific clientele, are much smaller than conventional vessels and usually have some luxury features.

Figure 51: Spirit of Source: Adventure cruises

5.3.5 Expedition Cruise Ships

Ships are specially designed for a specific purpose or adapted for icebreaker research. It is operated by specialized companies to offer customers a unique experience in the more remote destinations such as the Arctic and Antarctic regions and coastal areas and ecological reserves of the biosphere. They could be considered more like conventional private cruise ships for expeditions. the ships provide a suitable level of comfort, security and entertainment, including inflatable motorboats and sometimes even helicopters and land expeditions.

5.3.5.1 Akademik Sergey Vavilov

Built in Finland in the late '80s for the Russian Academy of Sciences, the original mission of the ship was to develop hydro-acoustic ocean research. It has a reinforced hull icebreaker.

- Length: 117 m; Breadth: 1m; Draft: 0 m.
- Speed: 1 knots.
- Passenger capacity: 107; crew: 53 passengers.

Figure 52: Akademik Sergey Vavilov. Source: Quark Expeditions

5.3.5.2 Scientific tourism Cruise 36 Pax.

This is an example of an ecotourism cruise: a vessel intended to cruise 36 eco-tourism and scientific tourism pax and adventure. This is a rendering by the author of this dissertation for his degree project (2).

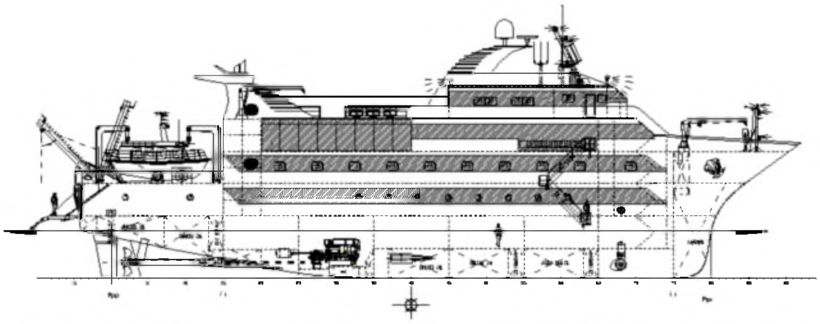


Figure 53: 36 pax scientific tourism cruise ship. Source: Own

5.3.6 River Cruise Ships

Always much smaller than ocean cruise ships, and with a capacity of no more than a hundred passengers, these vessels are specially designed to navigate the rivers and inland waters, offering services ranging from exciting experiences aboard the very latest units, nostalgic ships rowing vessels in rivers like the Amazon, Nile, Siena, Volga, Mississippi, Yagtse, and many more around the world.

5.3.6.1 St. George I

This ship, owned by Sonesta, sails down the Nile, between Luxor and Aswan, on 3, 4 and 7 night cruises. It has 47 deluxe cabins and 10 suites, offering spa, gym, restaurants, etc.

Figure 54: St. George I. Source: Sonesta Cruise Lines

5.3.7 Theme Cruise Ships

Cruise operators and yacht designers often try to offer the market something novel. One way to obtain this differentiation is through theme cruises. The art of producing a yacht or cruise theme is to weave a story through each of the elements of design in parallel with a large consultation with the client during the initial stages of the design process. This approach allows the creation to be truly unique from the general exterior to the smallest detail in the interior.

5.3.7.1 The Streets of Monaco

Yacht Island Design submitted this proposal in January 2011. Theme: Small Waterplane Area Twin Hull (SWATH) type ship of 155m bearing the principality of Monaco to the ocean. They selected the SWATH type hull not only because it offers the best performance at sea, but also because its unique length/width relationship provides a broad beam and gives greater flexibility to achieve the best use of space. It also allows the exploration of unusual design ideas without the constraints of a conventional hull shape.

Figure 55: Virtual recreation of "The Streets of Monaco". Source: Yacht Island Design

This type of SWATH cruise ship would be predominantly constructed of steel with the use of aluminum in the superstructure.

- Length: 155m
- Capacity: 70 passengers and 16 crewmembers.
- Propulsion. Electric diesel.
- Speed: 15 knots.
- Estimated cost for designers: 800 €m.

5.3.7.2 Sea Park By Oliver Design

This cruise ship was designed in 2002 by Oliver Design (Spain) to complement land hotels and in collaboration with a Spanish hotel group, although it has not yet been built.

It proposed a capacity between 1,000 and 1,400 passengers and would be designed to navigate for a few hours. The idea is to break out of the concept that a cruise ship must be operated by the builder, and thus raise the question of whether a hotel group that has a certain number of beds in a tourist region – not less than 1000- and that offers multi-day packages (usually one week) of sun and sand, could integrate a special cruise ship in its business. A tour operator may use it as a complementary product to its business like a theme park, with nightly dinners, conferences, weddings and hotel during the weekend of that week which would include the complete package.

Figure 56: Artist's rendering of the "Sea Park". Source: Oliver Design

5.3.8 Floating Hotels

As discussed below, cruise ships are often used as simple floating hotels (called “flotel”), at special events. The cruise ship is moored to the dock during the event, providing the same services as any other hotel on land. Recent examples are displayed in the section on floating hotels in Chapter 6.

5.3.9 Residential Cruise Ships

We will also devote a separate section to this topic, as the use of cruise ships as permanent residences is the most realistic near-term option for ocean colonization.

5.3.10 Mega Cruise Ships

Cruise companies have responded to the growing global demand for this type of service with the design and construction of cruise ships to accommodate more than 3,000 people. the mega-ships are a new class of cruise ship, and the next step in terms of capacity and services on board, with some units that routinely serve more than 5,000 passengers. Ships are larger and more sophisticated in the world, and are indeed genuine floating cities.

5.3.10.1 Voyager of the Seas

This ship can be considered the first mega-cruise ship. Completed in 1999 for *Royal Caribbean international*, it holds up to 3,114 passengers, and with its other two twin *Voyager Class* units, it remains the eigth largest passenger ship in the world.

Figure 57: Artist’s rendering of the *Voyager of the Seas*. Source: Royal Caribbean

It was the first ship to have a main street within the *Royal Promenade*, which is the heart of the activities on board.

Figure 58: the Royal Promenade inside the *Voyager of the Seas*.
Source: photo by the author of this dissertation taken onboard in October 2010 during his trip from Barcelona to Naples.

5.3.10.2 Oasis of the Seas

This vessel was commissioned by *Royal Caribbean international* in February 2006 and launched in late 2008. It set a new record, accommodating over 6,000 passengers. It is also the first ship to incorporate the concept making a cruise ship with seven themed areas called *neighborhoods*[45], a concept similar to that used in the planning of theme parks, providing passengers with a wide variety of experiences based on their personal preferences and styles. in this sense, it is practical concrete application of a themed cruises, but in this case seven different themes opposed to the single themed cruise ships mentioned earlier.

Figure 59: Comparison with Genesis project and a Freedom class, the first mega-cruise ship of all, the Voyager of the Seas. Source: Royal Caribbean

[45] Neighborhoods is the exact term used the company

The last image, from *Yran & Storbraaten Architects*[46], shows how *Royal Caribbean* designed this ship as a floating city, with a central avenue surrounded by apartments, shops, restaurants, parks, etc.

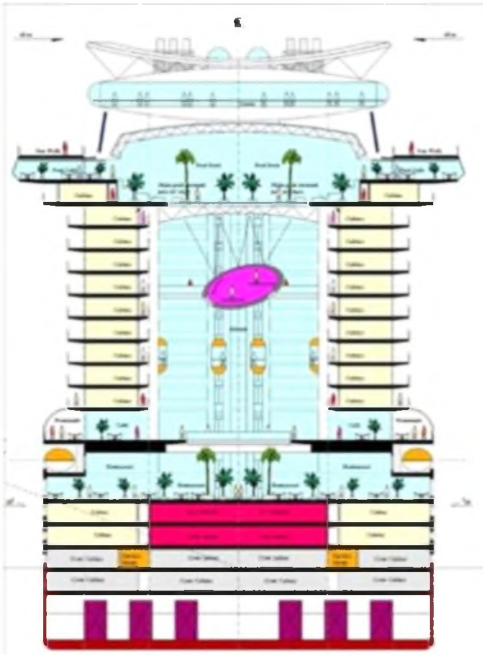


Figure 60: Central section of the *Oasis of the Seas*

Although the actual project eliminated many of the original elements shown in the image above for being too bold, it never fails to impress.

Technical Specifications:

Tonnage:	**225,282 GT**
Total length:	**360 m**
Waterline Breadth:	**47 m**
Maximum Width:	**60.5 m**
Draft:	**22.5 m**
Depth:	**25 m**
Capacity:	**5,400 passengers double occupancy; 6,296 maximum**
Crew:	**2,165**
Classification:	**Type: 401 - Passenger Ship DNV ✠ 1A1 Passenger Ship, COMF-V(1,) RPS, ECO, F-M, LCS-DC, CLEAN, FUEL(991 kg/m3), BIS**
Cost:	**$1,400 million USD (2006)**

[46] *Yran & Storbraaten Architects A/S* (Oslo, Noruega) fue fundada en 1983 y es una de las firmas de arquitectura líderes en el mundo en la industria de cruceros. Su lista de referencias incluyen algunos de los buques mencionados a lo largo de esta tesis: *World of ResidenSea*, *Magellan*, *Voyager of the Seas* y *Oasis of the Seas*. Más información en: www.ysa.no

5.3.11 Mega Cruise Ships Not Built

The brand spearheading the construction of mega cruise ships is Royal Caribbean. The engineering costs and market research costs of such large ships are high, and they will likely continue to come from the three principal worldwide companies that already have mega cruise ships in operation: Royal Caribbean, Carnival Cruise Line and Norwegian.

However, we consider interesting to mention some of the bold proposals of other entrepreneurs, although limited to those from the world of marine engineering, shipbuilding and design professionals in the industry. Specifically, the French shipyard of Saint-Nazaire has been very active in these ideas, as discussed below.

5.3.11.1 Cruise Bowl

In 2000, the cruise ship designer John McNeece conceived a concept he called "Cruise Bowl" and it was presented at the *Miami Beach Seatrade Shipping Convention*. It consisted of a theater/stadium weighing 240,000 tons, housing 12,000 people, and accompanied by two satellite ships of 130,000 tons each with 2,250 cabins each for a total of 6,000 passengers from the resort.

McNeece, one of the most important designers within the cruise world, with such works as the *QE2*, *Celebrity* and *Royal Caribbean*, was proposing essentially a kind of floating Las Vegas at sea with an area for sports and entertainment center called the "mother ship"[47] with two satellite ships.

The proposed overall dimensions of the mother ship to be built with light materials would be 423m long by 357m wide, which would require a review of international safety standards in addition to its technical difficulty of construction. The dimensions of the satellite vessel would be 278m long and 64m wide. All ships would be multihull to optimize stability and would be based on the principle of SWATH ships, with a conventional cruise speed of 22 knots.

The ship is designed to be 3 or 4 full days at sea, with the main objective of providing first class entertainment of sports, concerts, or conferences, TV shows, etc.

Figure 61: "Cruise Bowl"

5.3.11.2 Az Island

In 2002, the French architect Jean Philippe Zoppini and Alstom[48] shipyards presented a design of a fifteen-story floating island, 400m long and 80m high, with capacity to transport more than 10,000 people in 5,000 apartments. The project sought to create a refined service for the richest tourists who wanted take luxury cruise across the Pacific with little sense that they were at sea.

[47] Mothership,
[48] Today STX-Europe en Saint-Nazaire

The interior of the floating island, which has its own port to accommodate two ferries with six hundred seats each, would have a floating casino, apartments for time-sharing mode and many other activities.

The project was named AZ (Alstrom Zoppini) and is yet to to built. The cost of this project would be about that of three or four large cruise ships.

This gigantic naval engineering project would have a promenade that would stretch a mile long over the sea – a transparent surface – and provide more spacious cabins than the best liners (between twenty-four and thirty square meters).

According to the promoters, from a technical standpoint, the project was perfectly feasible, although many details of the original idea would be modified at the time of completion of the job. The island would withstand waves up to twenty meters in height. If it needed to avoid a hurricane or storm at high sea, it could move at a speed of ten knots. It would be powered by propellers and the energy would come from a diesel engine or gas turbine. Its paint could last up to fifty years. The maintenance of this island is presented as a challenge and possibly would be done at sea.

The project did not pass beyond a model presented at the Miami *Sea Trade Exhibition* in March 2003. The study of its performance did not provide size or cost data or the number of engineering hours it would need.

Figure 62: “AZ Island”. Source: Jean Philippe Zoppini

5.3.11.3 Eoseas

Eoseas is a cruise ship designed in 2008 by the STX-Europe shipyard in Saint-Nazaire (France). It would be 305 meters in length, 60 meters wide and have a capacity of 3,311 passengers. It would be a multihull pentamer vessel, providing it with more stability and lowered fuel consumption, which is also aided by its sail propulsion.

Obviously, such proposal has not even come close to becoming reality, and is rather a corporate product strategy.

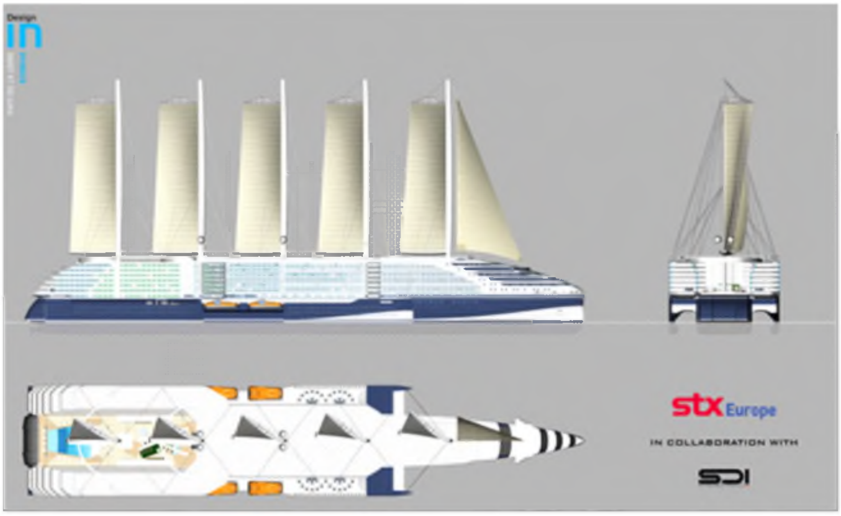


Figure 63: Elevation view, plan and profile of the ship Eoseas

5.4 Residential Cruise Ships

There is only one residential cruise ship in operation, the *World*. There are several more in development, including some with a Letter of Intent[49] for construction: *Utopia Residences* at *Samsung Heavy Industries* shipyard, and *Magellan*, at the shipyard *STX-Europa Saint Nazaire*, France (this shipyard is very active in this type of project).

Although these vessels contribute little innovation to marine engineering, they deserve special attention as examples of permanent residence in the ocean as they show developments in the concept of ocean colonization. That is why we devote a separate section to the study this type of vessel. Other times, the term Condo Cruise Ships is also used to refer to them.

Following we will see two of the above projects, *The World* and *Utopia*, which are the most significant, although there are several more that to date do not yet have a LOI with a shipyard. Some of them are:

- Residential Ocean Liners Inc.
- Four Seasons Ocean Residences of the hotel chain the Four Seasons
- Orphalese of Orphalese Holdings

5.4.1 The World

The concept of the first residential ship, the *World*, was conceived in 1997 by industry veteran Knut Kloster, Jr.[50] The ship was built by *ResidenSea Corporation* (Florida) in the shipyard of *Fosen Yard* (Norway) and began sailing in March 2002. With 165 residential units, the inhabitants can live on the ship full time while sailing across the world, but are also required to have residence elsewhere, as these cabins may not be used as a primary residence. The properties have a lease of 70 years, which is the expected life of the ship.

Unfortunately, *ResidenSea Co*. went to the ultra-luxury market just as the global recession was about to begin. In late 2003, residents bought the ship from the company to operate it themselves. It is said that sales of flats have increased, although there are several units for sale.

[49] *Letter of intent*, LOI, es un acuerdo muy frecuente en construcción naval.

[50] Knut Kloster Jr. es un miembro de la aclamada familia Kloster quienes fueron pioneros de la industria de cruceros a principios de los años 60. La familia Kloster fundó Norwegian Cruise Lines (NCL), y Knut Kloster, Jr. trabajó como presidente y consejero delegado tanto de Royal Cruise Lines como de NCL.

Still, it seems as if the original funding had not been successful. It is inherently difficult to get funding for a new business model and enterprise that requires substantial amounts of money, but the ResidenSea results make it even more difficult. But despite the relative failure, the idea had enough impact to plan other similar projects.

Figure 64: ***The World***

From a technical standpoint, this new approach to domestic life at sea was a challenge to the regulations of SOLAS. This was the first maritime legislation faced a dedicated vessel to circumnavigate the world with permanent residents on board. the ship was classified by DNV as a *passenger ship* like any other cruise ship but took into account some special considerations.

- **Equipment and furniture:** residents could, to some extent, equip their own apartments with their own furniture. To enable this, and also provide flexibility for future overhauls of spaces within each apartment and the replacement of furniture, space for all apartments was considered as public space in the category of increased risk of fire by SOLAS.

- **Kitchens:** traditional passenger ships only have a few main kitchens and the main security challenge is this ship was to adopt the practice of SOLAS over 110 individual kitchens operated by residents of the apartments. In close cooperation with DNV, the ship owner and the shipyard reached a solution with kitchens surrounded by bulkheads each of Class A and arranged with an independent exhaust system from the point of cooking within the kitchen itself. This exhaust pipe is also equipped with fixed fire safety systems as required by SOLAS.

Technical Specifications:

Tonnage:	**43,524 GT**
LOA:	**196.35 m**
Breadth:	**29.8m**
Draft:	**6.7m**
Speed:	**1 knots**
Crew:	**250**
Capacity:	**150-200 passengers on average**
	The ship has 165 residential units (106 flats, 19 apartments and 40 studios), all owned by the residents. The ship can accommodate 100 to 300 passengers and guests.
Classification:	**DNV ✠ 1A1 Passenger Ship E0, ICE-1C, COMF-V (crn) 1,**

	W1[51]
Cost:	**$265 millions (2002)**

Residence prices in 2010:

Residence	Bedrooms	m^2	Price $
Ocean Studio 661	studio	30.4	60,000
Ocean Residence 1006	2	12	2,950,000
The World Suite 1108/1110	6	38	13,500,000
Annual maintenance fee (*)	$90,000 to $240,000 , according to size		

(*) includes maintenance fees, shuttle buses at Port, laundry and a credit of $20,400 for food and drinks.

5.4.2 Utopia Residences

In early December 2009, *Utopia Residences Co*. of Beverly Hills, California, announced a Letter of Intent (LOI) to build a floating luxury residential complex in the shipyards of *Samsung Heavy Industries*, Korea, for $1.1 billion. *Samsung* and *Utopia* had planned to have the ship built and delivered in 2013, although today it has not advanced beyond this LOI.

This residential cruise ship called Utopia would have 200 private residences, a 204-room hotel and entertainment typical of a mid-class cruise ship: casino, spa, clubs, swimming pools and restaurants. The ship's investors, led by *Frontier Group*, a private equity firm in St. Louis, USA, had set a goal of creating "a platform for learning, cultural exchange and philanthropy," a perpetual journey sailing around the world, an idea that could be considered not very consistent with the luxury that on the other hand the ship accumulates, as we can see in its prices in the table below.

Technical Specifications:

Tonnage:	105,000 GT
LOA:	296 m
Breadth	36 m
Draft:	50 m
Speed:	22 knots
Crew:	600
Capacity:	200 luxury residences ranging from 130 m^2 to 614 m^2 204 luxury hotel rooms
Classification:	DNV
Cost:	$1.1 billion (2009)

Residence costs in 2010:

Residence	Bedrooms	m^2	USD $M
Olympian States	2	130	3.9
Royal Cup States	3	394	12
Utopian States	4	614	24
Annual maintenance fee	Information not available		

[51] This notation is no longer found at DNV and has been substituted for NAUT-AW

As we can see, the prices are at the level of the *World* of *ResidenSea*: expensive.

Figure 65: Utopia Residences. Rendition and corporate logo

Figure 66: Utopia Residences. Apartment type "Royal Cup Estates", size 394 m^2

5.5 Mega Residential Cruise Ships

The mega residential ships are more than a vessel; they are a destination. The idea is to dedicate them to tourism as giant structures that can move and offer sophisticated services at sea. If any such project were built, it would pose a major challenge to traditional tourist destinations, always exposed to downturns such as weather problems and political extremism arising from their geographical locations.

The mega-ship would be a big city where its inhabitants, who share a very comfortable space, find various services such as opera or theater, gymnasiums and numerous sports facilities.

We differentiate these mega projects of cruising in the sense that these mega residences are intended to become permanent residences and not temporary destinations for a week.

5.5.1 Freedom Ship

The *Freedom Ship* was a proposed mega-residential cruise ship by an entrepreneur named Norman Nixon, with a length of 1400 m, a width of 230 m and a depth of 110 m. Conceptual designs included a mobile modern city with luxury housing, international duty-free shopping, and a 160,000 m^2 deck for several companies to display their products. The *Freedom Ship* was designed as a place to live, work, retire, vacation or just to visit. The ship would circumnavigate the world constantly, covering most of the coastal regions. It would have a large fleet of high-speed ferries (hydrofoils and aircraft) that would transport residents from land to shop and vice versa.

The propulsion would be a 400 azipod thrusters. Despite that large number, the vessel would be among the slowest in the world due to the great displacement.

Despite having announced the date of 2001 for its entry into service, construction has not begun. Net estimates for the ship had risen from $6 billion in 1999 to $11 billion in 2002.

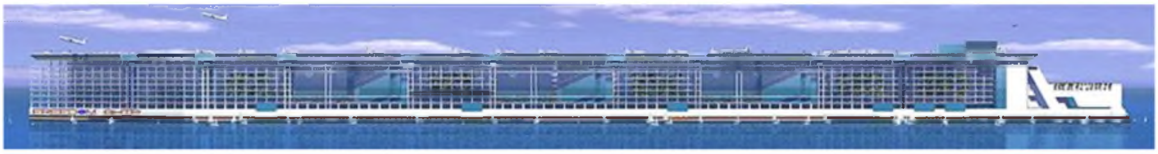


Figure 67: Virtual side view of the *Freedom Ship*

5.5.2 American World City

This concept of “city at sea” was conceived in 1978 by Knut Utstein Kloster (who also conceived the idea of The World) and his company *World City Corporation* A/S (Oslo) in what was called “Phoenix Project.” In developing the concept of this city, Kloster was joined by the admiral, attorney and entrepreneur John S. Rogers and Danish naval architect Tage Wandborg. It was then that he formed *World City Corporation* (NY) and *World City America Inc.*

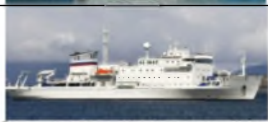
It would be a vessel of about 400 m in length, would host 6,200 guests in 2,800 staterooms and suites, offering a wide variety of services, restaurants, and shops. The floating city includes enormous gates at the stern of the ship that would open to reveal a large marina inside the hull and port. Fully independent ships would dock in the marina and would be deployed at high speed to and from the ports of various destinations within a 50-mile radius of the floating city.

According to the vice president and CEO of World City, John Rogers, the total project cost would be $1.3 billion, most of which would come from loans guaranteed by the U.S. government. But the Department of Shipping of the U.S. government rejected the application in January 1996 due to World City failing to provide satisfactory evidence that they met the economic, financial and technical resources to ensure security for the loan.

Figure 68: Rendering of *American World City*

5.6 Summary

The following table summarizes the segmentation discussed.

Type		PAX
Adventures		**< 100 approx**
Expeditions and Scientific		**< 200 approx**
Riverboats		**< 200 approx**
Luxury		**200-400**
Specialized cruise ships		**400-800**
General cruise ships – conventional (mainstream)		**800-3000**
Mega cruise ships		**> 3000**

Innovative Concepts		
Residential cruise ships		
Theme cruise ships		
Mega residential cruise ships		

Table 10: Segmentation of the cruise ship industry

Included in the table are residential ships, theme and residential mega cruise ships in section for projects partly in development (The World might be considered a pilot project that has not had the expected commercial success). But in the analysis of result of Part IV we will see the trends in the market for cruise ships seen here in the future which will enable the emergence of real **floating ship cities** similar to these.

6 Coastal and offshore Floating Hotels - Flotel

This chapter is an expanded version of the article and Castilian Floating o*ffshore and Coastal Hotels*: *Flotels* published by this author during the course of the dissertation in the *International Journal of Marine Engineering at the Royal Institute of Naval Architects*. (5)

Accommodation vessels, floating hotels, or just flotels, now represent the state-of-the-art in the maritime and offshore industries' offerings of holiday accommodation in semi-permanent fixed locations within bays, inlets, warm seas, or offshore in the ocean.

"Flotel", or "Floatel", are abbreviations of the terms floating and hotel, which refer to the accommodation facility on barges, ships, vessels or semisubmersible platforms. The flotels are used as hotels in rivers, bays, or in port areas as accommodation for workers, especially in the oil industry (1). The term *Coastel*[52] is also used when designed for coastal waters; this term is also an abbreviation of the terms coastal and hotel.

We will begin with the study of Coastels, classifying the various types according to their uses. These structures, which can only be used on the coasts, are not really good candidates for colonization of the ocean at high seas but, rather, can extend land space into coastal waters.

The offshore flotels are otherwise those who are closest to the concept of colonization on the high seas and therefore will be studied in greater depth than the coastels. We will classify the flotels by following the rules of the International Maritime Organization (IMO) and the classification societies.

6.1 Floating Coastal Hotels, Coastels

The *Coastels* are floating accommodation vessels that can be moored along a pier or anchored in harbors, bays, sheltered beaches, coves, and so forth. They can be leased during long or short periods of time and are used during the initial development of a project or for the life of it. Although the main use is as simple commercial hotels, they also offer a wide range of possibilities and applications such as (34):

- Floating prisons
- Accommodations for shipyard workers
- Floating power plants
- Accommodations for the construction of large bridges
- Temporary offices
- Training facilities
- Accommodations for military personnel
- Accommodations for refugees
- Casinos
- Accommodations for students
- Hospital facilities
- Headquarters in remote locations for events

[52] The term "Coastel" is also a trademark of the Bibby Maritime Ltd company, but we will use this term throughout the thesis to distinguish floating hotels on the coast of the offshore floating hotels.

- Floating office buildings
- Floating shopping malls
- Floating modular accommodations: the lowest cost solution

The main benefits of a coastel compared to building on land are[53]:

- **Mobility:** the unit can be transported anywhere in the world and located at any seaside destination. The only requirement is a location where the unit can be tied.
- **Lower cost:** the unit can meet all the requirements as far as quality of services as a 3, 4, or 5 star hotel as well as those of the most basic level of accommodation. The cost of construction is usually below land construction cost. These savings are particularly significant if the cost of ownership is calculated with the cost of construction on land.
- **Shorter construction time:** the time to build a floating accommodations unit is significantly shorter than construction on land.
- **Green technology:** by avoiding spills in the water, it makes this application most beneficial to the environment, from construction to operation.
- **Completely independent unit:** the unit can operate in any remote area if necessary. A floating accommodation unit typically can be located in an area where you can connect to the land network for both power and sanitation. However, all necessary health systems are located on board, and generate their own power, manage their waste, etc.
- **Immediate operation:** the unit can be built at a location of low construction cost and **delivered** to any destination worldwide. Floating accommodation units are put into operation immediately once you connect with land.
- **High security:** these units are very safe, and you can monitor the logistics of all people, as needed in the case of a high-level event conference or political events on board.
- **Coastal expansion solution:** the unit provides the alternative to expand the potential of accommodations in areas where land has been fully exploited, such as overcrowded tourist areas. Here it connects with one of the purposes of oceanic colonization expansion of the surface.

However, they have the disadvantage of being suitable only for still waters near the coast and therefore cannot be used for international waters where the waves, wind and currents are much stronger.

Figure 69: The Jascon 27 coastel being towed on the estuary of Coruña. October 20

[53] According to the Finnish accommodation systems company, ALMACO group.

6.1.1 Classification

Following the classification of *Det Norske Veritas*, *DNV* (32), these structures are usually classified as

- Type: 713 – Hotel Barge
- Notation: ✠1A1 RE Pontoon

If we go into more detail in the DNV notation, we find the following definitions:

- **Barge:** Ship type class notation for barges or pontoons without sufficient means for self-propulsion for their service area.
- **Class Notation RE**: defines a service area restriction
- **Purpose:** the notation is offered to vessels that are designed for a particular service. the notation is generally applicable to small vessels and normally less than 100 m long.

Benefits:

- adjustment of design loads based on the limited service area.
- retaining the same safety level as for vessels operating without service area restrictions is retained.
- may result in reduced building or conversion costs.
- **Features:** This notation indicates that the service area is restricted to enclosed fjords, lakes or rivers.

A few years ago, the coastel was classified under the class notation floating hotel. As before, going into detail on the DNV, we find the following:

- **Class notation:** Floating Hotel
- **Description:** Vessel with accommodation for guests at stationary locations in protected waters.
- **Application:** Passenger ships, mandatory as of July 1995
- **Remark:** Service restriction RE part of main class
- **Date of last issue:** July 1997

The hotel or accommodation facilities on the dock itself are currently being built under the SOLAS rules for passenger ships. Sometimes there are even applicable building regulations of the country's land in which they intend to operate.

Therefore, as discussed in the classification of offshore flotel, the rules applied to these floating hotels moored to docks and ports are not the same as would apply to a flotel in international waters. At first glance, they appear to be similar to the offshore accommodation barge (Accommodation Work Barge), but if we go into detail, the regulations, the stability, structural or safety requirements are very different.

6.1.2 Floating Commercial Hotels

The main application of coastels is as floating hotels, customized to meet luxury standards of 3, 4 or 5 stars, with all the same amenities as a hotel on land.

Figure 70: virtual concept of the luxury floating hotel “Green Marina”: ALMACO54

Barges and pontoons are the most common structures used as floating business hotels, but on occasion cruise ships are also used. We illustrate this with some examples.

6.1.2.1 Flotel 92

This is a project of the ‘80s of the former ASTANO[55] Spanish shipyard for a floating hotel with 1,000 rooms whose primary purpose is to provide temporary accommodations in certain cities without sufficient reserve capacity. It was to be used for events like the 1992 Olympic Games held in Barcelona (35).

This hotel was designed as an autonomous unit, to be anchored to the bottom or moored to a dock in tidal inlets, quiet beaches and ports with a minimum depth of 4 to 5 meters with access via ramps and pontoons. the unit is towed from one point to another when required, as it has no propulsion, and then anchored and/or tied to the dock. The hotel facilities are built on a steel pontoon in which all the machinery is located for autonomous operation of the hotel.

Figure 71: Rendition of the Flotel 92

The *Flotel 92* was designed under the following BUREAU VERITAS rules:

- Classification and Certification of Floating Hotels and Hospitals.
- *Towing at sea of ships and floating units* (NI 183A – CNI) to obtain classification note: I3/3E FLOATING HOTEL/NP, RMC-V

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[54] ALMACO, founded in Kaarina, Turku (Finland) in 1998 is a company that provides and installs products and customized services to shipowners and shipbuilders of passenger ships, accommodation barges and offshore accommodation platforms.

[55] ASTANO, an acronym for "Shipyards and workshops of the Northwest" was a shipyard based in Fene-Ferrol (Spain) that flourished during the 1960s and early 1970s. At the end of the late 1980s and early 1990s, it focused primarily on the offshore sector.

Like most types of floating structures with no permanent staff on board, this Flotel also complies with the rules of the International Maritime Organization, IMO. That is:

- International Convention for the Safety of Life at Sea (SOLAS).
- International Convention on Load lines 196
- International Convention on Tonnage Measurement of Ships, 196
- Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs)

But at the same time, the hotel facilities on the pontoon also meet all the standards of the hospitality industry on land that are not standard seals.

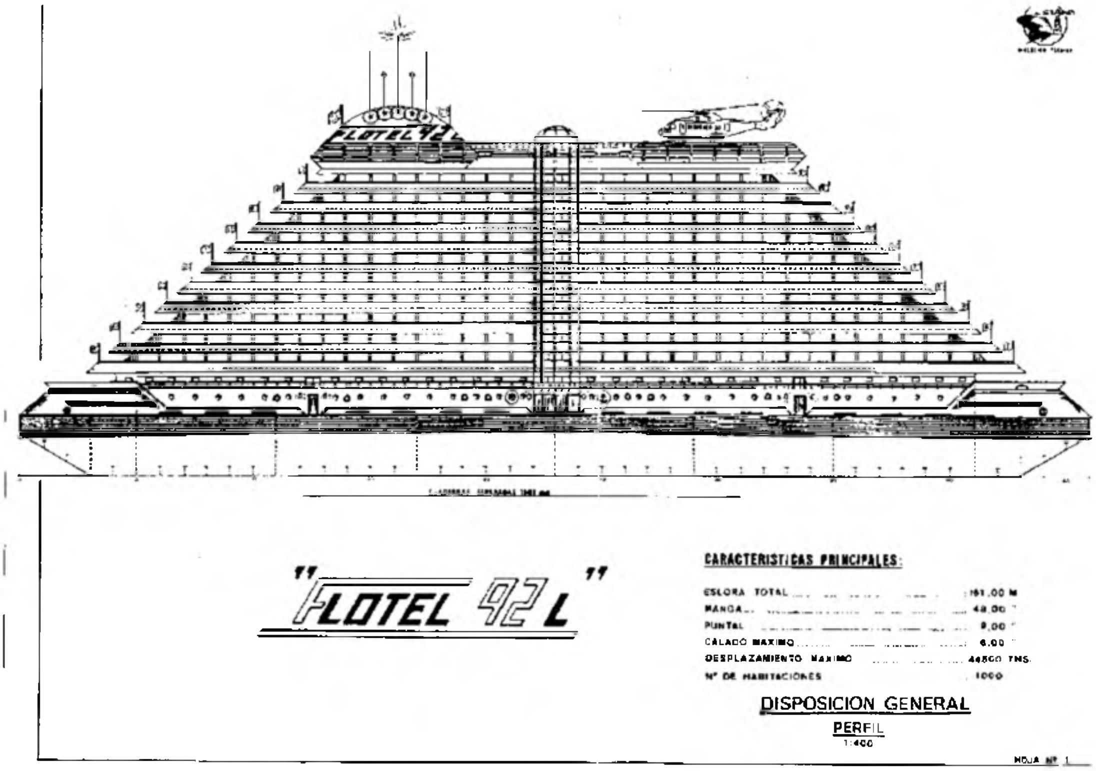


Figure 72: General layout of the Flotel 92

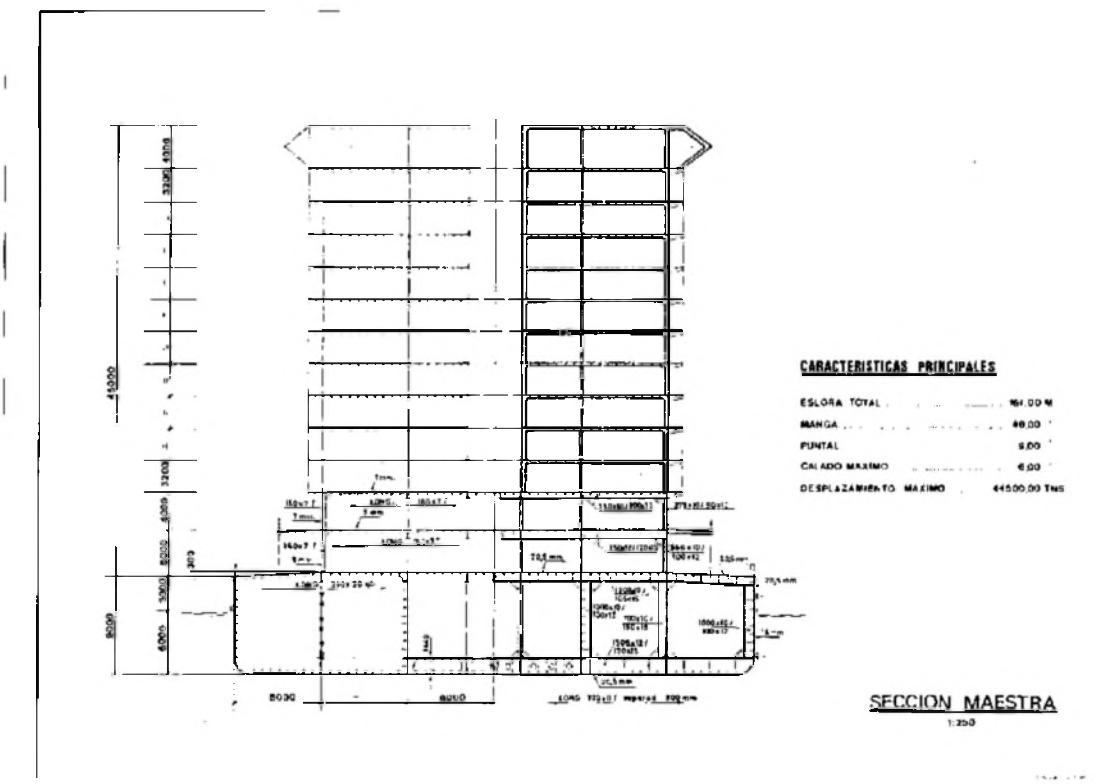


Figure 73: Midship section of the Flotel 92

6.1.2.2 Flotel for Workers in the United Nations in Haiti

Many cruise ships are used temporarily as flotels simply tied to the dock with the same philosophy as the Flotel 92. For example, the UN (United Nations) recently rented cruise ships as floating hotels to house humanitarian staff in earthquake-damaged areas of Haiti. "Ola Esmeralda" and "Sea Voyager", ships of 146 meters in length, were used as homes for the UN staff working in the ruined Haitian capital of Port au Prince.

Figure 74: Ship “Ola Esmeralda”

6.1.3 Accommodation for Shipyard Workers

The floating hotels, coastels, are suited to house shipyard workers as the yards are inevitably near water and usually have space available for mooring ships. Using a coastel to accommodate workers within shipyards not only offers a cost-effective solution compared to the use of hotels or camping ground, it helps to reduce logistics of moving workers from their places of accommodation and the workplace.

6.1.3.1 Bibby Renaissance

This coastel, though it has been used for other purposes, has been used to provide accommodation in shipyards as seen in the picture below.

Figure 75: Bibby Renaissance. Source: Bibby Maritime

Technical Specifications:

Tonnage:	**4,700 NT**
Total length:	**95 m**
Total breadth:	**27.5 m**
Draft:	**3.2 m**
Capacity:	**332 simple cabins**
Classification:	**Classification Society: Lloyds Register Class: 100 AN PONTOON**
Construction Code:	**Lloyds register classification UK Building Regulations**

6.1.3.2 Jascon 27

Jascon 27 is a suitable accommodation barge to house offshore construction project workers, capable of operating in restricted and/or protected waters. It houses more than 500 employees and contains facilities like a kitchen, dining, entertainment, gym, etc.

Figure 76: *Jascon 27* in the Port of Coruña.

Technical Specifications:

Tonnage:	13,512 GT
LOA:	103 m
Flotation breadth:	23 m
Total Width:	23 m
Draft:	3 m
Depth:	6 m
Capacity:	300 to 500 persons
Classification	Type: 713 – Hotel Barge Notation: DNV✠1A1 RE Pontoon

6.1.3.3 "Martin Quarters": Flotel Used in the BP Oil Spill

This barge was chartered by BP and several subcontractors to accommodate more than 500 workers hired for the cleanup of the worst oil spill in U.S. history: the disaster of the Deepwater Horizon, in June 2010. The temporary accommodation was the only way to have workers near Port Fourchon, a huge shipyard that serves to support offshore oil platforms surrounded by very ecologically sensitive marshes and beaches.

Figure 77: MARTIN QUARTERS.

6.1.4 Floating Prison

This type of accommodation barges offers high security, with a series of spaces that can be used as premises for medical examinations, security cells, local private consultation, and for visitors and local entertainment. Using a floating prison offers additional solutions to the excessive number of prisoners and insufficient space for them in detention centers on land.

6.1.4.1 The Weare (Today, Jascon 27)

HM Prison the Weare was a floating prison anchored in Portland Harbour in Dorset, England. the government established the Weare in 1997 as a temporary measure to address congestion in prisons. The barge was moored at an unused dock which the Royal Navy had on the Isle of Portland. In March 2005 it was closed primarily due to operating maintenance costs. It was sold and renamed Jascon 27, as seen in the previous section.

Figure 78: HM Prison the Weare, Port of Portland
The gray block in the center of the image is the prison

6.1.4.2 Bibby Stockholm and Bibby Kalmar

Bibby Stockholm and Bibby Kalmar were converted into floating prisons according to the customer's exacting specifications, the "Dutch National Agency of Correctional Institutions and the Dutch Government Building Agency." The facilities also include a large number of security cells, additional facilities for visitors, shops, security posts and offices for staff.

Figure 79: Bibby Stockholm and Bibby Kalmar. Source: Bibby Maritime

6.2 Offshore Floating Hotels, Flotel

The offshore oil industry is the main market for flotels and represents the “state-of-the-art”. Many projects have been developed in recent years with new concepts and innovative ships and systems to improve the living conditions of seafarers working in the offshore industry.

The main purpose of a flotel is to provide accommodation facilities for those working on offshore oil platforms, holding contiguous structure in position near fixed platforms and floating units such as FPSOs and semisubmersible drilling vessels. The means for maintaining the position range from the use of an anchoring and mooring system to dynamic positioning systems. The transfer of personnel between the offshore platform flotel is usually provided by a telescopic gangway.

Figure 80: Semisubmersible offshore flotels servicing an offshore oil field

The need for offshore flotels comes from oil platforms (FPSOs, drilling ships, etc.) that accommodate only those personnel required for normal operation, usually between 100 and 200. For example, the FPSO “Texaco Captain” has a capacity of 200 people and the drilling rig “Stena Clyde” has a capacity of only 160 people.

Figure 81: “Stena Clyde” and “Texaco Captain”

The problem comes when extra capacity is needed to house workers during construction and operations such as installation, maintenance, shutdowns, renovation projects, decommissioning, coupling satellite fields to existing infrastructure, etc. These operations not only require extra capacity of accommodation, but also other needs such as storage areas and repair shops, lift capacity loads, and underwater work. The options for meeting these requirements for accommodation and extra services are varied and depend on the most appropriate mix of services required. The following table shows schematically these options with approximate rates and operational meteorological environments.

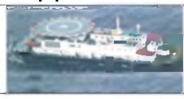
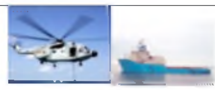
	Oil Platform	Vessel/barge submarine support	Ship crane Semi-submersible	Transport by helicopter
				
Operating depth	With DP: unlimited Anchored: 300 m	Unlimited	Unlimited	Unlimited
Capacity to accommodate	50-150	40-200	200-400	20-50
Daily rates (thousands $)	200-400	100-250	500-800	30-70
Meteorological environment	Strong	Benign	Benign	Medium

Table 11: offshore accommodation options

However, an accommodations ship is the best choice when the only requirement is extra accommodation capacity: whether the accommodation is needed for 2 months or 3 years, it can be ready in a few days. We will study in detail in the following sections each of these structures used as flotel, but by way of introduction, the table below shows the four major offshore structures used as flotels.

	Single hull vessel	Single-hull barge	Semisubmersible barge	Self-elevating barge
				
Operating depth	Unlimited	With DP: unlimited Anchored: 300 m	Con DP: unlimited Anchored: 300 m	<120 m
Accommodation capacity	400-600	400-1000	300-800	70-330
Daily rates (thousands $)	120-200	100-150	150-250	70-130
Meteorological environment	Medium	Benign	Strong	Strong

Table 12: Types of offshore flotels

The flotels are positioned along the mother plant and connected by a telescopic gangway. This platform also provides a “safe haven” in the case of an emergency. Along with providing various utilities to the facility to which it connects, these flotels provide welfare services, dining facilities and comfortable accommodations for staff.

Figure 82: First Gateway giving access to the rig.

JCE Group AB[56] built the first semisubmersible flotel in the world in 1977. Since its entry into service, these units positioned next to the platform have become the best solution to provide offshore accommodation in the short term. However, **these semisubmersible flotels also have some disadvantages:**

- High costs of acquisition.
- High operating costs.
- Limited mobility as they require towing in order to be transported.
- Lack of flexibility in their operation; they are not multi-purpose.
- Complex connecting systems.
- Operating frequency highly variable depending on adverse weather.

Figure 83: Semisubmersible Accommodation Platform “Chemul” being towed in February 2010. Source: Boa offshore AS.

In 2005, the ship MPSV[57] Edda Fjord of the Østensjø Reder AS[58] assembly was converted to provide accommodations on the shores of Nigeria for a total of 330 people. Therefore, one can consider it the first single-hull flotel ship. Bonga FPSO gave support to the site during construction, coupling and delivery of FPSO facilities. The ship Edda Fjord was connected to the FPSO through a

[56] ASTANO, an acronym for "Shipyards and workshops of the Northwest" was a shipyard based in Fene-Ferrol (Spain) that flourished during the 1960s and early 1970s. At the end of the late 1980s and early 1990s focused primarily in the offshore sector.

[57] Multipurpose Platform Support Vessel

[58] Østensjø Rederi AS was founded in 1973. Since its inception the company specialized in the sector of towing and offshore structures . It has built 30 ships. Web site:www.ostensjo.no

gateway and used the dynamic positioning system on board to maintain the position accurately and continuously. The accommodations were containerized modules, as shown in Figure 84 below.

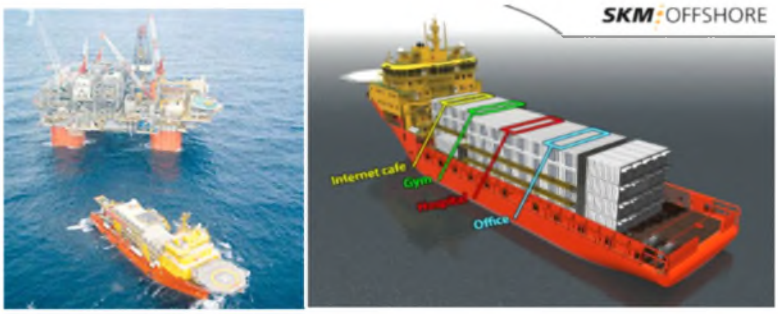


Figure 84: Edda Fjord in operation as a flotel and a rendition with accommodation modules type container

In the following years, and due to the excellent performance of Edda Fjord, several companies decided to build their own single-hull flotel ships. They offer the following advantages compared to single-hull flotel:

- A single-hull vessel is considerably cheaper to build and operate than a semi-submersible.
- A single-hull vessel has much lower costs in moving from place to place, and moves a lot faster.

But single-hull vessels also have a major drawback: a semisubmersible vessel is more stable than single-hull movements and is therefore more suitable for harsh environments. The problem of rolling motion can be minimized with the installation of anti-balance systems such as active stabilizers through tanks. But the heaving motion causes dizziness and cannot be avoided on a ship.

In addition to the vessels and semisubmersible **single-hull barges** have also been used for many years to provide extra accommodations in the offshore industry, also offering other possibilities such as high load capacity/elevation or pipelines. They are usually not self-propelled and represent a low-cost alternative in benign and intermediate waters.

- Advantages:
    - Less expensive than other types: single-hull vessels and semisubmersibles.
- Disadvantages:
    - Not self-propelled. Needs trailer for transport.
    - Only for benign and shallow waters, as they usually are not equipped with dynamic position systems and must be anchored.

But recently, there is a growing number of auto-propelled barge projects (at low speeds) with DP systems, which means that they are becoming one of the preferred solutions for a lot of marine contractors.

Figure 85: Accommodation barge "Camelot". Source: Intership Ltd.

In some cases, the jack-up platforms are used as accommodation vessels, but are limited to shallow water a few feet deep.

In the following sections, we will see in more detail each of the types of flotels used in the industry offshore.

- Single-hull ships.
- Single-hull barges.
- Semisubmersible barges.
- Auto-elevated barges.

6.2.1 Single-Hull Flotel Barges

As we mentioned, in 2004 Østensjø transformed the multi-purpose platform support vessel *Edda Fjord* to provide accommodations for 330 people who were doing work and testing connection belonging to Shell Bonga FPSO on the shores of Nigeria. During the 11 months it was working, it was necessary to disconnect it only for 10 hours and a half for meteorological reasons.

Therefore, the use of single-hull vessels as flotels is fairly recent, with the MPSV *Edda Fjord* being the first. It had such good performance that building other ships for the same purpose followed as shown in Table 15. However, during the years 2008 and 2009 the financial crisis and declining oil prices led to delays and even cancellations of some of these projects, but those that are still in force began operating in early 2011.

Table 15 shows some of these projects. You can see that most of them are not pure accommodation vessels but have other features mainly related to support offshore and sub-sea construction work. During the time in which service as a floating hotel is not required, these vessels can be used for rapid transport of offshore personnel in areas lacking an established infrastructure, to or between platforms, ships or ports. Some of them may also be used as offshore construction vessels with subsea operations with the assistance of ROVs or diving services. The large cargo deck can be used to store equipment or used as a cover offshore for work in different operations offshore such as repairing machinery.

Therefore, these vessels are equipped to perform the following functions:

- Support for accommodation.
- Support for connection work, testing, delivery and commissioning.
- Support for maintenance.
- Light offshore construction.
- Crane operations.

These ships are very versatile and are quite similar to any other offshore construction vessel. the figures below of the Ocean Hotels Plc and Equinox Energy companies illustrate all these ideas.

Figure 86: Layout of the flotel Ocean Hotels Plc

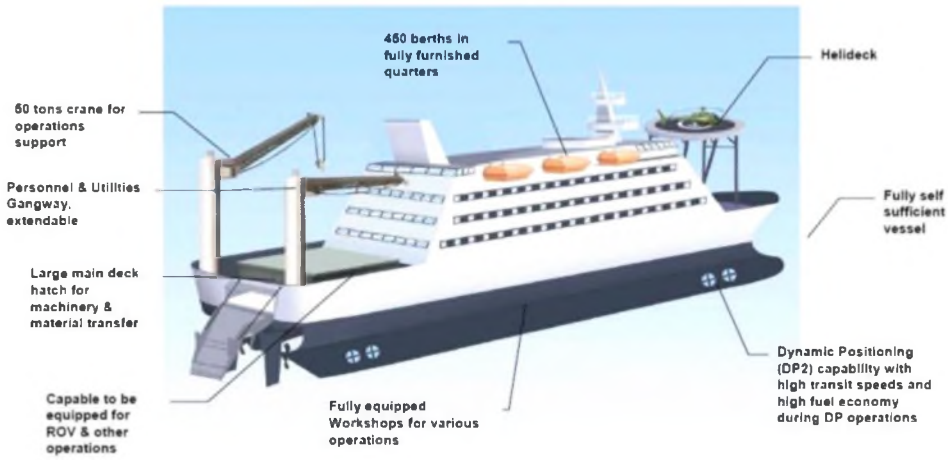


Figure 87: Layout of the flotel M/V ARV. Source: Equinox Energy

The advantages of single-hull flotels compared to semisubmersibles can be summarized in the following points:

- Self-propelled.
- Increased flexibility since the ship can move freely between the client's several units in the oil field.
- Ability to turn off the walkway of the platform in an emergency quickly and move out of it in response to possible danger of hurricanes and abrupt weather changes.
- Less expensive mobility.
- Normally, lower capital costs.
- Candidates for transformation offer opportunities for marine contractors and design solutions that are more versatile and inexpensive.
- A semisubmersible needs a tug to move, and one or two vessels to anchor, or bottomless tugs. A single-hull flotel does not require ships or tugs.
- Fast and flexible transfer of personnel between platforms as well as repositioning and mobilization.

