International Journal of GEOMATE, March, 2026 Vol.30, Issue 139, pp.144-151
ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2026.139.g15334
Geotechnique, Construction Materials and Environment

FLOATING OFFSHORE AIRPORTS IN TAIWAN: FEASIBILITY AND ENVIRONMENTAL IMPACTS

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ABSTRACT: Offshore facilities like floating airports are emerging as viable infrastructure for urban and industrial purposes. Floating airports, built on pneumatic or light materials, can be positioned in deeper waters or farther offshore, offering advantages over traditional coastal airports. An offshore airport provides certain advantages for the planning of sustainable infrastructure: (1) reduced air pollution and noise effects for adjacent neigh borhoods; (2) safe operation during difficult weather conditions; (3) an airstrip away from other urban structures to prevent accidents during take-off and landing; (4) the extension of city centers that are built near the coast; (5) the possibility of green planning at areclaimed plot. If the airport is floating, this allows to position it even further away from the city center, to prevent noise and air pollution and to provide safety to city inhabitants in the event of accidents on the airport and during take-off and landing. We present here a detailed analysis on the feasibility for the construction of an offshore airport at above site from a planning and engineering perspective. This study synthesizes literature (1930–2025) to evaluate the planning paradigms, engineering feasibility, and environmental impacts of floating offshore airports. Utilizing a systematic review methodology, we analyze projects (e.g., Japan’s Mega-Float, Dalian Jinzhou Bay) and case studies (e.g., Taiwan’s South Star Project). Key findings indicate: (1) Pneumatic Stabilized Platforms (PSP) offer deep-water adaptability but face cost-accessibility trade-offs; (2) Reclamation-based airports reduce wave instability yet accelerate coastal erosion; (3) Taiwan’s experience highlights stakeholder conflicts in coastal development. We conclude that floating airports require multi-criteria feasibility frameworks balancing technical innovation with ecological safeguards.

Keywords: Offshore airport, Floating house, Harbor construction, Environmental impact, Sustainable development.

1. INTRODUCTION

The rapid growth of global air transportation, coupled with accelerating urbanization in coastal regions, has intensified spatial, environmental, and socio-political constraints on conventional land-based airport development. Major metropolitan areas increasingly face severe land scarcity, escalating construction costs, aircraft noise conflicts, and environmental degradation associated with large-scale reclamation projects. In parallel, climate change and sea-level rise pose long-term risks to coastal infrastructure, prompting renewed interest in adaptive and offshore-based solutions for critical transportation systems.

Within this context, floating offshore airports—typically constructed on Very Large Floating Structures (VLFS) or advanced floating platforms such as Pneumatic Stabilized Platforms (PSP)—have re-emerged as a potentially transformative alternative. By relocating runways and terminal facilities offshore, floating airports offer several theoretical advantages, including reduced aircraft noise and air pollution impacts on urban populations, enhanced operational safety during take-off and landing, and increased flexibility in spatial planning for densely populated coastal cities. Moreover, floating configurations enable deployment in deeper waters beyond the practical limits of conventional reclamation, thereby expanding the range of feasible sites for future airport development.

Recent literature (2021–2025) reflects a marked shift toward evaluating offshore airport feasibility through sustainability and resilience lenses. Studies increasingly employ dynamic life-cycle assessment (LCA) to compare the long-term environmental footprints of reclamation-based and floating alternatives, highlighting trade-offs among carbon emissions, seabed disturbance, and ecosystem service losses. Advanced computational fluid dynamics (CFD) and coupled hydro-elastic–structural models are now routinely used to simulate platform responses under extreme wave conditions, typhoons, and long-term fatigue loading. In parallel, research attention has expanded beyond engineering performance to include governance frameworks, social license to operate, environmental justice concerns, and stakeholder participation in coastal infrastructure planning [1,2,3,4].

In theory, issues and problems of land-based airports could be minimized by locating airports several miles off the coast. Takeoffs and landings would be over water, not over populated areas, thereby eliminating noise pollution and reducing risks of aircraft crashes to the land-locked population.