Alternative solutions to these single-hull flotel vessels, such as **single-hull barges**, only work in very mild weather conditions, as they are not self-propelled. On the other hand, alternatives to adverse weather conditions, such as large crane vessels are much more expensive compared with flotel boats, if all you want is extra accommodations.

The advantages of the flotel ships compared with single-hull accommodation barge and jack-up type are similar to those quoted above in comparing the flotel ships:

- Do not need anchoring ships or tugs.
- Fast transfer and flexible while repositioning and mobilization.
- Flexibility to disconnect in case of an emergency or sudden danger or abrupt change in weather.
- Capacity for deep waters.

The flotel ships can normally be tested in channels for their ability to maintain high positions in DP and their suitability for transfer of personnel in a variety of environmental conditions. The model tests should be used to evaluate the comfort of the passage (called MIR or Motion Illness Rating) in accordance with the requirements of other passenger ships on vertical accelerations. Shown in the Appendix, **Chapter 12.5.1 is an example of a behavioral assessment at sea of the M/V Dan Swift.**

According to SOLAS and classification societies, we can find the type of *passenger* flotel or the type of specialized use "*special purpose ship*" as discussed in the following sections.

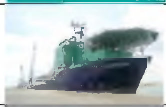
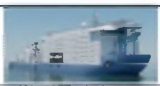
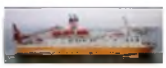
Name	Picture shows	Owner	Description
Atlantic Challenger		Deep ocean	Multipurpose vessel with spacious accommodations
Deep Endeavor		Deep ocean	Multipurpose vessel with spacious accommodations
Polycastle		Polycrest AS	Multipurpose vessel with spacious accommodations
Edda Accommodation		Østensjø Group	Special purpose ship for construction support services
Ice Maiden		Adams offshore Ltd.	Icebreaker made flotel
Ocean Hotels		Ocean Hotels Plc.	Special purpose ship for construction support services
Dan Swift		J. Lauritzen Pte. Ltd.	Support and accommodation vessel (ASV)
ARV 1		Equinox offshore	Ship repair and accommodation (ARV)
ARV 2		Equinox offshore	Ship repair and accommodation (ARV)

Table 13: Types of flotel ships in operation or under contract

As discussed in the cruise ship section, the ship class notation applies to passenger cruise ships and ferries, but cannot be applied to other structures such as barges, semisubmersibles, or other innovative structure, since they are not “ships”. Lately some accommodation vessels are also included in this category, as the following example.

6.2.1.1.1 Dan Swift

The DP offshore accommodation and support vessel *Dan Swift* was transformed in 2009 from an old cable ship at the *Blohm + Voss Shipyards* (Germany) by the offshore contractor *J. Lauritzen Singapore Pte. Ltd.* It is designed to work with both fixed and floating platforms or vessels such as FPSOs semisubmersible drillers with two gateways: port and starboard.

Figure 88: M/V Dan Swift, and positioned next to the fixed platform Peregrino B

Technical Specifications:

Tonnage:	13,600 GT
Length:	140 m
Width:	20.75 m
Draft:	10 m
Speed:	12 knots
Capacity:	291 beds in total with 256 for passengers: 4 simple cabins, 34 double cabins, 46 4-people cabins
Classification:	DNV ✠1A1 Passenger Ship, E0, HELDK-SH, DYNPOS-AUTR, NAUT-OC, CLEAN, BWM-E(s), COMF-V(3)

The following figure shows the positioning of one FPSO vessel with two possibilities: the Gateway port and starboard.

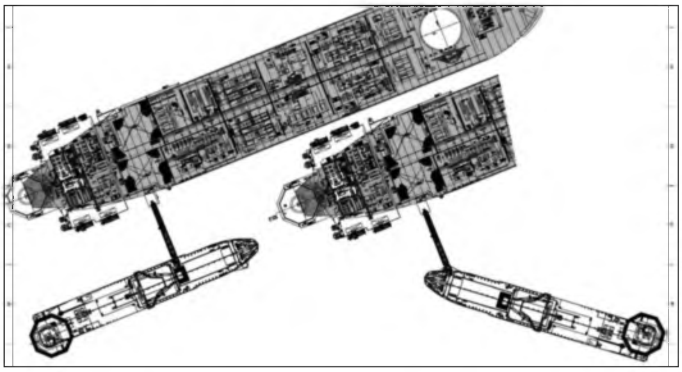


Figure 89: System Access between the offshore accommodation ship and the FPSO Dan Swift. Source: ***J.Lauritzen AS***

6.2.1.2 Flotels Classified as Ships With a Specific Purpose "Special Purpose Ship", (SPS)

SPS class notation, Special Purpose Ship, applies to virtually most of the ships that support the offshore industry (offshore support vessels). Because of that, some have been classified single-hull flotel with this notation. However, as discussed in Part IV of the Analysis, this is not the most suitable for this type of vessel.

6.2.1.2.1 Edda Fides

This is a multi-purpose accommodation and service vessel owned by the *Østensjø Group*, which has a long history in offshore services and also owns the *Edda Fjord*, the first flotel ship. The Edda Accommodation, which was built by the Spanish shipyard *H.J. Barreras*[59], was delivered in the first quarter of 2010. It is equipped with a dynamic positioning system of the highest class (DP3), and has a propulsion system of 5 Voith Schneider.

[59] Children of J. Barreras S.A., or Barrerras shipyard, is a shipyard founded in 1889 and located in Vigo, Spain.

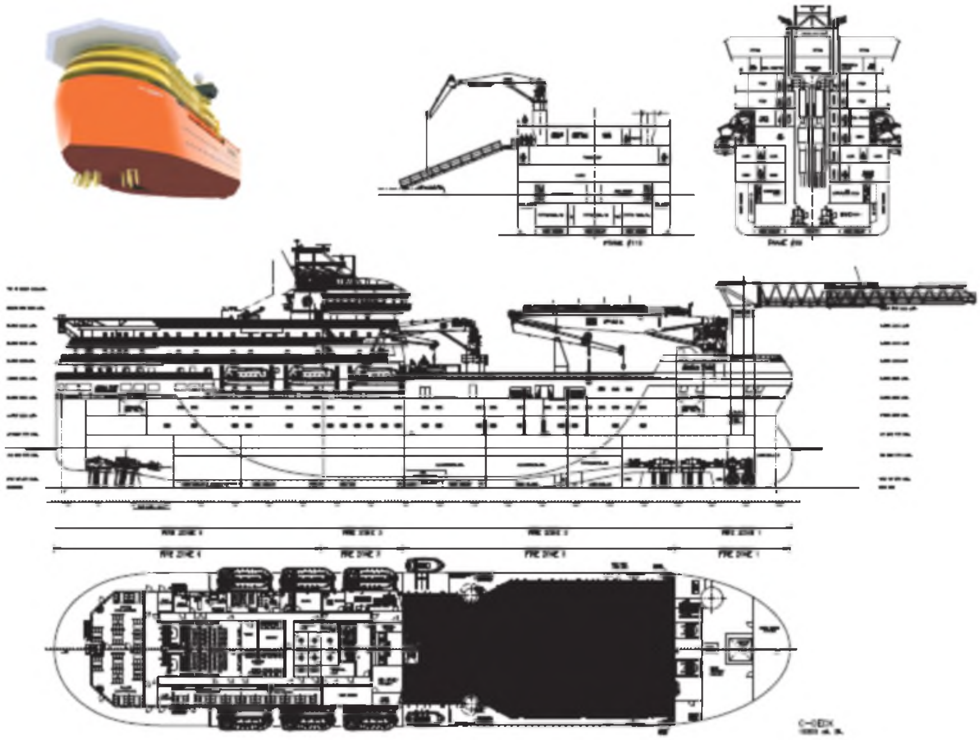


Figure 90: Profile, plan and sections of the ship Edda Fides

Technical Specifications:

Tonnage:	-
Length:	130 m
Width:	27 m
Draft:	7 m
Speed:	12 knots
Capacity:	600 beds in total in combination with 1, 2 and 4 beds per cabin - a total of 177 cabins.
Classification:	DNV ✠1A1, SUPPLY VESSEL, SF, EO, ICE C, DYNPOSAUTRO, CLEAN DESIGN, COMF-V(3), COMF-C(3),NAUT AW Note: no Class Notation SPS, but SPS complies with the IMO Code
Cost:	€14m

Figure 91: Rendition of the ship *Edda Fides* in operation

The Voith Scheinder propulsion system has the advantage that it has anti-rolling capability, increasing comfort of the vessel, without the need to install an active system with a "U" shaped tank, as with many other offshore vessels. (36).

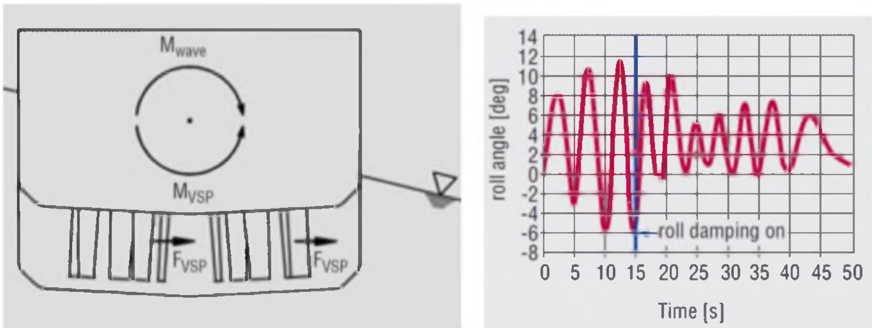


Figure 92: Torque produced by the engines and their dampening effect on the rolling period (36).

6.2.2 Single-Hull Accommodation Barges

According to Det Norske Veritas' definition (32):

Barges and pontoons are defined as vessels without sufficient means of self-propulsion for their service area. Assistance from another vessel during transit or transportation service is assumed.

Guidance note: in vessels with limited means of self-propulsion, an upper limit for barges or pontoons may normally be taken as machinery output giving a maximum speed less than V = 3 + L/50 knots, L not to be taken greater than 200 m.

Thus, the barges can be self-propelled but at very low speeds: this means that even with auxiliary thrusters for dynamic positioning a barge is still considered a barge and not a boat (ship). When in service, they are normally moored or anchored to the seabed, if they are not equipped with dynamic positioning. It may be of single-hull, semi-submersible, or even self-lifting. But the term barge often refers only to the single-hull.

Accommodation Work Barges (AWB) have been providing support to the offshore oil and gas industry from the beginning. the AWB have traditionally been used where there was need for extra accommodation and storage capabilities and offshore construction. the AWB is used to help in the following offshore operations, participating in all stages in the life cycle of an oil field:

- Help in exploration including seismic exploration.
- Connection and operation of oil fields.
- Support the construction of platforms.
- Offshore maintenance.
- Dismantling of platforms.
- And, of course, offshore accommodation.

The AWB can be positioned over the facilities in central locations where they act as field operational centers for maintenance of groups of platforms and other structures.

As opposed to barges for inland and coastal waters (see chapter on Coastels), a single-hull accommodation barge should be (37):

- Of sufficient length to have an adequate response to the waves which usually work well in pitch and longitudinal movement (surge). To do this, offshore accommodation barges are usually between 80 and 160 m in length.
- With sufficient width to have a minimum rolling motion. This ratio should be between 1/3 to 1/5 of the length.
- With enough strut to have structural strength against sheer, grief and torque as well as adequate freeboard. To this end, offshore barges have at least depth of 1/5 the length. Land barges subject to minimum wave loads required for operations in shallow waters may have props as low as 1/20 the length.

It has been found that these ratios are reasonable structural behavior under load compensated by waves.

We will see in the following sections some examples of single-hull accommodation barges, both self-propelled and non-powered.

6.2.2.1 Single-Hull Barges Without Propulsion

This is the most common type of Barge for Work and Accommodation (Accommodation Works Barge). But they are limited in depth, as they should be moored or anchored to the bottom. Although current technology makes it possible to reach depths of up to 1,700 m (38), dynamic positioning is most effective at such depths. In practice, the barge mooring system without DP is used in shallow water up to 300 m in depth.

6.2.2.1.1 Lancelot

This is a typical *Accommodation Work Barge*, owned by *Intership Limited*. It was built in China in 2009 and has an *8-Point Mooring System* and has all the facilities of accommodation for offshore workers as well as lifting capacity of 25 tons for auxiliary work.

Figure 93: AWB Lancelot

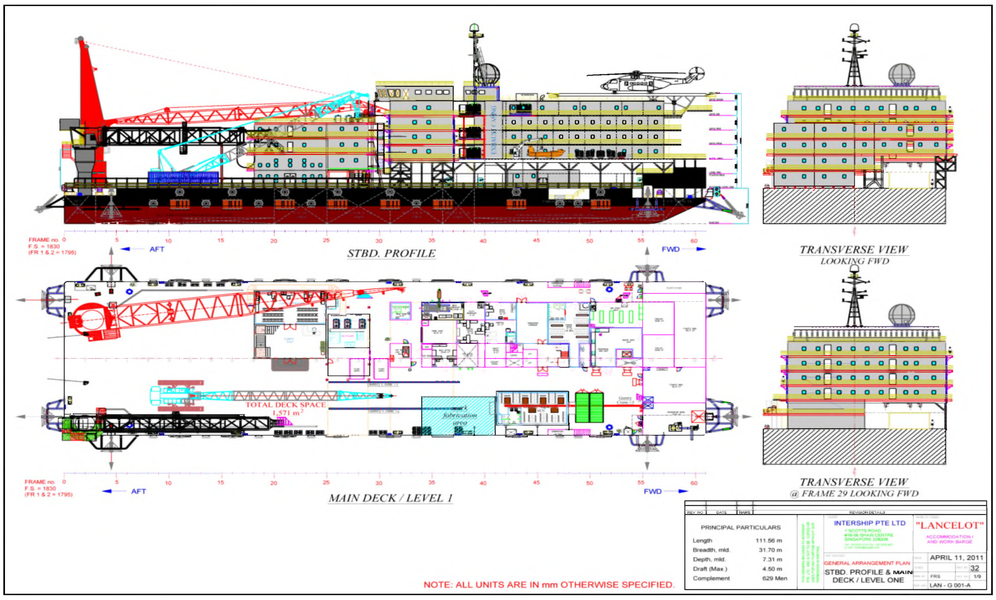


Figure 94: AWB Lancelot. Elevation, plan and sections.

Technical Specifications:

Dimensions:	Length: 11m; Width: 3m; Draft: 0 m
Capacity:	300 persons in simple cabins (8), double (14) and quadruple (66).
Classification:	ABS ✠ A1 Accommodation Work Barge
Cost:	$36 million

6.2.2.2 Self-Propelled Single-Hull Barges

These ships incorporate a propulsion system that is normally used to maintain the position; therefore, the DP system is a propulsion system for navigation. Therefore, the barge can be used in deep water, over 300 m deep, which is the practical limit for non-propelled barges and only with anchoring system.

6.2.2.2.1 Safecom–Accommodation Field Development Vessel (Afdv)

Offshore BH Property is very similar to the previous example, the *AWB Lancelot*. It also has an 8-point anchoring system, accommodation facilities for workers and a large capacity of offshore cranes for auxiliary work. It also has characteristics typical of flotels seen in previous sections: an offshore gateway and a DP system consisting of six thrusters.

Figure 95: Accommodation Barge SAFECOM 1

Technical Specifications:

Dimensions:	Length: 100.58 m; Width: 31.7 m; Draft: 4.5 m
Capacity:	400 total beds, with cabins of 1, 2 and 4 beds.
Classification:	ABS ✠ A1 Accommodation Work Barge DP2 Complies with SOLAS & MARPOL; SPS & MODU code stability compliant.

6.2.3 Semisubmersible Accommodation Barges.

A semisubmersible barge is a specialized vessel with great stability and performance characteristics at sea. The semisubmersible vessel design is normally used in a number of specific offshore activities such as offshore drilling platforms, ships, security, oil production platforms, "heavy-lift" cranes and finally as an **accommodation ship**. The terms "*semi-submersible*", "*semi-sub*" or simple "*semi*" are also commonly used to designate this type of vessel. The semisubmersibles are particularly well-suited to a number of roles as offshore support vessels due to their high stability, large deck areas and deck cargo variables (*variable deck load, VDL*).

In areas such as the northern North Sea (37), the semisubmersibles are widely used for construction, drilling and production in oil fields due to their ability to carry out such operations for extended periods of time without interruptions due to inclement weather. This is possible thanks to the better performance of pitch movements and righting moments with little effect of waves on the motion of the barge. This stability is due to both the relatively small change in tonnage and the much higher natural period of the ship, especially in roll, pitch and heave. While a single-hull boat comes standard with a natural period of 5-6 seconds, semisubmersible barges have a natural period of 17-22 seconds. However, there are three penalties to pay for this improved performance:

- The semisubmersibles have much greater response to externally applied loads such as weights, deck loads and ballasts. Another way of saying this is that their righting moment and metacentric height is much lower than those for single-hull barges. The operation of its stability is worse than a single-hull boat, and it is therefore not possible to install many accommodations or modules in its deck.
- The semisubmersibles have their deck cargo capacity severely reduced. It is based on a low center of gravity to maintain stability. This is related to the previous point and confirms

that single-hull barges offer more ability to install accommodation modules or superstructures.

- A semisubmersible costs more to operate and build than a single-hull. The ballast control is similar to that of a submarine. Single-hull barges are a cheaper option.

It could be concluded that for an accommodation vessel in the waters of middle and benign environmental conditions (seas of up to 6 meter waves), a single-hull boat is a better choice than a semisubmersible one. But in harsh environments, such as the North Sea, semisubmersible barges are the preferred choice.

6.2.3.1 Classification and Regulations

The semisubmersible barges are not normally called "barges" as that term is used primarily for single-hull barges. Both in the IMO and in the classification societies, the rules for single-hull barges are included in the rules for vessels (ships), while the semisubmersibles have separate rules. the *IMO MODU Code* is an accredited guide design and operation for *Mobile offshore Drilling Units* (*Mobile offshore Drilling Units*) of semisubmersibles. Classification societies also have different standards for single-hull ships and offshore structures. Accommodation semisubmersible barges are usually included in the class notation "Column Stabilized Unit Accommodation", similar to the DNV (*DNV Recommended Practice RP-C103*) and ABS (American Bureau of Shipping), which also must meet the IMO MODU Code. Let us see what is written on the semisubmersible in the DNV *Recommended Practice DNV-RP-C103* document:

The methods outlined in this RP are mainly developed for the analyses of twin pontoon units and ring pontoon units. Consequently this should be taken into account when other concepts are considered. Ring pontoon designs normally have one continuous lower hull (pontoons and nodes) supporting 4-8 vertical columns. The vertical columns are supporting the upper hull (deck).

Twin pontoon designs normally have two lower hulls (pontoons), each supporting 2-4 vertical columns. The 4-8 vertical columns are supporting the upper hull (deck). In addition, the unit may be strengthened with diagonal braces supporting the deck and horizontal braces connecting the pontoons or columns.

There are basically two ways of keeping the unit in position:

— mooring by anchor lines (passive mooring system)
— dynamic positioning by thrusters (active mooring system).

A combination of these methods may also be utilized. The units are normally designed to serve at least one of the following functions:

— production
— drilling
— accommodation
— special services (e.g. diving support vessel, general service, pipe laying vessel, etc.).

Units intended to follow normal inspection requirements according to class requirements, i.e. typically drilling units with inspection in sheltered waters or dry dock every 4-5 years, shall be designed with the design fatigue life equal to the service life, minimum 20 years, as given in DNV-OS-C103 Sec.

Units intended to stay on location for prolonged periods, i.e. production units without planned inspections in sheltered water or dry dock, shall also comply with the requirements given in DNV-OS-C103 Appendix A. These supplementary requirements for permanently installed units are related to:

— site-specific environmental criteria
— inspection and maintenance
— fatigue

For novel designs, or unproved applications of designs where limited or no direct experience exists, relevant analyses and model testing shall be performed to clearly demonstrate that an acceptable level of safety is obtained.

Thus:

- If they meet these requirements established in DNV-OS-C103 Appendix A, these units can remain localized in the open sea for years without the required inspection every 4-5 years.
- The new and innovative designs can also be included in this class notation if the necessary tests are carried out.
- There are two types of semisubmersibles according to the maintenance of the position: moored units and DP (dynamically positioned) units. We will see examples of both in the following paragraphs.

6.2.3.2 Brief History of the Semisubmersible Accommodation Units

J Christer Ericsson, founder and President of *JCE Group*, began as an officer and then captain in the Swedish Navy Reserve. In 1971, after several years at sea, he founded the company JC Ericsson *Safe Container* ("Consafe") which originally was dedicated to the development and sale of polyester slings and accommodation modules for both land and marine applications.

Meanwhile, the oil and gas sector in the North Sea was expanding and, as a result, demand for offshore accommodation continued to rise. In 1977, *Consafe* took an order for what would be the first semisubmersible built exclusively for accommodation purposes, and therefore the first semisubmersible "flotel". The platform was delivered in June 1978 and was called "Safe Astoria". It was followed by an additional 10 new buildings from 1979 to 1982, making the new company called *Consafe Offshore* the world leader in the offshore accommodation market at that time.

However, in 1985 there was a sudden and sharp decline in oil prices, resulting in low utilization of the company's platforms. Being unable to obtain sufficient support from creditors, *Consafe Offshore* had financial difficulties and its fleet of flotels and other assets were transferred (39).

Since that year, they made several attempts to re-enter the market for offshore accommodation. But by mid-2006, *Consafe Offshore* was acquired by the Norwegian company Prosafe through a tender offer. After acquiring the property Prosafe had 11 of the 17 semisubmersible flotels available worldwide, of which 7 of them had been originally built by the former *Consafe Offshore* in mid-1980 and three of them came from the acquisition of *Consafe Offshore* in 2006 (40).

In addition to Consafe and Prosafe, many others have made investments to acquire and operate similar units, especially in few years before the outbreak of the financial crisis. We shall later see some of these projects.

6.2.3.3 Safe Scandinavia

Safe Scandinavia, property of *Prosafe AS*, built in 1984, is an accommodation unit with a 12-point chain anchoring system allowing the maintenance of position in the toughest conditions. It is also equipped with gateway and cranes.

Figure 96: Safe Scandinavia flotel. Load shedding for transport and operating weighted in draft.

Technical Specifications:

Dimensions:	Length: 106 m; Beam: 98 m Draft (incl. Thrusters): Transit: 7m - Operation: 22m - Survival: 18m
Capacity	583 total persons and 59 work stations
Classification:	DNV ✠1A1 Column Stabilized Unit, EO, Non-Self-propelled, HELDK, SBM

6.2.3.4 **Floatel Superior**

Floatel Superior is the property of *Floatel International Ltd*[60], which owned a semisubmersible floatel delivered in early 2010 designed for for the Norwegian Continental Platform in the North Sea, an area with some of the harshest environmental conditions in the world. It is equipped with offshore gateways for the transfer of personnel and a dynamic positioning system for unlimited depths of water consisting of a DP3 system and an 8-point anchoring system. It is the first newly built floatel designed for the North Sea market in the last 20 years.

Figure 97: Floatel Superior. Rendering and in operation.

Technical Specifications:

Dimensions:	Total length: 94 m; Width total: 6m Draft (incl. thrusters) - Operation: 23 m - Survival: 18 m
Capacity:	440 beds, all one-bed cabins or 512 using “Pullman” type beds
Classification:	DNV ✠ 1A1 Column Stabilized Accommodation Unit (N), HELDK, E0, DYNPOS AUTRO, POSMOOR V ATA , BIS
Cost	$316 million

[60] Flotel International Ltd was founded in 2006 and operates under the laws of Bermuda. The vision of the company is to develop and operate the most modern fleet of vessels of accommodation and offshore support in the world.

6.2.3.5 Floatel Reliance

The second floatel of *Floatel International* is the "Floatel Reliance" delivered on October 29, 2010, beginning operations in Brazil. the vessel is designed to operate efficiently in moderate environments and is equipped with a DP2 system to support operations in the proximity of other offshore facilities.

Figure 98: Floatel Reliance. Rendition and in operation.

Technical Specifications:

Dimensions:	Length: 99 m; Width: 36 m
Capacity:	500 beds, all single-bed cabins or 512 using “Pullman” type beds
Classification:	ABS✠A1 Column Stabilized Accommodation Unit (N), AMS, DPS-2, FFV Class2

6.2.3.6 Gg4-A

The GG4-A semisubmersible DP3 class, the *Grendland Group* (Norway), is an advanced accommodation unit, compact and low cost. The GG4-A is ready to provide accommodation to 440 people in simple cabins and up to 600 people using Pullman beds. About 200 simple cabins are located in two temporary accommodation modules on the upper deck.

The total weight of steel is about 5,500 tons. the GG4 design is characterized by a shallow draft, pontoons and favorable hydro-dynamic columns, and minimal side bolsters (bracing). This design provides good conditions for maintaining the position in harsh environmental areas.

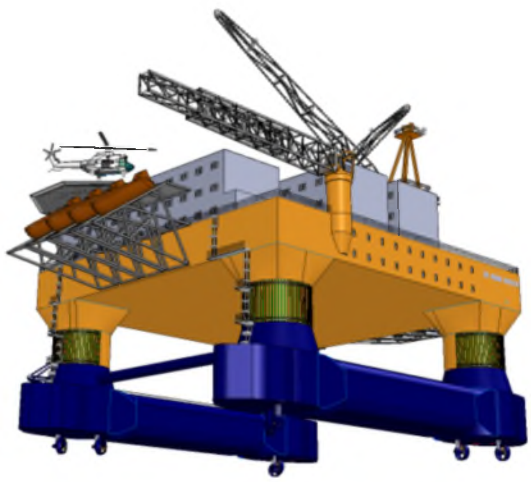


Figure 99: GG4-A

Technical Specifications	
Dimensions:	Length: 7m; Width: 42 m
Capacity:	440 beds, all one-bedroom cabins or 600 passengers using "Pullman" beds
Classification:	DNV ✠ 1A1 Column Stabilized Accommodation Unit (N), HELDK, E0, DYNPOS AUTR

6.2.3.7 Series GVA Accommodation Units

The series of semisubmersible type GVA of GVA Consultants AB are widely used in the offshore industry, and also in accommodation ships.

GVA accommodation units are all designed to provide safe operation under severe conditions regardless of where they work. In many ways GVA internal requirements are more stringent than the applicable rules and regulations of the industry and that is why the GVA design often makes its own offshore industry standards. The GVA semisubmersible accommodations are based on the hulls used for GVA drilling units that are prepared for deployment in deep waters and under harsh conditions. They provide the following benefits for the operator, according to GVA:

- Excellent seamanship and seakeeping that minimize downtime.
- High load capacity.
- Ample space on deck.
- Areas of high quality accommodations with recreational and public spaces.
- Compliance with the NORSOK, NPD rules and regulations or their equivalent.
- Costs of optimized operation/maintenance.
- Dynamic positioning system under the requirements of the customer.

The two most representative accommodations units are shown in the table below:

		
Record Name	Regalia	Jasminia
Built, updated	1985, 2003/2009	1982, 2002
Design	GVA 3000 – Re-enforced	GVA 2000
Traffic speed	10 knots	7 knots
Draft in transit	10 m	7 m
Length	90 m	74 m
Maximum nº of beds	300	535
Deck area	3250 m^2	690 m^2
Payload	1000 - 2200 t	640 t
Power generation	18,600 kW (6 groups of diesel generators)	6,300 kW (3 groups of diesel generators)
Freshwater production	200 tons / 24 hours	270 tons / 24 hours
Telescopic gangway	4+/-0m	30.4 +/-0m
Position maintenance	NMD3	Anchor mooring with 8 winches
Propellers	6 x 4 MW Azimuthals	2 x MW Azimuthals

Table 14: GVA accommodation units series

Shown in the following figure is Regalia's platform layout:

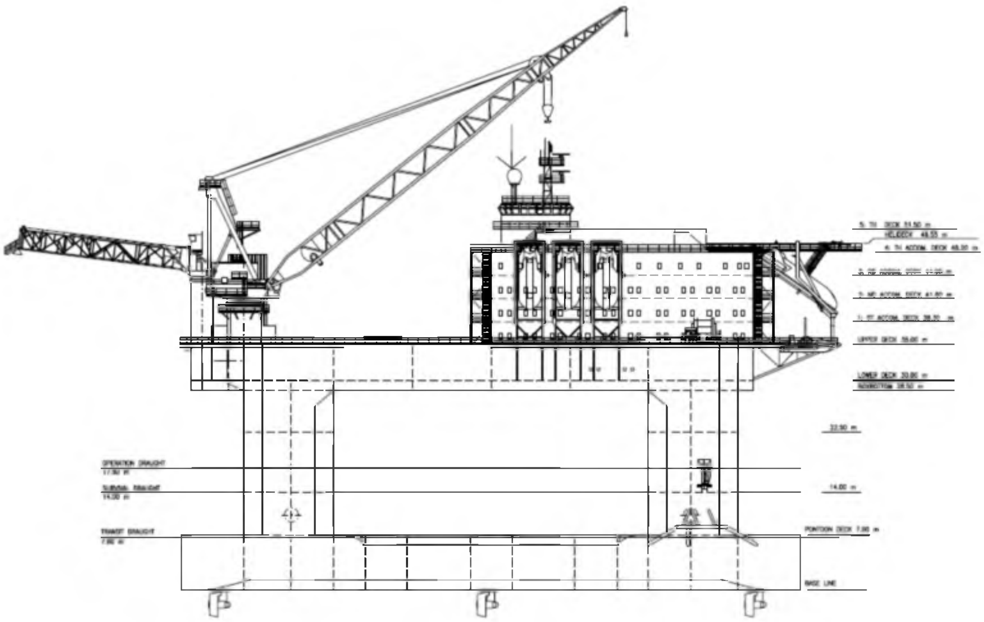


Figure 100: GVA 3000E "Regalia"

6.2.4 Jack-Up Barges

A self-elevating barge (jack-up) is a barge with long legs ready to support it. It can be elevated (in floatation) or lowered (when supported on the seabed). The barge is towed (though sometimes self-propelled) to the target location with the legs elevated and the barge floating on water. When it comes to its location, the legs are secured on the seabed. Then, there is the "preload" (preloading), in which the weight of the barge and additional water ballast is used to guide the legs safely on the sea bottom so that water does not penetrate more than necessary as the transactions occur. After the preload, the pinion system (jacking system) is used to raise the barge completely over the water up to a certain height or "air gap" so that the loads of waves, tides and currents act only in the relatively slender legs and the hull of the barge. The jack-up rig can only be placed in shallow water, usually less than 120 m deep.

The jack-up platforms, as well as being used for similar purposes to other platforms in the oil industry (mainly drilling) are also used as a base to serve other structures such as wind turbines, construction of bridges, etc. One such service provided by the jack-up is to provide accommodations as a floatel. We will see some examples.

6.2.4.1 Safe Esbjerg

Safe Esbjerg, owned by *Prosafe AS*, is a triangular self-elevating accommodations barge able to work in harsh environmental conditions in water depths up to 50 m. It was transformed in 2005 from a drilling jack-up rig to an accommodation barge/auxiliary services.

Figure 101: Self-rising platform Safe Esberg

Technical Specifications	
Dimensions:	Length: 62 m; Width: 51 m;
Capacity:	139 Persons
Classification:	DNV ✠ 1A1, SESU, MODU Code 2001

6.2.5 Innovative Proposals For offshore Flotels

Many designers, engineering companies, universities, etc. claim that their innovative structures perform beyond traditional designs in energy efficiency and power requirements in seakeeping, capital and operating costs, etc. But many do not have significant advantages over traditional designs, and actual costs could be significantly higher. Of course it's beneficial to have a naval engineering professional to innovate new designs, but any new proposal should be analyzed in detail before implementation. We have selected here some examples in the field of offshore flotels.

6.2.5.1 Minifloat

Designed by *Marine Innovation & Technology*, the MiniFloat (41) semisubmersible is a small platform prepared with anti-heave (heave plates) at the base of each column. While it shows movements similar to traditional semisubmersibles, the platform is significantly smaller, allowing cost savings in all areas. It is an alternative to traditional designs of offshore accommodation, with up to 192 beds. With a 3-DP3 system thrusters and mooring system of 6 points, it can safely be positioned near a floating or fixed platform.

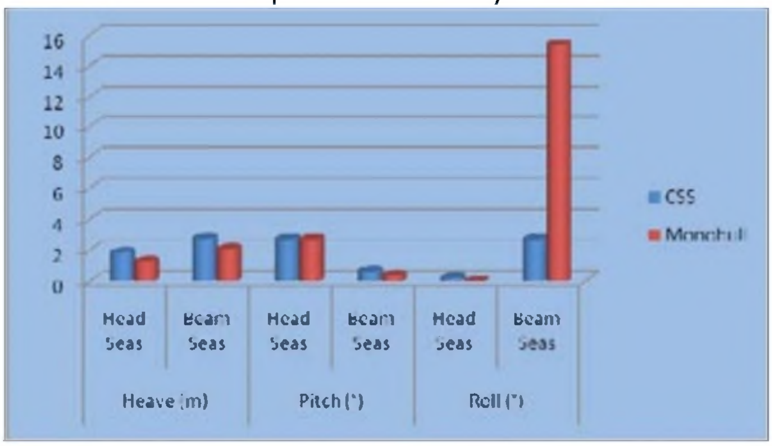
6.2.5.1.1 Analysis

To date no unit has been built of this patented three-legged semisubmersible. However, a variant of this design for offshore wind turbines will be deployed in the summer of 2011 in northern Portugal (42) in a similar patent known as *WindFloat*. (43).

Figure 102: MiniFloat – Rendering

6.2.5.2 CSS Accommodator

Hallin Marine Subsea International PLC developed the concept of *Compact Semi-Submersible-CCS (44)* as a low-cost alternative to traditional large semisubmersible DSVs[61] and services both in underwater work (subsea) and *well intervention*. The most important improvement in the design of this vessel is related to the rocking motion (roll) in the sea. As for *heave and pitch* angles a CSS unit 84 m in length is comparable to a single hull vessel of 120 m in length. As shown in the results of the graph below (44), comparing the hull design with CSS from that of single hull vessel of 120 m is comparable in the three situations identified as crucial in DP and stationary. The two hulls give similar measures except for the roll, in which case the semisubmersible hull shape gives a significant improvement in balance when compared with the design of the single hull. This will significantly improve the framework of operation that may occur with bad weather conditions.



Graph 7: Comparison of behavioral characteristics in the sea with a single-hull 120m CSS. Angles with Hs = 4m waves Tp = 12.4s

Subsequently, *Marine Asset Corporation* has been commissioned in May 2010 to make this design a reality, with the *CSS Accommodator* (45) as the first vessel. It will be used for accommodation for 500 people, not underwater work or well intervention. Fujian Mawei Shipyard is contracted to build it. Delivery is planned for December 2012 (46).

[61] Diving Support Vessels: support vessels for underwater work

6.2.5.2.1 Analysis

According to its promoters, the *CSS Accommodator* would be a lower-cost alternative to traditional accommodation vessels like larger semisubmersibles and self-elevating barges.

Figure 103: CSS Accommodator rendition

Technical Specifications	
Dimensions:	Length 84m, width 32m
Capacity:	230 cabins, most 2-person, capable of accommodating 430 persons, in addition to a crew of 20 and the hotel personnel, 50 persons, for a total of 500 persons.
Classification:	ABS+A1, Mobile Offshore Unit, +AMS(E), DP-3, U-WILD, Diving System, Helidk

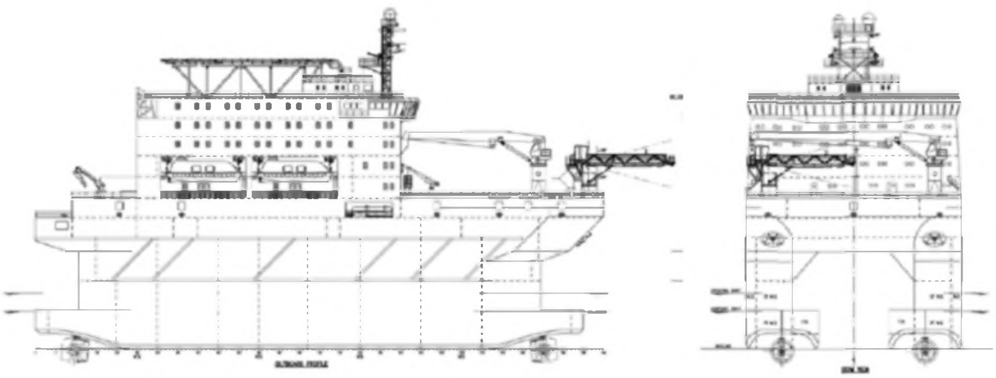


Figure 104: CSS Accommodator, profile and section

6.2.6 Offshore Structures not Used as Flotels

The offshore industry has designs being used for other activities and not yet as flotels. Following are some of these structures indicating the maximum depth that they have come to achieve.

		Depth Record			
Pos.[62]	Type	Name	Year	Depth (m)	Location
1 - 2	Conventional fixed Platforms	Shell's Bullwinkle	1991	412	GOM

[62] Pos. specifies the position within the figure starting with the left

3	Compliant tower	ChevronTexaco's Petronius	1998	534	GOM
4 -5	Vertically moored tension leg and mini-tension leg platform, TLPs	ConocoPhillips' Magnolia	2004	25	GOM
6	Spar	Dominion's Devils tower	2004		GOM
7 - 8	Semisubmersibles	Shell's NaKika	2003	20	
9	FPSO (Floating production, storage, and offloading facility)		2005		Brazil
10	Sub-sea completion and tie-back to host facility	Shell's Coulomb tie to NaKika	2004	07	

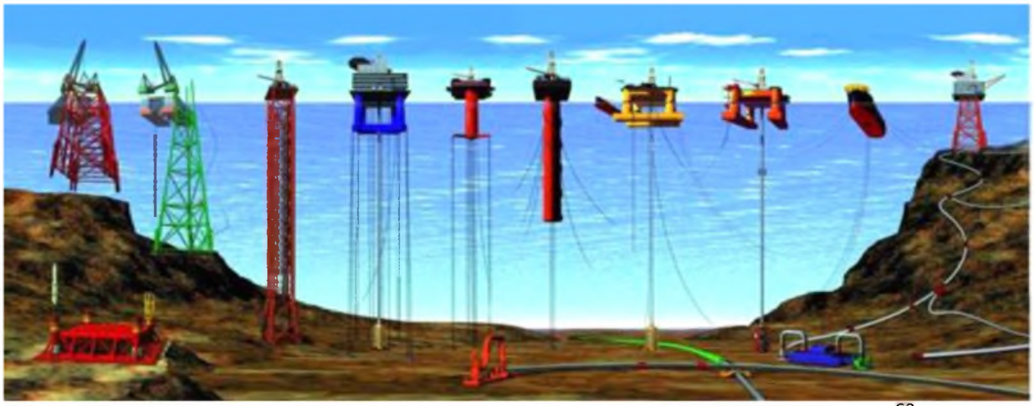


Figure 105: Structures used today in the offshore industry[63]

Comments:

- The maximum depth reached is limited by the umbilical, risers, etc. But, obviously, a structure with dynamic positioning has no depth limit. We present some of these structures indicating the maximum depth that have come to achieve.
- 1, 2, 3, 4, 5 and 6: are permanent fixed structures, not flexibile in location as required in a flotel.
- 7-8: Are already being used as flotels.
- 9: FPSO are single-hull barges similar to the Accommodation Work Barges with DP system.

6.2.7 The Market For Offshore Floating Hotels

6.2.7.1 The Offshore Flotel Value Chain of Oil & Gas

This is the typical life cycle of an oilfield.

→ Seismic Survey
→ E&D drilling
→ Pre-engineering / concept studies

[63]Reference: U.S. National Oceanic and Atmospheric Administration, NOAA, 2005

→ Hook-up / commissioning
→ Operation & maintenance
→ Decommissioning

- Use of flotels, in general, is as follows: 20% for connection of new platforms and production units.
- 70% of their time assisting in the repair and maintenance of existing platforms.
- 10% for decommissioning.

The offshore flotel can also be used in other areas such as disaster recovery facilities after hurricane damage (for example) and as support for underwater construction (subsea construction).

The next graph is the most comprehensive in the value chain of oil and gas market (O&G market) and illustrates how accommodation vessels intervene in this value chain:

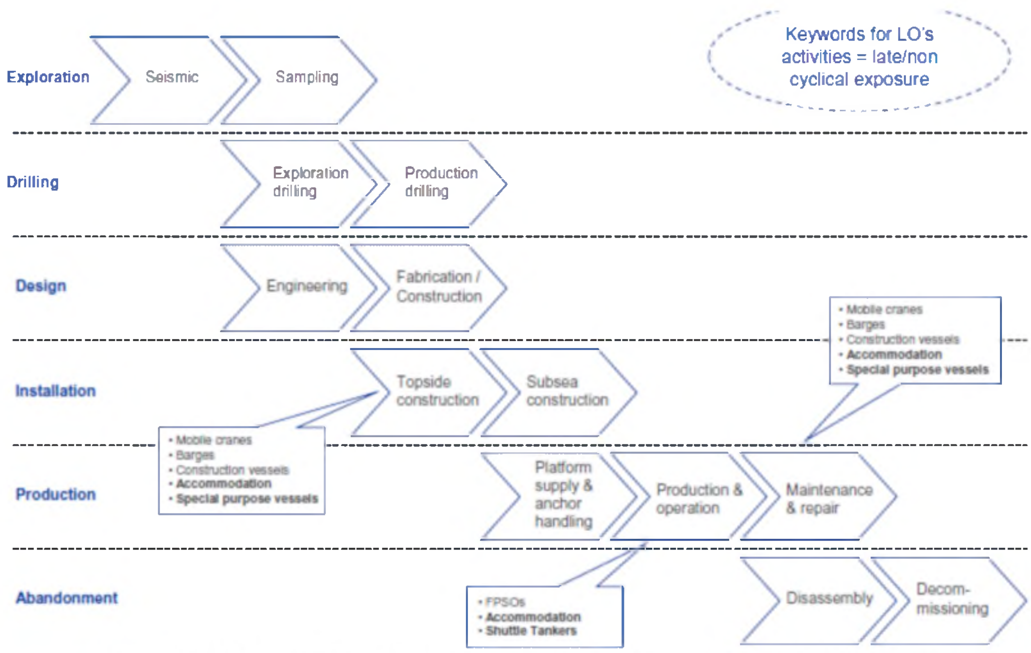


Figure 106: Accommodation ships in the Value Chain O&G sector. Source: Lauritzen offshore Services A/S

6.2.7.2 Factors of Demand

In recent years there has been a continuing demand for flotels due to the growth of offshore developments. Reasons:

1. Higher oil prices increase demand for the development of new fields, developing marginal fields and extending the life of existing fields.
2. The current lack of capacity , which is forcing companies to discover oil and gas as well as production of new fields.
3. Increased repair and maintenance work in a growing number of facilities in operation.
4. Outdated fleet (average age 20).
5. New regulatory requirements, prevention and occupational health.

The market is characterized by:

1. Few participants and limited capacity units.

2. Fees range by units in long-term contractual terms; there were no units available in 2007 and only a few available in 2008.
3. Average age of the fleet is between 20-25 years.

(Note: figures from 2009 and single-hull barges not included)

The "**customer criteria**" typical for an accommodation vessel or flotel are listed below:

- Maintenance of the position.
- Usage time of access/transfer gateway.
- Prevention of worker risks/safety and environmental protection.
- Operational capacity with cranes and flexible work areas.
- In general, operational flexibility.

6.2.7.3 Summary Profile of the Fleet – Breakdown By Type.

The following table summarizes the profile of the accommodation fleet (not including single-hull vessels):

Semi-submersible 	Most of the units with DP. Compatible with harsh environmental conditions. Mobilization is expensive and inflexible. High cost of investment and high maintenance cost. 20 units in total.
Barges 	Normally with mooring systems (some with DP). Only compatible with benign environmental conditions. Relatively inexpensive solution. Not normally have access to gateways offshore, although some do. Approximately 100 units, 45 with capacity over 250 persons.
Jack-ups 	Limited operating depth to 125 meters. Compatible with harsh and adverse environmental conditions. Fixed installation (vulnerable to typhoons, etc.). Mobilization expensive and inflexible. Between 20-30 units depending on the requirements/specifications, but very outdated.

Table 15: Profile of the accommodations fleet. Source: J. Laurizten, 2009

According to the "client's criteria" seen above, J. Laurizten made a chart with the competitors of his ship, the *M/V Dan Swift*, comparing criteria - Operational Flexibility (axis Y) and - Safety, Health and Environment (axis X):

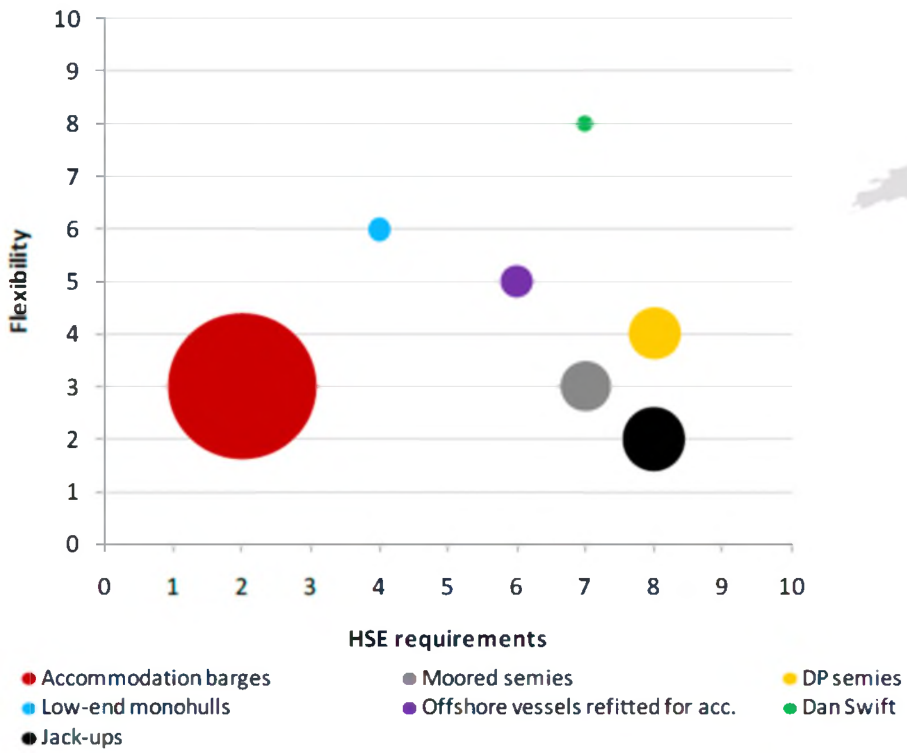


Figure 107: Competitors in the offshore accommodations market. Source: J. Laurizten, 2009

We obtained the following map of the world's oceans showing the distribution of vessels by type of accommodation from the same source as before:

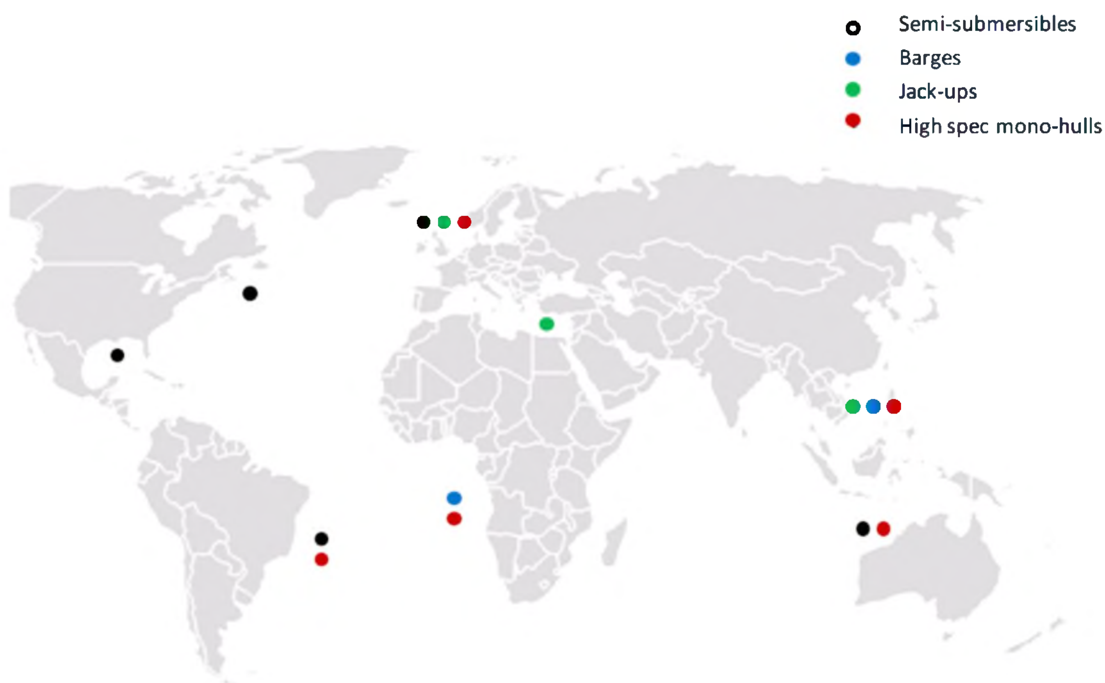


Figure 108: Distribution of accommodation vessels by type.

- As we can see on this map, accommodation vessels are distributed throughout the oceans and seas, and there is no single type of solution for each location. However, we can draw some conclusions:
- The single-hull barges are used only in benign waters: West Africa and Southeast Asia.

- The semisubmersibles are used in virtually all types of locations, except not in benign waters where it is cheaper and practical to use simple barges. This is because you do not need a structure with excellent seakeeping, as a simple single-hull barge is sufficient.
- Single-hulled vessels are used worldwide in both benign and harsh environments, including the harsh North Sea areas. They are a good choice for all locations due to their mobility: when in the path of a significant storm, they can move quickly to avoid it. That is not the case of a single-hull barge because they are not self-propelled, while the semisubmersible can withstand the storm, but during periods of calm they are a more expensive option than a single-hull boat.

In summary, there is no appropriate single solution for a flotel in all situations, but it depends mainly on two factors:

1. The location where you want to install the flotel (i.e., meteoceanic conditions).
2. The need to stay in a particular location during large storms.

6.2.7.4 The Offshore Accommodation Market During the Financial Crisis

After a delay in the offshore sector during the period from late 2008 to 2009, the offshore accommodation market has been growing much stronger and has improved substantially since January 2010. There was a general reduction in projects by major oil companies and their subcontractors during the years 2008 and 2009 due to:

- Low oil prices resulting in new projects that are not economically viable.
- Inability to secure debt financing, forcing many companies to delay (or delay and then cancel) installation projects, connections, and start-up and repair, where activities are primarily used for flotels.

Moreover, during the economic crisis, the number and type of vessels that offered accommodation projects was increased as the amount of offshore construction projects dwindled. This led to the temporary competition increase in the industry.

7 VLFS, Very Large Floating Structures

This chapter is a version of the article "*Very Large Floating Structures (VLFS)*: *Airports and Floating Ports* accepted for review and publication in the *"Journal of Public Work*," published by the Colegio de Ingenieros de Caminos, Canales y Puertos (Roads, Channels and Ports Engineering College) (8)

7.1 Introduction

The *Very Large Floating Structure(s)* (VLFS(s)) are the structures that, in the future, will colonize the oceans, providing large areas on which to develop any of the activities for any of the purposes mentioned in Chapter 1.

However, this chapter simply reviews the concept, types, and progress, but does not go much in depth as there are numerous studies, publications, doctoral theses and monograph conferences on the subject. However, in a dissertation on Oceanic Colonization it should be necessarily mentioned and taken into account. We will focus more on the concept than on the MOB Megafloat (both VLFS par excellence), since the former is more applicable to the open sea, while the Megafloat is restricted to bays and other sheltered coastal areas.

7.1.1 The VLFS: Response to Sustainable Development of the Sea in the 21st Century.

In recent years, demand for developable land around the coastal cities has increased significantly, not only for residential purspoes, but for industry and logistics. There are highly congested areas that need further expansion. But the available land on the coast is often fully developed and water is the only area to be developed. Dubai is the most significant area of development.

Some floating houses already exist in Holland, and there are plans to develop floating airports and ports both near the coast and even in open water (mainly for strategic reasons). But the size of an airport and/or port is huge compared to the existing floating structures (pontoons, barges, ships, offshore platforms) and is therefore necessary to develop a new concept of floating structures: the *Very Large Floating Structure (VLFS).*

7.1.2 Definition

A *Very Large Floating Structure (VLFS)* or *Very Large Floating Platform (VLFP)* is a unique concept of oceanic structure characterized by a range of length, displacement and unprecedented cost (respectively: 1,000 m to 10,000 m, 10^6 to 10^7 tons, $5,000 to $15,000 million) (47).

Its size and flexibility characteristics require special consideration in design, analysis, construction, assembly and operation.

The VLFS is characterized by a long design life, 50 years for the MOB and 100 years for a MegaFloat (47), and low maintenance costs. The durability and resistance to fatigue are key concepts for material selection, design and manufacturing.

7.1.3 Applications

The *VLFS* is designed primarily for **floating airports and ports**, depending on the design, for calm waters on the coast or at open sea away from it. However, there could be other uses:

- Civil engineering: bridges, water breakers and floating docks.

- Energy: storage facilities for oil and natural gas, and as power plants (wind and solar).
- Military and intervention: as military and emergency bases.
- Recreational and residential: casinos, amusement parks, housing, floating hotels, even entire floating cities.

7.1.4 Types

Some authors (48) (49) classify the VLFS in two categories according to their geometry: the pontoon type and the semisubmersible type. However, since there really are more types than mentioned above, we classify them here more broadly: **VLFS coastal** and **VLFS oceanic**. The pontoon type encompasses the coastal category and the category of offshore semi-submersible.

7.1.4.1 Coastal VLFS

These are suitable for use only in calm waters, often within a bay or lake and close to the coastline.

Coastal VLFS proposals are of a pontoon, as its simplicity is adequate for quiet water areas. These large floating pontoons have been called *MegaFloats*, although are well-known in literature as *mat-like* VLFS by its small draft in relation to its length.

It is a simple structure with a trunk that offers high stability, low manufacturing/maintenance costs and easy repairs. The VLFS pontoon type is very flexible compared to other types of offshore structures, so that the elastic deformations are more important than their movements as a rigid body. Thus, the hydro-elastic analysis is central to the analysis of pontoon-type VLFS.

7.1.4.2 Oceanic VLFS

In the open sea, the wave height is too much for the pontoon VLFS. There are several proposals of different geometries for ocean VLFS, being the semisubmersible which at first seems more appropriate. Here we see the following examples:

- Seadrome.
- Mobile offshore Base, MOB.
- Pneumatically Stabilized Platform, PSP.
- Versabuoy.

The most studied has been the MOB, which in turn also has different versions. Although some authors (48) (49) consider the platforms and devices as VLFS offshore industry, we do not consider them as VLFS for they do not reach the dimensions of 1,000 m in length, a characteristic required by the leading researchers in the field that defined the term (47).

7.1.5 Evolution Chronology

The first concept of VLFS that appeared in the modern world after the industrial revolution was the floating island described in the nineteenth century by the French novelist Jules Verne (Verne, 1895), one of the founders of science fiction. The first VLFS seriously promoted was the *Armstrong Seadrome* in 1924, discussed below. Its stability was demonstrated in channel trials, and other such platforms were promoted until the death of Armstrong in 1955.

The investigation of the VLFS in the last decade was initiated by two major projects: *the Mega-Float* in Japan, as a typical example of pontoon-type VLFS and *Mobile offshore Base* (MOB) in the U.S., as the main representative of the oceanic type. But other efforts have been made, like the *Pneumatically Stabilized Platform* or the *Versabouy*, as discussed below.

Milestones in the development of VLFS are listed in the table below. Although both programs of the MOB and the Mega-Float were initiated and executed independently of scientific principles and technological goals they are similarly structured and included parallel research objectives.

In the United States	
1924-1955	The Seadrome by Armstrong and related concepts
1942-1944	Flight Deck of Civil Engineers Corps of the U.S. Navy – SOCK Project
1963 C-130	Takeoff and landing demonstrations on the USS Forrestal
1960's-1970's	Research Laboratory/University of the U.S. Navy
1989-1996	Research sponsored by the NSF
1991	First International Workshop of the VLFS – University of Hawaii
1993-1996	Marine Technology Platform Program DARPA
1997-2000	Scientific and Technological Program of the Mobile Offshore Base – office of Naval Research, ONR
In Japan	
1950's	Floating Cities concept in architecture and urban design
1960's	Puppet drama "Hykkori Hyoutan Jima"
1973-1974	Floating Airport Proposed for Kansai International Airport Phaseconstruction, the structure of semi-submersible
1975	International Ocean Exposition in Okinawa - Aquapolis
1988	Kamigoto Oil Reserve: 390m x 97m x 2m x 5 Units
1994	Proposed Floating Landing Phase 2 Construction of Kansai International Airport, pontoon type floating structure
1995	Mega-Float/Technological Research Association of Maga-Float (TRAM, 1999a)
1995-1996	TRAM Experimental Phase 1: 300m x 60m x 2m (TRAM, 2001)
1996	Shirashima Oil Reserve: 397m x 82m x 2m x 8 units.
1997-2001	Experimental Phase 2 TRAM: 1000m x 60-120m x 3m Experiment of landing and takeoff (TRAM, 2002)
2001-2005	I+D by the Shipbuilding Research Center. Proposed Airstrip Haneda international Airport. Combination of old type and semisubmersible Pontoon.

Table 16: Milestones in the development of technologies for VLFS. (47)

7.2 Mega-Float

The Japanese program of Mega-Float, conducted by the Technical Association of 17 shipbuilders and steel makers, known as the *Technological Research Association of Mega-Float* (TRAM), was established in 1995 to carry out a joint research and development project for the creation of a large-scale floating structure.

7.2.1 Concept

A *Mega-Float* is a large pontoon in a fixed position, normally supplemented with a breakwater to protect against severe wave conditions. As shown in the figure below, a *Mega-Float*:

- Is a very large floating pontoon structure.
- Has facilities for mooring/anchoring to keep the floating structure on site.

- Has an access bridge or floating road to access the floating structure from land.
- Has a breakwater (usually needed if the significant wave height is greater than 4 m to reduce wave forces impacting on the floating source.

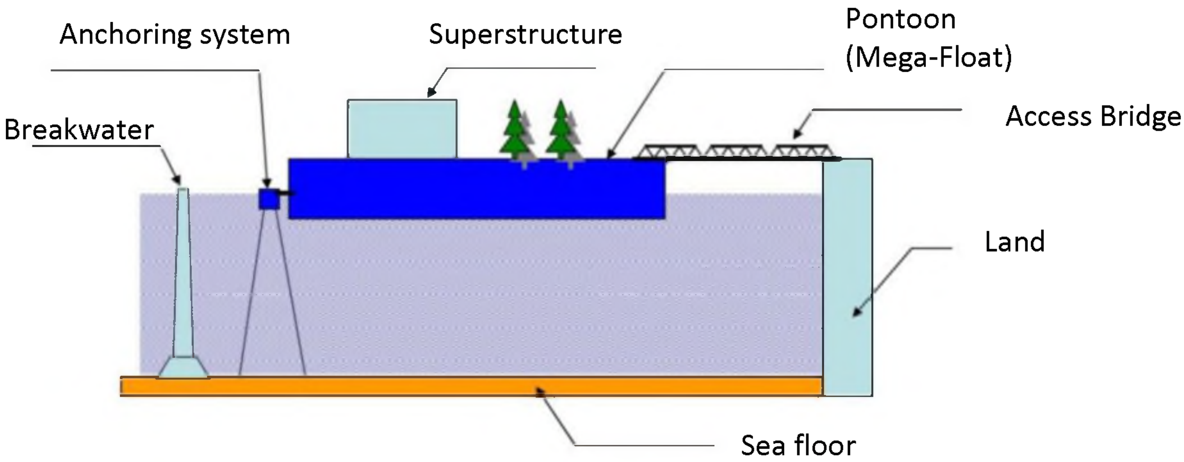


Figure 109: Mega-float: schematic arrangement of elements (49).

7.2.2 Building System

The pontoon has a structure similar to the construction of a hull of a steel ship. This type of construction has long been used in shipbuilding, and it has been proven to be strong and reliable yet lightweight.

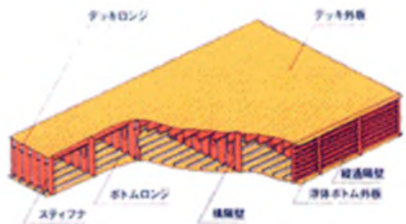


Figure 110: Mega-float: structural design of the pontoon (50).

The construction would be done with modules made on land from 100-300 m in length which are assembled at sea through welds (51).

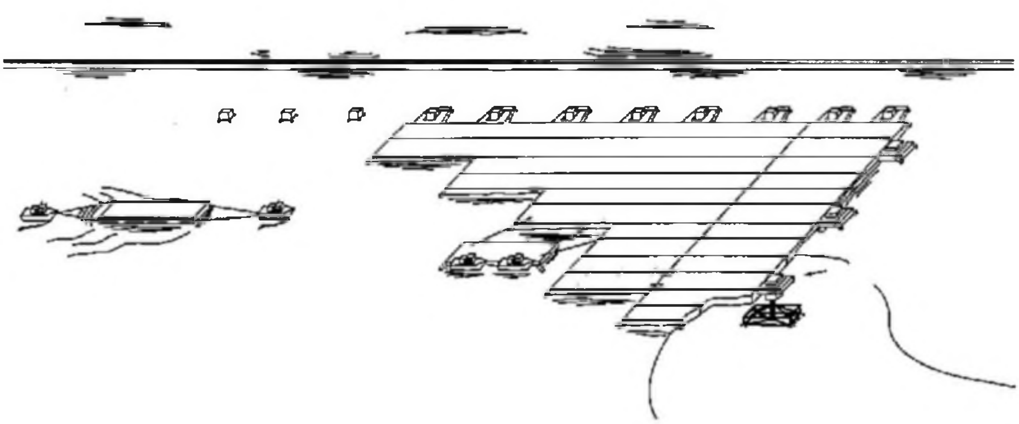


Figure 111: Megafloat: rendition of the construction. (51)

7.2.3 Stages of the Research Program

In Phase 1, a 300m x 60m x 2m structure was built.

In Phase 2, which began in 1998, TRAM initiated studies to build a model of a Mega-Float airport 1,000 m long, 60 (120) m wide and a 3 m strut in Yokosuka (Tokyo Bay) to experiment with landing and takeoff of small airplanes. This airport was built in 1998 and is currently the only Mega-Float that has been built.

TRAM concluded from the 2001 studies that it was feasible to build a 4,000 m long runway at Tokyo International Airport (Haneda).

The development of this technology is now conducted by the Department of Floating Structures (Mega-Float) *Structures in the Shipping Research Centre of Japan* (RSCJ) (50).

Figure 112: Mega-float: Experimental Phases (left) and 2 (right) (47).

7.2.4 Applications

In addition to these applications as a floating coastal airport, research was also conducted under the TRAM project in view of the requirements for floating bases with many other functions such as port and logistics facilities, recreational facilities, etc. Overall, implementation of the Mega-float is designed for more benign conditions than the Mobile Offshore Base (MOB) and the purpose of its floating surface be similar on land.

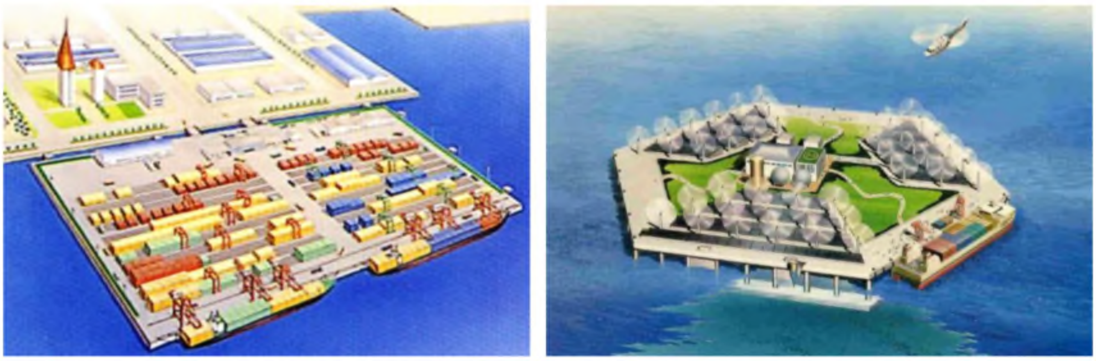


Figure 113: Mega-float: proposed container terminal, left, and renewable energy plant, right (47)

7.2.5 Technical Challenges

From a technical standpoint there are still many challenges (mainly hydrodynamic) to the understanding of the movements of these structures. The greatest of these challenges is that, due to its large size, it is not possible to model this structure as a rigid body and one must allow for tolerances to flexion movements. The simplest model for a VLFS is a Floating Elastic Plate. In fact, much of the research on this topic has been motivated by the application to VLFS (47) (48). in addition, due to its large size, the problem is often very demanding in terms of computer calculations (49).

The following figure shows the differences in behavior between a conventional vessel (rigid body) and a pontoon type VLFS (elastic body) to the application of a concentrated load.

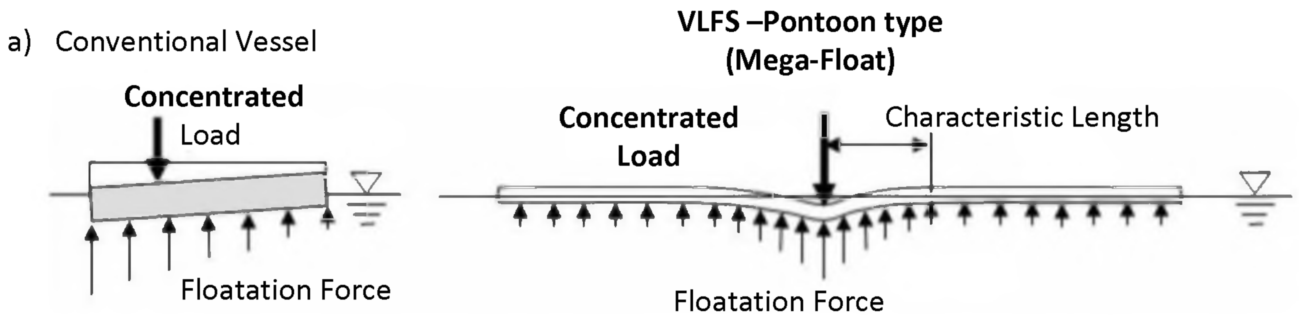


Figura 114: Overall response time under a static concentrated load (46)

7.3 Seadrome

The *Seadrome* (“sea aerodrome”) was a proposal made by the engineer Edward R. Armstrong from 1924 to 1946 to build a series of floating airports in the Atlantic (from the U.S. to Spain) to allow passenger flights between the U.S. and Europe before there were any long-distance flights without refueling. The planes would land, refuel, and fly to the next Seadrome in a series of jumps. Two issues prevented the idea from being implemented: the Great Depression and improvements in the field of civil aviation.

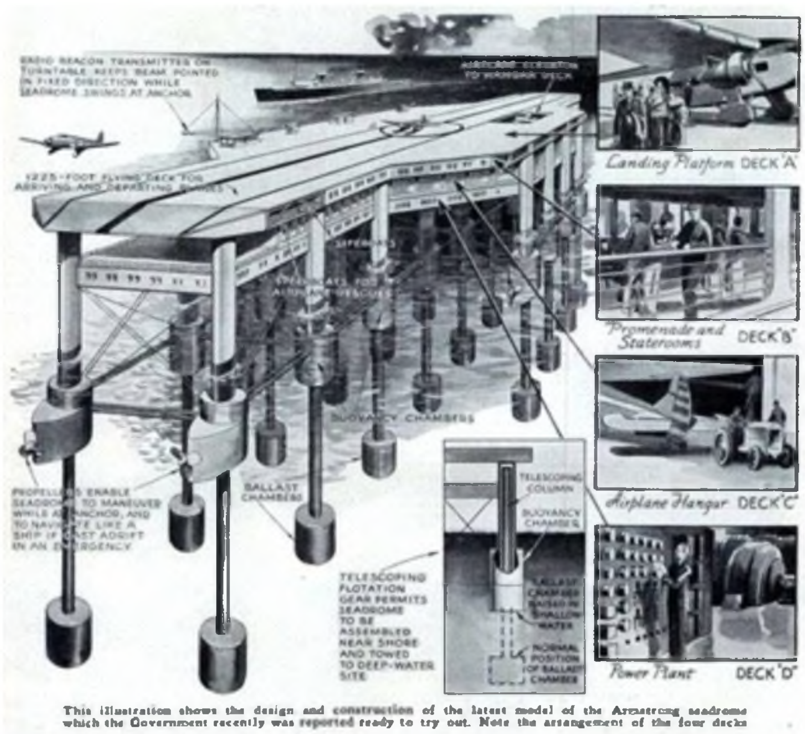


Figure 115: Rendering of the Seadrome (52)

We reproduce here the description of the airport as it appeared in February 1934 in the magazine Popular Science (52).

The 25-foot (373,38 m) airplane landing platform, supported 100 feet above the water on twenty-eight submerged buoyancy tanks, would not pitch and toss in stormy weather, because its supporting buoys float beneath the area of the sea that is subjected to wave motion and its openwork structure allows waves to pass unhindered beneath its decks.

[…] Another other innovation […] is an emergency propulsion system that enables the seadrome to navigate like a ship if it is necessary to cast the seadrome adrift to ride out a storm of phenomenal severity or if should break loose from its mooring. This is provided by four propellers, each operated by a 500-hp electric motor that is supplied with current from the seadrome´s gasoline-electric power plant.

To anchor his seadrome, Armstrong proposes to float a 1,600-ton anchor of steel and concrete to sea, and sink it on the selected site […].

As we see, it describes a semisubmersible rig equipped with both an anchoring system and a diesel-electric propulsion system. These structures exist today and are widely used in the offshore industry. Is it a coincidence? Well, no. in fact, Mr. Armstrong's efforts with the *DuPont* and *Sun Ship Building*[64] companies led to his ideas and basic designs now used by the oil industry to create the first offshore oil semisubmersible platforms (53).

7.4 Pneumatically Stabilized Platform, PSP

If you want to create a VLFS in the ocean, and as we have seen, we need a kind of structure that attenuates waves. Semisubmersibles are ideal for this, as in the case of the MOB. But other ideas and technologies are also being developed. The *Pneumatically Stabilized Platform, PSP*, is one of the most interesting ones in recent years.

The PSP, designed by *Float Incorporated, Float Inc.* [65] (San Diego, USA), is a type of platform composed of a number of cylindrical components packaged in a rectangular shape to form a single module. Each cylinder is sealed at the top, open to the seat at its base, and contains air at a pressure slightly above atmospheric. The PSP has characteristics of a platform (can handle loads) and also a breakwater (attenuates the waves). It is built in concrete, is very modular and easily configurable.

Figure 116: Channel module test cylinders and cylindrical component (54)

[64] Sun Shipbuilding & Dry Dock Company (Sun Ship) was a shipyard founded in 1916 by Sun Oil that was in operation until its decommissioning in 1989

[65] Float Inc. was founded in 1992 in San Diego, California. EE.(UU.) to develop the technology of the PSP. However, it has been inactive since 2006.

7.4.1 Operation Principle:

The PSP uses *indirect displacement*, relying on trapped air pockets that move water, and the primary buoyant force is provided by the air pressure acting on the underside of the deck. The water in each cylinder moves up and down, and the air pressure in the trapped air space changes. These spaces are connected by lines and pneumatic valves, so that these pressure changes cause movement of air between the cells. This dampens the waves and distributes forces to reduce peak loads on the structure (55). If you hook an air turbine to these lines, it becomes a wave generator.

This principle has been under development for about the past thirty years and used in the **wave pump,** first published in 1979 in Sunnmørsposten, Norway (56)

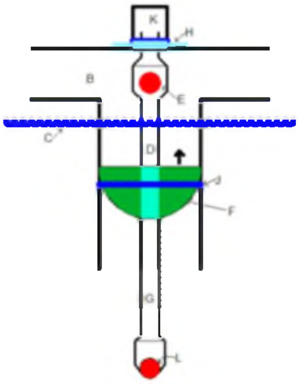


Figure 117: Principle of the water pump (56)

7.4.2 Modularity and Construction

The basic construction method is to throw water in each cylinder with a top slab subsequently used to assemble them together into larger modules through post-tensioned cables. These modules can then join with other modules to form a complete structural platform. This modularity is a key aspect of the concept.

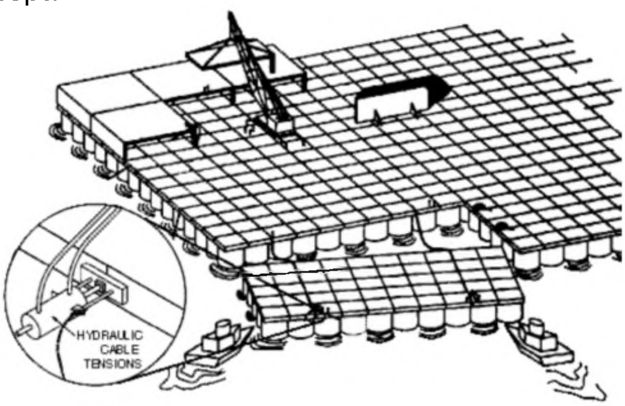


Figure 118: PSP assembly operation (54).

7.4.3 Application

The PSP was originally designed to build an airport for San Diego (California) in the Pacific Ocean, three miles from the coast, which in turn serves as a port for large ships, connected by a tunnel to the coast. It would therefore be a truly intermodal land-sea-air transportation center. However, in 2003, it was rejected as too expensive, so it is still an unproven technology.

The authors claimed that these floating intermodal centers were the best solution instead of continuing to build new ports and airports on the coast. The following figures show two proposals from Float Inc. as an extension of the San Francisco airport and an offshore port.

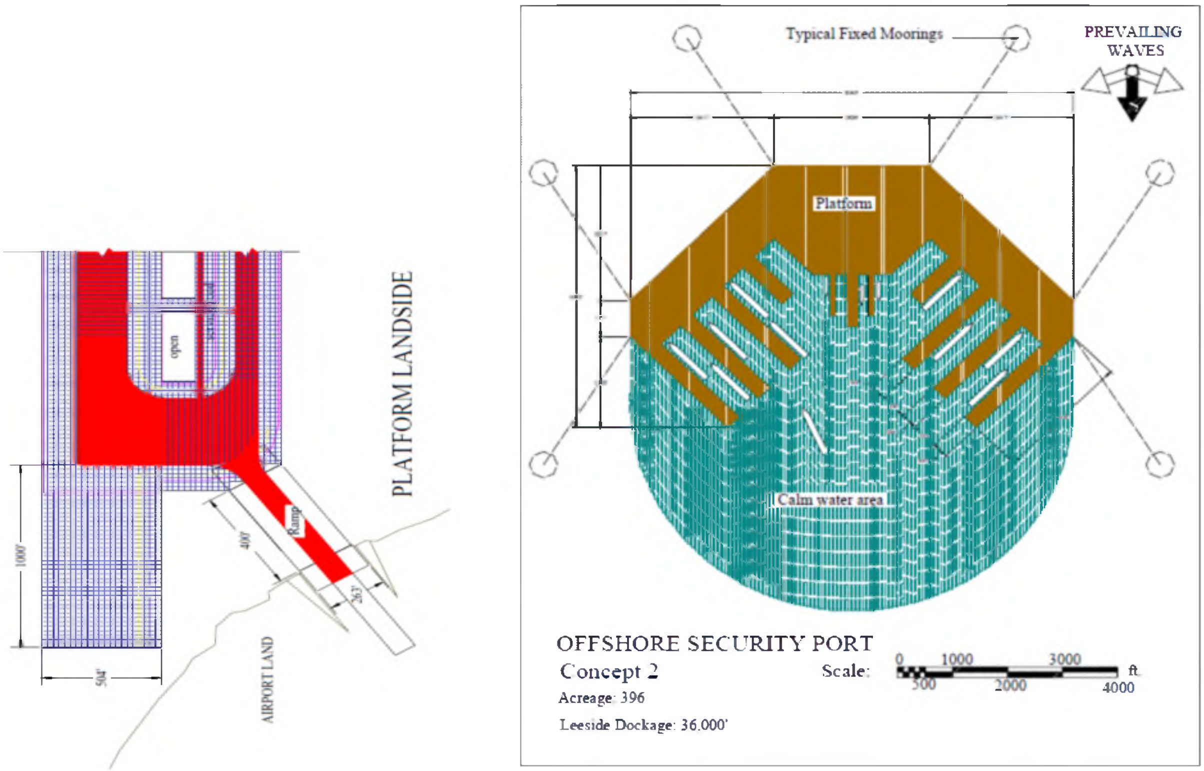


Figure 119: *Float Inc.*'s proposal for a floating airport (57) and offshore port (55)

7.5 Versabuoy

The Versabuoy system is a *Versabuoy International* patent (Urbana, Illinois, USA). the Versabuoy structure is similar to the form of an offshore type spar platform. The platform is basically a rigid lattice structure supported by buoys that are moored to the seabed by taut lines (taut mooring). The articulated connection between the structure and buoys allow independent rotation induced by wave action (58).

The spar type platforms are well-known for their good behavior in motion, with virtually no reaction from waves. The system has been designed for fabrication and modular assembly. This allows for expandability and would be excellent for a VLFS. However, this system requires tight mooring lines, which means it is subject to considerable vertical forces that need to be treated. This is not always achieved successfully, nor is it easy.

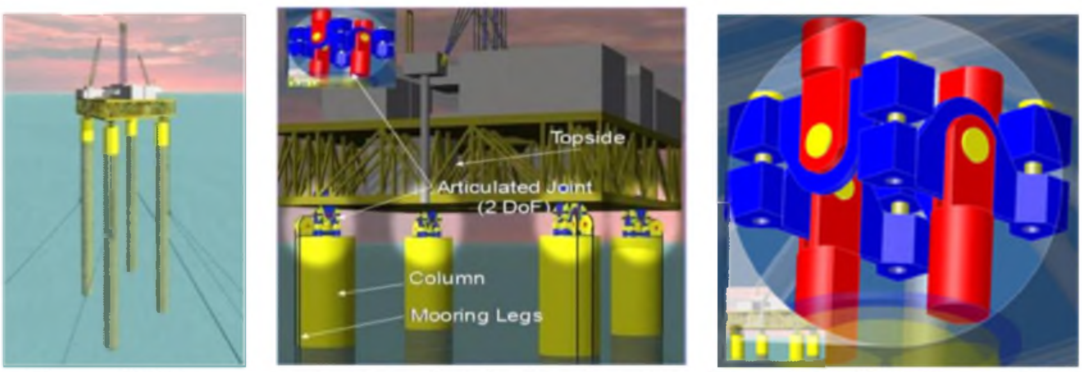


Figure 120: Layout concept and articulated connections of the Versabouy (58)

7.6 Mobile Offshore Base, MOB

7.6.1 Introduction

A Mobile offshore Base (MOB) is a concept proposed under the VLFS Mobile offshore Base Science and Technology program to support military operations wherever conventional land bases are not available. The MOB program was sponsored by the U.S. Office of Naval Research from 1997 to 2000 with an endowment of $35M. It was an open program that used international trade experts from 26 companies, 16 schools and 11 government agencies (59).

7.6.1.1 Concept

It consists of a modular floating base that can be deployed to an area to provide a landing/takeoff area, maintenance, supply and other logistical support advanced operations. With the MOB concept the U.S. could have a base anywhere in the world in within one month.

The base was designed to have virtually unlimited capacity and most of its creators never imagined just a floating landing zone but a floating military base the size of a city where ships could dock, as shown below.

Figure 121: Rendering of the Mobile offshore Base (60)

But after some time, it was decided to make it segmentable. The MOB was to have several self-propelled semisubmersible type modules that connect/disconnect as required.

- Length of each module: 220 to 500 m
- Width of each module: 120 to 170 m
- Number of modules: 3 to 5.
- Total length of aligned module: up to 2 km.

While in transit between locations of operation, the module is loadable and travels with the pontoons on the surface like a catamaran. When it reaches its destination, the pontoons are submerged below the surface, minimizing the dynamic movements induced by the waves[66]. The covers are located above the crest of the waves. The columns provide structural support and hydrostatic stability against overturning (61). Alignment is maintained through the use of dynamic positioning thrusters (Dynamic Positioning, DP) or connectors, or a combination of both.

Therefore, its geometry and function is similar to the semisubmersible offshore units, such as offshore semisubmersible flotels (5). In fact, one of the proposed MOBs of *Aker Maritime ASA* used DNV's (Det Norske Veritas) offshore industry rules for the MOB design (62).

[66] The difference between both elevations is referred to as Air-Gap.

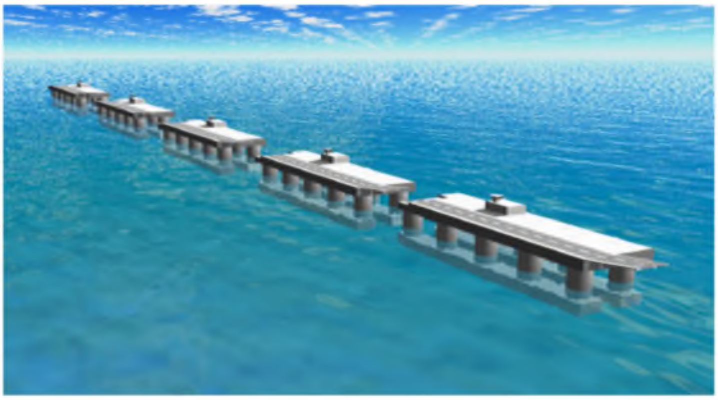


Figure 122: MOB, Vista schematic of the actual proposal (63).

The MOB program ended in 2000, affirming the technical feasibility of the idea. But in 2001 the Institute for Defense Analyses concluded that the estimated cost of between $5 and $8 billion for the MOB (approx. $1,500 million per module) was less cost effective than alternative solutions such as combined carriers with vessels of logistical support (61).

7.6.1.2 Operating Requirements

It would be designed to meet operational and survival conditions (64):

- **Operating Conditions:** would correspond to a significant wave height of about 1.9 m, and concentrated wave periods of about 9 seconds (later versions were even more ambitious, aiming for 6 m, as discussed below).
- **Terms of survival:** Require that the MOB bear loads of waves in the range of significant wave height of 16 m and periods in the range of 20 seconds.

7.6.1.3 Propulsion System and Alignment With DP

As mentioned, you would use a dynamic positioning system (Dynamic Positioning, DP) to keep each module properly oriented. Some tests and simulations with real models and virtual channel experiments were done and showed good performance of this idea (65) (63) (66). A *Multi-Module Control Dynamic Positioning System*, MMDPCS was developed for this purpose. In turn, these thrusters serve to propel the module in transit.

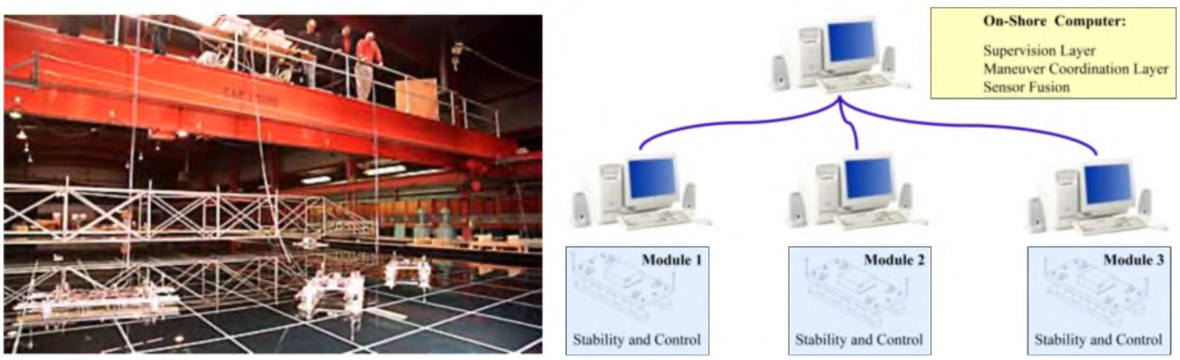


Figure 123: Simulations with three MOB modules in Berkeley's experiences channel (65).

7.6.1.3.1 Connectors

Along with dynamic positioning, connectors were also developed to keep the modules together. Later we will see two of them in two of the proposed MOB.

Figure 124: Tests to evaluate hydroelastic connectors (59)

7.6.1.4 Load Transfer Systems

- The MOB is also equipped with cranes to lift containers to/from ships docked alongside the MOB. The Division of Intelligent Systems of the *National Institute of Standards and Technology* established some requirements and needs to further develop the MOP concept to guide the design of the charge transfer between the MOB and supply ships (67) (68).

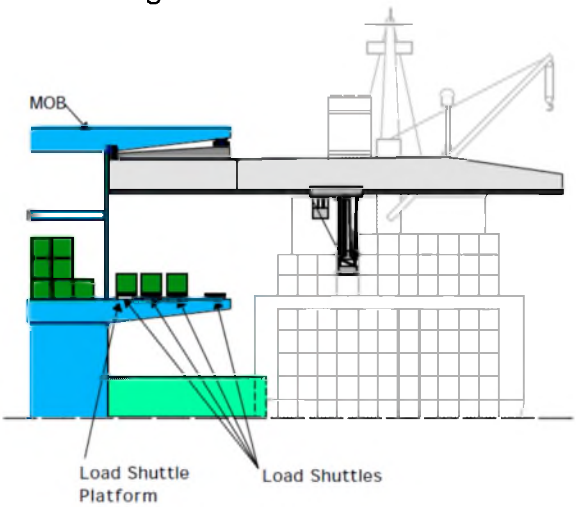


Figure 125: Load Transfer System (LO/LO) between an MOB and a ship (67)

7.6.1.5 Proposals

During those years there were several MOB designs proposed in order to reduce costs by varying the material (steel, concrete, or a combination thereof) and its form (single-hull barge, catamaran, semi-submersible). In the following sections we will see two of them.

- *Joint Mobile offshore Base*, by McDermott (Babcock & Wilcox).
- *Hybrid Mobile offshore Base*, by Aker Norwegian Contractors AS.

The following figure shows three other proposals.

Independent Semisubmersible Modules
Bechtel National Inc.

Semisubmersible Modules with Flexible Hinges
Kvaerner Maritime (Seabase Inc.)

Rigidly Connected Semisubmersible Modules
Brown and Root Inc.

Figure 126: Other proposals of Mobile offshore Base (61)

7.6.2 Joint Mobile offshore Base, By Mcdermott

The Joint *Mobile offshore Base* (JMOB) was a concept developed in the late 1990s and patented (69) in 1999 by *McDermott Technology Inc*. JMOB consisted of five semisubmersible steel propelled ships and a long track of a mile (1,800 m) connected with no load support structures (non-load bearing), the *Nonlinear Compliant Connector*. A lightweight, collapsible drawbridge allows transfer between modules.

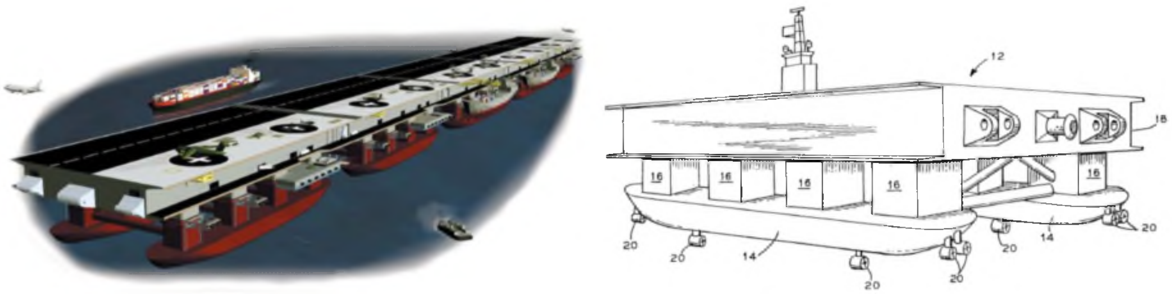


Figure 127: Joint Mobile offshore Base: five modules and the accessibility of one of them (69)

7.6.2.1 Nonlinear Compliant Connector

The *Nonlinear Compliant Connector (NCC)* is a connection system designed by *McDermott Technology Inc.*, specifically for the MOB. The hinged connection allows movement between two semisubmersible modules. The idea of this connection is to minimize the forces that interact between two platforms while preventing longitudinal movement forward/reverse, drift and heave (surge, sway and heave). This is possible by allowing relatively large rotations in roll, pitch and yaw. The implementation of the connectors that act as shock absorber systems rather than fixed or rigid connectors also leads to less fatigue problems that may affect the superstructure. **By allowing these relatively large rotations, the system is unfortunately not suitable for an airport operating civil aircraft (70).**

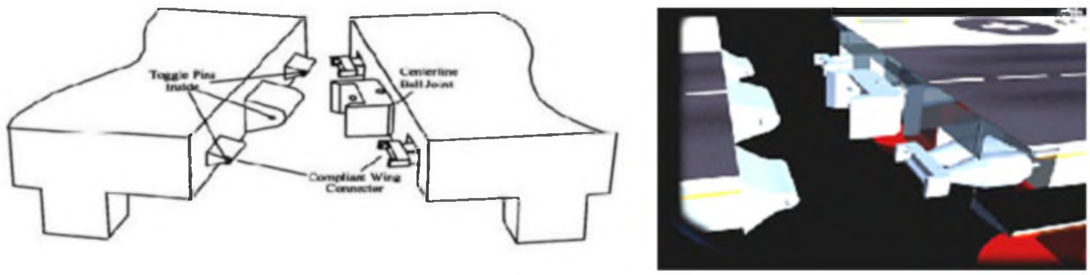


Figure 128: Non-Linear Compliant Connector (70)

7.6.3 Hybrid Mobile Offshore Base by Aker Maritime ASA

The *Hybrid Mobile Offshore Base* by *Aker Maritime ASA*[67] is a hybrid concept consisting of a base MOB concrete and steel superstructure. Studies carried out under the MOB program (62)

[67] Aker Maritime ASA is a Norwegian supplier of offshore products, technology, and services within the Group Aker Solutions

showed that high-performance concrete (HPC) meets the requirements of design and construction of a VLFS (durability and resistance to fatigue) and Mobile Offshore Base (MOB). These studies described two different types of Mobile Offshore Base (MOB).

- The first concept is a semisubmersible module consisting of four identical modules. The total length is about 1,525 m in length. For this concept, the following types were also researched: 1) pier type, 2) barge type, 3) vessel type, 4) catamaran, 5) semisubmersible type.
- The second concept is a single structural unit consisting of a central concrete 890 m in length with a steel cantilever body of 317 m on each end. The total length of the unit is 1,525 m.
- Concepts 5) and b) are hybrid concepts with high resistance concrete (high strength light weight aggregate concrete, LWC60 degree) in the steel hull and superstructure deck. It was concluded that fatigue is a major problem for a concrete shell with a design life of 100 years.

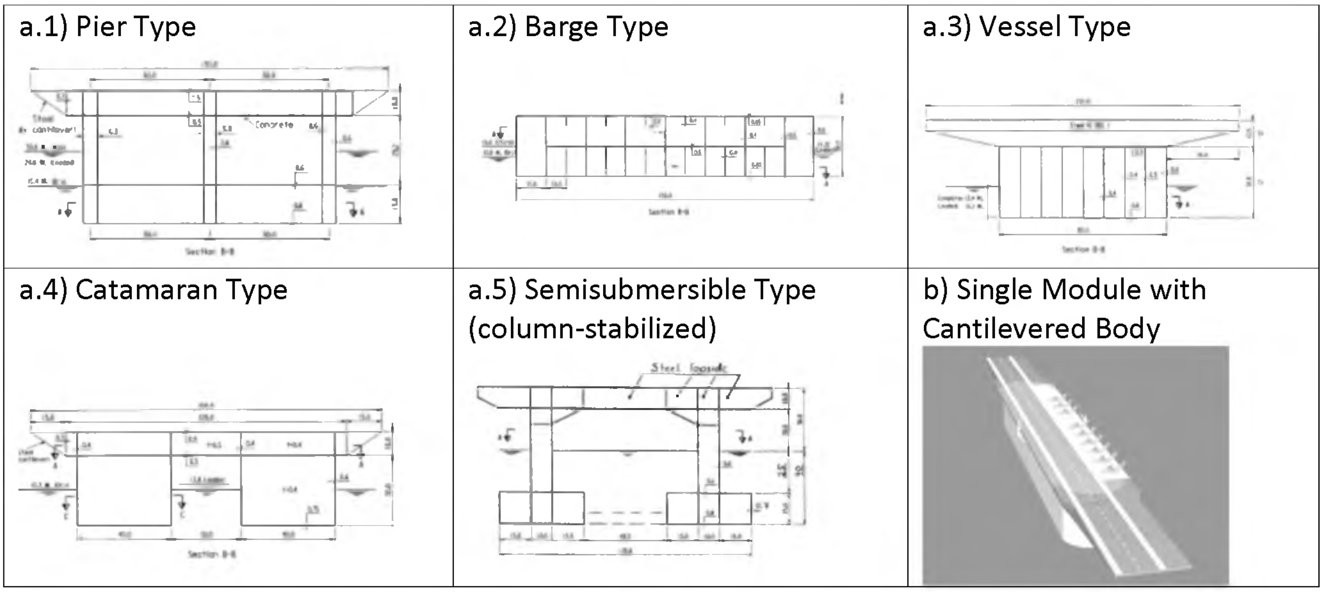


Figure 129: The five concepts studied by *Aker Maritime ASA* (62)

- The design criteria that were handled during the conceptual project to establish the best alternative were as follows:

Total minimum size	25 m x 15m
Draft (shallow water transit)	15 m approx.
Transit speed	10 knots approx.
Design life	40 years minimum
Acceptable limits for air operations landing/takeoff of aircraft	State of the sea 6; Hs = 6 m Maximum pitch angle between modules: 1.5% (0.86º)
Limits of survival conditions	Hs = 15 m Structural strength of the set Airgap = 25 m

Table 17: Criteria of the MOB design.

The concept a.5) hybrid with concrete semisubmersible LWC60 (grade LWAC light-weight aggregate concrete) in the hull and steel superstructure was selected as the most appropriate concept for the following advantages.

1. For the geometry of the semisubmersible hull:
   - A semisubmersible has better seakeeping than other structures. (7) (5)
   - The concept can be optimized to have a relatively high speed transit draft (5).
2. Because of its hybrid structure:
   - A steel superstructure is lighter than concrete and therefore favorable with respect to depth and hydrostatic stability.
3. By using *high performance LWC60 grade concrete (HPC)*: (71):
   - Greater resistance to fatigue.
   - Low maintenance cost.
   - Robustness against accidental loads.

7.6.3.1 Semisubmersible Concept:

The selected hybrid concept consists of four modules interconnected in operating conditions giving the required 5000 ft (1,525 m) long runway.

Main Specifications	
Length	381 m
Beam (width) to the level of steel decks	152.5 m
Draft for aircraft operations	36.5 m
Draft transit during transport (self-propelled), i.e., on the pontoons	15.7 m
Aircraft landing/takeoff strip width (located on one side of the top deck to allow for parking, loading and unloading on the other side)	61 m
Power of each of the eight (8) thrusters	6 MW
Speed	8-10 knots

Table 18: Semisubmersible hybrid MOB specifications.

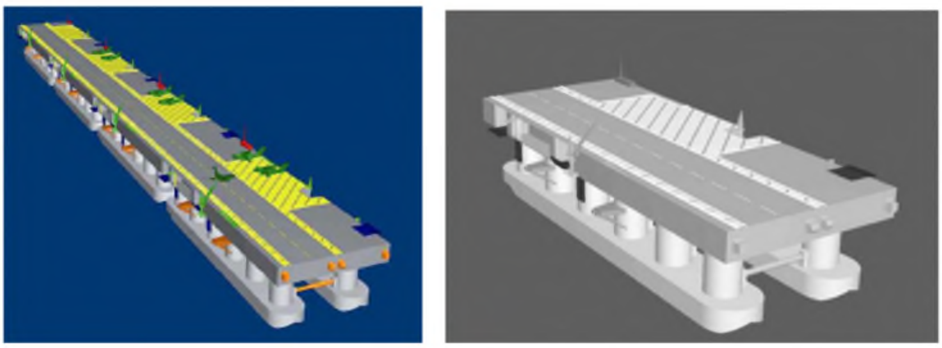


Figure 130: MOB semisubmersible Hybrid Concept: 4 modules together and a single module

Other features:

- Modules can be passed from the operating draft (3m) to the transit depth (1m) in 31 hours. The reverse operation takes 11 hours.
- The area within each compartment is a circular column floatation. The docks area between columns is divided into two compartments. This gives adequate stability for both hydrostatic stability as well as failures.

7.6.3.1.1 Connectors

The connector system between the four modules (one central and two lateral) is designed to absorb axial forces, shear horizontal and vertical, and torsional moments (roll). However, it allows both the pitch and yaw motions.

To reduce the forces on the connectors:

- wave directions are limited to ± 45° relative to the axial MOB axis.
- Outside the operations area, with significant wave height <7.5 m, the modules are disconnected so that each module works individually.

We used a binding coupling technology proven flexible in the Troll A offshore project in the North Sea: “ball and socket”.

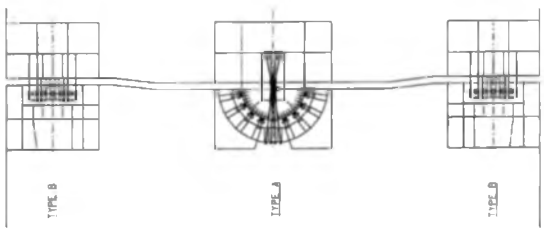


Figure 131: Central and lateral connectors’ plan view (62)

8 Offshore Concrete Structures

8.1 Introduction

Although modern shipbuilders uses steel for virtually the entire structure, they also use other materials such as aluminum, especially for fast boats, the Reinforced Plastic Fiberglass (RPF) for recreational or small fishing boats, or wood in traditional boats. But a material that has not had enough acceptance in shipbuilding is concrete. Despite having been used for years on offshore projects outside shipbuilding, there are few cases of ships built with this material and most are limited to simple barges.

However, recently the offshore industry, as a client of shipbuilders, is rediscovering the great potential of concrete compared to steel. This way, it is being proposed more and more for more projects such as LNG offshore terminals, with even a more suitable material for this purpose than steel. (24) (72)

We intend for this article to examine the use of concrete in the offshore industry, marine applications even though **concrete applications cover a larger types of fields such as dikes, breakwaters, artificial islands, etc**. However, these applications are restricted to coastal and shallow waters; for example, the floating concrete dock of more depth (the one in Monaco is only 55 m deep). (73)

It is therefore the offshore oil industry that has led to concrete and deep and high seas.

8.2 Definition and Applications

Concrete offshore structures are designed to remain permanently or semi-fixed to the seabed either by gravity or piling or anchored to stay afloat (moored) (74).

Concrete offshore structures are used mainly in the offshore oil industry as drilling units, for extraction, or for storage of oil or natural gas. These large structures house the machinery and equipment needed to drill and/or extract oil and gas but may have other specialized uses such as LNG offshore terminals or offshore support wind turbines, especially in deep water.

8.3 A Brief History of Ships and Offshore Concrete Structures

The use of concrete in marine structures dates back to ancient Rome and Greece, and its use extends to diverse applications such as bridges, piers, docks and lighthouses.

But the use of concrete as a building material for commercial hull vessels began in the late nineteenth century. Initial applications were generally for use in waters around the world and consisted of barges and concrete pontoons. The first sailing vessel to use reinforced concrete was the “Namsenfjord”, built in Norway in 1917 (74). The shortage of steel ships made it necessary to use concrete in the First and Second World Wars. Subsequently, a series of 19 barges made in the Philippines by Alfred Yee for *Lusteveco* in 1960 had great success and showed the ability to compete with steel especially as it relates to maintenance (76).

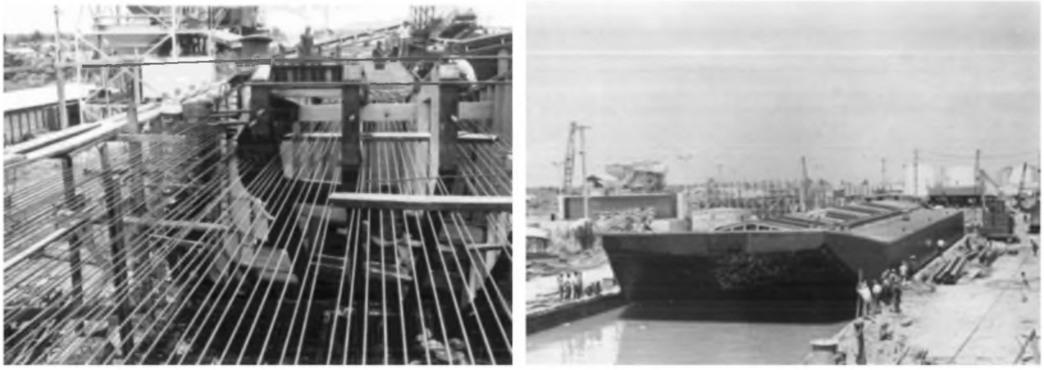


Figure 132: Building and launching of the first pre-stressed barges in the world designed by Alfred Yee (1964) (76)

The first concrete platform for oil and gas production in the Gulf of Mexico was installed in 1950 and since then there have been more than 1,000 small concrete-like structures built in that area (74). But the first major concrete offshore structure supported at its base by gravity (*gravity base structure*) was installed in 1973 in the North Sea: the *Ekofisk Tank*. This marked a milestone in the industry and has since more than 40 concrete offshore structures have been built for use in the North Sea, West Africa, the Gulf of Mexico and the Sea of Java (77).

In Spain we find the first references on the subject published in 1947 in the article "Vessels with reinforced concrete hull (78)." The LNG terminal "Adriatic", the concrete box built by Acciona in Algeciras in 2007, is the last major milestone in concrete offshore structures in our country.

Figure 133: Construction of a concrete box for the LNG terminal "Adriatic" in Algeciras. Source: Acciona.

8.4 Features of Concrete Versus Steel

Of all types of concrete, two are applied in shipbuilding and offshore industry: reinforced concrete and pre-stressed concrete. We compared the steel properties against material usually used in shipbuilding.

8.4.1 Reinforced Concrete

Reinforced concrete is what is inside steel armor, properly calculated and placed. This concrete is able to withstand compressive forces and traction. The tensile stress of steel reinforcement is resisted by reinforced steel. Concrete is the most common.

Reinforced concrete has far fewer maintenance requirements than steel, if properly executed. However, if loaded with tension, the concrete develops cracks over time, which may cause the rebar to rust. In addition, their efforts in tension limits restrict its range of applicability in shipbuilding, as marine structures, floating above all, are constantly subjected to tensile stresses.

Given the *yield strength of steel* on top of concrete, withstanding a given load requires much more concrete than steel in terms of volume. Even if the concrete has a lower density, this translates into heavier components, roughly a factor of 2-3 times more weight to standard concrete (79). Even so, the cost per weight of concrete is much cheaper than steel, so the concrete structure would have a lower cost.

8.4.2 Pre-Stressed Concrete

Pre-stressed concrete is the one that has special steel reinforcement under tension inside, which yields much higher tensile stress than normal concrete. Although it superficially resembles concrete it should be considered as a different material. It can be:

- pre-stressed if the armor has been tightened before placing fresh concrete.
- Post-stressed if the armor is stressed after the concrete has gained strength.

In pre-stressed concrete, steel tensioning supports all loads, and the concrete role simply completes protection against corrosion and as a non-thermal link (*non-thermal bond*) for steel. Due to the fact that they do not need to be welded but are embedded in concrete steel, of a lot more resistance can be used, so the limit on the influence of these armors is a factor of about 8 times higher than those of a typical steel plate.

8.4.3 Applicability of Concrete as Material in Shipbuilding

Therefore, we draw the following conclusions concerning the application of concrete in shipbuilding:

- The cylindrical constructions that are loaded by a dominant compression force such as submarines could be built of reinforced concrete. In fact, there are examples of small submarines built of concrete (80).
- The elongated structures such as barges and large platforms that may experience large net tension forces can be performed effectively only with pre-stressed concrete. In fact, all concrete offshore structures in place are constructed using pre-stressed concrete.

Figure 134: Installation of pre-stressed reinforcement in the barge Nkossa (81)

8.5 Advantages and Disadvantages of Front Steel Concrete Shipbuilding.

Concrete offshore structures show excellent performance:

- They have very high durability.
- They are constructed of maintenance-free materials.
- Better performance in motion, in the case of floating structures.
- They are suitable for harsh and/or arctic environments, such as ice and seismic regions.
- Can carry heavy “topsides” (equipment and oil systems on deck).
- Provide storage capacity within the structure.
- Most supported platforms at the bottom (gravity based) do not need an additional anchor because of the large dimensions and weight of its support, which makes them suitable for soft and shaky floors.
- Fire resistant.
- Free of sparks, making them ideal as storage for flammable and explosive charges and, therefore, function as a bunkering barge, FPSOs, LNG terminals and in general for the offshore oil and gas industry.
- Pollution due to corrosion and other damage to the load is minimized by the low thermal conductivity and corrosion resistance of concrete (76).

Many of these benefits have been documented in the past for ships and barges studies (77):

- Lower maintenance costs:
  - This fact is supported by studies of concrete floating docks during the 1970s, showing dramatic savings, requiring less than 10% of maintenance than similar springs made entirely of steel.
  - Sare and Alfred A. Yee documented costs of repair and maintenance barges insignificant for the 19 pre-stressed concrete built in the Philippines during 1964-6. The average annual cost of maintenance of concrete barges was found to be 1/3 compared with steel barges (77). They worked continuously for 35 years without drydocking (76).
- Lower manufacturing costs:
  - The cost of manufacturing Alfred A. Yee’s barges showed a saving of 16% compared with the same ones made of steel.
- Downtime of the structure.
  - In Yee barges in the period from 1974 to 1975, the total idle time for floating barges per year for maintenance work was six days for concrete structures. the steel barges had a similar median time of 24 days of inactivity.
- Increased life of the structure.
  - In a concrete structure, there is no significant additional cost associated with extending the design life of 30 years to 50 or 70 years. One reason is the fact that the reinforced concrete and pre-tensioning is not sensitive to fatigue.
- Better performance at sea.
  - The characteristics of motion of a concrete hull are usually higher than for a steel float designed for the same purpose. This conclusion is based on reports from captains of vessels (those vessels of the Second World War and the Yee barges), several studies, and recently confirmed by many analyses and model tests for large FPSO offshore units (BP Atlantic Frontier State 2/Schiehallion, hull

length 280 m), the weight and depth are usually slightly higher having an effect on improving motion characteristics.

However, because concrete structures weigh more than equivalent steel structures, this increases the displacement and hence the vessel's fuel consumption. This was the main reason that few ships were built in concrete.

Another advantage of concrete is its good thermal performance for storing cryogenic liquids such as LPG (Liquefied Petroleum Gas) and LNG (Liquefied Natural Gas), which are stored at temperatures from -40° C to -160° C respectively, and are highly flammable. Pre-stressed concrete hulls have many advantages over steel for containing cryogenic liquids: excellent resistance to cryogenic temperatures and shock impacts.

The following table summarizes the findings of a study performed (82) to compare floating LNG terminals of concrete and steel. We observe the same advantages already mentioned above, coupled with good behavior for cryogenic liquid storage.

Concrete hull benefits	Steel hull benefits
Superior cryogenic behavior	Manufacture in existing yards (*)
Good processing/storage separation	Potentially, the lowest cost for a single unit
Reduced downtime due to inspection	Traditional engineering knowledge and well established
Reduced maintenance costs	Construction process with years of experience, traditional
Economies of scale	More steel manufacturers available
Good impact resistance	More steel designers available
Low center of gravity/good seakeeping/reduced movements	Increased flexibility reduces thermal efforts
Excellent Fatigue Resistance	Not subject to damage by freeze-thaw
High MOI	No tensioning of the reinforcement required
Lower thermal response/better insulation	Resistant to gas and liquids
Resistance to fatigue and crack propagation	Similar to numerous LNG/LPG vessels
Resistance to buckling	No membrane required

Table 19: Advantages of a steel hull and a concrete floating LNG terminal (82)

(*) This is one of the biggest drawbacks compared to steel because, if there is an area prepared for this purpose, the cost of building a concrete drydock just to build one unit triggers the total project cost. This depends on the size, soil depth, and so on and could cost $8 million (77).

Figure 135: Drydock on the coast of Nigeria to make concrete offshore platforms (83) in construction and operation.

With regard to maintenance, studies conducted recently on concrete offshore structures (84) also show a degradation process inherent in any structure at sea. Many of the causes are common to steel, concrete and others. Thus we find: chemical degradation, corrosion of steel reinforcement, pre-stressed reinforcement corrosion, fatigue, impact of ships, falling objects, bacterial degradation, thermal effects, pressure loss, erosion and settlement, etc. for which it does not get rid of damage and needs some maintenance, although less than steel, to repair it.

8.6 Performance and Quality of Concrete in Offshore Structures

The quality of concrete used on offshore platforms as well as in the construction process has a more demanding requirement than in residential buildings, but not much more than those in civil structures such as bridges, large buildings, docks, etc. In general, best practices for concrete construction, including material selection and mixing ratios which exist in the various building codes, specifications and standards of most developed countries, are sufficient for use in the offshore concrete industry. Due to exposure to marine environment, it may require some different values for the water to cement ratio, cement content of the material and/or in the lining of concrete on the reinforcements, but these values are well documented.

Like most other types of concrete, concrete used for offshore structures is usually made with materials made by local workers in compliance with local guidelines and specifications. So, it can vary widely in quality. Depending on the particular application, its quality can range from 25 to 65 MPA. All they are required to be is extremely durable, and once a concrete structure is located at sea, maintenance becomes very difficult and expensive due to the hostile environment. Concrete offshore structures have a design life of 50 to 70 years (74).

Figure 136: Construction activities typical of a concrete offshore platform (81) (83).

8.6.1 Concrete Specification

There are essentially two types of concrete offshore platforms that can be used:

1. *Normal density* concrete (ND).
2. *Lightweight aggregate* concrete (light weight aggregate, LWA).

LWA concrete is about 20% less dense than ND concrete, which is an advantage for floating platforms. However, they acquire their stability by weight, so they need to lower the center of gravity, and consequently, have weight in the base. Therefore, it might be beneficial to use ND concrete bottom and LWA on top. This advantage must be compared to the possible disadvantage of having to deal with two different materials both in the engineering phase and in construction. Feasibility studies (77) recommend that the hull is made of and ND concrete of C60 grade and LWA concrete grade LC55, as defined in Norwegian Standard NS347. These qualities of concrete have been tested in many countries and are considered fairly simple to implement. For ordinary reinforcements and pre-tensioned concrete, KT500TE (NS3570) and St 1570/1770 (EURONORM) grades are recommended.

8.6.2 Steel/Concrete Connection Method

The steel/concrete connections are typically based on the principle of embedding steel within the concrete behind the reinforcing steel layers, so that the elements are part of the structure. To achieve enhanced subsequent layers, dowels, steel rods or the like can be used. Examples of steel/concrete connections are the connections between the hull and the "topsides", guides and mooring and towing consoles, support pipes, supports for roofing elements, etc. (77)

8.6.3 Implementing Regulations

There are several specific industry regulations for the design of concrete platforms. These include (86):

- Government Rules: in the U.S., UK and Norway who apply them in their territorial waters.
- Regulatory standards: Canadian Standard, ISO, Norkse Standard (with NS 3473 Concrete Structures).
- Class Certification: Lloyd´s Register or Det Norske Veritas. The latter has a specific regulation for floating concrete structures: DNV-OS-C502 Offshore Concrete Structures (87). It explicitly states that it can be applied to "Floating concrete production of oil/gas structures. The structure may be any type of floating structure, i.e. Tension Leg Platform (TLP), column stabilized units and barge type units" which are the types of existing concrete floating structures at present, as discussed below.

- Specifications of oil companies: when the previous ones were not enough. An example is the NSD 001 of Statoil (Norway).

8.7 Types of Concrete Structures in the Offshore Industry

Concrete offshore structures are usually classified into two major types:

a. *Gravity Base Structures* (GBS) – fixed structures. Many of them also need to have some buoyancy in various stages of its life, for easy removal and dismantling, so they are sometimes called "semi-floating."
b. Floating Structures.
c. Since it is a very simplified classification, within these two types are in turn a huge variety and versatility, and each composition is subdivided differently. Here we will establish this subdivision, trying to collect and combine those made by several different authors. (74) (88) (89) (86)

The following figure shows a GBS platform type "Condeep" and a floating type "TLP".

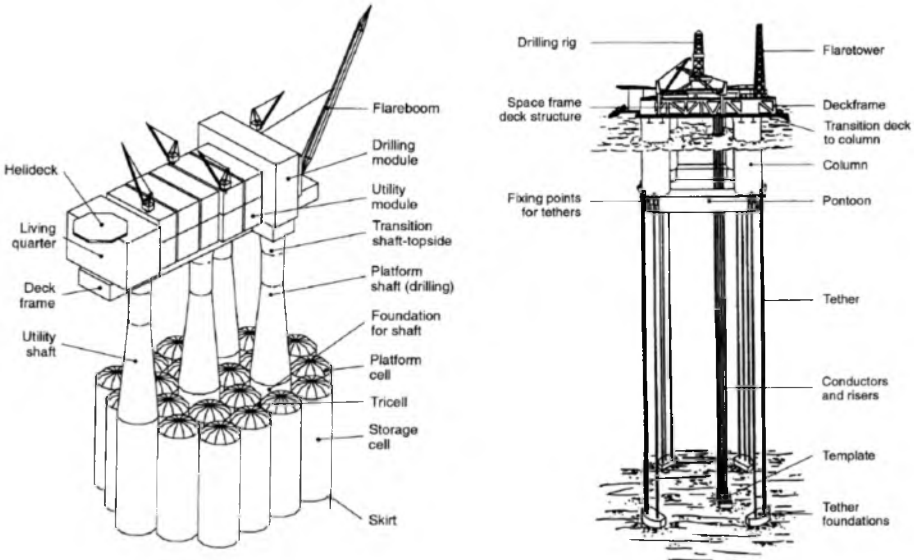


Figure 137: Platform supported on the bottom type "Condeep" and floating type "TLP" (86)

8.7.1 Supported Structures in the Deep – Gravity Base Structures (GBS)

Concrete structures supported on the bottom (*Concrete Gravity Base Structures, CGBS* or simply *GBS*) run their support loads directly over the upper layers of the seabed that supports them. The structure provides buoyancy during construction and towing and acts at the same time as structural support in the operation phase. Furthermore, the structure can be used as storage for oil and other liquids (88).

Most GBS-like platforms rest on sandy seabed with a thick *skirt* of short steel penetrating the sand for protection against corrosion. Soft ground requires deeper skirts. Ground conditions with very soft clay require skirts to penetrate hard layers of the soil (77). Therefore, the study of support in the deep is one of the major drawbacks of these structures, especially when not firm.

In any case, its use is restricted to shallow water, with the *Troll A "Condeep"* with 303 m depth (77). Today, however, they are limited to shallow waters 25-30 m, with the floating option being the one that works best (83).

8.7.1.1 Cylindrical Tanque Types

The first concrete offshore platform in the North Sea was the Ekofisk, which was built in 1973 as the concept of the French-Canadian CG DORIS *(Compagnie General des pour les Richesse*

Operationelles Developments Sous-Marines) to Phillips Petroleum. The design consists of a large box made up of cylindrical tanks that once attached from a single structure that forms the basis for the upper deck. It is supported at the bottom of the sea and surrounded in turn by an exterior breakwater, built in two pieces.

Figure 138: Breakwaters constructed separately and under construction around the structure.

Following in the North Sea three additional concepts (Frigg CDP-1 in 1975; Frigg MP-2 in 1976; Ninian Centre in 1978) and one in Canada in 1997 at the Hibernia Field.

8.7.1.2 Condeep Type and Subsequent Developments.

8.7.1.2.1 Condeep Type

The *Condeep* concept (*concrete deep water structure*) was the most popular for a period of time. It consisted of a circular cell base and one to four hollow columns (axes), so it had the advantage of having a slender form at the zone of greatest wave impact. The upper deck was not part of the concrete structure itself. The majority were made of post-tensioned concrete (89).

Between 1975 and 1995 a total of 14 "Condeeps" settled in the North Sea (86) with depths of 104 m to 30 m (the Aker Kvaerner "shipyard" in Hinna (near Stavanger, Norway) was in charge of building them. The following figure shows these 14 "Condeep" platforms.

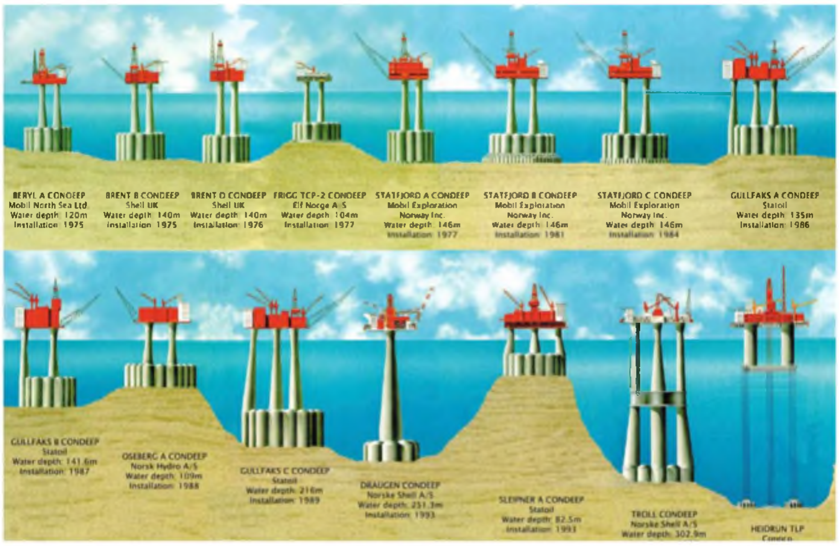


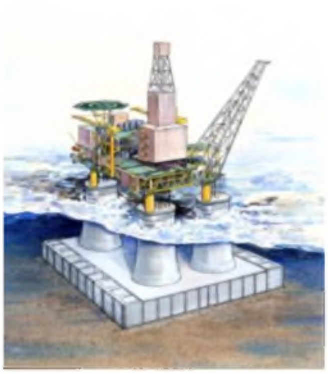
Figure 139: The 14 "Condeep" platforms and the "TLP" type were built by Aker Kvaerner in Hinna (77)

8.7.1.2.2 Subsequent Developments

Other designs by other companies were based on the same principles, except that the cells in the structure were rectangular: four platforms were built in the North Sea from 1976 to 1978, and also the “BP Harding” in UK waters, 1995, and “South Arne” on the Danish continental platform (86).

8.7.1.2.3 Sakhalin II of Arup Project

The most recent project developments “Condeep” with rectangular cells is by *Arup* for ExxonMobil *Sakhalin II Project* (Russia). The following figure shows the layout of the two *Concrete Gravity Substructure* (CGS) vessels designed by *Arup*. The base was 90m x 100m, with a depth of 12m (90) (77).



Platform *PA-B* and *Lunskoye* of Arup’s Platform

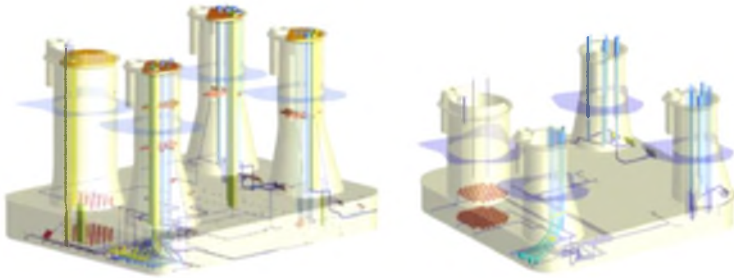


Figure 140: Evolution of the concept “Condeep” (90) (77)

8.7.1.3 Barge Type

We could define a barge type structure as a floating ship with almost vertical sides and almost rectangular at the bottom. The bow and stern may or may not be straight. As defined, these structures are designed to operate while floating either temporarily or permanently. But some barges do not operate afloat; they are towed to a deployment site, sunk to the bottom and refloated at a later stage (91). Following are two examples.

8.7.1.3.1 CIDS (Concrete Island Drilling System), 1984

The *Concrete Island Drilling Platform System (CIDS)* was built in 1984 with precast pre-stressed concrete to withstand the severe pressure of ice in the Arctic. It used the patented Honeycomb (92) by *Yee Precast Design Group Ltd*. This platform replaces the construction of islands made of gravel, which cost at the time about $100 million. In contrast, CIDS cost only $75 million and was reused to explore numerous locations along the north coast of Alaska and Russia without having shown any deterioration. They were ballasted and seabedded where they were needed after relocating (85).

Figure 141: Honeycomb System and CIDS operating platform (93)

8.7.1.3.2 Adriatic LNG Terminal

This is the first offshore gas terminal that has been installed in the world. The terminal consists of a pre-stressed concrete structure resting on the bottom (GBS), 180 m long, 88 m wide and 47 m in height, whose budget was over 200 million euros. All of the concrete structure is heavily reinforced with pre-stressed concrete. It was executed by Acciona and subcontracted by Aker Kvaerner, which was responsible for the design, final towing from Algeciras to Adriatic (17 km from the coast of Venice) and its commissioning and delivery (75).

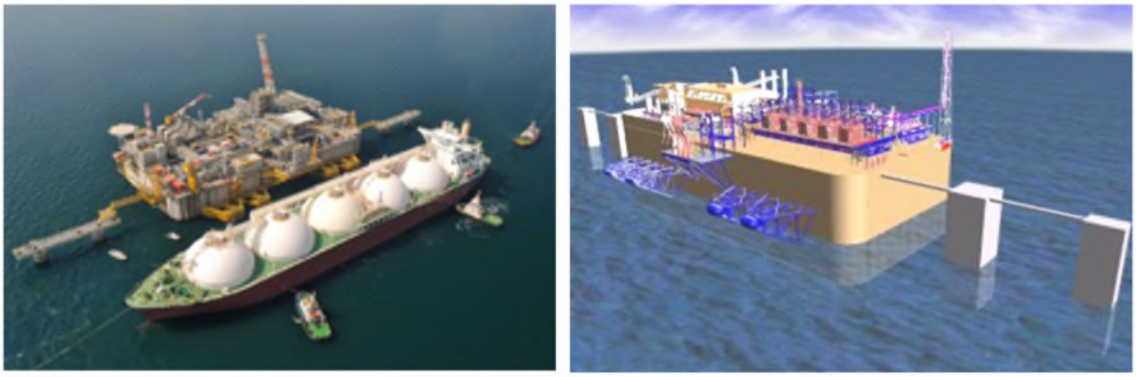


Figure 142: Adriatic LNG Terminal (94)

8.7.2 Floating Structures

Since concrete is very resistant to salt water and keeps maintenance costs low, floating concrete structures have become quite attractive for oil and gas industry in recent decades. Temporarily floating platforms such as "Condeep" float during construction and towing, but are finally placed on the ocean floor. Permanently floating concrete structures were used in the discovery of oil and gas deposits for production, storage, offloading units and in some cases as a system of heavy lifting.

The common floating concrete structures designs are of the barge/single-hull vessel (such as FPSO and FSOP), column-stabilized (type Tension Leg Platform semisubmersible), and floating terminals, for example, for LNG. They are designs widely used and proven in the offshore industry that are simply used for hull construction of concrete instead of steel.

8.7.2.1 Semisubmersible and TLP Types

The geometry of semisubmersible and TLP platforms are very similar: they have a pontoon at the bottom and stabilization columns that cross the waterline to support the steel deck. The differences are mainly the anchoring system: while the semisubmersible type has a traditional system of anchors, anchor chains in catenary, the TLP has an anchoring system with steel tendons fixed vertically at the bottom, which do not allow the vertical movements. The semisubmersible instead may be ballasted and de-ballasted to vary the depth.

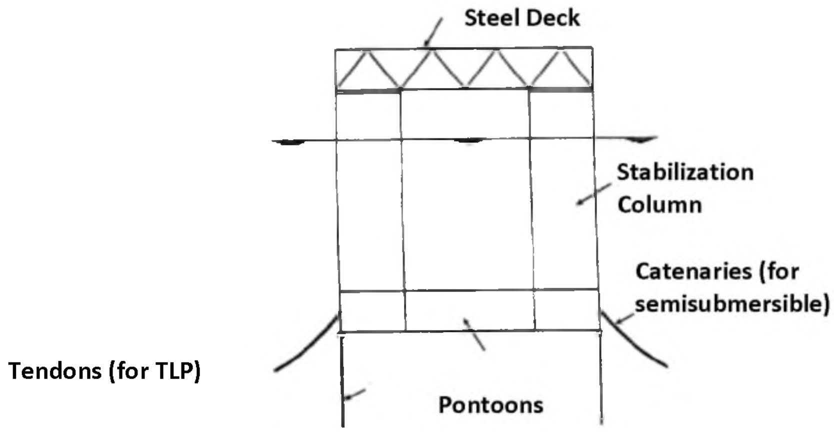


Figure 143: Common semi-submersible platform and TLP diagram

Here we show only two semisubmersible and TLP platforms made of concrete.

8.7.2.1.1 Troll B

The Troll B semisubmersible rig was designed by *Doris Engineering*[68], entering the waters 335 m deep in 1995.

Figure 144 Platform "Troll B".

8.7.2.1.2 Heidrun TLP

The Heidrun TLP platform was designed by Aker Maritime and installed in June 1995 and is operated by Statoil.

[68] Doris Engineering based in Paris (France) is an engineer who has worked in the offshore field since 1965.

Figure 145 Platform TLP "Heidrun"

8.7.2.2 Barge Type

We have already seen the definition of a barge (91) and how Yee barges built in 1960 performed well. The main use for barges/single-hull vessels in the offshore industry is as an **FPSO** (floating production, storage and offloading) or simply as an **FSO** (floating production, storage). The FPSO and FSO are units for oil and gas storage tanks located in the ship's hull, which remain anchored to the bottom through a "turret" or other mooring system that allows the ship to find the best wind conditions and waves, allowing the flow of oil/gas.

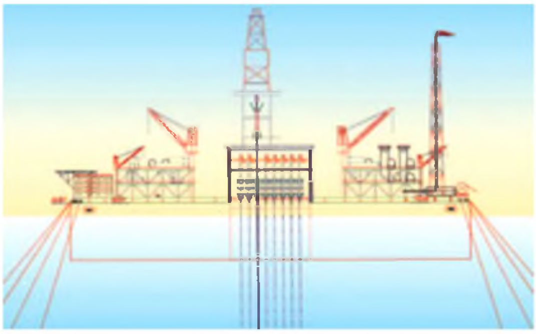


Figure 146: Oil barge FPSO (82)

8.7.2.2.1 Ardjuna Sakti Lpg

It was the first pre-stressed concrete barge and the first LPG FSO unit. It was completed in 1975 to function as an LPG storage barge (Liquefied Petroleum Gas) in the Ardjuna Field (Indonesia). This LPG FSO unit is built of reinforced and pre-stressed concrete cylindrical contained tanks, as shown in these images.

Figure 147: Floating LPG terminal "Ardjuna Sakti" (95)

8.7.2.2.2 Nkossa

The “Nkossa” Elf Congo barge is the largest pre-stressed concrete barge in the world. It was built in the docks of Marseilles, France, and towed to the coast of Congo, where it remains anchored to 170 m depth since 1996. Its dimensions are: Length 220 m, breadth 46 m, depth 16 m, draft 10 m. Its expected service life is 200 years.

Figure 148: Oil production barge “Nkossa” dam construction and operations (81)

8.7.2.2.3 Uses of Single-Hull Barges Out of the Offshore Industry

As mentioned, single-hull barges have a wide range of uses outside of the offshore industry. Current applications include barges as well as transport and storage for docks, industrial plants, bridges, jetties, helipads, parking garages, and airports. The current success of the concrete technology of barge-like structures will be even more diversified and expanded in the future (81).

An example is the Rofomex I, built in 1980, which contains a phosphate processing plant designed for uninterrupted life of 80 years. It was also the first barge with the Yee Honeycomb system.

Figure 149: Barge Rofomex I: under construction, Honeycomb system in sight, and afloat (76)

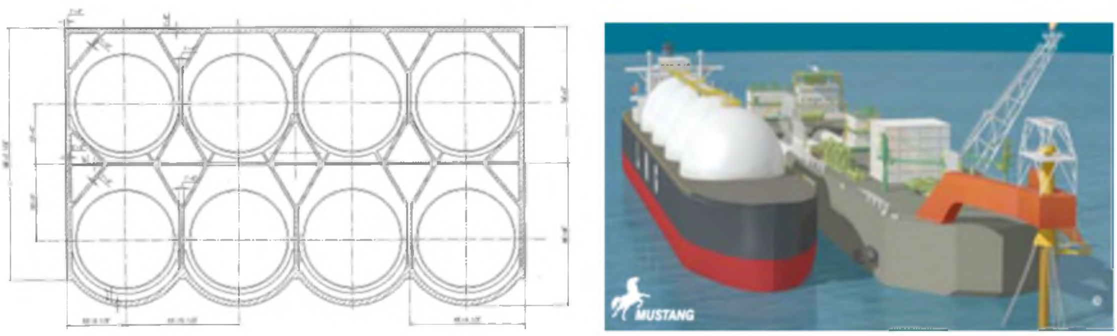


Figure 150: LNG FPSO concept of concrete hull Mustang: cross section and rendering (72).

9 Legal and Regulatory Aspects of Ocean Colonization

9.1 Introduction

So far we have taken a look at different structures, some with better performance or more workable than others due to technical and economic aspects.

- Technical aspects determine whether an ocean colony survives under certain conditions in the ocean.
- Economic factors determine the return on investment of the platform.

However, long-term foreign policy factors can be even more important issues than the technical and economic aspects. These aspects of foreign policy are based on the legal basis of such settlements.

The ocean enables great freedom, but only at some distance from the coast in high seas outside the EEZ. Furthermore, even when at sea, structure should comply with regulatory standards if we want this structure to be recognized by the international community as a guarantor of compliance to requirements of safety, quality and environment. This international recognition is necessary because the oceanic community is obliged to deal with companies from other countries and regimes. Even in the extreme case that the purpose of this colony is the creation of a micronation, this interaction is necessary, and more so when oceanic colonization is for recreation, resource exploitation and expansion of terrestrial space.

These ideas will be discussed in this chapter of the dissertation.

- First we will make an introduction, and examine the main instrument governing the right into the sea in the establishment of floating structures, artificial islands, etc: the United Nations Convention on the Law of the Sea.
- Following we will see the basic rules to be observed by any floating structure that has as its purpose to house people. These regulations are mainly those of the IMO and classification societies.

9.2 International Law of the Sea

9.2.1 United Nations Convention On the Law of the Sea – UNCLOS III

The United Nations Convention on the Law of the Sea (UNCLOS)[69] is the international agreement that resulted from the *United Nations Conference on the Law of the Sea* (UNCLOS III), which took place from 1973 to 1982. The Law of the Sea Convention defines the rights and responsibilities of nations in their use of the oceans around the world, establishing some guidelines for economic exploitation, environmental protection and management of marine natural resources. The Convention, completed in 1982, replaced four treaties of 1958. UNCLOS entered into force in 1994 and today, 158 countries and the European Community have joined the Convention.

However, the extent to which the Convention actually codes international maritime law “de facto” is sometimes called into question. The General Secretariat of the United Nations receives instruments of ratification and annexation in the Convention, and the UN has a direct operational role in the implementation of the Convention grounds. However, organizations such as the

[69] Known in English as Law of the Sea Convention and Law of the Sea treaty

International Maritime Organization, the International Whaling Commission and the International Seabed Authority (the latter established by the UN Convention) do play an important role.

9.2.2 Ordinance of Sea Space According to UNCLOS III

Based on the provisions of the United Nations Convention on the Law of the Sea the following areas can distinguish maritime space:

1. Inland Waters (IW).
2. Territorial Sea (TS).
3. Contiguous Zone (CZ).
4. Exclusive Economic Zone (EEZ).
5. Continental Platform (CP).
6. High Seas (HS), or International Waters.

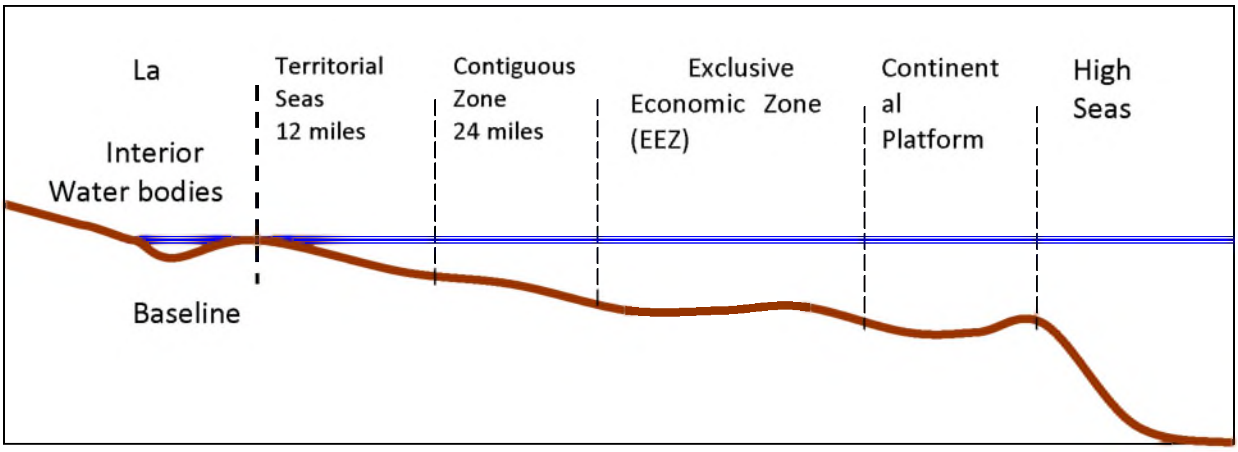


Figure 151: Sea areas according to the Third United Nations Conference on the Law of the Sea

9.2.2.1 Inland Waters (IW)

It covers all water and waterways on the landward side of the baseline. The coastal state is free to set laws, regulate use, and use any resource. Foreign vessels have no right of access to inland waters.

9.2.2.2 Territorial Sea (TS)

Within 12 nautical miles from the baseline, the coastal state is free to set laws, regulate use, and make use of any resource. Vessels were given the right of "innocent passage" through any territorial waters. "Innocent passage" is defined by convention as the passage through the water quickly and continuously and that is not "prejudicial to the peace, order and security" of the coastal State. Fishing, pollution, military practices, and spying are not "innocent", and submarines and other underwater vessels shall navigate on the surface and fly its flag. Nations can also temporarily suspend innocent passage in certain areas of its territorial waters, if it is essential to protect their safety.

9.2.2.3 Contiguous Zone (CZ)

Beyond the limit of the 12 nautical mile territorial sea is another 12 nautical miles, or 24 nautical miles from the baselines, which is the contiguous zone, in which a state may continue to enforce laws in four specific areas: **pollution, taxation, customs and immigration.**

9.2.2.4 Exclusive Economic Zone (EEZ)

The EEZ extends to 200 nautical miles from the baseline. Within this area, the coastal state **has exclusive rights to all natural resources**. Sometimes the term may include the territorial sea and continental shelf. The EEZ was introduced in the Convention to end the increasingly intense fighting over fishing rights, although oil was also becoming increasingly important. Foreign nations have **freedom of navigation and overflight subject to the regulation of coastal states**. Foreign states may also lay pipes and cables.

9.2.2.5 Continental Platform (CP)

The continental shelf is defined as the natural prolongation of land territory to the outer edge of the continental margin or 200 nautical miles from the baseline of the coastal State, whichever is greater. The continental shelf of the state may exceed 200 nautical miles from the natural extension until this ends. However, it will never exceed 350 nautical miles from the baseline. Coastal States have the right to harvest mineral and non-living materials in the subsoil of its continental shelf, to the exclusion of all others. Coastal states have exclusive control over the living resources of the continental shelf adjacent to, but not those in the water column beyond the Exclusive Economic Zone.

9.2.2.6 High Seas (HS)

This is the area beyond the EEZ and Continental Shelf, which are commonly called International **Waters**. Apart from its provisions on maritime special planning, the Convention on the High Seas asserts general obligations to safeguard the marine environment and the protection of freedom of scientific research, and also creates an innovative legal regime for controlling mineral resource exploitation seabed, through the International Seabed Authority and the principle of Common Heritage of Mankind.

Landlocked states are given a right of access to and from the sea, excluding taxes or fees on their way through the zones of coastal states.

The following map shows in aqua blue the international waters around the World:

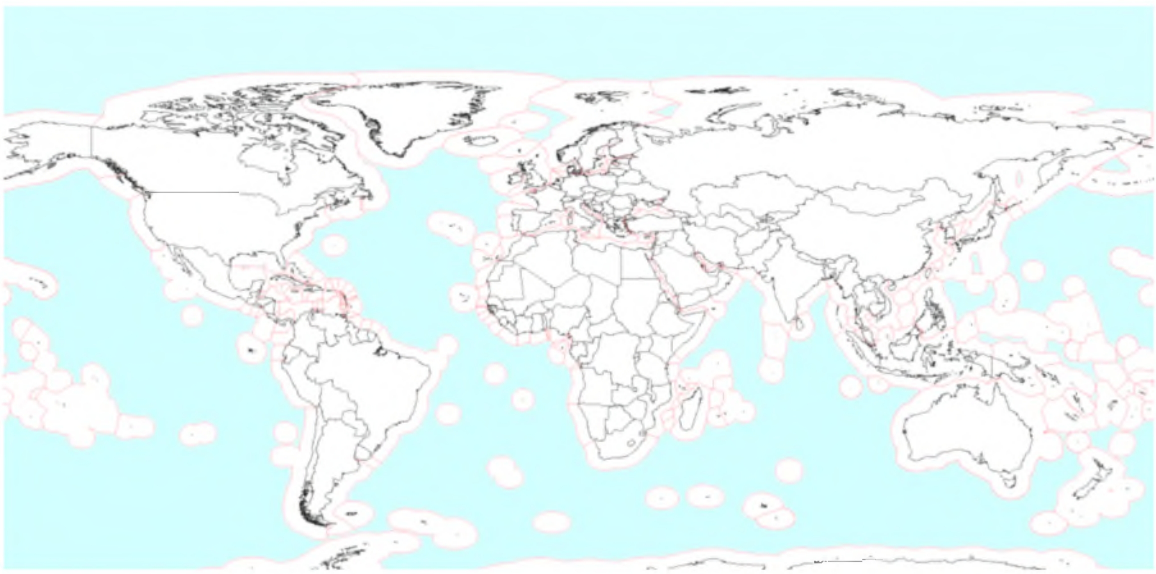


Figure 152: International Waters, in aqua blue, outside the EEZ

9.3 Artificial Islands in the Law of the Sea

9.3.1 Introduction

As we introduced in Chapter 1, the existing legal vacuum around the establishment of maritime artifacts and floating islands in the ocean is what has encouraged many entrepreneurs to attempt to colonize the ocean with sovereign goals.

With regard to artificial islands, these are the references to the subject at the Conference on the Law of the Sea UNCLOS III:

- According to **Article 11**, artificial islands should not be considered a "working port". Consequently, the coastal State cannot claim the same rights that have been collected for permanent havens in relation to baseline and the measurement of sea areas.
- According to **Article 56**, artificial islands are under the jurisdiction of the coastal state if found in the EEZ.
- According to **Article 60**, artificial islands are not considered suitable to have or claim its own territorial sea or EEZ, and only the coastal state may authorize construction if they are within the EEZ.
- According to **Article 87**, in the High Seas (International Waters), any state can build artificial islands.
- Therefore, we come to a very clear conclusion at first glance: artificial islands and floating structures must be outside the Exclusive Economic Zone (EEZ) if you want to avoid interference with the governments of coastal states. Such is the case of those who pursue the objectives of sovereign ocean colonization.

But while the law is clear by referring to the EEZ (and other areas that include it) the situation is quite different on the High Seas. There is some confusion here between conclusions from different experts in the field.

One of the conclusions on this subject is found in the dissertation of Rene Kardol (97). According to him, the right to build an artificial island in international waters is legal, with one limitation. in UNCLOS III it specifically states that it would be legal to build an artificial island in international waters. However, this "law" would be limited by the intended use for the island. If the intention is to exploit the resources of the seabed, then the "owners" of the island, usually members of a company or a state, should request authorization and a license from the International Seabed Authority. Therefore, the conclusion might be that it is legal for states (and private companies) to construct artificial islands without special authorization (based on **Article 87** of UNCLOS the agreement), provided it is not for exploitation of the seabed.

But Galea (98) believes that the legal vacuum surrounding the system to establish artificial islands offshore is done on purpose to avoid precisely the colonization and appropriation of the ocean, which is considered a good for all humanity.

9.3.2 Distinction Between Natural Islands, Artificial Islands and Ships

We therefore obtain from the previous section that under UNCLOS III:

- Within the EEZ the coastal State is vested in the establishment of artificial islands.
- A sort of legal loophole exists in high seas and in principle it is possible to establish artificial islands without authorization provided its establishment is not to exploit the seabed.

However, UNCLOS III itself does not establish a clear difference between what would be an "artificial island" and what would be a "boat". These differences are of great importance in establishing a sovereign ocean colony. Although there are impediments in establishing an "artificial island" in the EEZ, there would be no impediment to a "vessel" navigating in the EEZ of a coastal state. Thus, under the Convention, a hotel ship with PD that sails at 1 knot can stay in the EEZ of a state without hindrance, although it is subject to certain regulations of that state.

One of the most comprehensive studies on this issue was by Frances Galea in his doctoral dissertation (98). This dissertation presents the study of artificial islands in the International Law of the Sea with the evolution in time of this issue from the Hague Conference on Codification of International Law 1930 (The 1930 Hague Codification Conference) to the Conference of the United Nations Convention on the Law of the Sea of 1982 (1982 United Nations Conference on the Law of the Sea). The study analyzes the status of "ships and vessels" ("ships and vessels") in relation to "artificial islands" as well as that of "natural islands". Galea makes clear that these concepts are not sufficiently clear in the Convention and even makes an attempt to shed light on them, recommending that international authorities create a separate legal category for **artificial islands**.

9.3.2.1 Importance of the Concept of "Artificial Islands" in UNCLOS III

Although the issue of artificial islands had significant importance in the agenda of UNCLOS III, many suggestions regarding their legal status and jurisdiction in the end were never applied. Thus the issue was covered by a general provision applicable in the context of the Convention, but without being given special. The inadequacy of the current legal mechanism governing artificial islands is a consequence of these past decisions.

9.3.2.2 Natural and Artificial Islands

The initial statements that led to the formulation of the Law of the Sea do not have the "artificial islands" or "natural islands" distinguished. The construction of artificial structures was not a realistic proposal until recently.

9.3.2.3 Ships, Artificial Islands and Other Floating Artifacts

There are many definitions of "ship" in different national laws, commercial codes, etc. However, we take the definition of Professor Ignacio Arroyo[70], which refers to a "ship", in the broadest sense, as "any structure intended for navigation", once past the consideration as a transport ship and the exclusion of inland navigation. But he also stressed that although the ship has ceased to be the core concept of maritime law (because it is one of many floating vessels), it should be kept as an unadulterated concept not to assimilate foreign bodies, giving these new floating artifacts a special status. Thus, structures floating without navigation or destination is not and cannot be considered ships for this purpose. This includes:

- floating cranes.
- pontoons.
- drydocks.
- oil platforms.
- other artificial islands.

In general, these structures, permanently attached to the bottom, have no ability to move.

Thus, Professor Ignacio Arroyo agrees with Galea in that artificial islands must have a special status. But while it may be that an all-inclusive definition of "artificial islands" is a task that can lead to more legal problems if not properly formulated, both authors would recommend a system that at least notes the variety of artificial islands.

But **in practice, many of these floating structures seem to enjoy the status of a ship in international law.** Their similarity to vessels, however, is misleading and is limited to the ability to float and sail, as the purpose for which they are used as well as the dimensions and other considerations are clearly differentiated.

[70] Legal encyclopedia - ship concept. www.Enciclopedia-Juridica.biz1com

Therefore, these new floating artifacts are not recognized by the law. But while some professionals involved in their use (mostly in the offshore oil industry) have been interested in knowing well the limitations of freedoms and depth their artificial islands, others are willing to register their floating islands like vessels, and therefore apply the flag state jurisdiction. **An example we have seen is the semisubmersible floating hotels and barges. They are not ships because they do not have the ability to**.

9.3.2.4 Conclusion: Ships as Artificial Islands and Micro-Nations

The study of artificial islands as a means to create micronations shows that several states have taken different approaches when similar events have been referenced. So while the REM Island Rose Island was dismantled, the Principality of Sealand is still intact. States generally do not act before the installation of an artificial island in the EEZ, unless considered a threat to its integrity. Others, however, have refused to take action because they feel legal uncertainty over how to deal with such new situations.

Therefore, before embarking on any ocean colonization project based on an artificial island (much more for sovereign purposes), there should be a clear legal status, which is itself confused by the variety of designs, locations and uses. In the absence of a legal regime, artificial islands are usually just regarded as "ships", and need to meet certain rules and regulations as discussed below.

9.4 Regulations to Meet for Ocean Colonization. IMO and Classification Societies.

9.4.1 Introduction

Living at sea does not mean that one is free of all kinds of regulations, since one has to comply with the coastal state if within its EEZ, or the state under which the ship is flagged in case of being at High Seas. However, we can choose the flag of the ship. Therefore, in the case of establishing a micronation in the High Seas, we could choose the country to belong to, or one may even establish a new nation. But in any case, one would need to establish political and commercial relations with other nations of the world, or even if you have your own country, one would ask the United Nations to recognize the status of the artificial island. There is an international UN agency charged with ensuring that all ships and ocean structures meet certain safety standards – the International Maritime Organization (IMO). Besides this, some private organizations can ensure compliance with standards – the Classification Societies.

9.4.2 International Maritime Organization, IMO

The International *Maritime Organization (IMO)* is a special agency of the UN responsible for actions to improve shipping safety and prevent pollution from ships. It is also responsible for legal issues, including duties and compensation and the provision of international maritime traffic. The IMO slogan sums up its goals: safe, secure and efficient shipping on clean oceans[71].

Specialized IMO committees and sub-committees are the focus for the technical work to update existing legislation or develop and adopt new regulations, with meetings attended by maritime experts from member governments, along with those interested intergovernmental and non-governmental organizations.

[71] 71 From www.imo.org

The result is a wide range of international conventions, with the support of hundreds of recommendations governing every facet of shipping. These include measures to prevent accidents, including standards for ship design, construction, equipment, operation and staffing; key treaties include SOLAS, MARPOL Convention (International Convention for the Prevention of Marine pollution from ships) and the STCW Convention (International Convention of training Certification and Watchkeeping for seafarers).

9.4.3 IMO and Classification Societies.

All boats and marine structures should be examined in order to issue certificates to establish their seaworthiness, type of ship, etc. **This is the responsibility of the flag state.** However, the flag State ("Directors") may "entrust the inspections and surveys either to surveyors nominated for this purpose by organizations it recognizes" (Chapter 1 of SOLAS regulation 6). In practice, these "recognized organizations" are often the classification societies. The International Association of Classification Societies (IACS) is a nongovernmental organization that was granted consultative status at the IMO in 1969.

9.4.3.1 Classification of Marine Structures.

Classification is a representation of the level of compliance of a vessel or offshore marine structure according to the rules established by a classification society. This classification is established according to plan approvals and inspections made by experts of the company, as stated in its rules. The classification of vessels provides a benchmark for safety and reliability on ship owners, shipyards, agents, managers of the flags of the vessels, insurance companies and the financial community. This is represented by a level of class, introduced in the classification certificates and transcribed in the register of ships published periodically by the company.

The following table illustrates the symbols given by each classification society for a boat built under the special inspection regime in full compliance with class rules and authorization for unrestricted navigation.

Society	Symbol
ABS	✠ A1
BV	I
CCS	★ CSA 5/5
DNV	✠ 1A1
GL	✠ 100 A5
IRS	SUL
KR	✠ KRS1
LR	✠ 100A1
NK	NS *
RINA	100-A-1.1 or C
RS	KM★

Table 20: Symbols used by each classification society according to their inspections

The mission of classification societies is to contribute to the development and application of technical standards for the ship and the environment. Today, there are more than 50 marine classification organizations in the world, the three main ones being British *Lloyd's Register* (LR), the Norwegian *Det Norske Veritas* (DNV) and the *American Bureau of Shipping* (ABS), members of the three International Association of Classification Societies (IACS).

Membership in this association requires certain codes of conduct that prevent commercial pressures that may influence the approach of the society and reduce the level of security. Today, more than 90% (by tonnage) of cargo ships is classified as design, construction or already in service, one of ten classification societies belonging to IACS.

Classification societies have developed networks of offices that cover most of the world, making it easier to offer equivalent services elsewhere. This has helped many governments that have delegated some legal obligations to classification societies, which are then authorized to issue certificates on their behalf.

But how does a classification society work? When deciding to build a ship or other marine structure, we choose a classification society and first drafts are sent for approval, thus beginning a relationship that often lasts the life of the vessel. All construction plans of the vessel shall be approved by the classification society, in addition to sending an inspector to verify that the ship is built according to plans and the rules of society. If the flag has delegated the process of verification to the classification society, the boat will also be reviewed with respect to compliance with all standards set by international conventions.

During the life of the ship, the classification society must check that the structure and machinery of the ship still meet the set criteria, and will require repairs necessary to do so, if necessary. Maintenance criteria must be met so that the ship can continue “in class”. With "loss of class", the vessel loses insurance coverage and statutory certification. In addition to these permanent certificates, major classification societies are authorized to issue provisional or temporary certificates. These do not change the primary certificate, but detail the conditions that the owner must comply with certain requirements in time (for example, the replacement of damaged parts, correcting damage to the hull or machinery, incomplete repairs, etc.). Normally, the classification societies work closely with the owners for renovation and maintenance of these certificates, giving them a regular and continuous (quarterly or semiannually) report of the situation and what has to be revised.

According to DNV and also applying to the rest of the Classification Societies, all ships have a mandatory class notation and an optional class notation:

Pt.1 Ch.2 Sec.1 A

Table A1 Class notations structure	
Mandatory class notations	Construction symbol, see B200
	Main character of class, see B300
	Service area restriction, see B400
	Main ship types, survey scheme and class notations for additional strengthening, see Table B3, B4, B5 and B6
Optional class notations	Related to ship types, see Table C1
	Related to cargo, see Table C2
	Related to service area, see Table C3
	Related to survey scheme, see Table C4
	Related to equipment and systems, see Table C5
	Related to design features, see Table C6
	NAUTICUS notations, see Table C7

Table 21: DNV mandatory and optional class notations

9.4.3.1.1 Mandatory Class Notations

- The symbol of construction ✠ will be assigned to ships built under the Society's supervision.
- The notation 1A1 will be assigned to ships with hull, machinery, systems and equipment that are in compliance with the mandatory class requirements.
- Restricted service areas: the notation R is followed by a number or letter that will be assigned to ships with certain modifications to the layout, equipment or fixtures in relation to ships constructed for unrestricted navigation.
- The main class of the ship. Apart from the above notation, the vessel must also have an additional class note with the type of vessel or structure it is: oil tanker, Roll-on and Roll-off (Ro/Ro) vessel, passenger vessel and those with stabilizer column units, among others.

9.4.3.1.2 Optional Class Notations

These optional class notations certify that the vessel meets the requirements regarding auxiliary systems, equipment systems, areas of operation.

Described here as an example are some of the optional class notations which we believe should be included in any structure designed for an ocean sovereign colony. All of them are referred to the DNV, and most of them are included in the above examples of possible structures and vessels for ocean colonization.

- BIS: indicates that the ship is ready for inspection on the water
- COMF: indicates that the ship reaches a certain level of comfort in relation to:
- V: Noise and vibration
- C: interior climate.
- DYNPOS: Relative to Dynamic Positioning
- E0: automation system to get an unattended engine room
- HELDK: ships with a platform or landing area

9.4.3.2 Classification of Concrete Structures

As discussed in Chapter 8, concrete is a good alternative to steel. In recent years, the use of concrete is taking an increasingly important role mainly in offshore structures. There are standards for offshore concrete structures in some classification societies as, for example, in OS-C502-DNV for Offshore Concrete Structures. It can be used for "*Floating Structures for concrete production of oil/gas.Tthe structure may be any type of floating structure such as Tension Leg Platform (TLP), column stabilized units and barge type units*."

9.4.3.3 Classification of offshore Structures for Colonization

Considering the above explanations, any structure to be used to colonize the ocean must be classified by one of the classification societies, even if for sovereign purposes. Even the classification society itself could be responsible for ensuring compliance with other international regulations that apply internationally: SOLAS, MARPOL, and ILO (International Labor Organization). Therefore, in an early stage of the conceptual development of the oceanic structure it would be desirable to work with the classification societies.

In previous studies on oceanic colonization structures, we saw some notations used for certain types of marine structures (ferries, cruises, flotels, offshore platforms, MOBs, etc.) and how they might apply the concept of ocean colonization.

9.5 Conclusions and Results

In the first part of this chapter we have reviewed the international law of the sea. It is clear that whatever the purpose of colonizing the ocean, if we are within the EEZ, the structure that we might establish must have the approval of the coastal state. Beyond the EEZ, it is unclear whether it is possible without the approval of international organizations.

The term "artificial island" in the Law of the Sea is unclear, since many structures that are now in operation or under design were hardly known when drafting this law. A ship, for example, has right of passage through the Exclusive Economic Zone, but has no right to anchor and settle permanently in it without the consent of the coastal State. What would happen to a vessel with dynamic positioning?

In either case, it is quite clear that whatever the structure used for ocean colonization must meet certain requirements for security, quality, and environment which are regulated by the IMO. It is also clear that the best way to ensure compliance with these requirements is to work with the classification societies.

PART IV: ANALYSIS OF RESULTS

10 Future Evolution of the Oceanic Colonization

10.1 Introduction

So far through the dissertation we have analyzed:

- **PART I: Oceanic colonization for the establishment of micronations and oceanic cities.** We have seen that studies, designs and attempts were made mostly without any rigor, often ignoring basic aspects of Oceanic and Naval Engineering for the design of the platform. Hence, they all end in failure; though in reality most have not even developed beyond simple designs and internet presentations.
- **PART II: Mandatory requirements for an oceanic colony.** We have discussed the four requirements common to all types of ocean colonization, seeing that, in the case of sovereign oceanic colonies, the legal requirements are particularly important.
- **PART III: Platforms for ocean colonization.** We have examined the various platforms in existence today for each of the oceanic forms of colonization that have become a reality, and as well scrutinized and discussed proposals for the future of each one of them, along with the legal issues that surround them.

We now have information necessary to **undertake the objectives of the dissertation itself:**

Evaluate possible options (present and future) presented by Oceanic and Naval Engineering for the establishment of autonomous communities offshore *that would allow the creation of oceanic micronations. At the same time, try to present the future evolution of the other three forms of oceanic colonization: expansion of land holdings, mobile settlements and semi-permanent settlements for access to marine resources.*

This chapter will be an analysis of the results obtained during the investigation of all possible platforms applicable to oceanic colonization. Said analysis will be a way to pose a scenario for the future evolution of all forms of oceanic colonization, with special emphasis on a possible scenario for the creation of a sovereign oceanic colony, an oceanic micronation.

The future evolution of oceanic micronations will be addressed in section 10.6 , while the future development of other forms of ocean colonization will be discussed in Chapters 10.2, 10.3 and 10.4. Section 10.5 will be devoted to the analysis of concrete as a material to be used in the future in oceanic colonization, due to the positive characteristics it holds.

10.2 Future Evolution of Landholdings and Coastal Spaces

The expansion of the landholdings along the shore have two principal motivations:

- To acquire more residential space.
- To obtain logistic surfaces designed for ports and airports.

Although strictly speaking of oceanic colonization, we should only refer to ports, most of the proposals have included airports, which is why we have discussed them in the dissertation.

10.2.1 Expansion for Residential Urbanization

Many demographic studies predict that by 2050 about 70% of the world population will live in urbanized areas. Given the fact that about 90% of the world's largest cities are located adjacent to the sea, we are forced to rethink our relationship with the coastal areas and the way that they become urbanized. Since future coastal development is unpredictable, it is of great importance to allow for flexible strategies in the planning of such developments. Large-scale floating projects in coastal urban environments provide a solution to these problems while being flexible and sustainable.

Although we saw a first approach to these floating urban developments in the Coastels (Chapter 6.1)and in some architectonic projects such as Waterstudio (Chapter 3.2.1) and Aquabase (Chapter 3.2.2), their full potential will not be realized for another fifty years. Population pressure will be intense in those cities and areas for possible land fillings will be scarce. The following would be possible trends for future floating urban developments.

- Year 2020: Typical services from urban centers would have to be brought to the coast line to enable the establishment of the first shore based houseboats. This would allow for the regeneration of the coastal zones, while at the same time relieving urban pressure from more expensive, high density, areas within the city.
- Year 2030: Expansion of the “urban fabric” over the waterfront; floating buildings would be constructed on the water with normal urban configurations, typical densities and typologies (apartment buildings, townhouses, etc). The floating neighborhoods would look like traditional terrestrial areas but with the particularity that the floating settlements can adapt to water fluctuations.
- Year 2040: The full potential of floating developments starts when we begin to think about dynamic city planning. Floating developments are highly flexible because buildings and even entire parts of cities can be relocated easily to adapt to shifting demands. This way we would move forward towards a dynamic approach of our homes and buildings, similar to the concepts of dynamic geography discussed in Chapter 2.5.3.3.

In about 50 years this could be a possible scenario to address ongoing seaside development based on reclaimed land from the sea. What we envision otherwise would be the development of a more sustainable floating dynamic planning.

If we observe the development of Singapore over the past 50 years, its costal area has been completely urbanized. What we foresee is that in the next 50 years, similar urban expansions would be made available through floating developments.

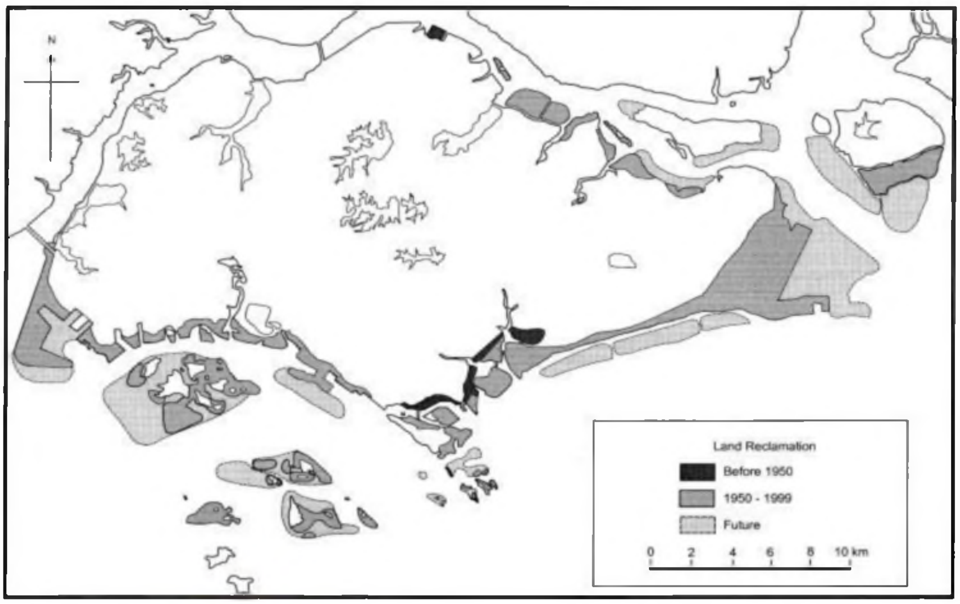


Figure R8 Reclaimed land in Singapore.

Figure 153: Reclaimed land in Singapore

10.2.2 Expansion of at Port and Coastal Services. Future Development of VLFS

VLFSs possess two principal advantages over the conventional solutions of reclaiming land from the sea; they have low cost and low environmental impact:

1) **Cost:** Floating options have a lower cost when the depth of the water column begins to be significant (Fousert, 2006) (studies for floating docks stipulate this after a depth of 30 m is reached), because they are quick and easy to:
   a) Install, so that the maritime space can be exploited quickly.
   b) Dismantle, in case the maritime space utilized is required by another need in the future.
   c) Expand, by virtue of being modular systems.
2) **Environmental impact:** the VLFS are respectful of the environment, because they:
   a) Do not harm the ecosystem.
   b) Do not interrupt currents.
   c) Are not permanent structures on the seabed.

VLFSs also present other advantages:

a) The structures are protected from seismic impacts by being inherently isolated from the bottom.
b) They do not suffer from differences in land consolidation.
c) Their position with respect to the water's surface is constant (they are not affected by tide) making it easier for small ships and boats to dock at any time.
d) When located in coastal waters, they provide alternate facilities of marine developments around the main structure, making them suitable for recreational activities and water sports.
e) The possibility of creating mega-ports offshore would allow for access of bigger ships, creating a savings due to economies of scale.
f) The smaller ports would benefit from the traffic that these ships would bring to the mega-ports. Cargo could then be distributed by smaller ships to ports much closer to their final destination.

•

In the following table we summarize, the advantages and disadvantages of each type of VLFS discussed.

Structure Types	Advantages	Disadvantages
Mega-Float 	**Manufacturing and assembly procedures simple and inexpensive. Unlimited size (modular). Positive cargo capacity. Positive load capacity.**	**Suitable only for benign conditions (inlets, bays, etc.). Low mobility. Effects of water on deck on the ships motion or "green water"effect. Theory of "Elastic Plane Plate" largely undeveloped.**
Mobile offshore Base (MOB) 	**Mobility. Suitable for all types of waters. Including deep and shallow waters as well as benign and harsh conditions. Good behavior at sea**	**Limited load capacity (being a semisubmersible). Broad internal movements (danger of structure fatigue). Connector technology in an experimental phase.**

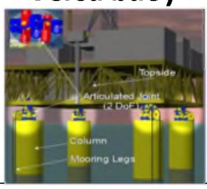
Structure Types	Advantages	Disadvantages
		High construction and operating costs.
Pneumatically Stabilized Platform, PSP 	**Manufacturing and assembly procedures simple and inexpensive, but not as much as the Mega-Float.** **Suitable for all types of water, although not as hard as the MOB.** **Unlimited size (modular).** **Low to almost zero maintenance.**	**Experimental technology at its most basic principles: the indirect displacement.** **Joining technology with tensors requires extensive development and study.** **Low mobility.**
Versa buoy  	**Great reduction of wave-induced motions.** **Expandability.** **Modular assembly system.**	**Large vertical forces.** **Mooring system of complex anchoring lines.** **No mobility.** **Experimental technology.**

Chart 24: Advantages and disadvantages of the various VLFS.

One of the most important findings of this study is to observe how a semisubmersible concept built of concrete is the most advantageous choice compared to other options (the MOB hybrid of Aker Maritime ASA). **No doubt these two concepts, "semisubmersible" and "concrete", will prevail in the future when designing structures to colonize the ocean.**

As for regulation, there are still unsolved matters referring to VLFS characterized as ships, offshore installations or something else. This determination will depend on the different international regulatory statements, principally by those involved in the enforcement of environmental and maritime regulations (such as IMO), along with the nature of property and their mission.

We understand that as land facilities costs increase along with the awareness for coastal protection, the option of floating logistics facilities (ports and airports) will be increasingly interesting. Because of this, the 21st century will surely see major developments in this field, perhaps with the solutions seen previously or with completely different concepts that are yet to be developed.

This may even be a solution for our Spanish coast, if we want to continue developing it in a sustainable and environmentally friendly way without sacrificing the wealth it provides.

10.2.2.1 Specific Considerations About MOB

This research seems to be very promising for oceanic colonization, because nowadays the technology required by the MOB concept has been widely used by the offshore industry: concrete construction, dynamic positioning, semisubmersible designs, etc. To show that it is economically viable, we need to continue investigations and designs in many areas. These include:

- Validation of software tools to predict load and motion responses.
- Design and analysis of the connectors between modules.

- Alternative Concepts.
- Marine materials of durable resistance.
- Construction Technologies.
- Long term maintenance and repair.
- Position maintenance (anchoring, mooring, dynamic positioning).

10.2.2.2 Specific Considerations About PSP

A similar idea to ease the movement of the waves uses anti-rolling systems with active type tanks, where the water that flows between tanks is controlled by automatic valves and air entrapment. This technology is used for swinging movements and not for heave like motions, as on the PSP. It has been used for several years on many ships, mainly of the offshore industry.

So it would not be unreasonable to think that in a few years, the PSP concept could become commercially viable, as the material of the structure itself, concrete, does not seem to be the problem. The **main advantage for oceanic colonization is that the energy supply problem and the attenuation of wave motion are solved simultaneously.**

10.3 Mobile Settlements. Cruise Ships Future Evolution.

10.3.1 Introduction

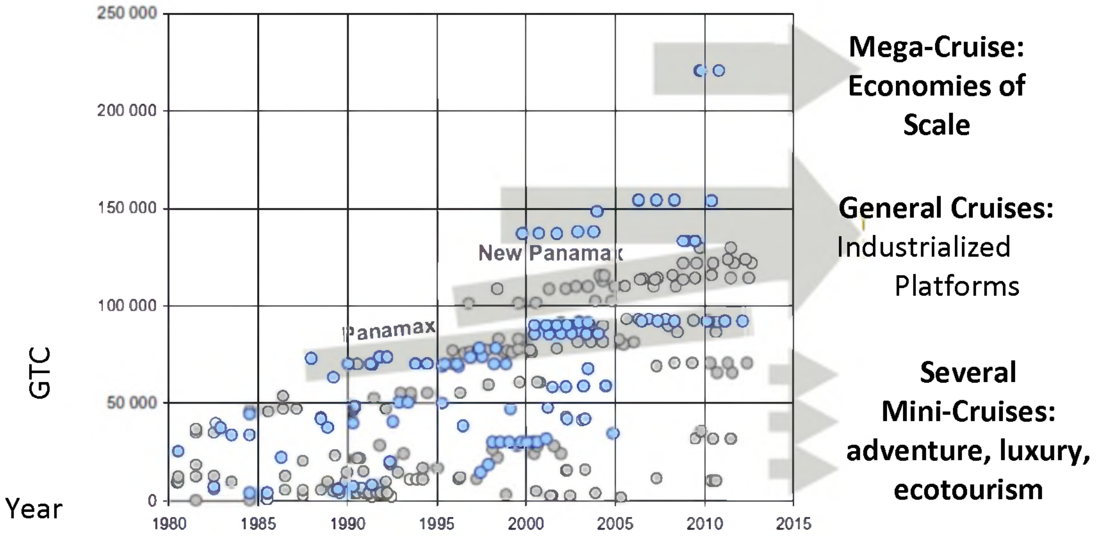
The transatlantic ship has come a long way since the nineteenth century when the liner shipping services offered vital means of transport. In the second half of the twentieth century it evolved to the transatlantic cruise and the ship became a floating resort, and early in the twenty-first century we have seen a new development: residential ships.

Although a cruise ship can be considered a true floating city, they are far from being self-sufficient. Modern cruise ships are only able to sail for a week or two before having to replenish supplies and food. Most of their population (cruisers) remain onboard for 1 to 2 weeks, while their employees (crew), though they usually remain onboard longer longer, are not permanent "residents". So while cruise ships support a very large population, they are far from being genuine floating cities, despite the increasing attempts by the cruise industry to resemble them. However, three cruise ship market trends (reviewed in Chapter 5) that bring us closer to this reality:

- Scale economies.
- The cruiseship, itself, as a destination in itself.
- New concepts: residential ships.

10.3.2 Economies of Scale

The market segmentation for cruises, addressed in Chapter 5, differentiates between three types of ships as shown in the following graphic:



Graph 8: Tendencies in the cruise market segment

- **Mega-cruises:** large cruise ships are being built today in order to achieve unprecedented economies of scale.
- **General cruisers:** traditional cruiselines are aiming at general audiences.
- **Mini-cruises and small cruises:** target market niches such as adventure cruises, ecotourism, luxury, etc.

For the future development of cruise ships into genuine floating cities, it is interesting that economies of scale are being achieved in the mega-cruise segment. As shown on graph 8, the size of cruise ships have increased continuously and linearly, up to the mega-cruise ships with 225,000 GT, which has meant a qualitative leap in the linear increment.

Not so long ago, in 2005, it was not believed that a capacity of 5,000 passengers could be exceeded without causing logistical problems at the ports (according to Maurizio Cergol, the Italian designer of the Fincantieri shipyard, who during that year had built the Carnival Glory with 3000 passengers[78]). This capacity was overcome only four years later by the Oasis of the Seas. The following table shows how it took 80 years (1911 to 1988) to double the ships capacity, while this capacity has nearly doubled again in the last 20 years:

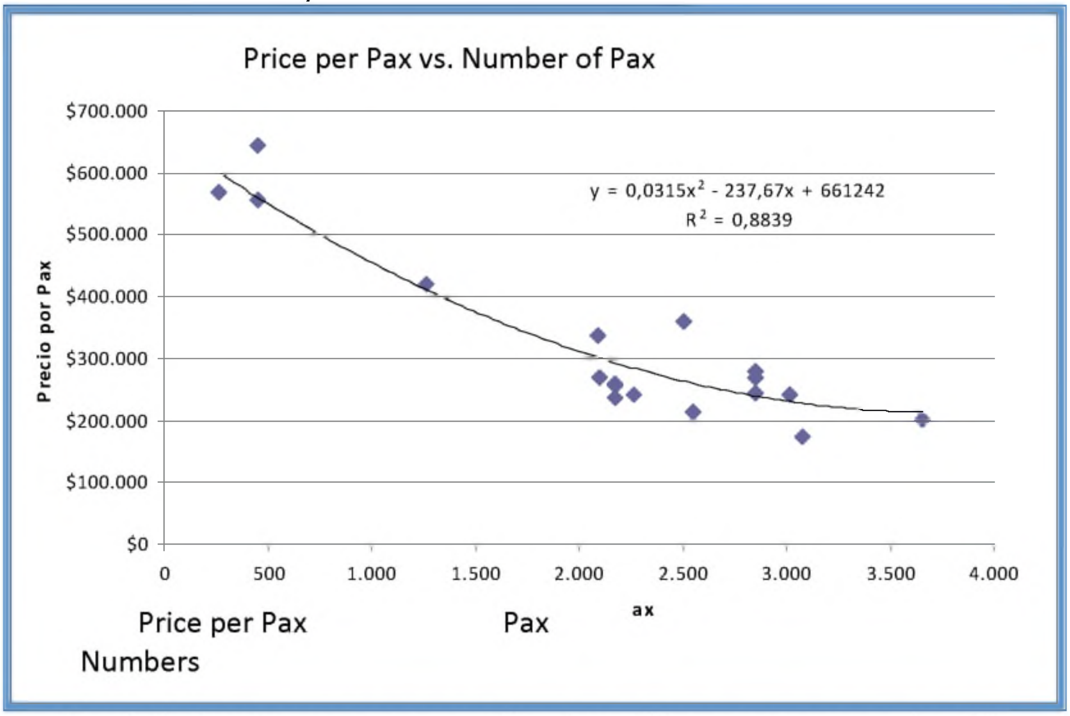
Name	RMS Titanic	Royal Caribbean Sovereign	Royal Caribbean Freedom of the Seas	Royal Caribbean Oasis of the Seas
Launching year	1911	1988	2006	2009
Length (m)	269	266	339	360
Passengers	1,341	3,588	4,370	6,295
Crew	885	800	1,112	2,165
Velocity (knots)	21	21	22	22

Chart 25: Evolution of cruise sizes

[78]Source: http://www.theglobeandmail.com/life/are-mega-ships-better-ships/article345995/page3/

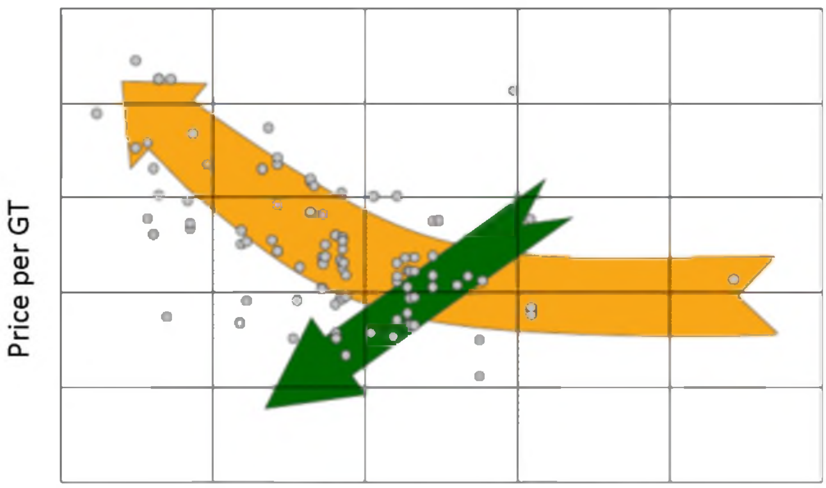
Larger ships boost profits, as the economies of scale in both CAPEX and OPEX (supplies and operations) reduce overall costs. The cruise companies that operate the mega-cruisers can offer all-inclusive fares for about $100 per person per day, less than half the cost in smaller vessels and comparable to land resorts. **We're talking about authentic ocean colonization, when comparing oceans costs with the shore costs.**

If we graph the cost per passenger and the number of passengers the mega-cruisers can accomodate, we observe a negative correlation between the two parameters. This clearly shows the economies of scale mentioned above. Smaller ships have a more expensive ratio per passenger, and therefore cannot compete in costs with the large cruise ships. This is the reason why these small units are usually dedicated to market niches.



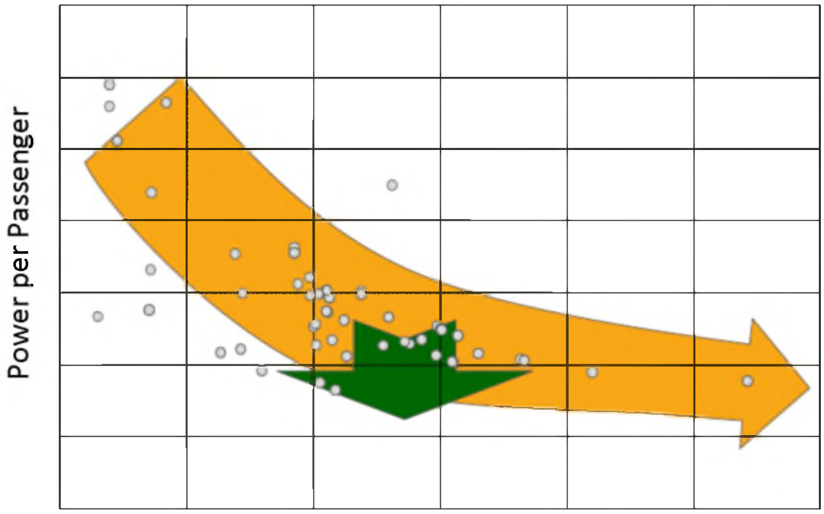
Graph 9: Cost per passenger vs. Number of Passengers on a cruise ship

A similar graph to the one above, but using GT instead of number of passengers, is presented below:



Gross to nnage - GT
Graph 10: Cost by GT vs. GTS on a cruise ship.

From the same source we also found the following graph, which studies the installed power capacity per passenger. Other scale effects are also observed, the greater the number of passengers, the less power capacity installed.



Graph 11: Cost per GT vs. GTS on a cruise ship.

The scale effect is present in two aspects:

- CAPEX: in capital costs, since the construction cost by number of passengers is reduced by increasing this parameter.
- OPEX: in operating costs, as more passengers lower the installed power required, and therefore lower the fuel costs, supplies costs, etc.

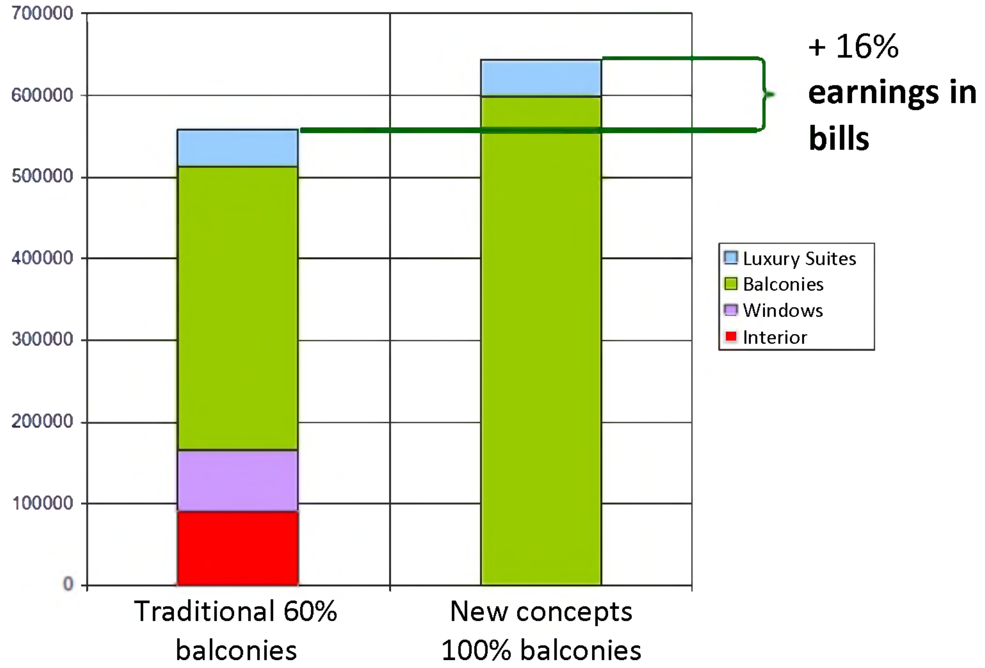
10.3.3 Cruise Ship as a Destination in Itself

As we have seen also in Chapter 5, the cruise ship industry has followed a trend for years trying to position the cruise ship as a destination in itself and not just as a mean of transport. One can travel at night to take advantage of visiting new destinations by day. The challenge is in trying to position the cruise as a leisure destination, a complement of leisure to land destinations, or sometimes as a more daring and unique destination. This requires creative effort and engineering that not all shipping companies, shipyards and designers have met with the same enthusiasm.

- Creative efforts:
    - The range of multiple activities offered on board cruise ships.
    - The varied spectrum of cruise ships that exist today has led to a very large segmentation of that market.
- **Engineering efforts,** largely focused on offering maximized comfort:
    - **Analyzing ways to minimize the vertical accelerations of the ship**, both in free shipping and while stationary. The forms of the hulls of the EOSEAS, ship pentamer, or the Streets of Monaco, with a SWATH form, all of these are responses to that requirement.
    - **Offering a sense of spaciousness for the inside spaces on board**. This optimizes the enjoyment of leisure activities and leads to vessels with wide sleeves linked with the concept above; some proposals have been presented with multihull, SWATH or pentamer forms. On the Mega-cruises, due to its high beam a

configuration with a central avenue that runs through the ship is viable without the necessity of a multihull form.

- **Designing ships with all outside cabins,** which not only result in passenger comfort, but also with 16% extra income, as we see in the chart below made for a vessel of 1800 cabins.



Graph 12: Additional revenue per ticket on a ship with 100% of outside cabins against one with 60% of outside cabins

10.3.3.1 "The Nation of Why Not"

Following these efforts, we found that Royal Caribbean has been a pioneer in creativity and engineering, with a very clear idea about what they want to offer to their customers. Their concept "The Nation of Why Not" reflects their idea of what a cruise should be: the escape of the cruiser to a country in the middle of the sea (reflecting freedom once again) where everything is possible. This is therefore, consciously or not, a form of ocean colonization with sovereignty goals.

Royal Caribbean is also a pioneer in mega-cruise ships. With their concept of "The Nation of Why Not" they do not see these mega ships and simple cruise liners, but actually have a concept closer to floating cities. This is what is shown in one of their publicity brochures:

With 21 floating ship-states, 251 ports, and 361,000,000 square kilometers of ocean terrain, Royal Caribbean is practically its own independent country and now we´re making it official.

In "The Nation of Why Not", our mission is simple: to provide you, our Professional Travel Agents, with the information and tools needed to inspire everyone to visit the floating states (okay, ships) of the Royal Caribbean Nation of Why Not, the Nation where everyone is encouraged to do something dıfferent and unroutine at every turn, at all hours of the day.

What is it?

The Nation of Why Not is a place where innovation and imagination reign supreme. While other cruise lines have always asked "why?", Royal Caribbean's philosophy of "Why Not" has guided us since our founding in 1960's why we were the first to build ships solely for the purpose of cruising the Caribbean, and the first to feature cantilevered whirlpools, rock-climbing walls, and ice skating rinks onboard, making our ships a destination in themselves. and now it's why we've decided to start our own Nation, the Nation of Why Not, a place like no other place on earth.

While Royal Caribbean now officially considers itself a Nation, just remember that we're still Royal Caribbean, and wouldn't be where we are today without you, our Professional Travel Agents, who've helped build the Nation over the years. So other than a few flags, a new advertising campaign, and an even greater sense of pride, not much will change at Royal Caribbean, other than the usual stream of amazing innovations that continue to make us the most incredible cruise line on earth

Where is it?

The Nation sails to over 281 ports worldwide, and is home to over 20,000 resident citizens (also known as crew), responsible for showing the ways of "Why Not" to more than 50,000 guest citizens each week.

Our Nation is made of 21 states (ships) that roam the world's oceans, constantly changing latitude and longitude. We are a Nation constantly on the move, looking for bigger and better things to challenge our imagination, and say "Why Not" too.

Figure 154: Promotional image of "The Nation of Why Not"

Even though it is pretty clear that this is a marketing strategy (communicating to their costumers that they will travel to a country filled with unlimited options while enjoying complete freedom to do as they please), at the same time this is a revolutionary concept for a floating nation.

- Each ship is its own state.
- Crew members are citizens that inhabit the ship for periods of 7 months at the time (depending on their rank).
- Cruiser are guest citizens.
- A passport is needed in order to enter the different states (ships) called "seapasses", which are the control cards for access deemed mandatory by the regulations of the ISPS.

There is still a lot of progress that needs to be made before being considered a country:

- The U.S. dollar is used as the normal currency of exchange.

- They pay taxes to the countries whose waters they operate in or are passing through.
- They operate under the flag of an already established nation, in this case, the Bahamas.

In any case, this idea of separate oceannations are a small step towards oceanic colonization with sovereignty purposes, though unintentionally.

10.3.4 Residential Ships

For years, and supported by experts from the cruise industry itself, many advances have been made along the idea of ocean colonization with numerous proposals for residential vessels. Daring extensions of what we mentioned before have been introduced. Specifically that the ship is not only a destination in itself, but already a home. According to this idea, the ocean is already being colonized. Making these settlements an exception due to their mobility and ability to temporaily anchor in ports.

In 2002, *The World* was launched by the *World of Residensea* as the first residential ship built for that purpose. For the first time, a cruise ship was sailing the oceans of the world with a residential community on board a residential condominium ship. Giving people the opportunity to travel on board as a traditional cruise guest or become permanent resident of the ship. *The World* has lit the fuse for a new generation of ships known as "residential ships" or "residential condominium ships" that have ocean residents on board.

In 2007, the *Four Seasons* was introduced which took the residential ship concept a step further than *The World,* limiting passanger admission to full time on-board residents only. Unfortunately the international economic crisis paralyzed many of these projects.

10.3.5 Conclusions

Although we might be a long way from seeing a **floating city** becoming a reality, one thing is certain: the ocean passenger ship that has origins in the transatlantic of the nineteenth and twentieth centuries will continue to evolve and we will see interesting developments in the future. As technologies continue to advance, shipbuilding may one day produce ships in the style of genuine floating cities created on a scale never seen before. Concepts have been proposed for such floating cities including *America World City* and the *Freedom Ship*. These huge floating cities would be too big to dock at any port and thus would be constantly circumnavigating the ocean with shuttle ferries transporting residents to and from land. Therefore, they would not be cruise ships, but a real floating cities with ocean mobile homes, shops and local businesses. As current technology has not yet transformed these concepts into reality, it is possible that such floating cities are still a distant possibility. However, by harnessing the optimized combination between economies of scale, the cruise ship as a destination and the introduction of new concepts, such as residential ships, the floating city concept is destined to become a reality.

Graph 13: Evolution towards the concept of Ship - Floating City ship

10.4 Future Evolution of Semi-Permanent Settlements, Improve Access to Marine Recourses

10.4.1 Introduction

We have seen in the chapter on offshore hotel ships how to use a wide variety of marine structures in the form of accommodation vessels or flotels. From barges to jack-ups and passenger ships to semisubmersible barges, the most suitable structure will depend on the location of where it's intended to operate. The depth and metocean conditions (waves, wind and currents) are the main parameters to consider. There is no single solution to providing floating accommodation.

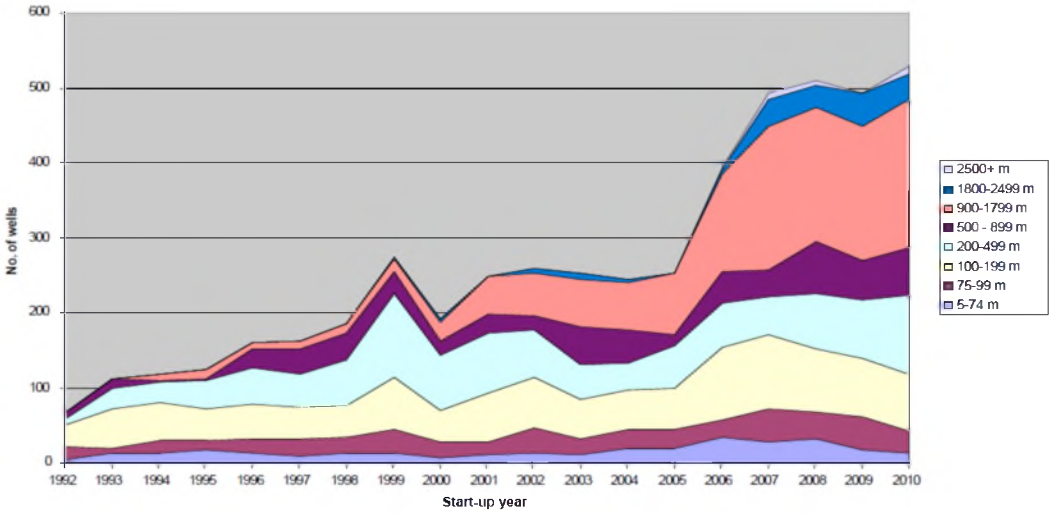
As the oil and gas industry are moving to deeper waters, the offshore wind industry seems to be the next one to require offshore flotels (with some specific requirements that differ from those in the oil and gas industry). This emerging market will lead to the creation of such flotels as the *Wind Farm Mother ships* to accommodate demand.

In the following sections we will analyze:

- The rise of DP systems in accommodation vessels for deep waters.
- Classification notes on these types of ships.
- Future projections of an untapped market for these units that will undoubtedly see interesting developments (ie. offshore wind farming).

10.4.2 Future Necessities of Offshore Accommodation Ships in the O&G Industry

Despite the current economic crisis, the increase in E&P activity in deep waters will require the support of accommodation ships with DP. Dynamic positioning is the best option for maintaining the position on waters beyond a 300 m depth. Most of the planned mono-hull semisubmersible flotels are equipped with DP systems. Some existing units are even being transformed to accommodate them.



Graph 14: Global development of oil wells by water depth

Historically the market for accommodation vessels has been a sort of niche in the context of a globalized market. These vessels were often confined to benign environmental conditions and shallow waters. However, the discoveries made in deeper waters and harsher environments led the industry to require vessels with higher specificity. The market has reacted by increasing the accommodation capability of semisubmersibles such as the company, *Floatel International*, which has two units already in operation and two more to be added by 2013.

As long as the industry approached ever deeper waters and the oil prices remained high, other marine construction activities (ie. infrastructure) that require accommodation vessels increase the potential demand for this type of vessel. Despite the boom in the years before the economic crisis, traders were less inclined toward the option of chartering an accommodation vessel despite their inherent advantages. It is possible that operators will shift their attention toward previously presented alternatives such as transportation of personnel from land and back on helicopters due to the lower costs associated with simplified solutions. However, in the offshore areas these alternatives will become increasingly difficult, so the accommodation ships market has the opportunity to grow to the same extent as the E&P market.

10.4.3 Comparison of Position Maintenance Systems in Flotels

10.4.3.1 Introduction

An ongoing debate discusses the optimal type of position maintenance system in accommodation vessels. In this analysis, we will respond to this question and observe that the DP systems are the ones with the greatest benefits. Contrary to what could be expected, the fuel consumption is not as high as you might think.

10.4.3.2 Advantages and Disadvantages in Each System

The general methods used to maintain the position of flotels are the *anchor spread*, *dynamic positioning* and the use of *auto- elevated platforms* (*jack-up barges*).

As we have seen, the first two are the ones that prevail, with the DP wining popularity in the last few years. All present advantages and disadvantages as summarized below:

	Advantages	Disadvantages
Jack-up Barge	No complex systems of propellers, generators or extra controllers.	Lacking maneuverability once positioned.

	Advantages	Disadvantages
	There is no possibility of losing their position due to failure or blackout. There are no threats to underwater propellers.	Limited to water depth of 150 m.
Anchoring	No complex systems of propellers, generators or extra controllers. There is no possibility of losing their position due to failure or blackout. There are no threats to underwater propellers.	Lacking maneuverability once positioned. Cable ships are required Less suitable in deep water The anchor time varies from several hours to several days Limited by blockages in the seabed: through pipes, by the very terrain, etc.
Dynamic Positioning	Excellent maneuverability: it is easy to change the position. Anchorman ships are not needed. Not dependent on the water depth. Not limited by obstructions on the seabed.	Complex systems of propellers, generators or extra controllers. Potential loss of position due to failure or blackout. Threats to underwater propellers. Higher capital costs Higher fuel costs Higher maintenance costs

Table 24: Comparison of position maintenance systems options

Although all methods have their own advantages, the development of dynamic positioning during recent years has enabled many operations that were not feasible before.

The costs are lowering due to new and cheaper technology, the advantages of jack-ups systems and anchoring are increasingly constraining as the offshore industry goes into deeper waters and the environment (ie. coral fields) is kept more in mind. Cruises for example, may benefit from DP that will enable them to anchor without the need for anchors on beaches with great ecological importance.

One of the advances in cheaper technology is energy efficiency. Contrary to what one might think, a vessel with dynamic positioning has no excessive consumption, as explained below.

10.4.3.3 Fuel Costs Versus Dynamic Positioning Anchor Anchorage

One of the main disadvantages of dynamic positioning systems when compared to anchorage systems are the high costs of fuel required in operation. It is necessary to quantify the difference to make a correct balance between the two options.

In (Aalbers, Vries, & Vugt, 2006) the next graph, we compare fuel consumption between an FPSO mooring system and an FPSO with dynamic positioning system. The FPSO concept was based on a design by IZAR-Fene[79] shipyard.

[79] Now NAVANTIA-Fene

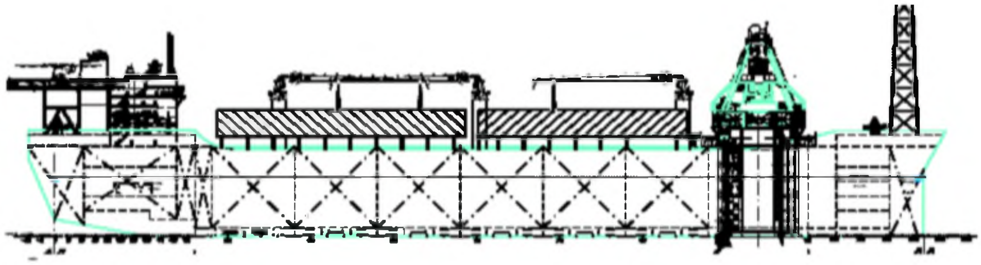


Figure 155: FPSO version with anchorage (Aalbers, Vries, & Vugt, 2006)

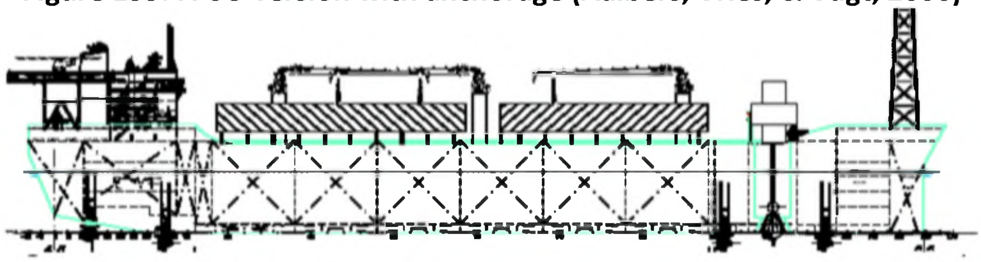


Figure 156: FPSO DP version (Aalbers, Vries, & Vugt, 2006)

The results of this study showed that the DP-FPSO concept required only about 7% more fuel compared to an anchored FPSO, speaking of the total consumption of the "marine" plant. While it is only 1.5% higher if we consider also the FPSO process facility.

If we consider the use of the "processing plant" as equivalent to the "hotel plant" of a passenger ship or offshore accommodation (it is a rough estimate inclusive of all lighting, ventilation and air-conditioning, kitchens, etc.), the expected difference between the two options for a passenger ship or offshore accommodation may be only 1.5%. In any case it will fluctuate between the range of 7% -1.5% depending on the proportion of power that the hotel plant would have over the plant ship's total power.

Bottom line, the expected difference between the two options is very small and leans the scale in favor of the DP system.

The difference in fuel cost per year between the DP and anchored versions is only € 100.000. Therefore, the annual consumption of the DP system is estimated at 100.000 €, which means:

DP annual fuel consumption	100.000 €
DP monthly fuel consumption	33 €

If we calculate it with parameters well above the likely number of residents available in the FPSO, we obtain the following results:

LPP	262.4	m
B	46	m
Space in the main Deck	10,863	m2
Nº of decks	5.00	
Total space on the decks	54,317	m2
Average space per residence	100	m2
Number of apartments / cabins	543	
Monthly cost for "residence" due to the DP	15 €	

This means that the cost for each "residence" is quite low and shows that the DP system is not excessively costly when the city-ship has a size similar to the 262 m in length of the FPSO.

10.4.3.4 Notes and Conclusions

These findings refer to the CAPEX and OPEX, and do not take into account differences between the cost of a facility in DP and an anchoring system. Even when the cost of an anchoring system for shallow water is economical, an anchoring system for deep water is more expensive.

In any case, according to the study we can conclude that DP systems should not be penalized compared to anchoring systems based only on the extra fuel consumption, since it is minimal compared to overall consumption of the ship and the extra cost would be offset by other advantages already mentioned above such as its maneuverability, the possibility of self-propulsion, and so on.

10.4.4 A Dilemma On the Notation of Class in the Monohull Accommodation Vessels

[Article Adaptation of *"Class quandary for monohull accommodation vessels"* published by the author of this dissertation in the magazine *"Offshore Support Journal"* in February 2011] (Lamas, 2011).

We have seen in Chapter 6.2 that regarding single-hull accommodation vessels we found vessels classified as *SPS* and others as *Passenger Ships*.

Special Purpose Ships (SPS) is the main classification applied to ships that serve offshore in oil platforms such as construction vessels, supply vessels, Anchorman and others, including accommodation vessels or flotels. The staff on board these ships, although not seafaring skilled, are very experienced in facilities at sea. They are not considered passengers, but "special personnel". Some rules apply for passenger ships, along with other rules for merchant ships.

Recently, the IMO and some classification societies such as DNV have reviewed the definition of this category of Special Purpose Ships (SPS) due to the increasing demand for sophisticated types of ship that are being developed with specialized personnel on board. These personnel are not "crew" or "passengers" as defined in SOLAS 197. The IMO has recognized, through the 2008 SPS Code, that certain safety standards can be accepted to complete the SOLAS instead of considering these ships passenger vessels. Depending on the number of people on board, the code compliance will result in a security level between one corresponding to a dry cargo ship to one of a regular passenger ship that carries on board an equivalent number of people. The new classification of Det Norske Veritas SPS can be assigned to vessels designed and constructed in compliance with the code SPS 2008 and can be considered suitable for special personnel carried on board in addition to its conventional crew. The new code SPS and SPS classification take into account the fact that many provisions for cargo ships have been substantially improved since the first SPS Code was adopted. It is hoped that, in the future, this may simplify the transformation of dry cargo vessels to relatively new SPS vessels. In relation to accommodation ships, there has been some controversy within the classification societies about the use of the SPS categories. In principle, the SPS Code should be a voluntary code and it should depend on each administration to decide how it should be applied. However, the SPS Code clearly states that *"the code is not intended for ships used to transport and accommodate industrial personnel that are not working on board"*. On this basis, an accommodation vessel or flotels that only operate with cargo ship certificates supported by a certificate of SPS may have problems with local authorities and future flag changes. For this reason, the DNV (Solstad, 2010) clearly recommended that a *Passenger Ship Safety Certıficate* or the *MODU Code Certıficate* would be a better option for statutory certificates.

The case of the *M/V ARV1 (Repair Vessel Accommodation)* from the Equinox offshore company is an example. This ship was originally designed to become a Special Purpose Ship, but ultimately had to surrender in the summer of 2010 to be a Ro/Ro passenger ship. Other ships, such as the *Dan Swift* or the *Ice Maiden,* were originally designed as passenger ships when they were transformed from cable and icebreaker ships, respectively.

10.4.5 Mother Ships for Offshore Wind Farms

10.4.5.1 Accommodation Requirements for Sailors in Offshore Wind Farms

The Marine Renewable Energy Sector (ENERMAR) shares many of the same challenges as previous ventures in marine environments. They have the same dependence on new technologies as well as the same requirements for operations in challenging conditions in the middle of the ocean.

There is one key difference from what has been done so far. To develop an oil and gas field generally represents a high and valuable opportunity with great income. The infrastructure required to exploit this resource is a facility that can justify a large capital investment in CAPEX and the operating costs are low OPEX, compared with the return of long-term investment for the promoters of these oil fields.

In contrast, wind is a very diffuse resource and the infrastructure required to exploit it needs multiple and widely distributed facilities. Wind generators are located far from on another. These facilities may have relatively low capital costs CAPEX. In contrast, because of their great dispersion, operating costs will require significant OPEX[80].

This makes the risks and rewards associated with the development of wind farms differ significantly. No goose of golden eggs for this sector: simply a source of income to exploit, which is very regulated and predictable. As a result, company's providers of offshore services are asking developers to maximize the potential returns on fixed income by focusing preliminary engineering work on reducing risks and lowering maintenance costs.

How has the industry responded? Installing the turbine is merely the first step. Among a lot of installers' ship designs; most of them use the jack-up type. However, to keep them operational is the biggest ongoing challenge.

Currently, wind turbines are kept by landbased working ships and crews. The challenge of permanently moving the maintenance to more distant offshore locations is yet to be resolved. *Carbon Trust*[81] figures indicate that 97% of all downtime incidents in offshore wind turbines are simple control adjustments or small maintenance work. What is needed, it seems, is a new series of technicians that provide quick solutions to such incidents.

One of the key issues to be solved is how to transfer these technicians (even though they are experts on land based wind farms, the technicians are new to marine environments) to and from the turbines in the middle of North Sea several times during their working day. Access by helicopter has been dismissed for health and safety reasons and is effective only in exceptional cases. Standard transfer systems are limited to operations in waves below 1.5m. As discussed earlier on installation ships, it is required to increase capacity to face the conditions presented in the places that conform the UK Round 3.

[80] Study done by the English Engineering Firm HOULDER LTD. for the *Royal Institution of Naval Architects*
[81] Public institution in the United Kingdom that is responsible of regulation for the offshore Wind Industry.

Figure 157: Offshore wind farms in the UK. *Round*

Secure access to a turbine from a working ship is literally a small step for any maintenance crew member. There are already several proposals for access systems to the turbines (Turbines Access System, TAS) that are being developed to enable maintenance to be done at the most possible adverse conditions in a way that can be carried out throughout the year, even in winter.

But, there are more challenges associated with the parks of Round located 100 km from the coast. Continuous displacements and associated comfort levels become unacceptable using land-based workboats. Again, these are key indicators of safety, low risk and effectiveness. The obvious solution is to provide some form of **offshore accommodation unit** properly located to work as a base for workboats and technicians. The ongoing debate appears to be about the capital investments required to build permanent structures to accommodate the crew, spare parts storage and workshops. Besides, could fixed platforms provide a base to service all turbines over a large offshore wind farm? Would they provide the platform services required for large turbines of tomorrow? Rather than a fixed structure, a flexible floating structure is required to serve the entire wind farm and that is how new ideas emerge to meet this challenge.

10.4.5.2 A New Concept of Accommodation Vessel

A new class of ship is emerging in the market for offshore wind farms: the Wind Farm Mother Ship. This type of vessel is designed as a mother ship that would remain stationary, offshore, close to the wind farms providing a safe haven for a number of catamaran workboats to carry engineers to service the turbines.

The ship's hull would have a break for landing (on the stern or side) to allow work boats to dock. The ship would also be provided with a safe haven in the stern to protect the work boats during adverse weather conditions, provide **accommodation** for wind turbine engineers, service personnel, support ships and crew and also support helicopter operations. All this, in addition to its ability to deploy workboats. It would be able to support remote marine and helicopter operations from the mother ship providing a safe haven in case of emergency or rescue situations.

We could highlight two designs, each of them quite different from the other as discussed in the following sections. Despite having quite different settings, these mother ships for wind farms are authentic floating city-ships with the ability to stay in place for years, offering a safe place for small boats in bad weather.

10.4.5.3 Proposals for Wind Farm Mother Ships

We present below four of the mother ship proposals for wind farms made by technical offices and ship operators.

10.4.5.3.1 Mother Ship Houlder Ltd

In early 2011,Houlder Ltd developed the concept of a mother ship for the interior of offshore wind farms. The key idea of the concept is for operation and maintenance, O&M, providing accommodation, workshops, hotel services, and storage with lifting capacity of 5 tons. The dimensions would be: L = 8m, B = 20 m with capacity for 12 crew members and 48 workers.

The ship hull would not be a self-propelled barge and the intention is that it would be anchored to a single buoy mooring system oriented in time to the prevailing wind direction. This would allow the ship to function as the "weathervane" and effectively eliminate the element of list (roll) movements of the ship, leaving only the pitch and heave. With relatively short seas, these movements would be acceptable for up to 60 people living on board.

The ship's hull would have a break for landing at the side to allow work boats to dock at its side. The ship would also have a place of refuge in the stern to protect the work boats, and would have a long and hoisting system to allow that the work boat may be stored on board during adverse weather conditions. the ship would also have a small helicopter to allow emergency shipments.

The vessel would be designed so that it could remain in position for a minimum of 7 years.

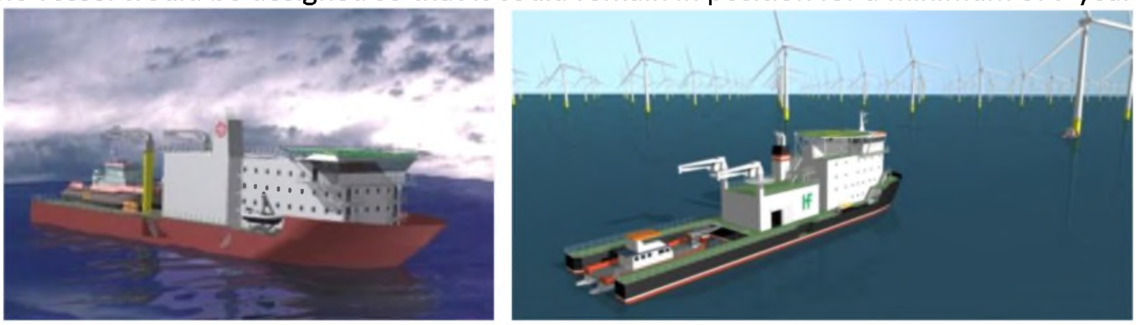


Figure 158: Wind farm Mother ship. Source: Houlder Ltd.

10.4.5.3.2 Seatel

An offshore hotel with a design similar to the previous one was presented in June 2011. The hull shape is more pontoon type it has no maritime forms and no lifts. The following figure shows the mooring system.

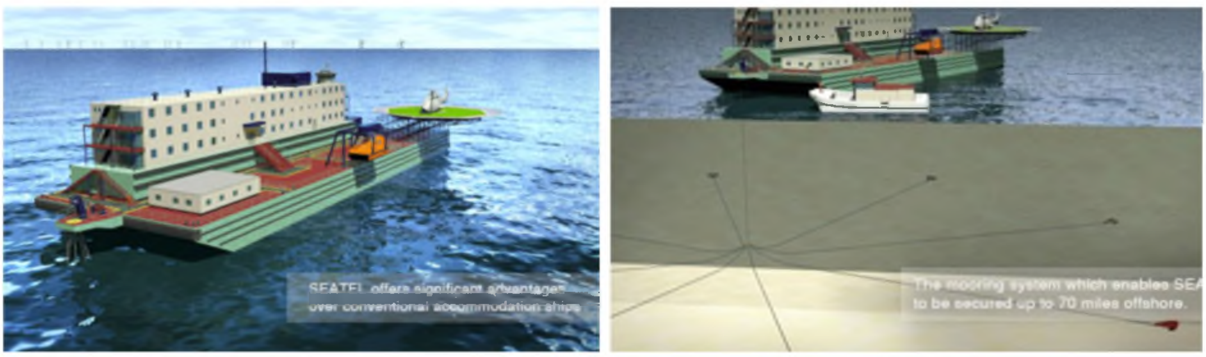


Figure 159: Seatel

10.4.5.3.3 Sea-Wind Wmv

Offshore Ship Designers[82] launched its mother ship proposal for offshore wind farms in early 2011, the Sea-Wind WMV. According to its designers, it reduces maintenance costs and improves uptime of turbines installed in deep waters It also offers a solution to the logistics problem to carry out maintenance of multiple wind turbines simultaneously. The ship (187 m, diesel-electric propulsion with a capacity for 200 people) would remain in place in deep waters thanks to the DP2 system, offering a safe place for several work catamarans to carry engineers to service the turbines.

The concept itself is a submersible dock ship with a large flooded dock accessible from the stern.

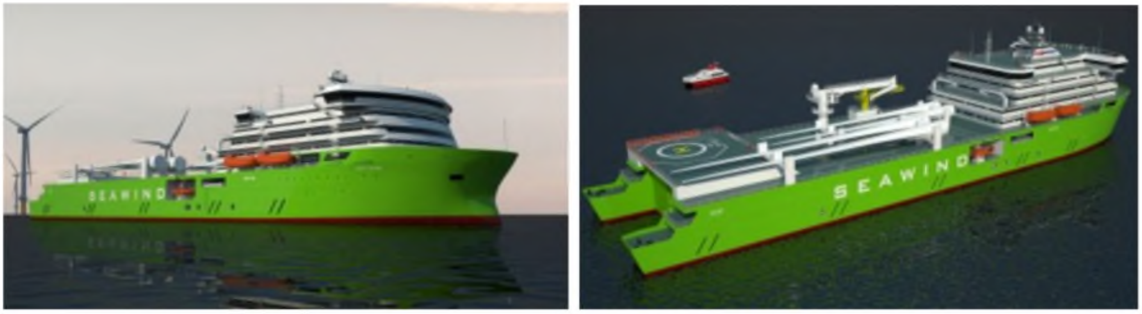


Figure 160: Sea Wind WMV. Source: offshore Ship Designers

CSS-Seabreeze

As a result of the rise of this market, other accommodation ship designs began to be offered as Wind Farm Mother Ships. This is the case in the concept of the CSS, Compact Semi Submersible, which is offered by MAC as a DP-3 offshore Wind Farm Mother Ship with the name of CSS-Seabreeze.

Figure 161: CSS-Seabreeze DP-3 Wind Farm Mother Ship. Source: MAC offshore.

10.4.5.4 Future Development

As we can see, there is no single solution to all of the problems faced by position maintenance systems. It is curious how there are four different solutions to offer the same accommodation service at sea, all of them very different from each other:

- Two designs of not self propelled barges anchored at fixed point

[82] *Offshore Ship Designers*. With head office in IJmuiden, The Netherlands is an autonomous, independent, consulting company offering naval architecture and marine engineering services.

- Single hull vessels with diesel electric propulsion, DP3, and so on.
- An innovative compact hull semisubmersible.

The market response to these concepts has been of great interest but the optimal solution will depend on the entire supply chain that is raised by a particular field at Round 3. What is clear is that these sites cannot be supported on a daily basis from a local port along the coast. Since Round 3 facilities will not operate until 2018, it is certain that we will see many new concepts for these vessels with accommodation for offshore wind farms.

10.5 Concrete: the Material to Colonize the Oceans

In the offshore industry there are two possible materials for the construction of the structure's hull: steel and concrete. The first, steel, has been widely used so far in the naval construction of both merchant and war ships. Materials such as aluminum, FRP or wood are used in small units with lengths that are longer than 100 m and for units that experience less adverse conditions in the offshore industry.

Some concrete ships were built in the past, but have been rather isolated cases which have not induced practical changes in the industry. In the First and Second World War they were built due to the scarcity of materials, while the numbers of Alfred A. Yee barges were a rare exception. Other units were also made of concrete, but almost anecdotally.

Still, the behavior of these concrete structures, especially in terms of maintenance and fatigue has been excellent. The fact that concrete has not had an adequate reception so far in shipbuilding does not mean that concrete is not the most suitable material for the future offshore industry.

The additional displacement and fuel costs associated with concrete ships have been found prohibitive in the past for sea navigation. The loss of mobility of a concrete shell relative to a steel hull can be perfectly compensated by the advantages offered by concrete, as the shipping and offshore industries have very different priorities. One of the main differences in these priorities is in terms of maintenance and resistance to fatigue, a field where concrete performs better. According to several studies, concrete has other advantages. Although it is important to these findings were made by stakeholders having been performed by people within the concrete industry. In recent years, actual concrete offshore units have been built, proving that, in certain cases, the advantages of concrete over steel tilts the balance towards concrete. Concrete platforms types that are supported at the bottom (Gravity Base), known as "Condeep" have been built since the first unit became operational in 1976, cohabitating well with a few floating platforms similar in its geometry to those made of steel (barges types, semisubmersible and TLP).

One of the concepts in concrete which promises to become a boom in the 21st century are floating barges resting in the bottom for its use as LNG terminals or floating plants. The useful life of these boxes can be **designed for 200 years**, as the Nkossa barge, so it can be a good alternative to the construction of these facilities on land, thus avoiding fillings of the already degraded coastline that has been impacted in industrialized countries. The challenge is to optimize their capital costs to make the floating facility competitive against all landbased ones.

In addition to these demands, the use of concrete in offshore structures is also being applied to conceptual ideas for the Very Large Floating Structures (VLFS) as floating airports (Lamas Pardo & Carral Couce, Very Large Floating Structures (VLFS). Puertos y Aeropuertos Flotantes, 2011) and floating wind turbines, which are currently designed in steel but would be better suited to concrete. (Roddier, Cermelli, Aubault, & Weinstein, 2010)

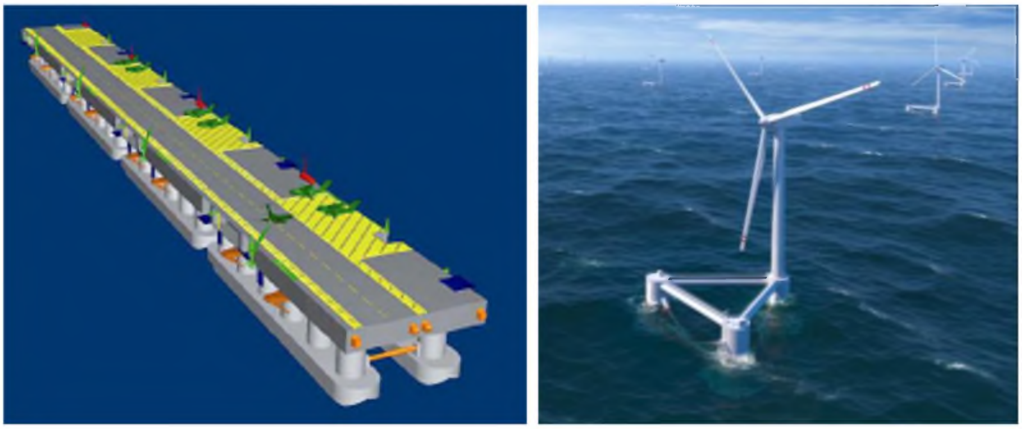


Figure 162: Floating airport concept for the U.S. Navy (Rognaas, Xu, Lindseth, & Rosendahl, 2001) and floating wind turbine (Roddier, Cermelli, Aubault, & Weinstein, 2010).

Ultimately, concrete is presented as the future material to colonize the ocean in the broadest sense, to establish offshore autonomous communities on a permanent basis with or without sovereignty objectives. In fact, as discussed in the next section, our commitment is to the use of concrete for possible platforms as a base for oceanic micronations. One of our objectives is to have concrete used to create the platform "Green Float" instead of the magnesium alloy proposed by Shimizu.

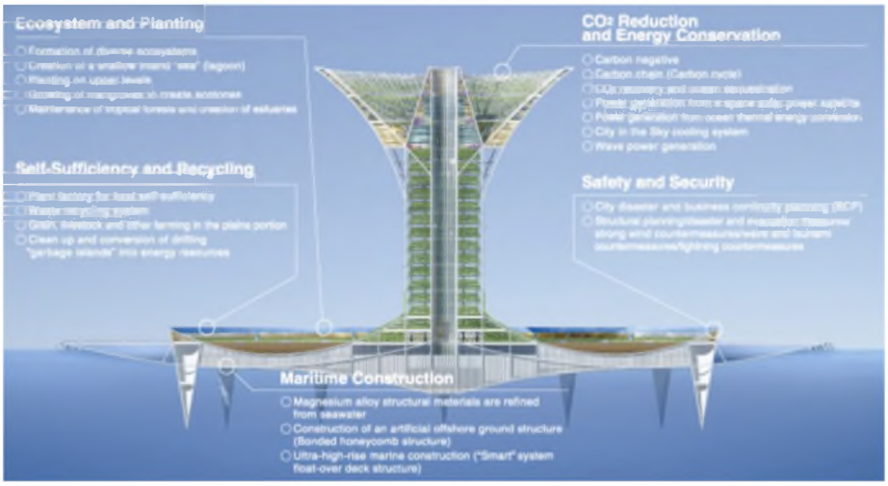


Figure 163: Green Float. Source: Shimizu Corporation

10.6 Future Evolution of Oceanic Micronations and City-Estates

10.6.1 Introduction

As we saw in Chapter 2, the majority of attempts to create oceanic micronations aim to establish new government systems to compete with existing systems that have currently collapsed (according to its proponents) and therefore have become obsolete. Taking advantage of the lack of regulation to exploit businesses prohibited in other states.

We have shown that the establishment of oceanic colonies is not a subject of science fiction, but, rather that man has always had the need to colonize the oceans to exploit its resources, as a means of transport. Colonization to establish new ocean states has not been successful because it did not meet the requirements outlined in Chapter 4.

This final part of the dissertation will address the main objective of the dissertation which is analyzing the possible present options, existing and future, by the Oceanic and Naval Engineering for the establishment of offshore Autonomous Communities that will allow the creation of oceanic micronations

We will suggest various **scenarios** to explore ideas as to **where the evolution of this form of colonization might go**. To do this we will look at key considerations in choosing the most appropriate location and then present three scenerios (short, medium and long term) addressing the criteria to be met in each.

10.6.2 Considerations for Localization of Sovereign Oceanic Colonies

For entire oceanic colonization projects with sovereignty' purposes, it is essential to identify a suitable place to develop this idea. Only with a specific location proposed is it possible to present a sovereign ocean colonization project. This particular location will depend, to some extent, on the level of sovereignty that is desired to bestow the colony. For example, the location could be within the EEZ, or if needed, on the high seas.

From the requirements enforceable in an autonomous oceanic community or colony, there are three of them that will influence its location.

1. Commercial and Economical.
2. Technical for the Platform.
3. Legal or external relations.

10.6.2.1 Economical and Commercial Requirements

It has been seen throughout history that self-reliance and self-sufficiency have lead to poverty, particularly in middle sized and small countries. Generally speaking, all countries need to maintain contact with the outside world. Even sovereign oceanic colonies will need to do business with the rest of the world. They will need to import all kinds of goods such as food, labor and equipment and also sell goods that exploit the competitive advantage of being at sea (medical treatments, vacation experiences, flexible legal systems, etc). We need to be near certain business partners to enable the development of a particular business model.

Since, for small oceanic colonies the ferry will be the main means of transport to the rest of the world, proximity to a large city with an airport and ports is an important consideration. For many business models, travel time to and from major cities will be crucial.

To import labor, proximity to skilled human capital with affordable wages will be crucial.

Therefore, these requirements influence the location of the platform in the following aspects.

1. The business models to be develop: proximity to markets will define business viability.
2. Business partners: its proximity to the colony.

3. The interest of **potential residents**: will depend on the nearby metropolitan areas.

10.6.2.2 Platform's Technical Requirements

The requirements will differ depending on the choice between:

a) A floating structure that maintains its position with a dynamic positioning system.
b) An anchored structure resting on the bottom, necessary for a location in shallow waters.

Within the EEZ, it is possible to find shallow water. But, the anchored choice or establishing a permanent structure resting on the bottom within the EEZ is ruled out, since this would necessarily require the approval of the coastal state.

Outside the EEZ under UNCLOS III, as we saw in Chapter 9, it is possible to establish artificial islands (with the limitations described above). The depth of the deep sea does not allow for anchored or resting structures, **which is why our focus has been on floating ones.**

However, it is possible to find shallow water areas on the high seas in the form of underwater mountains.

10.6.2.2.1 Option A: Floating

Behavior at Sea or Seakeeping is the main technical aspect to be considered in the location of the platform.

The structure on which the colony will settle has to have superior at sea performance characteristics. The platform or vessel must be safe, comfortable, and in every way effective in its marine environment. This means that we must consider how the platform or vessel chosen meets certain environmental marine conditions and how it affects the mission itself in order to offer suitable conditions of comfort. The response of a ship to marine environment is influenced mainly by motion and acceleration. This has a number of effects in terms of comfort such as noise, vibration and motion sickness.

The external technical considerations that will influence the location of a floating colony are:

1. **Wind-** the wind force affects the ease or difficulty of controlling the position of the vessel.
2. **Waves**- are the physical aspects that most influence the integrity of the structure and even harmless waves in principle are an important factor when determining the comfort of the platform. While the importance differs in each scenario, in general, we need a maximum, lower and middle wave height, and it is better if the direction of the waves is unique and does not change.
3. **Ocean currents.** Some platforms have excessive underbody. With strong currents, the control of the location will become more expensive and difficult, both with dynamic positioning systems and anchoring systems.

In the Appendix, Chapter 12, we study this subject with a bit more detail considering it crucial for oceanic colonization.

10.6.2.2.2 Option B: Anchored At a Seamount

While the DP will be a cost effective way to maintain the position, we also need to consider other options. Finding locations with shallow waters to allow anchoring at sea is another solution to the problem of position control. Being anchored in a seamount may also have other **advantages**:

- Underwater scenery, which is useful for tourism.
- Protection against waves.
- Access to marine resources.

A major **disadvantage** is the descent on key benefits in aspects of **dynamic geography** as discussed in Chapter 2.5.3.3. An optimized structure anchored in shallow water regions will only be able to find a few suitable locations, thereby restricting its dynamism.

The **Ampere Seamount**, which is described in **Chapter 13.1.1**, seems a suitable location. The question is whether we could find similar or more suitable locations. Some important criteria when tryng to locate a seamount would be:

- A depth of 100-150 m or less. If less than 70 m a jack-up could be installed (critical).
- No ice (critical).
- Little to no waves (important, critical if the design is ship type).
- Unidirectional waves (important if the design is ship type).

Option B, being anchored at a seamount, is not considered as a viable option in the final stage because:

- It is conditional on finding a suitable location, which restricts its dynamism.
- The anchoring of various structures together becomes more complicated as we increase the number of platforms, due to the interference of the mooring lines.

10.6.2.3 Legal Requirements or External Relations

The level of autonomy and sovereignty "given" in a sovereign oceanic colony will depend on how the nearest governments of coastal states and international organizations (UN, IMO, etc.) will respond to sovereign claims of the colony. This will also depend on the design of the platform and the economic activities of the colony:

Design: Ships and artificial islands are treated in different ways within the international Law of the Sea, which is why choosing either one of them will bring different consequences.

- **Economic activities:** the development of certain activities not allowed in neighboring coastal states can be a source of conflict in relations between the colony and those states.

As we can see, the three requirements that determine the location of a colony(technical, economic and legal) are intertwined. Therefore, the legal considerations that will most affect the location of the colony would be:

1. **Legal status of the location according to the Law of the Sea:** as a coastal state has almost total sovereignty over their territorial waters (12 miles from the coast), it is impossible to consider whether it will want a minimum level of autonomy in that area. In its EEZ, the coastal state has less control but can regulate certain economic activities. The first steps into oceanic colonization with sovereignty objectives will probably exist within the EEZ once they come into existance in international waters where they will gain more independence.
2. **Rights implementation of the nearest coastal state**: countries differ greatly in how they exercise their rights over their maritime zones (EEZ patrol for example). In addition to the legal status of a particular location according to the Law of the Sea (when in the MT, ZC, EEZ) it is important to know what level of independence the state would be willing to grant a coastal state within its own EEZ. The Isle of Man, for example, are in the United Kingdom's EEZ, but do not belong to it and also do not have an EEZ: it holds a special status.
3. **Proximity to several coastal states**: if we are within the EEZ of one state and we can move to others nearby in case of conflict with the first, this will certainly strengthen the bargaining power of the colony. Even if we are outside the EEZ, having several nearby states would allow a better negotiation position for the sovereignty claim.

10.6.2.4 Residential Requirements Or Self-Government

Though this requirement is enforceable in an autonomous oceanic community or colony, it does not affect the location of the colony, as it is an internal factor, not an external one.

10.6.3 Short Term (2015-2040): Small Colony Within the EEZ

10.6.3.1 Introduction

The first incremental step toward a sovereign oceanic colony will probably be with a relatively small ship outside territorial waters but within an EEZ. Business models for this type of colony vary, but are likely to be hotels/resorts, tourist or medical destinations or conference centers without visa requirements. Since the first colonies will be vessels, and will be capable of moving; seasonal migration may be an option.

10.6.3.2 Considerations

The aspects to be considered in this scenario, along with the weight they have in their assessment, are contained in the following chart:

Aspect	Valuation
Outside the territorial waters but within the EEZ	Critical
In an area with little waves (Hs <4 m)	Critical
Near a city equipped with an airport and port. Between 3 and 30 nautical miles would be acceptable. 13 or less would be ideal	Critical
In the EEZ of a friendly country	Very Important
Outside the CZ or in the CZ of a benign State	Very Important
Near affordable human resources	Moderately important
Close to several coastal states	Moderately important, depending on the friendliness of the country in whose EEZ the ocean colony is situated
Nice weather	Moderately important

Chart 27: Considerations for establishing an oceanic colony in the EEZ

10.6.3.3 Platforms

During this short period, proven designs with no technical challenge should be chosen. As said before, the other challenges are economic, legal and residential and are already sufficiently complex to deal with. So we will opt for:

- First phase: single-hull vessels.
- Second phase: semisubmersibles.

This means that in the first stage, the wave conditions are of the highest importance, which makes small waves (Hs <4 m) a critical factor. As discussed in Chapter 12, the ship is designed after *Dan Swift* conditions Hs = m, obtaining adequate comfort conditions. So we will take that value as a reference: to 4 m Hs

10.6.3.4 Description

Although having large cities out the control of coastal states is the crucial long-term goal for the sovereigntist oceanic colonization, the first colonies need to be small and close to civilization. This scenario will be the small incremental step that any organization with such goals can undertake, and it would be given a reasonable amount of political autonomy by *de facto*, which will probably mean less political autonomy *de jure*[83] which would be ideal. This way, we would need to identify locations as desirable as possible in terms of economic and oceanic conditions.

The need to attract recreational tourists makes a location with a pleasant climate desirable. A location with an intense marine life or with underwater scenery to dive would be an advantage.

Since the early oceanic colonies will be small, the proximity to civilization is important. The small-scale displacements will have to be on fast but comfortable boats like the catamarans used in the offshore wind industry.

Since the first business visitors are likely to be based on short visits to the colony, we need to be near a big city with a port and airport. This means that locations outside the EEZ are not viable. Even outside of the contiguous zone, ZC could be too costly (in terms of time spent traveling to and from the mainland).

Being inside the EEZ, and potentially in the CZ of a country, makes the jurisdiction where we locate the colony a very important issue. In that sense, it would be ideal to find a country unable to enforce its jurisdiction in its EEZ, while avoiding the most active in protecting their EEZ.

The Mediterranean, Baltic and Caribbean seas contain locations that meet these criteria. The key issues to be addressed in these areas are:

- What are the best wave conditions in these seas?
- Are these good enough conditions for a ship/barge design?
- Can we find locations with desirable wave conditions that also meet our legal and economic criteria?

In terms of metoceanic conditions, the best scenario now seems to be the Mediterranean Sea, followed by the Baltic and then the Caribbean. In any case, as we saw in Chapter 6, vessels of the flotel ship/barge type are widely used in the Gulf of Mexico. Therefore, it is assumed that a design of ship/barge shall meet the requirements of an oceanic colony anywhere in the Mediterranean, Baltic and Caribbean.

Since vessels are highly mobile, seasonal migration may be possible. We could choose separate quarters summer/winter, and/or choose to travel in circles rather than to stay permanently in a particular point. Or, rather than closed circles in the ocean, which make no sense due to fuel costs and logistical difficulties, we could navigate a path between 4-10 cities that would be logistically and economically feasible. For example, a ship could travel around the western Mediterranean in summer and around the Caribbean from December to May to avoid hurricane season. As we pointed out in Chapter 5, this idea is already being exploited in the residential ship "The World of ResidenSea" and it is what is being planned for "Utopia Residences".

[83] *De jure* (in Classical Latin *de iure*) is an expression that means "concerning law", as contrasted with de facto, which means "concerning fact". A de iure situation is recognized by current legislation or by the competent authority under any agreement or formal act.

The situation de jure does not have to match the real situation is in those cases where the state is opposed to de jure and de facto. For example, a country can be independent, de jure acknowledgment by the UN and other countries, but in practice is a satellite state. That is, their independence may be fictitious and its mechanisms of power are completely dominated by another country. A de jure government is invested with all the legal guarantees but it may be unable to exercise its legitimate powers as de facto government has usurped.

10.6.3.5 Milestone Year 2015-2025

We should see the first significant milestone, a **monohull flotel** with about 100 people permanently living there sailing in the Mediterranean Sea, between the CZ and EEZ of several countries. It would take a flag of convenience or of any interested state. Its promoters and owners will seek some regulatory freedom to exploit any kind of internet business, conference center, or other profitable activities employing several dozens of employees.

Figure 164: year 2015-2025: a cruise or ferry converted in Flotel

In the appendix, **Chapter 13.2.1,** we evaluated how much it would cost to retrofit a ferry into a flotel that had the following:

- Dynamic positioning.
- Anti-tilt System.
- Helicopter deck.

10.6.3.6 Milestone Year 2025-2040

We would see the settlement of about 300 people permanently in a semisubmersible flotel that would remain in Dynamic Positioning outside the EEZ, but inside the territorial waters and temporarily close to a large metropolis such as London, Hamburg, Rome, San Francisco, Miami, or Singapore. It would wave flags of convenience. It would have, for the most part, a transitory population and a remaining permanent one. It could have a few different businesses operating simultaneously.

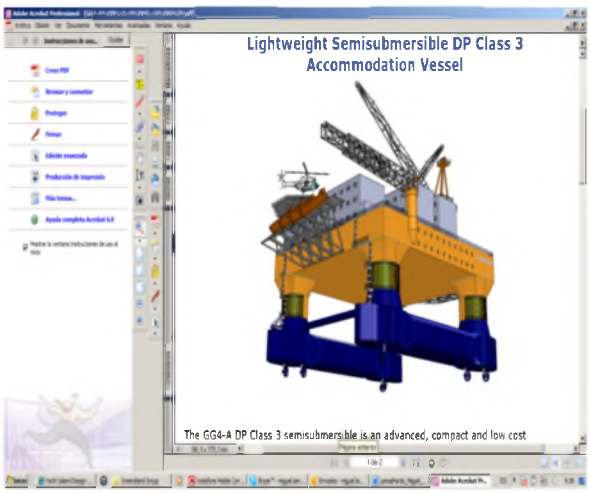


Figure 165: Year 2025-2040: Semisubmersible Flotel

10.6.4 Mid Term (2040-2100): Platforms Between the EEZ and the High Seas

This would be a transitional stage between the EEZ and the high seas. It would begin with a single concrete semisubmersible unit similar to the M.O.B. and it would culminate with several similar units connected at the same M.O.B.

In the Appendix, Chapter 13.2.2, we describe that concrete semisubmersible platform.

10.6.4.1 Years 2040-2060

Over a thousand people, some transitory and some permanent citizens, will live aboard a large **semisubmersible concrete platform**. There will be multiple businesses, and the space on board will be available for real estate. The platform may not need a flag of convenience, since it could negotiate a treaty for a flag that allows substantial independence. It may also have treaties with nations in whose EEZ it could park, as it would be in an EEZ most of the time (70% of total) somewhat near cities.

It would become a Micronation claiming independence.

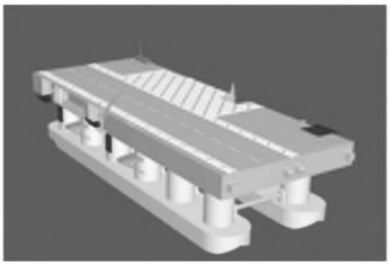


Figure 166: Year 2040-2060: Concrete Semisubmersible Platform

10.6.4.2 Years 2060-2100

In less than a decade, the first town would emerge. It would be a conglomeration of concrete semisubmersible platforms near each other, or physically connected to each other forming a *Very Large Floating Structure* of the *Mobile offshore Base* type. Thousands of people would reside in this oceanic village exploiting various businesses. This village would be located most of the time at sea (70% of time), and the rest within the EEZ with agreements that would guarantee substantial independence.

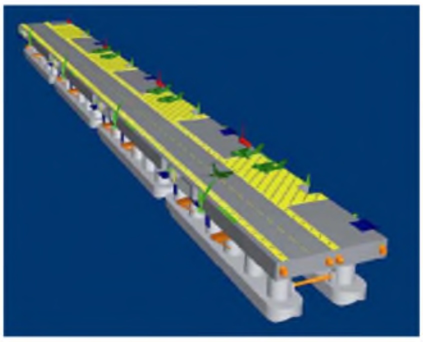


Figure 167: Year 2060-2100: Many Concrete Semisubmersible platforms forming a VLFS

10.6.5 Long Term (2100-?): High Seas Cities

10.6.5.1 Introduction

The full potential of oceanic colonization with sovereignty objectives would only be feasible in international waters outside the EEZ. Finding suitable locations on the High Seas is therefore essential to this goal.

10.6.5.2 Considerations

The aspects to take into account to find a suitable location on this stage along with the weight they carry into this assessment are contained in the following chart:

Aspect	Valuation
Outside any EEZ	Critical
As close as possible to civilization transfers by air in short flights of a few hours or ferry trips of no more than 2 days where possible.	Critical
Close to target markets	Important
Near qualified human capital	Important

Chart 28: Considerations to establish an oceanic colony on the high seas

10.6.5.3 Description

The long-term ambitions of a sovereign oceanic colony require appropriate locations on the high seas outside the EEZ. To move away from the coastal states to achieve such sovereignty will increase the economic costs in both CAPEX and OPEX:

- CAPEX: an adequate platform that would need to be able to resist the high seas and be capable of accommodating 100,000 people would require a huge initial investment.
- OPEX: the costs of transportation, among others, to/from the coastal states would be very high. However, as the colonies on the high seas would have a much larger population than those within the EEZ, we would obtain **economies of scales** making air travel feasible.

For the latter, the proximity to civilization is still important in order that a short flight from an international airport would be economically profitable. Similarly, this proximity would also allow for nearness to the target markets and skilled human capital.

The scenario that we assume possible is very similar to that described in the "Green Float", but with the exceptions of the platform and location.

10.6.5.3.1 Platform

The platform will also be composed of concrete modules like the "Green Float", but more similar in concept to the PSP (Pneumatic Stabilized Platform), allowing to obtain energy while mitigating the waves effect.

10.6.5.3.2 Localization

It would be located in the equatorial Atlantic high seas moving between Brazil and Mexico. Two emerging state-powers during the 22nd century that will be developed state-powers. This location is preferable to the equatorial Pacific high seas because it is:

- Outside the EEZ.
- Relatively close to major population centers.
- Gives access to large markets: Latin America.
- Gives access to low-cost human capital: the entire West Africa.
- An area where average wave of 100 years is between Hs =3,5 and 6,5 m.

10.6.5.4 Years 2100-2150

There will be a cell (district) "Green Float" on the high seas with 50,000 inhabitants that does not go into the EEZ. It would be able to ask for full sovereignty, but it will constitute a **Micronation** until it gets it.

The scale effect has made the land cost curves vs. ocean costs to cross. Therefore, this appeal will be the first cell to promote the creation of other sub-cells.

10.6.5.5 Years 2150-2200

Over time we will have several "Green Float" sub-cells forming a floating module of 100,000 residents. Economic activity will be as diverse as in any similar city on the mainland.

This module "Green Float" is a politically independent city, due to legal precedents, alliances, agreements, and mutual respect with its nearest coastal states and international organizations. The city is already considered a **sovereign city-state.**

10.6.5.6 Years 2200- and Beyond

In the year 2200 there will be more than 10 cities and which will have reached one million inhabitants. Each city will have gained international recognition reaching full sovereignty.

The political landscape of the world will be transformed by government experiments of many oceanic cities that will influence in the evolution of governments on the mainland. These cities will no longer need treaties, since they will be recognized by the United Nations with its own sovereignty as city-states, being able to join each other forming large city-states comparable to modern cities such as Hong Kong, New York and Singapore.

Year 2200 1 Unit (nation-estate) 1 million people	**Year 2150-2200 1 module (city-estate) 100.000 people**	**Year 2100-2150 1 cell (Micronation) 50.000 people**

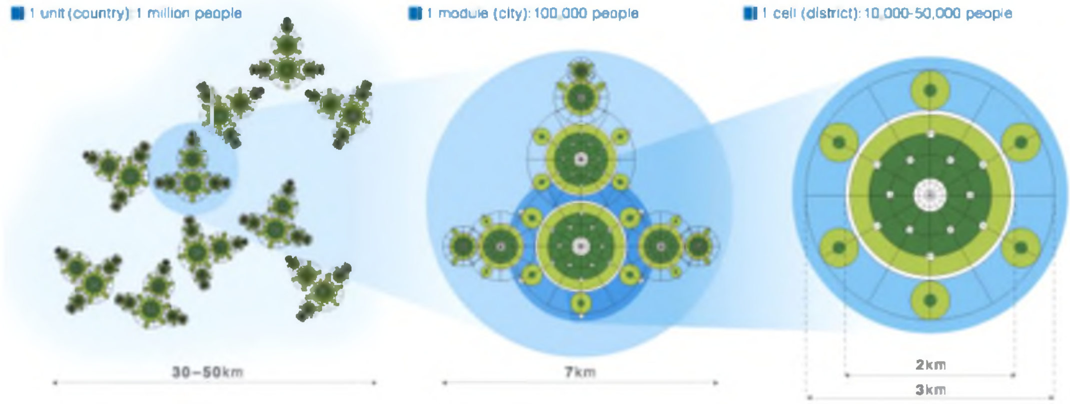


Figure 168: Evolution from right to left since 2100 to 2200

10.6.6 Summary Possible Future Evolution Scenario for Sovereign Oceanic Colonization

The table below summarizes the milestones discussed above:

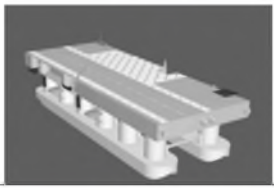
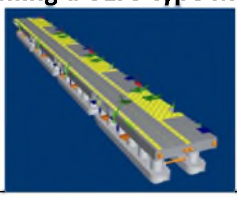
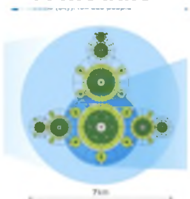
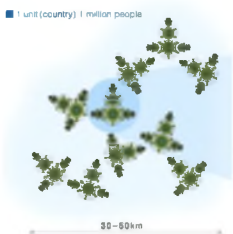
Year	Platform Type	Platform Classification	Localization by UNCLOS III	Population	Legal status
2015	Ferry or Cruise reformed to a Flotel 	Passenger Ship	sailing between the CZ and the EEZ	100 permanent 100 transitory	Convenience Flag
2025	Semisubmersible Flotel New 	Stabilized Accommodation Unit	in DP in the EEZ	300 permanent 500 transitory	Convenience Flag
2040	Concrete Semisubmersible 	Stabilized Accommodation Unit + DNV-OS-C502	High Seas (30% time) EEZ (70% time)	>1000, permanent and transitory	Micronation claiming Sovereignty
2060	Various Semisubmersible forming a VLFS type MOB 	Stabilized Accommodation Unit + DNV-OS-C502	High Seas (70% time) EEZ (30% time)	>10,000 mainly permanent residents	Especial Regimen
Year	Platform Type	Platform Classification	Localization by UNCLOS III	Population	Legal status
2150	A module 	New type of certification	High Seas Equatorial zone	> 100,000 permanent residents	City-state with sovereignty
2200	“Green Float” 	New type of certification	High Seas Equatorial zone	>1,000,000 permanent residents	Nation-state with sovereignty

Table 22: Possible future evolution of sovereign oceanic colonies

PARTE V: CONCLUSIONS

11 Conclusions and Contributions

11.1 Introduction

We restate the objective of this dissertation mentioned in Chapter 1:

To analyze the possible options (present and future) that Oceanic and Naval Engineering can present for the establishment of autonomous communities on the high seas that would allow for the creation of oceanic micronation. At the same time, we will try to expound the future evolution of the other three forms of oceanic colonization: 1) the expansion of land holdings, 2) the establishment of mobile settlements and 3) the establishment of semipermanent settlements to access marine resources.

As such, the objective was not to obtain a specific structure with which to give a final solution to the complex challenge of colonizing the oceans. Each form of colonization will require its own solution and thus there will be as many solutions as the number of challenges presented. We analyzed the state of the art of the main forms of oceanic colonization, and presented possible options that in the future could provide a solution, with special attention to oceanic colonization with sovereignty objectives.

We shall present a breakdown of the most significant points, and showcase the most relevant results, highlighting the following points:

- Originality, relevance of the results and contributions.
- Satisfaction of the research objectives and future work.
- Final conclusions.
- Epilogue: the oceans as humanity's new frontier.

11.2 Originality, Relevance of the Results and Contributions

The first item to discuss in this conclusion is the originality of the study and the relevance of the results, which have been the novel contributions by Oceanic and Naval Engineering, not only Spanish, but worldwide.

11.2.1 Oceanic Colonization

The subject of oceanic colonization is vast and reaches into several disciplines. But this is the first time it is addressed from a technical and rigorous perspective view from the prism of Oceanic and Naval Engineering. **To date there is no single document, whether in Castilian or in English, that addresses the subject of oceanic colonization in such a deep manner from a technical view point.** Patri Friedman and Wayne Gramlich in their book *Seasteading: a Practical Guide to Homesteading the High Seas* (19) had addressed the subject of marine appropriation (seasteading) to establish sovereign nations, but without delving into an analysis that includes the review of ideas from an naval engineering perspective. Until now, all the objectives had not been **compiled** in a single document.

So, the main contributions to this subject have been:

- We have developed our own **definition for oceanic colonization,** that to date only had precedent by Bolonkin (14).

"Oceanic Colonization consists of the establishment of autonomous communities in the oceans aboard artificial platforms".

- We have proposed o***ceanic colonization***, to separate and distinguish concepts that previously were intertwined and were confusing. Thus, for example, it was noted that many authors clumped together a residential cruise ship like The World with an oceanic micronation as *Sealand*, when it is clear that their individual objectives are totally different, as discussed in the pertinent chapters for each subject.

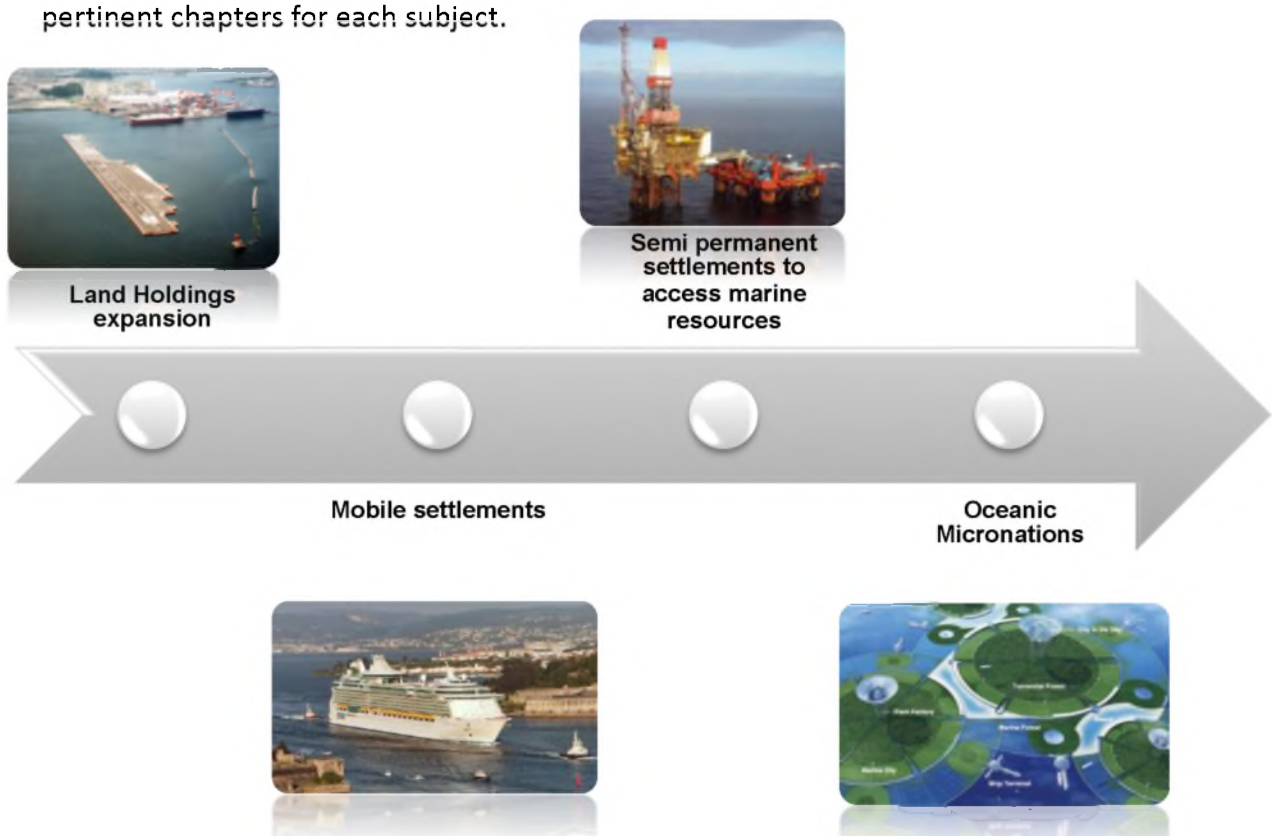
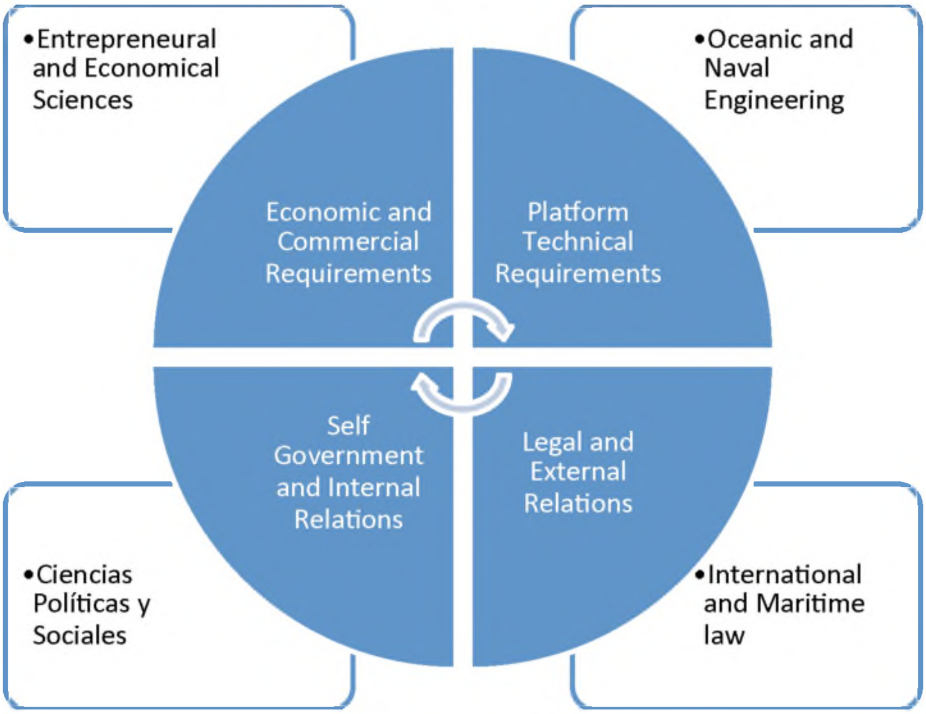


Figure 169: Ocean colonization forms from lesser to greater degree of implementation

- We have presented the ***requirements for the establishment of an oceanic*** *colony that are common to all the categories proposed.* Said requirements were obvious for some of the forms of colonization such as cruise ships and oil rigs, but not as obvious for the establishment of oceanic micronations. It is thus important to discern if a project presented as viable, has indeed a solid foundation, regardless of its objective.



Graph 15: Mandatory requirements for an oceanic colony and the sciences that study them.

- And finally, we have presented ***future scenarios*** for each of the categories of oceanic colonization. They examine which direction each of the categories could evolve.

11.2.2 Oceanic Micronations and Oceanic Colonization Outside of Naval Engineering

Chapters 2 and 3 established "State of the Arts of Oceanic Colonization" to demonstrate that the concept was used in a non rigorous manner to primarily refer to:

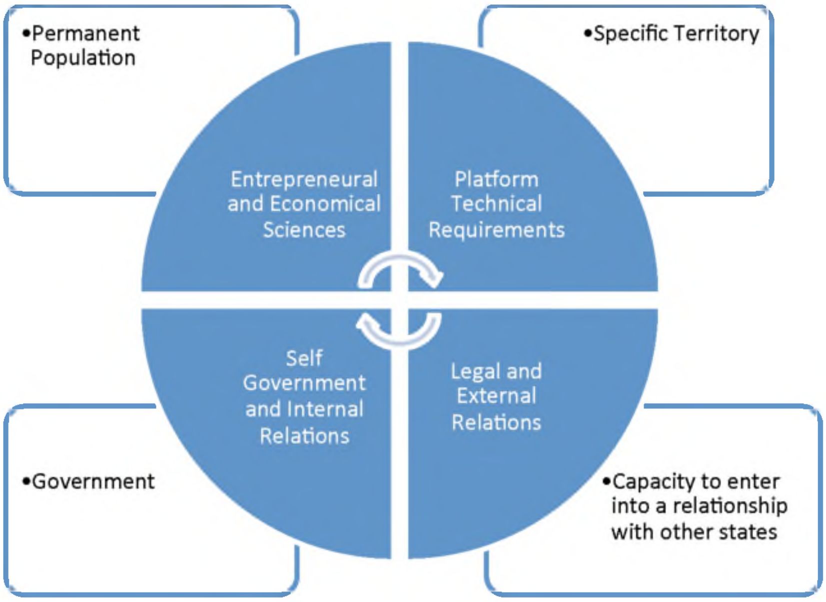
- The establishment of micronations, which were addressed in chapter 2.
- Media-hyped projects, foreign to Oceanic and Naval Engineering, which propose platforms for colonization of the ocean that seek only publicity for their authors, utilizing the concept of floating cities. This was addressed in Chapter 3.

These chapters discussed a series of projects without any technical rigor, economic sustainability or legal basis. Though it had been done previously on an individual manner, **they had never been evaluated as a group, and never from the perspective of Oceanic and Naval Engineering.**

11.2.2.1 Oceanic City-States

If one truly wants to establish a micronation, an oceanic city-state, or sovereign colony, we have discussed the theoretical exercise of establishing a possible colony:

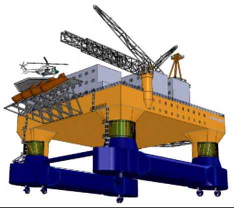
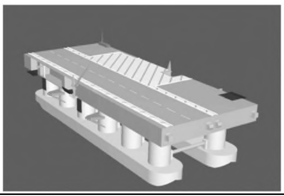
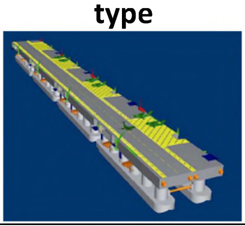
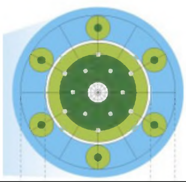
- The requirements that they would need to meet are listed in Chapter 4, but they have also been linked to other requirements that are mandated by the Montevideo Convention:



Graph 16: Mandatory Requirements for an Oceanic Colony and their parallels to the criteria established by the *Montevideo Convention*

Possible platforms and relevant legal aspects were discussed in Part III- Results.

In Part IV, Chapter 10.6, we analyzed all the platforms that have already been employed in other categories of Oceanic Colonization, and based on the requirements noted in Chapter 4, we provided possible scenarios for the future creation of oceanic city-states. Though it is just a simple hypothesis, it serves to exemplify the possible path for those that would have interest in the topic, while restating that it is only through Oceanic and Naval Engineering that these type of ambitious subjects can be properly addressed. **Never before had this topic of oceanic micronations been treated with such rigor.**

Year	Type of Platform	Platform classification	Positioning per UNCLOS III	Population	Legal Status
2015	Ferry or Cruise ship retrofitted to a Flotel 	Passenger Ship	Navigating between CZ and the Exclusive Economic Zone(EEZ)	100 permanent 100 transitional	Convenience Flag
2025	New semisubmersible Flotel 	Stabilized Accommodation Unit	PD in the EEZ	300 permanent 500 transitory	Convenience Flag
2040	Concrete semisubmersible 	Stabilized Accommodation Unit + DNV-OS-C502	Deep Sea (30% time) EEZ (70% time)	>1000, permanent transitory	Sovereign micronation
2060	Various semisubmersibles forming a VLFS MOB type 	Stabilized Accommodation Unit + DNV-OS-C502	Deep Sea (70% time) EEZ (30% time)	>10,000, primarily permanent	Special Regime
2100	“Green Float” cell forming a VLFS PSP type 	New type of certification	Deep Ocean Equatorial Zone	>50,000 Permanents	Sovereign micronation

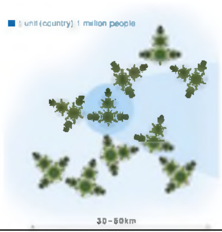
2150	**A module** 	**New type of certification**	**Deep Ocean Equatorial Zone**	**>100,000 Permanent**	**Sovereign city -state**
2200	**“Green Float” fleet** 	**New type of certification**	**Deep Ocean Equatorial Zone**	**>1,000,000 permanent**	**Sovereign city- state**

Table 23: Possible evolution of sovereign oceanic colonies.

11.2.3 Floating Hotels

Chapter 6 on floating hotels is one of the main contributions of this dissertation. Even as a collateral aspect, the author found that it had never been addressed in technical publications. The fact of having published articles regarding this matter in magazines of international renown, give credence to:

- The article has been written in purely technical magazines such as *International Journal of Maritime Engineering* of the *Royal Institution of Naval Architects*. In the article “Offshore and Coastal Floating Hotels: Flotels” (5), which is a summary of Chapter 2, analysis was made on all the structures that have been utilized as floating hotels both as expansion options to coastal spaces, and as floating hotels to support the offshore oil and gas industry. Until now, no one had categorized all the floating hotels, the author finding that many times the term *flotel* was being used incorrectly.
- The articles have also been published in magazines of more of a commercial nature such as offshore *Support Journal*, with the article “Class quandary for monohull accommodation vessels” (6). in this article, I have delved into the dilemma that a new type of vessel, a monohull offshore accommodation vessel, faces, and that until now there has been no consensus as to which category it belonged in per the classification societies. The debate centers in whether to classify it as *Passenger Ship* or a *Special Purpose Ship*.

Thereby, one of the main contributions has been to segregate concepts that gave rise to generalized confusion. Categories for floating hotels are presented in the next table, and had never been done in such a complete manner.

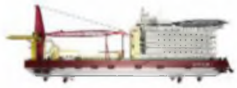
	COASTELS	OFFSHORE FLOTELES			
	Monohull Pontoones	Monohull Vessels	Monohull Barges	Semisubmersible Barge	Self Raising Barge
					
Operational Depth	Limited: Bays, inlets	Unlimited	Con DP: unlimited anchored: 300 m	Con PD: unlimited anchored: 300 m	<120 m
PAX Capacity	500-2000	400-600	400-1000	300-800	70-330
Oceanic Environment	Coastal Zones	Intermediate	Benign	Harsh	Harsh

Table 24: Types of Floating Hotels

11.2.4 Cruise Ships, VLFS, Concrete Structures and Legal Aspects

These subjects have been studied in other occasions (outside Spain, of course) and at first it could seem not to lend itself to much further contribution. Nonetheless, **the manner in which it has been addressed has been** original in as much as its focus has been on the analysis of future trends. Let's analyze the originality and contributions to each of the subjects.

11.2.4.1 Cruise and Residential Ships

We have touched on the subject of the floating city-vessels. Though they may seem utopian, we have seen that three cruise ship industry tendencies are likely to become a reality. The question is when?

Graph 17: Evolution towards the concept of a Floating City

11.2.4.2 Very Large Floating Structures (VLFS)

Information regarding this topic is limited to certain groups that have researched the idea, but being practically unknown in circles outside of their sphere of influence. Thus the corresponding Chapter, Chapter 7, appropriately adapted, has been accepted for publication in the Magazine *La Revista Obras Públicas* (8).

It has been found that its technology requires some development to make it economically viable. The following table of advantages and disadvantages summarizes the idea:

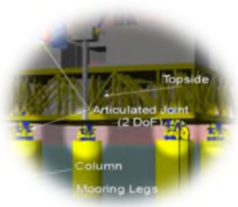
	Advantages	Disadvantages
Mega-Float 	• Manufacturing procedures and assembly is simpler and less costly. • Size is limited (modular). Positive cargo load.	• Appropriate only for calm or benign conditions (inlets and bays, etc.) • Low Mobility • "Green water effect" on deck • The theory of "Plane Curves Volume" is not fully developed.
Mobile offshore Base (MOB) 	• Mobility • Appropriate for all types of water: - Deep and shallow waters. - Benign conditions as well as harsh (excellent behavior at sea).	• Limited cargo capacity, by being semisubmersible • Ample internal movements: structure fatigue danger • Connector technology in experimental phase • Construction/operation costs are high.
Pneumatically Stabilized Platform, PSP 	• Manufacturing and assembly procedure is simple and inexpensive, though not as much as Mega-Float. • Appropriate for all water conditions, though not for as harsh conditions as MOB. • Limited size (modular) • Maintenance low or nearly null.	• Experimental technology in its base principles: indirect displacement. • Coupling technology with tensors requires ample development and study. • Low Mobility.
Versabuoy 	• Great reduction in wave induced movements. • Expansion potential • Modular system and assembly.	• Great vertical forces • Complicated anchor line system • No mobility • Experimental Technology

Table 25: Advantages and Disadvantages of the VLFS.

11.2.4.3 Concrete Offshore Structures

Contrary to what has been thought for years, concrete represents a good alternative as a material to be utilized in oceanic colonization, both for structures that are free floating and those that are supported on the bottom:

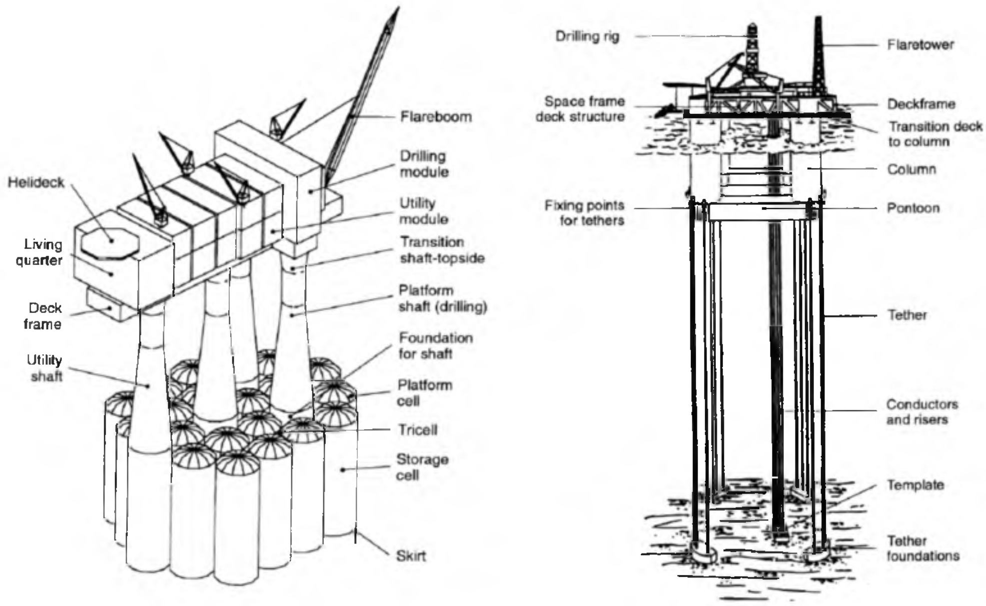


Figure 170: "Condeep" and floating "TLP" types -Bottom Supported Platforms (84)

Unfortunately, the main impediments are that the concrete construction industry is not very developed and it is not easy to find a contractor that offers competitive prices as compared to those offered by the steel construction industry.

Advantages to the use of Concrete	Advantages to the use of Steel
Better cryogenic behavior	Manufacture at existing shipyards (*)
Distinct process and storage	Potential lower costs for one unit
Reduced lost days due to down time for inspections	Traditional engineering and consolidated knowledge
Reduced maintenance costs	Building process backed by years of experience, traditional
Economy of scales	Availability of higher number of Steel manufacturers
Crash resistant	Availability of higher number of Steel designers
Lower center of gravity. Good behavior at sea/reduced movement	Greater flexibility lowers thermal strain
Excellent resistance to material fatigue	Not bound by damage due to freezing and thawing
High inertia movement	The framework does not need tensioning
Lower thermal response/better insulation	Impermeable to Gas and Liquids
Resistant to material fatigue and fissure propagation.	Similar to various vessels of LNG/LPG
Resistance to sagging/bending	Does not require membranes

Table 26: Advantages of a Steel Hull and a Concrete Hull on a floating terminal of LNG (80)

Because of this, one can foresee that in the future this material can be as viable option an as steel. As with the VLFS, this subject was not well known in Spain, and the corresponding chapter 8 has been accepted for review by the Civil Engineering magazine (9), demonstrating the subjects originality.

11.2.4.4 Legal Aspects to Oceanic Colonization

This subject had been addressed by other doctoral dissertations (98) (97), yet with contradictory conclusions. Because of these prior contributions to the topic, additional insight opportunities by the author were already narrowed. Nonetheless, the application of said conclusions to the stated scenarios in Chapter 10.6, reflected on Table 29, can be considered original.

11.3 Objective Fulfillment and Future Work

The second item to be addressed in the conclusions of this doctoral dissertation is the analysis of how the objectives of the dissertation have been fulfilled. Though this body of work may end here, it does open venues for other studies in the future for those aspects were not addressed due to lack of space.

Said venues of study were based on the challenges stated in PART II: APPROACH AND CHALLENGES. In the corresponding Chapter 4, the mandated requirements for an autonomous community in the high seas opened up various research paths. The objective of the thesis was to attempt to provide clarity via the study of the platforms.

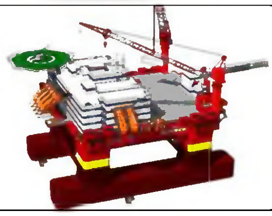
Chapter	Platforms Reviewed		Oceanic forms of Colonization
7	**Very Large Floating Structures - VLFS**		**Land holding expansion**
6.1	**Floating Hotels and Coastal Hotels**		
5	**Mega-cruisers and residential cruise ships**		**Mobile settlements with logistical, commercial, military, tourist and residential objectives**
7.6	**VLFS MOB – Mobile offshore Base type**		
6.2	**Floating Hotels-Offshore Hotels**		**Semi-permanent settlements to provide better access to marine resources.**
8	**Concrete offshore structures**		**ALL**
9	**Legal as pects and rules to establish ocean platforms**		**ALL**

Table 27: Schematic of the study of platforms for the objective of oceanic colonization for the creation of micronations.

Following is an assessment as to whether all the enquiries have been given a resolution, and which will be possible paths for future studies.

11.3.1 Research and Requirements of the Platforms.

The research enquiries to be addressed/responded to are those that have been presented in Chapter 4.7 and are described in the following sections. It will be discussed whether an adequate response has been provided or if there is an opportunity for future work.

11.3.1.1 General aspects:

- Review of the Oceanic Industry's State

→ This topic has been addressed at the 49º Congress of Oceanic and Naval Engineering (ONE) (3).

- Understanding the basic principles of Oceanic Engineering.

→ These principles have been garnered across all the studies of ONE, thus this idea is deemed satisfied.

- Design Criteria of a platform for Oceanic Colonization; for example, comfort and convenience

→Though it also forms part of the plan of study of the ONE, in Chapter 12 a summary is provided about the behavior at sea as one of the main challenges to be addressed. Brief notes to the topic of comfort and convenience were included, though the applicability of the topic is very ample. It could be offered as a future path of research.

11.3.1.2 Staged Growth:

- Grow from a community of 50-100 inhabitants to a micronation of 100,000 inhabitants. Which would be the best structure type for each stage of growth? How would the scaling be accomplished (50-100,000 inhabitants).

→ in chapter 10.6 and specifically in Table 29, these inquiries have been addressed.

- How would this curve look, that is, cost vs. size? What designs would be best suited for each growth stage? How would this curve look, that is, structure vs. size?

→ In the chapter oncruise ships, scale effects have been included in the topic to demonstrate that the increase in structure size should diminish costs. Nonetheless, there is an option for future studies to apply this same schematic to other structures such as semisubmersibles, VLFS, etc.

11.3.1.3 Structure Types:

- Vessels/barges. In which metocean conditions can they operate? How could they be improved for stability and comfort? Are there any good anti-rolling systems, and what of anti-jaw systems? How would costs be lowered? How would one make them modular? What subtypes would be useful (SWATH, etc)?

→ In the chapter on offshore hotels, we responded to these inquiries. Novel concepts like CSS, which are similar to SWATH, attempt to resolve the jaw issue in these units.

- Oil rig platforms, particularly the semisubmersibles ones. How do they compare to vessels? In which environmental conditions and at which size ranges are they better? How could they be made more cost effective? Could they be made modular?

→ This topic has been addressed as well in the flotel chapter in addition with the M.O.B. study it has been pointed out that various platforms could be joined to make a singular module of up to 2 km in length.

- Wave breakers. Do they work? Do they require anchoring? What are their characteristics of cost and laws of scale? To what size are they rentable? Could they include energy generation and at what margin of energy unit cost?

→ Although this topic has not been included in the dissertation, the author has studied their applicability and has concluded that today, they are not rentable in open ocean settings. In the blog "Cost of Floating Breakwaters" (102), the author of the dissertation has rejected the premise that today's technology would allow their application short term. Notwithstanding, project like "Green Float" include this concept as a form to attenuate wave effects, thus making this an interesting topic of research.

- Other innovative options. What other types of structures could be considered? What has already been considered for the VLFS? Mega-Float, M.O.B., PSP, etc.

→ all these structures have already been evaluated in this dissertation. However, each of them individually can be considered as interesting research paths if focused on how to make them economically viable.

11.3.1.4 Challenges

- Materials: Best quality relationship (durability, maintenance) - concrete, steel, are there other possibilities?

→ concrete can be a good alternative to steel. Its future development is also a possible research path.

- Size: How many people live there? How much weight can it support?
- Concepts: semisubmersible, submersible;
- Location: At what distance from the coast would it be best located (within the concept of international waters). If it were near shore, could it be used as a shield?

→ in Chapter 10.6 , and in particular in Table 29 we have responded to these issues.

- Mobility: anchored (fixed) or free. What is the best location for needs such as import, export, sun, wind and weather protection, the impact of the waves, tsunamis and strong winds? If you are sailing free, what is the best source of energy for propulsion and navigation?

→ in Chapter 10.4.3, we have seen that dynamic positioning and therefore electric propulsion is one of the best choices today for any floating structure that aims to remain at sea. Although applied to offshore flotels, it may be applied to any other similar structure.

- The forces acting on the platform: studies of waves, winds, earthquakes, tsunamis, hurricanes, storms, buoyancy, stability. Security control.

→ Chapter 12 has responded to this inquiry and in particular a major concern: the giant waves. In principle, within the offshore industry, these forces are not taken into account, as the structure is designed for the 100-year wave.

- Urban Planning: Working on the concept of a new space. How to develop the city, what are the future needs? Limited spaces.
- Architecture: Ideas for recycling containers as buildings? Or green-concrete-works? Futuristic architecture and deconstruction of the moment, to "order" the chaos, the power of technology.

→ the subject of urbanism and architecture is not discussed in the thesis. At the beginning of the dissertation, we examined the proposals of many architects that appeared to show oceanic colonization as a realistic option, but found them unfeasible. However, we recognize that once the base of the platform is designed, it requires the work of architects to make this platform an attractive place for residents. In the case of Clubstead (20) this had been done. It is therefore an interesting path of research but is beyond the scope of Naval and Oceanic Engineering.

It is interesting to note that the platforms analyzed for existing floatels and the VLFS that are still in an experimental phase bear similarities to each other as we shall see in the following table:

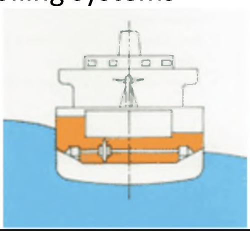
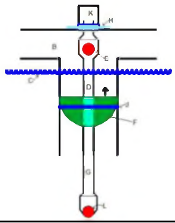
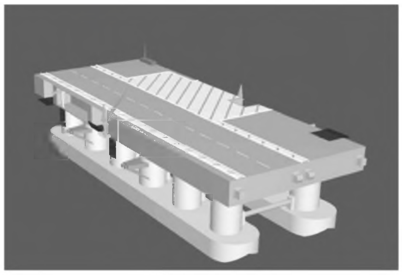
	Ideal Floating Structure	Floating Hotel Flotel	Very Large Floating Structure VLFS
Interior waters such as (inlets, bays); benign conditions	Pontoon	Coastal Hotel (Coastel) 	Mega-Float 
Open Ocean (deep water) - intermediate conditions	Monohull with suspension system	Offshore Flotel monohull with anti-rolling systems 	Pneumatically Stabilized Platform, PSP 
Open ocean (deep water) – adverse conditions	Semi-submersible	Flotel offshore semisubmersible. 	Mobile offshore Base 

Table 28: Between Floating Hotels and VLFS.

This means that future research paths about platforms must take into account current developments and try to improve upon them, as has been done thus far with VLFs.

11.3.2 Legal Research Requirements

Future research opportunities in legal aspects are many. In the dissertation we have overviewed very basic aspects of International Maritime Law, but it's complex mainly because of the possible loophole - the legal vacuum that Galea (98) makes note of that may be intended for the purpose of protecting the oceans from exploitation and private use beyond international agreements.

11.4 Final Conclusions

In the previous sections we discussed the originality of the issues discussed and the contributions made, yet addressed them at an individual level. We also analyzed one by one if they had met the challenges posed at the beginning which would be a path for future research. So now we have to make global conclusions about the body of work.

The author's conclusion as a result the review performed is that there is still a long way to continue colonizing the ocean. According to our definition:

"Colonization is the establishment of autonomous regions in the oceans aboard artificial platforms."

And as we continue making use of the oceans in all its forms, this settlement shall continue, as detailed below.

11.4.1 Expansion of Coastal Space

If we are to continue to expand the coastal area as we have done for thousands of years, we must think of new ways to do it without continuing to degrade the coast. In this sense, the floating solutions such as the VLFS are presented as a good solution.

11.4.2 Mobile Settlements

The waterway will be a means of transportation and communication in the future due to its efficiency and environmental friendliness. The chief exponent of this means of transportation will be future cruises, which over time will become floating-cities.

11.4.3 Access to Marine Resources

The establishment of these colonies is usually done on board the platform making use of the ocean: that is, the platform becomes the area of accommodation. But when this is not possible, either for lack of space or because the structure does not allow it, there is a need to devise new structures such as offshore flotels.

The development of offshore wind power, for example, is the next step to colonizing the ocean to access its resources. It will be necessary to establish colonies for their maintenance, and these will be a totally separate facility from the ones dedicated to exploiting it.

11.4.4 Creating Micronations and Oceanic City-States

In our view, the creation of micronations will be marked by the evolution of three forms of ocean colonization.

In the past, American colonies were able to become independent nations. Maybe in the future we may see that a colony established to exploit an oceanic region rich in mineral resources, oil and wind may achieve independence. But it will take years to see it.

The discussion in Chapter 10.6 and in Table 29 is only a hypothetical scenario. If it should come to fruition, Oceanic and Naval Engineering will be a contributor.

11.5 Epilogue: the Oceans, the New Frontier of Mankind

Frontiers have always been critical for humanity. Some historians emphasize the unique and innovative example of America, just emerged from its years as a frontier, where individuals resistant to all kinds of vicissitudes struggled for self-sufficiency. But today we can say that we have come to the end of frontiers. Virtually the entire Earth surface is claimed by some country, mapped, and even the summit of Everest and Antarctica are visited frequently even with permanent settlements. Space technology still needs many more decades of technological development before it's feasible to colonize the Moon or Mars. It therefore appears that the oceans are the next frontier that humanity faces in the coming centuries.

But the lack of development of our next frontier is the major unresolved task for the oceans and humanity, as to establish oceanic settlements would have enormous benefits for both:

• Benefits to humanity: the development of this oceanic frontier will benefit humanity as it will allow for civilization to advance to a new level of evolution. The oceans are a major source of energy resources, ENERMAR. If we are to continue to pursue sustainable development of humanity, no doubt the development of these renewable energy sources will be essential. But the development of ocean-based renewable energy will require the establishment of colonies to exploit it.

•Benefits for the oceans: Having permanent residents in the ocean would also lead to greater conservation of the oceans, and more people fighting against pollution of the same. Right now, few people are concerned about the conservation of the oceans in the same way we care to preserve forests and rivers, because the oceans are distant and far. Communities in the ocean would care much more about their conservation, and would be the most powerful lobby to defend the oceans.

Organizations and individuals that promote oceanic colonization have aimed to fill this need, so that humanity and the oceans can benefit from greater collaboration.

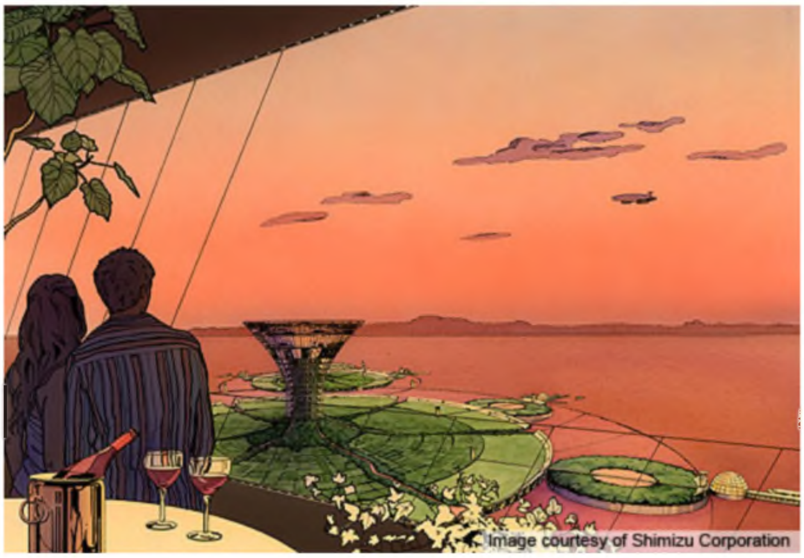


Figure 171: Floating city "Green Float". Courtesy of Shimizu Corporation

PART VI: APPENDICES AND REFERENCES

12 Floating Structure Seakeeping

Expanded version of the article "*Floating Structure Performance at sea*" was published by the author during the drafting of the dissertation, in the magazine *Annals of Mechanics and Electricity* (7)

12.1 Definition

Behavior at sea or seakeeping is a measure of the response that a floating structure has when adapting to the prevailing conditions. A ship, boat, pontoon, platform or any other floating structure that has a good response capacity the seas is said to be "seafaring" and thus able to carry out in an efficient manner its objective, even in adverse seas.

In the famous engraving of the figure below (*Great Wave of Kanagawa Katsushika* by Japanese artist Katsushika Hokusai, 1823-1829) can be seen that a small fishing boat is able to survive big waves, but is far from a comfortable condition for the fisherman who are on board. These two different ideas, **survival** and **comfort** are critical ideas to keep in mind in designing any floating structure. The first one, survival, has been widely studied in marine engineering for decades. However, the idea that a structure must be comfortable only recently has begun to develop, thanks in part to new software that can predict fairly reliably the behavior of the structure when subjected to a certain state of the sea.

Figure 172: *The Great Wave of Kanagawa,* Katsushika Hokusai, 1823-1829

12.2 Behavior at Sea in the Design of Floating Structures

12.2.1 Behavior At Sea in Vessel Design

Seakeeping directly impacts ship design. Ship motions are taken into account when determining the main dimensions and developing general rules for internal spaces. For example, the bow experiences the worst movements and is never acceptable locations to locate cabins for neither passengers nor crew members. Incases where ship movements are a threat to the crew, structure or machinery, or ship movements interfere with the ship's ability to fulfill its mission, then the design must be modified so that the vessel's movements are reduced.

To illustrate this better within the overall ship design process, we present the design spiral. The spiral describes the process as a sequence of specific design disciplines, both synthetic (i.e.

hull geometry, layout) and analytical (i.e. stability, seakeeping) in order to achieve a balanced design that meets the sought-out requirements. The spiral nicely illustrates important features of the design process such as interactivity and the progressive development of the design. However, the spiral represents the process at a macroscopic level. Some of these disciplines incorporate hundreds of activities. Seakeeping is a good example.

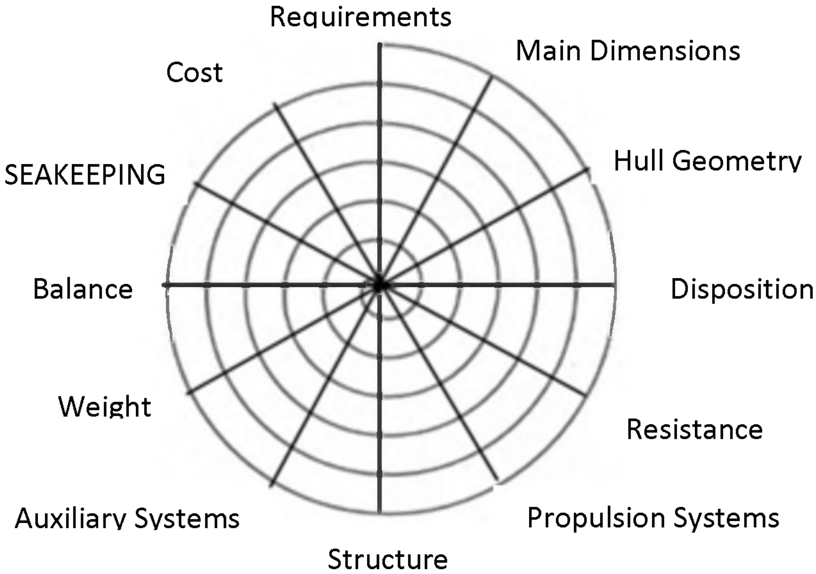


Figura 173: Generic Spiral of Vessel Design

In connection with seakeeping, the comparison between different designs or evaluation of a particular design against specific criteria depends on accurate information regarding three concepts described in the following sections. The evaluation of performance at sea depends strongly on the marine environment that ships are subjected to, and the criteria used to compare these designs. This is one of the reasons why comparison of behavior at sea is much more complicated than comparing drag in calm water or power requirements to achieve a given speed. This implies that the analysis of behavior at sea is much more difficult than the one of resistance in calm water, and until relatively recently has played a poor second in the preliminary hydrodynamic design for most ships.

This is particularly true in the merchant fleet, with the performance assessment of the ship at sea addressed relatively late in the spiral design (as shown in the figure above) through expensive scale models tested in channels of experience. In fact, the behavioral characteristics of the ship at sea depend on so many interrelated factors that it is virtually impossible to tell what will happen if a specific change to the hull is made without a detailed analysis. This is because the behavior of a ship at sea depends not only on the motion response of the hull, but also on the marine environment . Fortunately, designers now have several tools for assessing seakeeping to choose from, and are ideal for a preliminary design. Seakeeping software is sufficiently sophisticated and computers today powerful enough to analyze a potential design in minutes.

With proper analysis, it’s possible to optimize a hull to specific routes (the sea conditions that the ship will probably encounter en route) and the characteristics that are important to successfully complete the mission of the ship. For example:

- a cargo ship can be optimized to reduce drag.
- a passenger ship may be optimized for passenger comfort.
- a warship could be optimized to minimize movement on the heliport deck.

Each of the pieces of the problem – marine environment, movement and response criteria – are important, but the third is perhaps the least understood and requires careful consideration.

12.2.2 Behavior At Sea of Offshore Platform

We can see that the behavior at sea is the last process in the cycle of ship design and has until recently been relegated to the background, which could be a problem on some ships where the behavior at sea is a key factor. This is the case of offshore structures and other structures designed to keep position in a given location during the entire life of the structure, where therefore the resistance and propulsion are key factors as in conventional vessels.

The safety and availability of offshore structures designed for a particular purpose in a particular location depends largely on their seakeeping. The naval engineer adjusts these capabilities during the design process by adapting size and hull shape and weight distribution. All these properties are set extensively during the earliest stages of design. To avoid costly changes in later stages, the design must be checked with the requirements of classification societies and the allowable limits for efficient operation. Typically, engineers design the hull interactively, moving the vertices and lines using computer-aided design software, CAD. Only after the evaluation of the completed hull form will the engineer know the relevant parameters such as displacement and flotation centers. The characteristics of performance at sea are evaluated in a separate step. Interactive processes of geometry changes and assessments are repeated until the design meets the requirements. Therefore, the spiral design of an offshore structure is different from that of a vessel. The figure below shows an example of the spiral design of a semisubmersible structure (103)

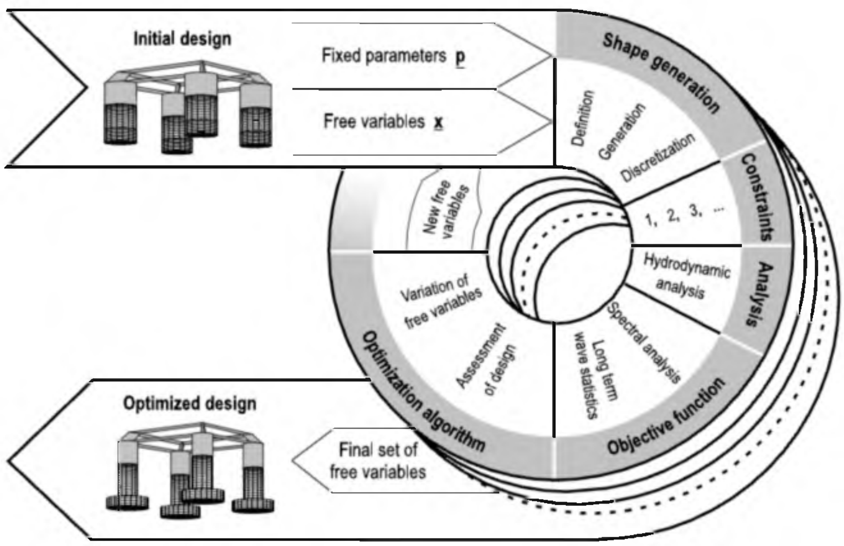


Figure 174: Procedure for hull shape optimization in offshore structures

12.3 The Three Main Problems / Concepts to Understand the Behavior of a Vessel or Structure at Sea

In general, as we have seen, the operational capacity of ships and offshore structures depends on their behavior at sea. Given a particular area of operation, the percentage of time that the vessel will operate in conditions appropriate to their mission in a particular sea state can be determined from an oceanographic database and then through the application of the concept of RAO (response amplitude operators), a transfer function that defines the vessel's response to that particular sea state. The prediction of movement response was compared with the movements limit criteria for operability rates. However, operating rates are strongly affected by the choice of these criteria limit.

Analysis of behavior in the sea is essentially a problem that consists of three parts.

12.3.1 First Problems / Concept: the Marine Environment

This is the assessment of the marine conditions that the vessel is likely to encounter in a marine environment. This includes both the state of the sea, such as wind speed, currents, or a combination of these in a particular geographic region. The databases and ocean wave spectra obtained from them define the marine environment.

We will not dwell here on how to obtain these databases. A brief summary will be presented which shall be taken into account, detailing the conditions of operation and survival.

12.3.1.1 Meteocean Operating and Survival Conditions

Any marine structure should be designed to support two types of requirements:

Operational: Movement in operational sea-states must be limited to the established criteria limit (for comfort of passengers in the case of cruises, as an example).

Survival: extreme conditions are applied to evaluate the survival of the structure in terms of loads that affect it, stability, etc.

To study these aspects of design, it is important to know the sea-state characteristics in both operational and extreme conditions.

12.3.1.1.1 Operating Conditions

The *wave scatter diagram* is a table that gives the significant wave height, Hs, against the dominant period, Tp, which defines the operational sea-state per a defined sea spectrum as expressed by Jonswap, Bretschneider, and Pierson-Moskowitz, among others. Each combination of Hs and Tp is a corresponding probability of occurrence.

H_s-classes in [m] $H_{smin} - H_{smax}$	T_0-classes in [s] 5.0 0.0	7.0 5.0	9.0 7.0	11.0 9.0	13.0 11.0	15.0 13.0	17.0 15.0	19.0 17.0	21.0 19.0	23.0 21.0
12.0–15.0	0	0	0	0	1	0	0	0	0	0
11.0–12.0	0	0	0	1	2	0	0	0	0	0
9.5–11.0	0	0	0	1	0	0	0	1	0	0
9.0– 9.5	0	1	6	8	17	3	1	1	0	0
8.5– 9.0	0	2	5	13	6	1	1	0	0	0
8.0– 8.5	0	0	5	4	11	7	2	0	0	0
7.5– 8.0	2	2	16	9	11	13	5	1	0	3
7.0– 7.5	0	5	16	18	11	7	3	3	0	0
6.5– 7.0	0	8	16	10	7	7	1	0	0	0
6.0– 6.5	1	14	18	35	29	5	4	1	0	0
5.5– 6.0	0	11	21	42	28	8	3	1	0	0
5.0– 5.5	0	3	27	19	12	5	1	0	0	0
4.5– 5.0	1	11	29	32	10	3	1	0	0	1
4.0– 4.5	7	48	120	115	82	19	15	5	1	0
3.5– 4.0	6	49	136	105	54	17	14	2	1	0
3.0– 3.5	8	84	197	150	67	22	4	2	0	0
2.5– 3.0	19	149	220	131	54	10	1	4	1	0
2.0– 2.5	37	285	317	159	46	12	2	3	0	0
1.5– 2.0	72	382	267	76	22	7	5	1	0	0
1.0– 1.5	248	498	191	46	20	4	3	0	0	1
0.5– 1.0	381	252	46	16	5	1	1	1	0	8
0.2– 0.5	199	16	7	3	1	2	1	0	0	6
0.0– 0.2	50	0	2	3	1	0	0	0	1	0

sum of observations $r_\beta = 6276$

Figure 175: Example of a Wave Scatter diagram

From said database one obtains the spectrum of waves. The following figure (103) illustrates this transformation.

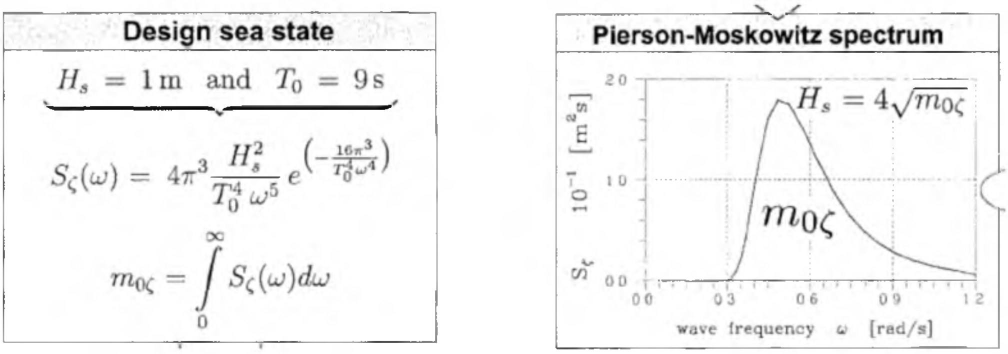


Figure 176: Getting the Wave Spectrum from a Wave Scatter diagram

12.3.1.1.2 Extreme Conditions

An **extreme sea-state** is defined by a combination of maximum wave height Hs and maximum wind speed Ws that is likely to occur in a given period. The periods that are usually taken into account for extreme conditions are those of the 100-year conditions. The figure below depicts those values obtained from the KNMI Wave Atlas.

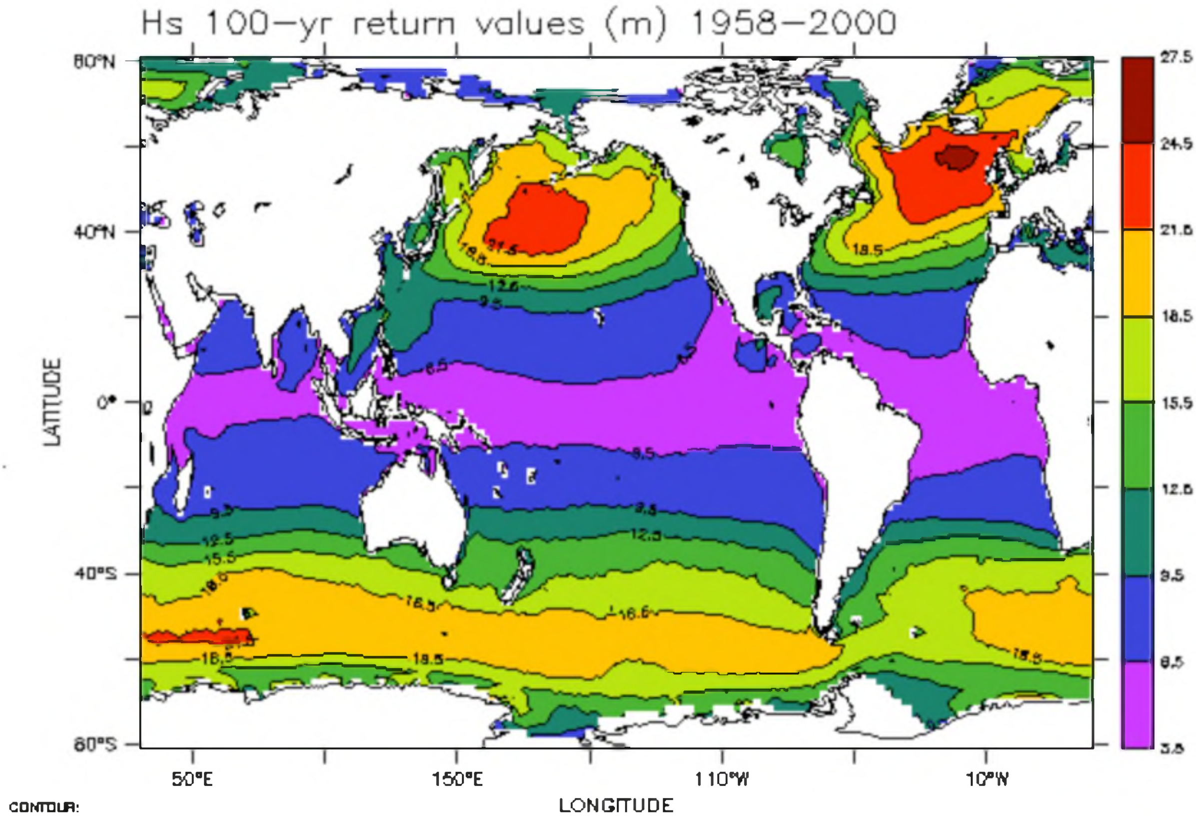


Figure 177: 100-year significant wave height heatmap 1958-2000. Source: KNMI Wave Atlas

12.3.1.1.3 Rogue Waves

One possible discussion in establishing a platform in the ocean is if you have to take into account the giant waves *(rogue waves, freak waves).* These have been detected on some instances, the first recorded being the New Year's Wave measuring 25.6 m in height. The wave is shown in the figure below:

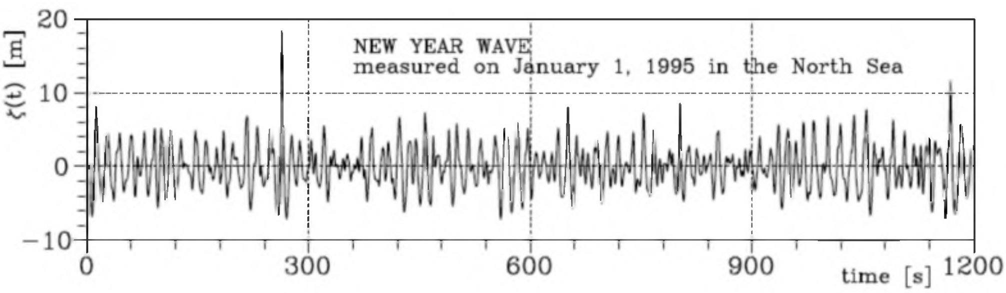


Figure 178: Data Record of the New Year's Wave of January 1, 1995 Draupner Field, North Sea (103)

However, according to *Grenland Group* designers (Norway) consulted on this subject for the thesis, they confirmed that these rogue waves are not directly taken into account when designing a platform, but to some degree they are incorporated in their own wave spectra based on the 100 year conditions:

" About your question [regarding] freak waves. No, we are not using freak waves to the global dimension structure. We use the Environmental Criteria in the DNV-RP-C203 to define the maximum wave height to be used, as well as the steepness criteria to September wave height to max-out the contour line vs. period. Remember that the max wave height set out in the DNV offshore standard for North Atlantic/worldwide criteria was raised from 16.8 m Hs to 17.3 m Hs partially due to the fact that one has had experience with freak waves.

Though, we should have in our mind that the position of lıfesaving appliance should be evaluated for accidental high wave heights, i.e. 10-4 return period (25% higher Hs)."

In short, it would have no special consideration. Although, it has been shown that designs like the GVA4000 would be able to survive these waves. (104)

12.3.2 Second Problem / Concept: the Movement of the Ship Response

The problem is to predict ship movement in the marine environment conditions. The answers are a function of:

1. The design conditions of the state / marine environment described above to provide the spectrum of waves.

2. Vessel characteristics: **geometry of the hull** (hull) and weight distribution, given the transfer function called **Response Amplitude Operator (RAO),** which is used to evaluate the movement of a vessel along the six degrees of freedom.

Motions:	
1 vertical movement up and down: heave	Heave
2 Lateral movement on both sides: drift	Sway
3 Longitudinal movements forward or backward.	Surge
Rotations:	
4 According to the vertical axis 'Z': Yaw direction.	Yaw
5 According to the transversal axis 'Y': Pitching.	Pitch
6 According to the longitudinal axis 'X': Balance or lean	Roll

Table 29: the six degrees of freedom

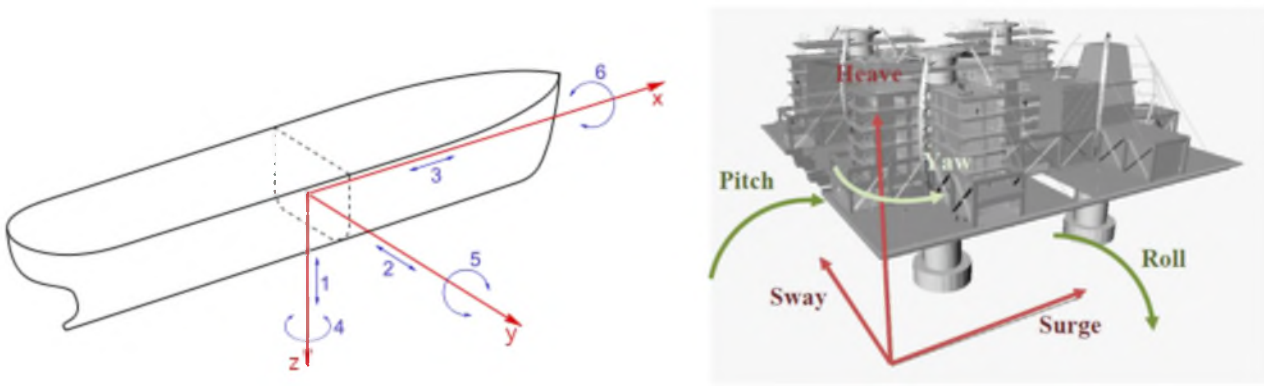


Figure 179: The six degrees of freedom on a ship and the Clubstead (19)

As we mentioned earlier, today's computers have facilitated the resolution of this problem, with several commercial programs available.

The following figure (103) summarizes the whole process from setting the database with sea-state system response (vessel or platform) in the form of movements.

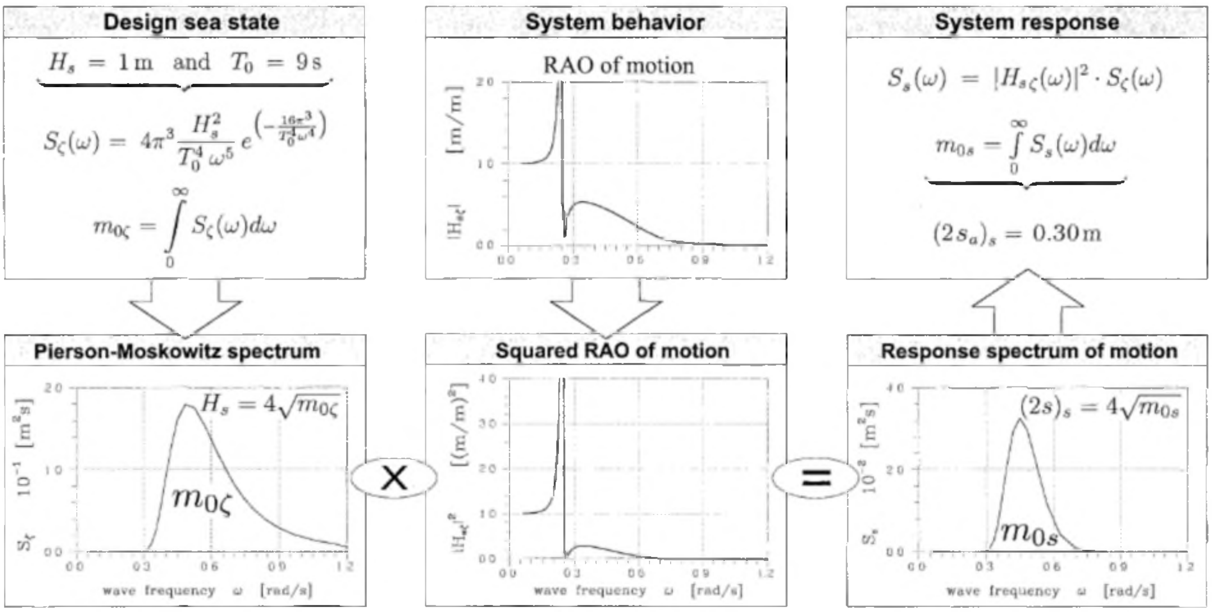


Figure 180: RAO filters the wave signal spectrum (wave spectrum) to obtain the range of movements *(spectrum of motion)*.

12.3.3 Third Problem / Concept: Vessel's Mission and Criteria Limit

This problem consists of defining the mission the vessel is intended to undertake, and from there, obtain the criteria to be utilized to evaluate its seakeeping. These criteria will therefore also define the manner by which we compare the performance of different ships with similar missions. The mission is the role played by the vessels / platform while at sea, and compliance or not of said mission is determined by the movement criteria limits.

Clearly, a drill ship and a ferry have different missions and operate in different environments. Thus, the performance criteria will also be different.

Therefore, there are several acceptable levels of movement, acceleration or other events that can occur without affecting the vessel's mission / platform depending precisely on the scope of said mission. Such criteria may include:

Motion induced interruptions - MII.
Motion Sickness in cidence, MSI.
Accelerations, such as the ISO standard in 263
Relative motions.
Relative velocities.
Slamming.
Propeller immersion.
Wave reach across the deck to prevent dynamic loads on semisubmersibles - what is coined "Air-Gap".
And so on.

In the case of a ferry or any other passenger ship, and any structure for colonization of the ocean, the criteria take the form of the limits of habitability, usually framed by passenger dizziness.

The ISO-2361 standard is the most widely used to evaluate this. The standard provides for severe discomfort boundaries in terms of RMS values (root mean square, RMS) vertical accelerations for different exposure times as a function of center frequency/3 octave band in the frequency range from 0.1 to 0.63 Hz, as shown in the figure below.

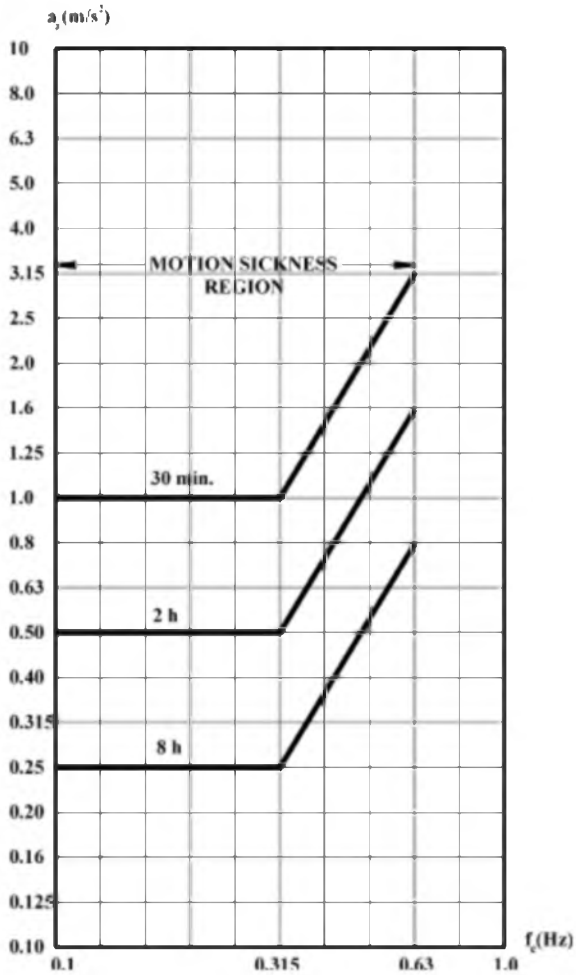


Figure 181: ISO 2631, severe limits of comfort (104)

We will not overemphasize the subject as there is abundant reference literature on it. The bibliography includes some references that we found of interest: (105), (106), (107), (108).

12.4 Evaluation of Seakeeping

Once we solve the three problems above, then we would be in a position to carry out the evaluation of seakeeping rates for operations.

The figure below shows a summary of the evaluation of behavior at sea.

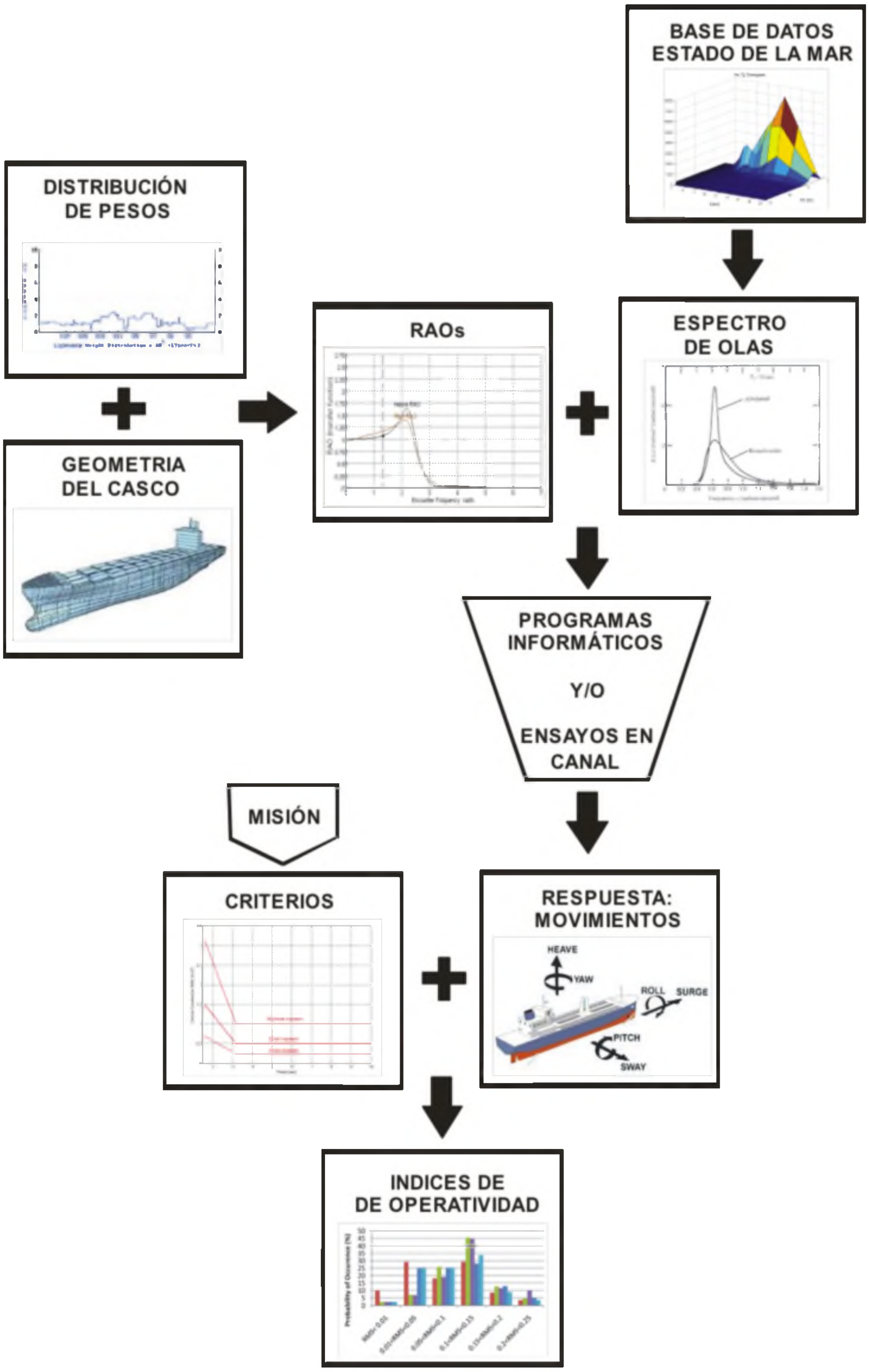


Figure 182: Evaluation Process for Seakeeping

In summary, the procedure starts with the prediction of the response to characteristics of hydrodynamics a vessel / platform will encounter for a set range of speeds and wave angle values (heading). The magnitude of movements in seas of different severities can then be predicted using the wave spectrum representative of the operational area selected.

Finally, the habitability of the ship can be estimated, based on the likelihood that the vessel's motions remain within defined limits of habitability. This is the case of passenger ships, but would be the same for any other structure designed to colonize the oceans.

The following figure shows as an example the probability of exceeding various limits of vertical accelerations, expressed in RMS, at different sites of the platform Clubstead (20).

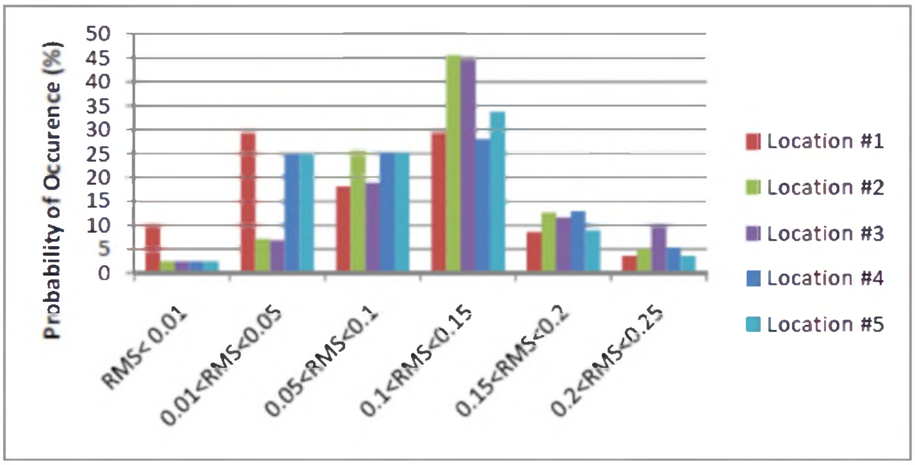


Figure 183: Probability of occurrence of root mean square (RMS) vertical acceleration on the platform Clubstead

12.5 Evaluating Seakeeping - An Example

12.5.1 Offshore Accommodation Vessel *M / V Dan Swift*

We shall evaluate the offshore accommodation vessel *M / V Dan Swift*, which classifies midway between a passenger ship and offshore artifact. Its behavior at sea is vital as discussed below, as it is designed to stay in one geographical position off the coast of Brazil, providing comfort at all times as a floating hotel, regardless of the conditions of the marine environment it encounters.

12.5.1.1 Mission and Criteria

The vessel is used to provide hotel services to staff working aboard oil rigs, processing and storage vessels (Floating-Production-Storage-and-Offloading, FPSO). The transfer of personnel is done by means of a flexible bridge/gangway between the vessel and platform. The maximum strain of this bridge/gangway is an important down-time factor, because it can prevent the passage of accommodation vessel staff to the platform and vice versa. The Dynamic Positioning System (DPS) is controlled in such a way that it tries to limit the effort exerted on the bridge/gangway by mimicking the accommodation vessel movement at the bridge/gangway-platform connection point. Therefore the mission of the ship, in addition to providing comfort as a floating hotel, is to allow the transfer of staff to the platform. The evaluation criteria will therefore be of comfort and performance of the bridge/gangway.

Figure 184: The vessel *Dan Swift* in actual operation next to an oil rig.
Source: Offshore Lauritzen A / S

12.5.1.2 Marine Environment

In this case study, the ship is designed to operate at "Campos Basin," which is an oil rich area located several miles off the coast of Rio de Janeiro (Brazil).The evaluation of performance at sea took place in average environmental conditions with the spectrum of waves of Campos Basin:

- Wind: 15 m / sec.
- Significant wave height, Hs: 3.5 m.
- Wave period, peak swell, Tp: 12.8 sec.
- Wave period, peak wind, Tp: 9 sec.
- Current: 1.1 m / sec.

Figure 185: Site Map of Campos Basin off the coast of Brazil

12.5.1.3 Vessel Response

The shipping company, Lauritzen, asked MARIN (Maritime Research Institute Netherlands) to evaluate the seakeeping of the ship through both numerical simulations and computer models with real tests. The scenario under consideration was one in which the ship hotel had to work alongside a typical FPSO turret-anchored to the bottom.

Numerical simulations. Several numerical simulations were performed using the RUNSIM (a software dynamic positioning control trials also used in channel), coupled to LIFSIM (simulation in time domain for multibody). In these simulations, we took into account the hydrodynamic interactions between wind, waves and current. The analysis showed that the concept was feasible and the scenario scope was used to select the appropriate environmental conditions and the coefficients of dynamic positioning to perform actual trials with models.

Model tests. Subsequently, tests were performed in the offshore-testing-channels of MARIN, combining factors of wind, waves, current and swell. A 1:33 scale model of the whole system was prepared: the accommodation vessel positioned next to a FPSO turret moored in 200 m deep water. We considered several seakeeping and environmental conditions, coupled with very high wind speeds, multi-speed streams and showers. All tests showed a significant swell in the natural FPSO's rolling period.

Figure 186: Channel testing of the Accommodation Vessel model *Dan Swift*. Source: Offshore Lauritzen A / S

12.5.1.4 Operational Indices

Operability rates obtained were as follows:

- Time of operation of the walkway. The results showed that the operational time for the bridge/gangway would be high, based on the spectrum of waves expected at Campos Basin. The operational probability for the bridge/gangway was close to 95%, while its ability to connect to the FPSO vessel was estimated at 82% of the time.
- Comfort of the passage. We also analyzed rates of MIR (Motion Illness Ratio) and checked against European standards and practices currently used for ships ferries. It was shown that the operational probability expected was that about 9% that the crew would not expect to feel worse than an index MIR 25, which is an acceptable standard for the industry.

13 Proposed Locations and Structures for the Creation of Micronations.

13.1 Site Locations

13.1.1 Ampere Seamount

13.1.1.1 Introduction.

As we have seen, Option B for the location of a colony sovereign ocean provides for the establishment on seamounts, with the Ampere seamount one of the possible sites.

13.1.1.2 Site Location

As we see in the image below obtained from Google Earth, Ampere Seamount is located partially outside the EEZ accessible to the following continental locations:

- Portimao (Portugal): 255 nautical miles.
- Madeira (Portugal): 239 nautical miles .
- Casablanca (Morocco): 277 nautical miles.

Figure 187: Site Location of Ampere Seamount. Source: Google Earth

With this seamount, we have located an area outside the EEZ only 139 m depth: 35 º 03'54 .24''N - 12 º 53'03 .21 "O.

But according to a report by Susan Gubbay (109), Ampere's shallowest depth has been documented to 60 m, although this could be within the EEZ of Madeira (Portugal). In any case, 60 m or 139 m, we might consider this place "shallow" for purposes of anchoring: this depth could have a barge anchored without the need for dynamic positioning, as in other areas, making it less expensive to establish oceanic colony.

Another advantage, as we shall see, is that the place is located right in the middle of the trade route of a ferry line, which runs from Portimao (southern Portugal) to the island of Made.

13.1.1.3 Expeditions

The figure of 60 m depth was also confirmed by Mr. José Augusto Silva Portuguese organization *Associação Selvagem Atlântico* (Atlantic Wildlife Association) that in the year 2000 launched an expedition to seamount Ampere[84]. Theu were able to reach the bottom at a depth of 60 m. Unfortunately, we do not have the exact location of that point. The photos of the expedition can be found on its website. We have included here two of those wonderful pictures.

Figure 188: Photos taken during the Expedition of Atlantic Wildlife Association in 2000

13.1.1.4 Geological Description

The Ampère Seamount, 600 km west of Gibraltar, is one of nine inactive volcanoes along a bent chain, the so called Horseshoe Seamounts. All of them ascend from an abyssal plain of 4000 to 4800 m depth up to a few hundred meters below the sea surface, except two, which nearly reach the surface: the Ampère massif on the southern flank of the group and the summit of the Gorringe bank in the north. the horseshoe, serrated like a crown, opens towards Gibraltar and stands in the way of its outflow. These seamounts are part of the Azores-Gibraltar structure, which marks the boundary between two major tectonic plates: the Eurasian and the African plate.

Ampere Seamount is located between the Seine and Horseshoe Abyssal Plain. It rises from 4, 800 m to 60 m below the surface and extends over an estimated area of 3,600 km.

The east and south sides are extremely steep, almost vertical for several hundred meters. The western and northern flanks have a smooth gradient, but are interrupted by short slopes that provide a tiered structure or terracing (Kuhn et al., 1996, WWF, 2001):

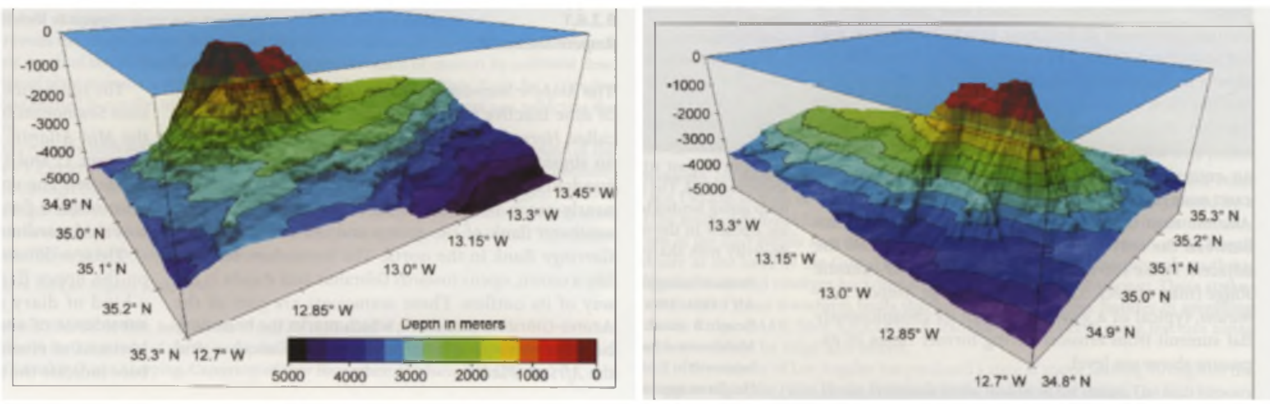


Figure 189: Ampere seamount. 3D Image multiband echo sounder.

[84] The same information can be found at http://atlanticoselvagem.org/relampere.htm

Source (109)

13.1.1.5 Tsunamis and Seismic Activity

One of the most seismically active areas in the south of Europe is at the ends of the Eurasian and African plates, which extend from the Gorringe Bank and the abyssal plain north of Algiers. Therefore, the Gorringe Bank, north of Ampere Seamount, is supposed to be one of the areas with greatest potential for earthquakes, and therefore the creation of tsunamis in the Atlantic (111).

Although this should not affect the daily living conditions of an oceanic colony, it should be considered for possible evacuation if affected by a tsunami originating in the Gorringe Bank.

Figure Location of Gorringe Seamount and the three plates (111)

13.1.1.6 Metocean Conditions: Wind, Waves and Currents.

Since there is no buoy in the area, there are no historical records of wind and waves on the water surface of the Ampere Seamount. Observations made[85] when the report was issued (March 2010) note the following maximums:

- Significant wave height: 4.5 m.
- Wind: Beaufort 6

[85] Source: https://www.fnmoc.navy.mil/wxmap_cgi/cgi-bin/wxmap_loop.cgi?&area=ww3_atlantic&prod=sgwvht&dtg=2010033012&set=SeaState

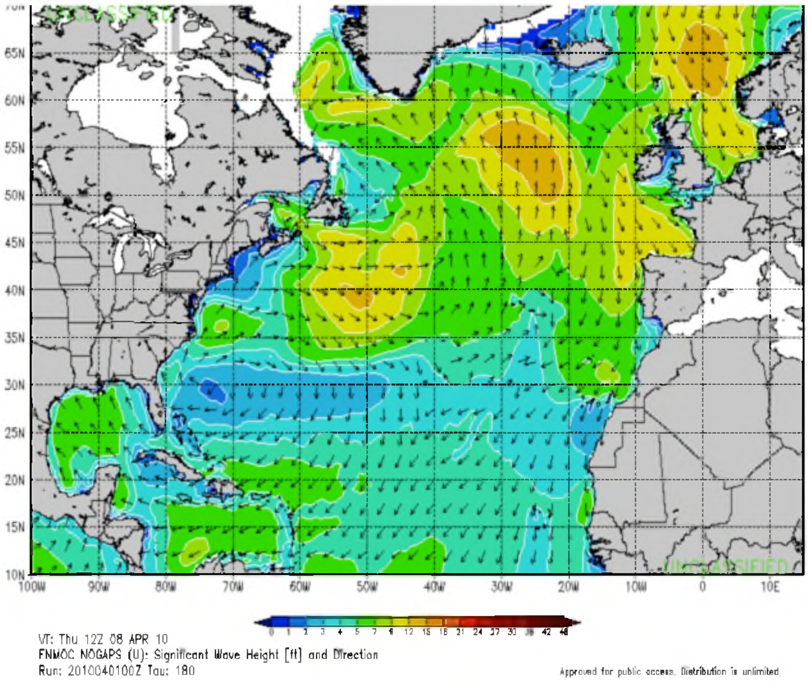


Figure 190: significant wave height in the North Atlantic.

At any rate, it is situated better than any location in the North Atlantic, and not as prime as one situated in the Gulf of Mexico, as seen in the pictures above. Considering the typical conditions of operation and design of a barge crane survival in the Gulf of Mexico:

Marine Condition	**Wind Speed**	**Wave Height (Hs)**	**Period (Tp)**
Maximum Operational	19.40 m/s	4.57 m	9.50 sc
Survival	42.43 m/s	12.00 m	14 sc

This means that a typical single-hulled barge designed for the Gulf of Mexico could also operate in Ampere Semount. A semisubmersible barge would be even better.

13.1.1.7 Trade Routes and Transfer to Land.

As mentioned previously, Ampere Seamount is in the middle of the route of the ferry company ARMAS[86] between Portimao (Portugal South) and the island of Madeira. This route is covered by a traditional ferry, with a speed of 23-25 knots. Given the distances shown above:

- Ampere Seamount - Portimao: 258 nautical miles.
- Ampere Seamount - Madeira: 235 nautical miles.

This means that transfer to and from land would require approximately 10 hours. With a fast ferry (speeds between 38-47 knots), the time required would be only 5-7 hours[87].

With a typical offshore helicopter like the Sikorsky S-92 (151 knots cruise speed)[88], it would require less than 2 hours to reach the nearest seashore.

[86] http://www.navieraarmas.com/index.php?id_pagina=1&idioma=en
[87] knot =nautical mile per hour.
[88] Source: http://es.wikipedia.org/wiki/Sikorsky_S-92

13.1.1.8 Peculiarities About the Ampere Seamount.

Finally, we discuss here some interesting facts about Ampere Seamount. The first is about the lost kingdom of Atlantis. The second is a project of a city in this place, as discussed in chapter 3.

13.1.1.8.1 The Lost Kingdom of Atlantis

During the last glacial period, and thanks to the height of its peaks, current seamounts in the *Gorringe Bank* and banks as far south as Ampere Seamount, were true emergent islands. This led many experts in the Lost Kingdom of Atlantis to suggest that Seamount Ampere could be the location of this mythical kingdom. As an example we present:[89]

> *When Soviet oceanographers examined their underwater photos taken of the Ampere Seamount, they discovered what seemed to be walls, stairways, and other artificial stonework. the Ampere Seamount is 450 miles west of Gibraltar, just the area where Plato placed Atlantis!*

It is of course a possible location along with all the other suggestions made in recent years.

13.1.1.8.2 Autopia Ampere.

As we saw in Chapter 3, this site was also chosen to establish Autopia Ampere, by the architect Wolf Hilbertz.

13.1.1.9 Summary and Conclusions

Ampere Seamount is an ideal setting for the establishment of a sovereign ocean colony for the following reasons:

- Outside the EEZ.
- Shallow water.
- Not far from the coast, and on a trade route.
- Environmental conditions not very hard.

[89] Source: *Science Frontiers* #15, Spring 1981. © 1981-2000 William R. Corliss. Published on-line at http://www.science-frontiers.com/sf015/sf015p0htm

13.2 Structures

- Short-term: a ferry ship converted to flotel.
- Medium term: Mini-MOB

13.2.1 Short-Term: a Ferry Ship Converted to Flotel

13.2.1.1 Introduction

As discussed in 10.6.3, the option of single-hull vessels is the best option for the short-term goal of an oceanic colony aiming to achieve sovereignty. Platforms with better performance are possible (like semisubmersibles), providing a better structure for an oceanic colony than single-hull vessels, but these represent an immediate. As with any new technology, it is important to be able to test the economic viability to investors and donors before launching large capital investments: a business based on a ship would provide a lower cost, and would be an option available immediately for ocean business models which do not depend greatly on the type of platform.

Both flotel ships and cruise ships are classified as residential "Passenger Ships", according to the SOLAS regulations and the DNV, with some special considerations. Therefore, we assume that a possible oceanic colonization vessel (shipstead, in the nomenclature of The Seasteading Institute) should be classified as a "Passenger Ship", also with some considerations. **We understand that neither the IMO nor any company classifying them as DNV or ABS prepares a special notation for a shipstead.**

In principle, it would seem that there could be synergies between the cruise industry and what could be the first sovereign ocean colony, particularly with respect to aspects of classification and statutory and regulatory aspects. At least in the initial stages, the seastead could compete for some of the same customers the cruise operators such as Royal Caribbean are trying to attract with their marketing strategy based on his concept of "The Nation of Why Not".

However, a sovereign ocean community is not the same concept as a cruise ship. Entertainment, activities, accommodation, etc. in a cruise ship are all oriented around a central idea of "holiday".

The choice of a single hull vessel seems the most appropriate for the short term, since it is a well known and inexpensive structure. To lower the price even more, one could retrofit an existing ship , as the *Equinox Offshore Accommodation Ltd.* company did with a passenger ferry vessel.

13.2.1.2 Ship Base: the Equinox Project

Equinox Offshore Accommodation Ltd. was an established as an offshore sector company to convert RO-RO ships into Accommodation and Repair Vessels. In December 2007 they acquired the ferry vessel *M / V Melodia de Tallinn* of the Swedish Melody Line Ltd, a subsidiary of Tallink Grupp, for a price of €15 million euros ($136 million USD). The *M / V Melodia* was a ro-pax with capacity for 1,600 passengers built in Germany in 1979, which in 2008 was then converted to an ARV in a shipyard in Semarang, Singapore. The contract price was $34.5 million USD.

After the final conversion, the vessel would be ready with a 50-ton crane for operational support, DP2, a base of 521 beds and a transit speed of 18 knots. The accommodation and repair vessel would thus be more than a "flotel", being rather a MOBILE logistical installation and providing offshore support.

The vessel's hull accommodation and repair has been demonstrated in specific movement characteristics to make them suitable for most operations in offshore locations worldwide.

In March 2009, Equinox filed this announcement concerning the classification of the ARV:

As previously announced, the rules applying to the accommodation and repair vessel concept created signıficant extra engineering work and delayed class approval of the vessel. One mitigating step that the Company took in December 2008 to ameliorate these delays was to revert to the vessel’s original classıfication society, Bureau VERITAS.

The Company is very pleased to announce that all plan approvals have now been issued by BV and full certıfication of the vessel as an ARV with full capacity to operate as both an accommodation and repair vessel will be issued upon completion.

As we can see, even something as simple in principle is not necessarily as simple in practice.

Based on the conversion of the ferry *M / V Melodia*, an ARV1, in the following pages we will perform an study on engineering, systems, available space, and costs required to build a ship that could be the beginning of a sovereign oceanic colony (a shipstead) starting with an old ferry.

13.2.1.3 **General Provision**

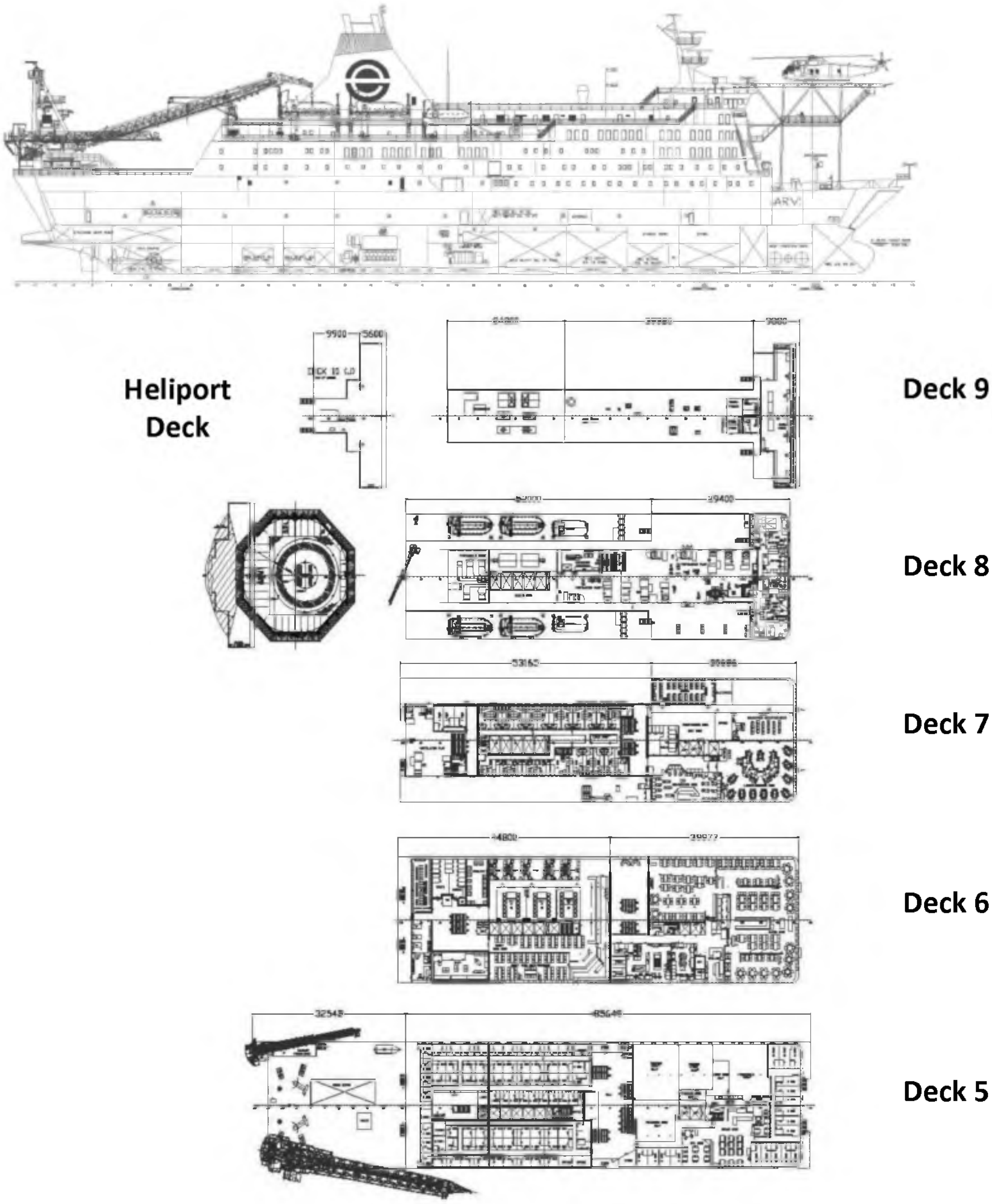
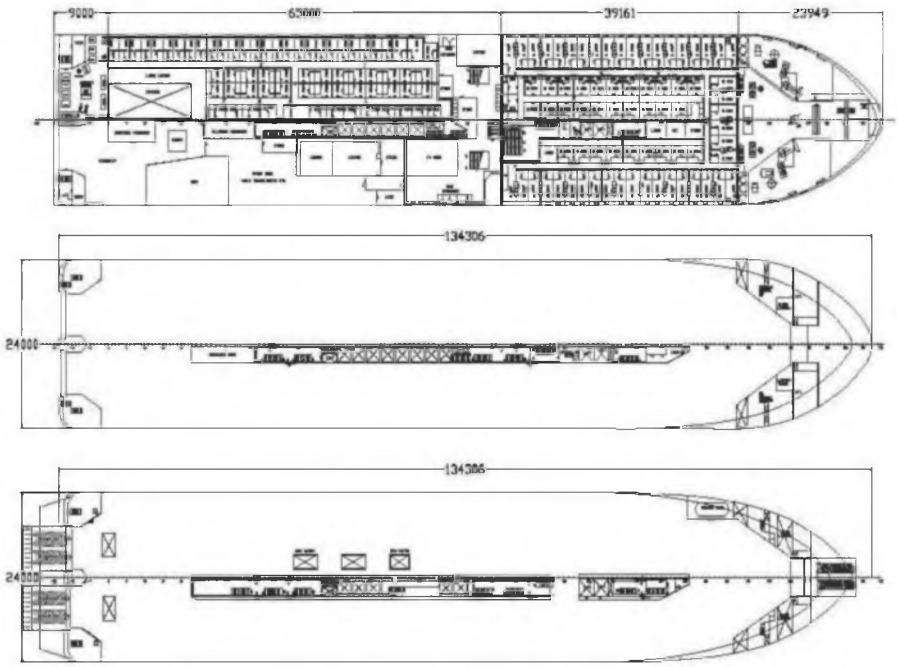


Figure 191: Layout of the ship ARV1 -of 2

Deck 4

Deck 3

Deck 2



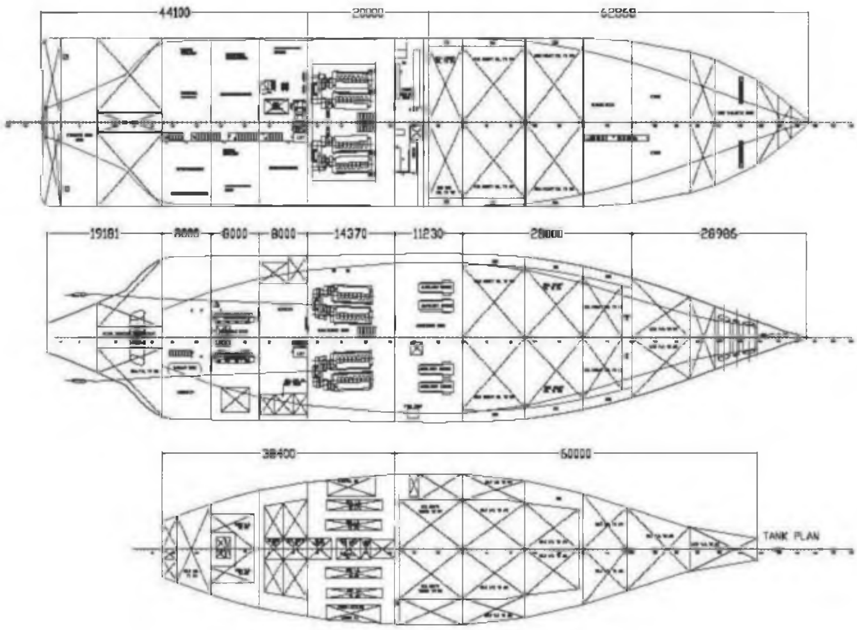


Figure 192: Layout of the ship ARV1 - 2 of 2

13.2.1.4 Architectural Study

13.2.1.4.1 Living Spaces and Business

The main challenge of the project is the price **per m²**. The price should be competitive enough to entice the first settlers to move their permanent housing and/or businesses to a ship.

13.2.1.4.2 Crew Living Spaces:

Living spaces are required for the ship's crew: captain, chief engineer, and officers. About 20 people would be enough.

13.2.1.4.3 Crew

The number of staff on board that can be accommodated will depend on the space one wants to utilize. For example, the ARV1 is ready for 521 people with a total space of 7,069 m^2, which is 14 m^2 per person.

If we include the two garage decks (decks 2 and 3) we get a 12,549 m^2, and 24 m^2 per person.

If we use only the existing accommodation space and only accommodate 200 people, there would be 35 m^2 per person.

13.2.1.4.4 Planning Board

Ferry vessels are designed to have customers inside for a few hours a day.

Cruise ships are different: people usually stay on the ship from the evening, when the ship departs port, till the morning, when the ship arrives at port. During the day, passengers walk on the exterior of the ship as tourists.

There is often not much space dedicated to walk inside, public areas, etc. The cruise ship "Oasis of the Seas" is the first cruise ship to incorporate this concept. A colony ship that serves as a sovereign nation should include something similar.

Normally in an inland urban project, a percentage of the space should be devoted to public and common areas and gardens.

Figure 193: Inside Oasis of the Seas. Source: Royal Caribbean

The ferry *M / V Melodia* itself has the space available, currently used as technical areas. These areas should be converted into recreational spaces, similar to those shown in the figure above. The following table shows the technical areas in covered garages and superstructure areas that would become public spaces:

Superstructure	L (m)	B (m)	Coef.	Area (m2)
Deck 5	30	200	0.90	702
Deck 7	11	100	0.90	1,276
Deck 8	20	100	0.90	318

Deck 9	**62**	**100**	**0.90**	**699**
CBTA. heliport	**20.00**	**20.00**	**0.85**	**340**
			Total	**2,633**

Garages	L (m)	B (m)	Coef.	Area (m2)
Deck 2	131	200	0.85	2,740
Deck 3	131	200	0.85	2,740
			Total	5,480

Table 30: Technical areas that are transferred to public recreational spaces

13.2.1.5 Engineering

Preliminary engineering work is normally done after an independent consultant was hired by the shipyard to complete the classification drawings. Asmentioned, the first step before any engineering work and estimation of the necessary systems, should be to contact a classification society to ensure that all steps are performed correctly, especially with regard to its level of classification.

13.2.1.6 New Systems to incorporate

In any case, we shall mention here some of the main systems that a shipstead requires and ferry may not have. Other systems such as rescue or fire would also be improved but should be studied carefully with the requirements of the classification society.

13.2.1.6.1 Dynamic Positioning System, DP2

The system required to maintain the vessel in a fixed position in the ocean. The facility has some consequences: redundancy in services and the installation of new thrusters.

a) System:

The dynamic positioning system itself includes computers, software, sensors, and other equipment. It also requires new consoles on the bridge and the re-installation of old equipment.

b) Changes due to redundancy in services

The Dynamic Positioning Class II requires some redundancy in plumbing, electrical systems: fuel, lubricating oil, and cooling water. Ferries are not built with such redundancy. Therefore, it requires some piping and electrical work.

c) Lateral thrusters

Normally these types of ferries are equipped with only two transverse bow thrusters. This gives them an acceptable ERN (70,70,23). But they are far from offshore vessels equipped with more thrusters (90).

13.2.1.6.2 Balance Stabilization System

Passenger ships are usually fitted with stabilizing fins for rolling motions. These work quite well with ships sailing at cruising speed, but not for dynamic positioning vessels.

Figure 194: fixed and retractable fins

These types of ships (supply vessels, offshore construction vessels) are installed with passive or active pitch stabilization:

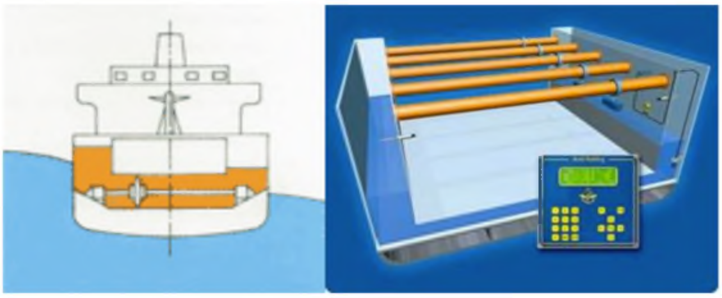


Figure 195: System clearing activities list

Ferry vessels and are usually equipped with anti-heeling tanks for loading / unloading. Therefore it is quite easy to install these anti-heeling systems.

13.2.1.6.3 Heliport

Some ferry vessels are already equipped with helipads. In the case of ARV1, a new one was added.

13.2.1.7 Accommodation

13.2.1.7.1 Decks 2 and 3

These decks are devoted to garages in vessels that operate as a ferry. Once converted, these areas would be dedicated to new spaces/functions.

13.2.1.7.2 Decks 4 and 10

These are now used as accommodation. They only require renovating.

13.2.1.8 Other Retrofitting Work

As mentioned, other studies will be needed because the ship will not be a ferry, but an accommodation ship for use in ocean waters. Some systems will require totally new facilities.

13.2.1.9 Budget

The following table embodies all the transformation work in the form of a retrofitting budget:

CODE	· Description	€	$	COMMENTS
0	LABOR			
0 - 1	Steel	400.000	576,240	Steel works outside of accommodation required for renewal
0.2	Armament	600.000	864,360	Weapons work out of accommodation required for class renewal and DP2
0.3	Trials and tests	150.000	216,090	Hours for testing
0.	Aid	200.000	288,120	
1	STEEL MATERIAL	120.000	172,872	For the reinforcement of the anti-heeling system ...
2	HULL AND PAINTING EQUIPMENT			
214	Paint.	1.500.000 €	2,160,900	Repainting of the vessel
3	RATING			
	Redecoration of decks 4-10	3.534.662	5,092,034	See the accommodation page [7]
	Redecoration of the deck crew	311.931	449,368	See the accommodation page
4	SYSTEMS			
401	Heliport	400.000	576,240	Turnkey cost
402	Anti-heeling system	150.000	216,090	System cost
5	Space propulsion systems.	100.000	144,060	Estimate for installation of the required new equipment
6	AUXILIARY SYSTEMS	100.000	144,060	Estimate for installation of the required new equipment
7	ELECTRICITY AND NAVIGATION			
	Dynamic Positioning System	1.800.000	2,593,080	Dynamic Positioning System
	Renewal of electrical installation	300,000	432,180	
8	AUTOMATION	200.000	288,120	Changes in the automation system
9	OTHER COSTS			
	Insurance			
	Classification, certified test	200.000	288,120	
	Engineering and project management	600.000	864,360	
	Ancillary costs	50.000	72,030	
	Launching, testing and guarantees	100.000	144,060	
	Rentals: scaffolding, cranes,	200.000	288,120	

CODE	· Description	€	$	COMMENTS
	...			
	Inspection of the guard	100,000.	144,060	
	Financial costs	400.000	576,240	
	Commission broker and consulting	300.000	432.180	
	Total Cost	11.816.593	17,022,984	
	Margin and overhead costs	2.363.319	3,404,597	
	Total cost with margins	14.179.911	20,427,580	

Rate used:	€ 1	$ 1.4406

Table 31: Budget of retrofitting of a ferry to shipstead

13.2.1.10 10 Comparison of Magnitudes Obtained

Adding the cost of acquisition cost to that of the transformation of the ferry we obtain the total project cost of creating a "Shipstead"

CODE	Description	€	$	COMMENTS
	Total cost with margins	1	20,427,580	
	Ferry Cost of acquisition	140	18,360,000	Acquisition by Tallink Grupp to Equinox offshore in 2007
	Total cost	2201	38,787,580	

And from this cost, with the existing living areas on the ferry get a price per m$^{2:}$

		Price / m^2	Price / m^2
7,069 m^2	Existing living areas	€ 3.809	$ 5.487

But if we include parking decks as new living areas we get an even lower price (at the cost of reducing that other recreational spaces as we indicated in the section "Planning board"):

	Enabling Cost decks 2 and 3	€ 10.959.288	$ 15,787,950	See the accommodation page
	Total cost with the decks 2 and 3	€ 37.883.889	$ 54,575,531	

Thus, the new price per m^2 would be lower:

m^2		Price / m^2	Price / m^2
7,069	Existing living areas		
5,480	Old garages / New living areas		
12,549	Total Living Area	€ 3.019	$ 4.349

Finally compare with the average prices for land:

Price m^2 January 2010:		
Vigo	$1,800	$ 2,593
Madrid	€ 3,375	$ 4,862

13.2.1.11 Conclusions

The price obtained from 3.019 € / m^2 is similar to a big city like Madrid but away from smaller cities like Vigo. **That is precisely the challenge of ocean colonization: that the land development curves intersect with the curves of development in the ocean as we explained in Chapter 4.**

In any case, for an initial experiment as described in Chapter 10.6.3, this would be a reasonable price.

Once the platform is designed, the next challenge is to develop the business models that make it profitable and attract residents to it.

13.2.2 Medium Term: Concrete Semisubmersible.

The proposed structure for "Marine Innovation & Technology" for "The Seasteading Institute", the "Clubstead" (20) is undoubtedly the best proposal made so far as a structure for the mid-term that can be used to establish an oceanic micronation. However, it has a couple of drawbacks:

- Lack of mobility: it is designed to remain in a fixed position, not having pontoons that allow you to surf the position of load shedding like other semisubmersibles.
- The proposed structure "Tensegrity" has never been tested at sea. It may save on materials, but the technical risk is high.

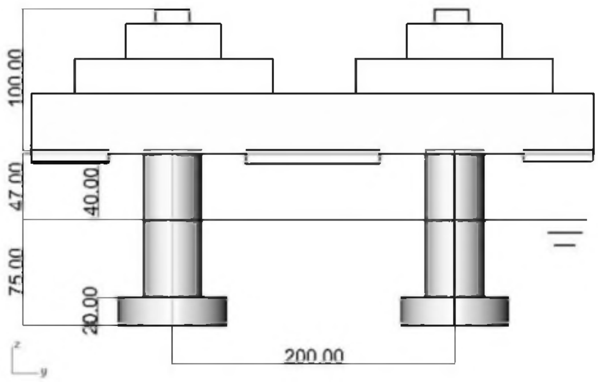


Figure 196: Dimensions of the Clubstead (19)

On the other hand, we have seen in Chapter 7 that one of the ideal structures for settlement for all types of offshore locations and metocean conditions is a "Mobile Offshore Base" by "Aker Marine”. But its cost was too high even for a military project.

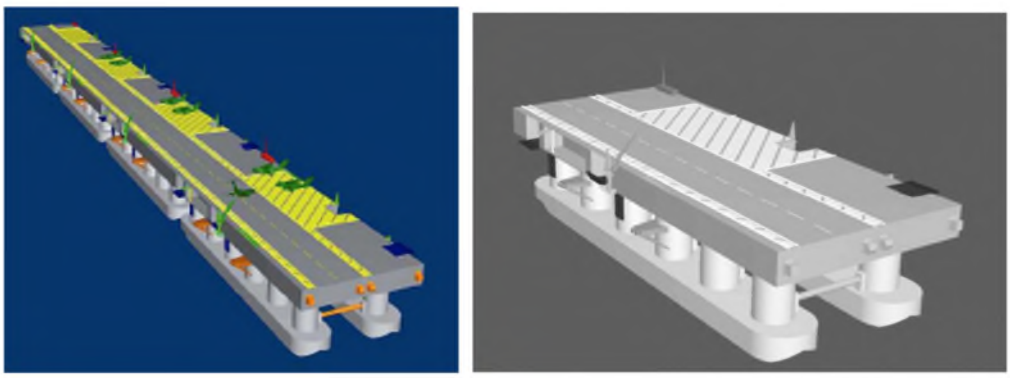


Figure 197: Concept hybrid MOB semisubmersible: 4 modules together and a single module

Therefore, we believe that a more conservative structure which offsets these drawbacks would be more appropriate. The very attempt to create a micronation is inherently risky, so the more you alleviate the technical and economic risks, the higher probability of success.

Thus, the mid-term proposal we would suggest is a structure similar in size to the Clubstead, but with the characteristics of the MOB. For this we:

- Add a pontoon to allow mobility.
- Change the material from steel to concrete in the submerged portion of the platform to increase the life cycle of the structure.

Each module would be similar to a concrete semisubmersible platform we have seen in Chapter 8.

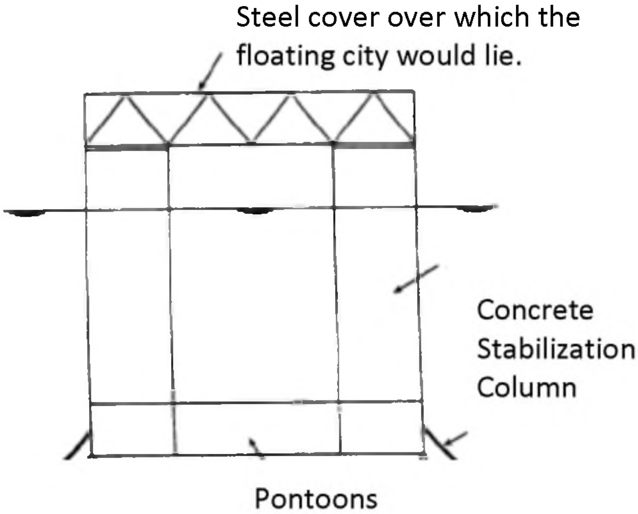


Figure 198: Diagram of a semisubmersible rig.

Then if one lines them up one, behind the other, it forms a MOB.

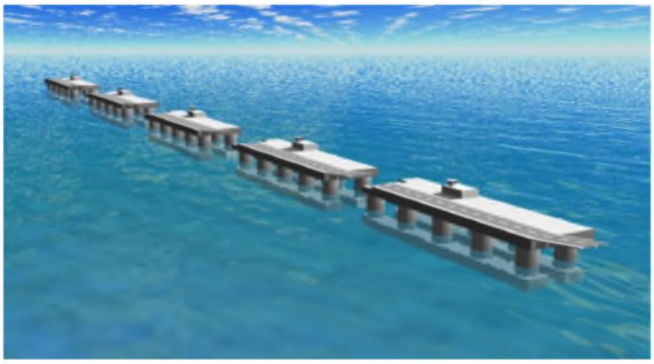


Figure 199: MOB, schematic view (62)

13.2.2.1 Geometry and Dimensions of the Hull

For the hull shape we have chosen the series of semisubmersible platform type GVA4000, this being a typical offshore platform for harsh environments. The GVA4000 is a typical semisubmersible platform for worldwide operations (104).

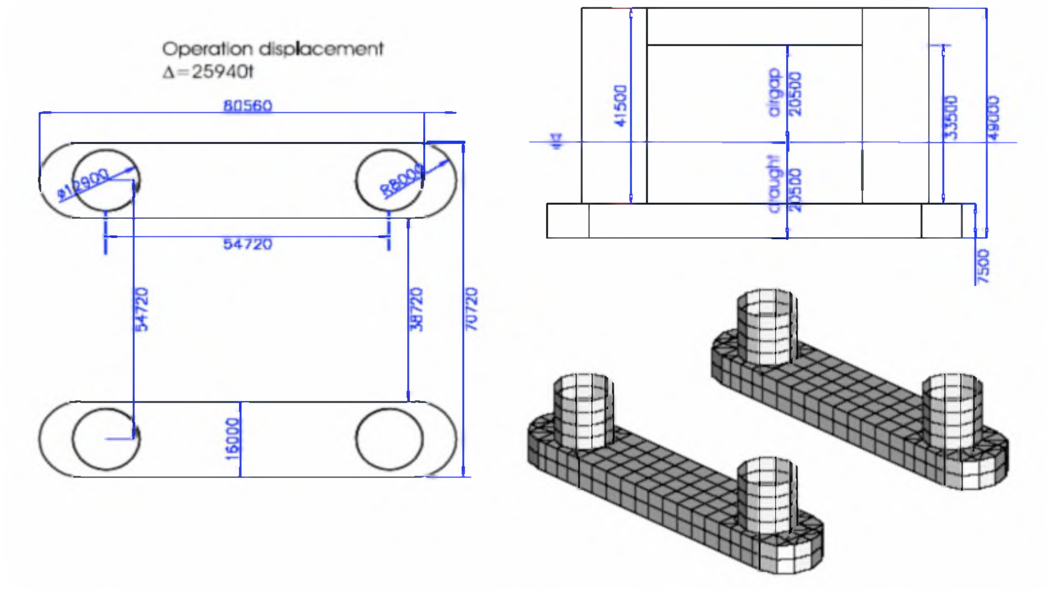


Figure 200: Dimensions (in mm) of the columns and pontoon GVA4000 platform (103)

The main interest of this new structure is not so much the behavior at sea, which we have already achieved with the Clubstead, but the speed and stability obtained on the way.

13.2.2.2 Survival

This structure is able to survive giant waves of 30 m.

13.2.2.3 Operational indices

We do not have indexes of operation of this structure, but as we saw in the chapter on flotels, there are several units that come from the series GVA2000 and GVA3000. So we understand that GVA4000 series will behave even better, and therefore provide adequate comfort.

13.2.2.4 Propulsion and Positioning System

Engines fitted would be "pod" types for propulsion and dynamic positioning, similar to any semisubmersible platform, as shown in the figure below.

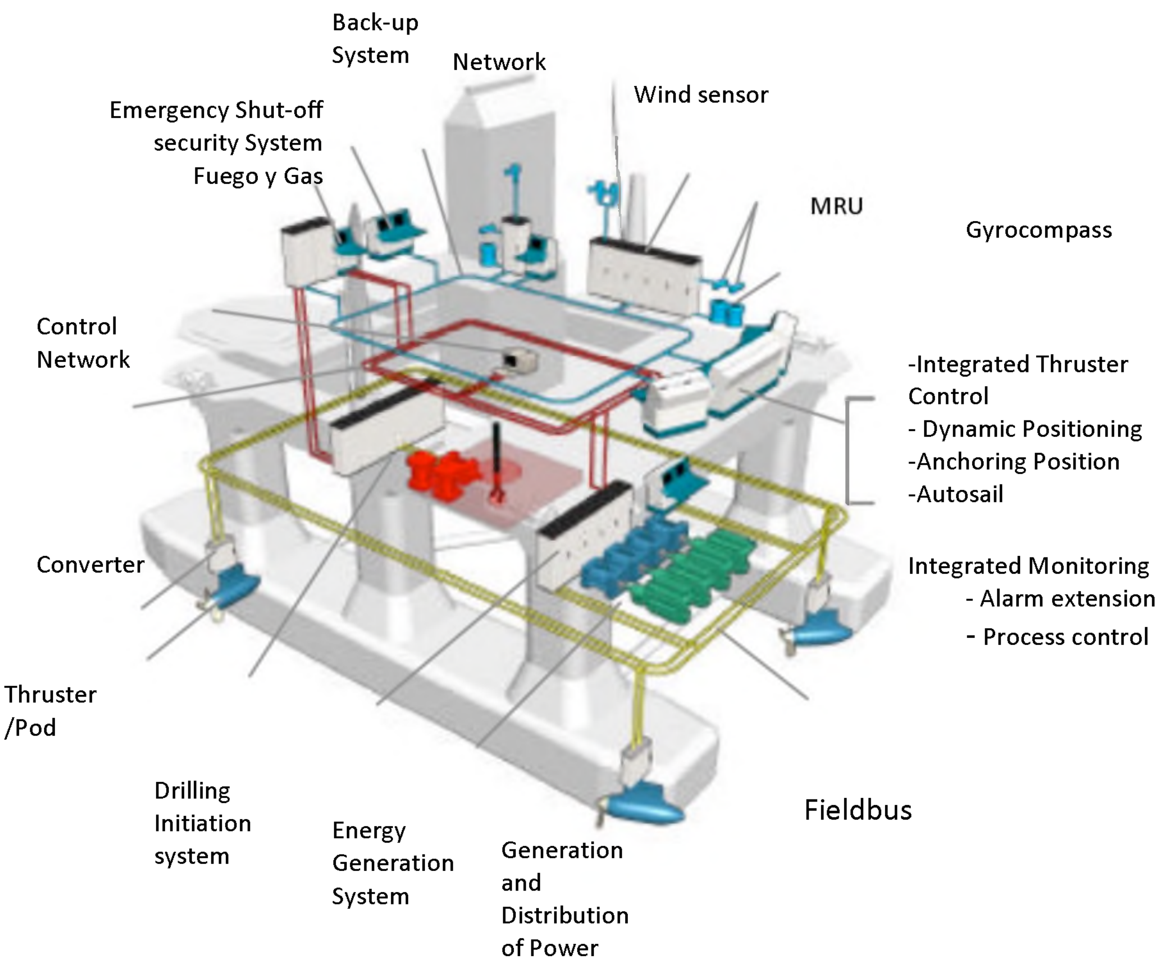


Figure 201: Example of the layout of the electrical system and DP semisubmersible drilling unit.

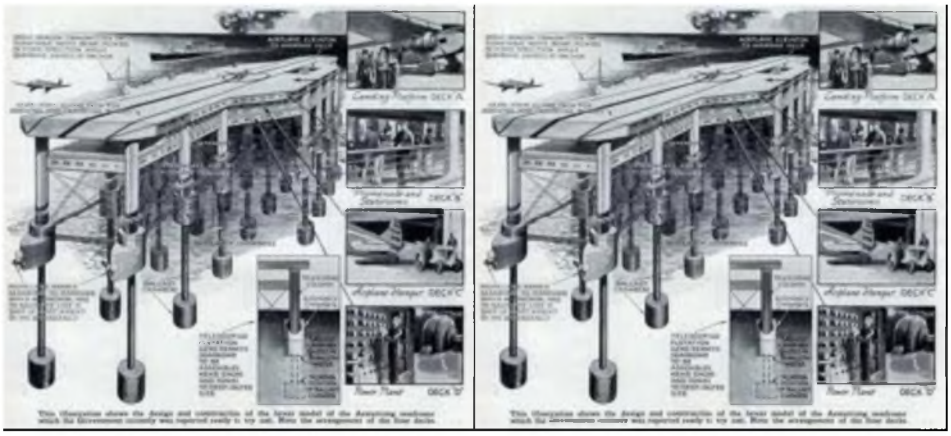
13.2.2.5 Structure Material

As seen in (77) the ideal for a semisubmersible concrete structure is:

- ND C60 for the base .
- LWAC LC55 level for columns.
- Over the columns would rest a steel structure that would be the basis for the ocean colony.

13.2.2.6 Conclusions

It is not the aim of the dissertation to design any structure. However, based on geometry and regulations described in Chapter 8 on concrete structures, it would be possible to outline what would be the proposed structure for the mid-term: a concrete semisubmersible.



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14.3 Table of Contents –Figures

14.4 Lista of Tables

14.5 Table of Contents-Graphics