Since little of the ocean's surface is currently being used for human activity, growth and alterations in configuration would be relatively easy to achieve with minimal impact to the environment or to local residents who would utilize the airport. Water taxis or other high speed surface vessels would be a part of an offshore mass transit system that could connect the floating airport to coastal communities and minimize traffic issues.

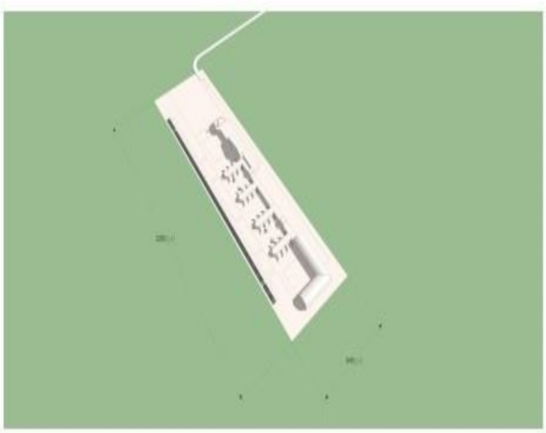

Fig. 1 Offshore floating airport with land connection.

Fig. 2 Floating airport close to the city-center.

A floating structure, such as a floating airport, is theorised to have less impact on the environment than the land-based alternative. It would not require much, if any, dredging or moving of mountains or clearing of green space and the floating structure provides a reef-like environment conducive to marine life. In theory, wave energy could be harnessed, using the structure to convert waves into energy to help sustain the energy needs of the airport [7,8].

Despite these advances, several critical gaps persist in the existing body of knowledge. First, most studies remain fragmented, addressing engineering feasibility, environmental impacts, or socio-political challenges in isolation, rather than within an integrated decision-support framework. Quantitative approaches that simultaneously balance structural performance, environmental dynamics, economic uncertainty, and stakeholder engagement remain scarce. Second, comparative analyses of competing technological paradigms—such as PSP-based floating systems, conventional land reclamation, and hybrid configurations—often focus on single performance indicators (e.g., construction cost or stability), providing limited guidance for site-specific decision-making that accounts for local bathymetry, ecological sensitivity, and governance context. Third, although floating airports are frequently promoted as climate-resilient solutions, empirical long-term monitoring data on operational performance, maintenance demands, and adaptive capacity under accelerated sea-level rise and intensifying storm regimes remain limited.

Taiwan's coastal development experience, particularly the prolonged stagnation of the South Star Project (SSP), exemplifies these challenges. While technically feasible reclamation-based airport expansion has been proposed for decades, unresolved environmental conflicts, funding constraints, and insufficient stakeholder integration have significantly delayed implementation. This case highlights the necessity of rethinking offshore airport feasibility not solely as an engineering problem, but as a coupled technical–environmental–governance challenge.

Accordingly, this study conducts a comprehensive literature synthesis spanning 1930–2025 to critically examine the planning paradigms, engineering feasibility, environmental trade-offs, and governance dynamics of floating offshore airports. By integrating global project experience with an in-depth examination of Taiwan's SSP, the research aims to provide a more holistic and policy-relevant understanding of offshore airport development under conditions of environmental uncertainty and climate change.

The remainder of this paper is structured as follows. Section 2 presents the research significance, emphasizing the novelty and originality of this study. Section 3 reviews modern floating airport projects and the core engineering technologies underpinning them. Section 4 examines coastal development challenges through an in-depth case study of Taiwan's South Star Project. Section 5 discusses climate change and sea-level rise as overarching drivers and constraints for offshore airport feasibility. Finally, Section 6 concludes with synthesized findings, practical recommendations, and directions for future research.

2. RESEARCH SIGNIFICANCE

This study advances the existing literature by transcending the traditionally compartmentalized analysis of floating offshore airports and instead proposing a comprehensive, interdisciplinary framework. This research reconceptualizes governance dynamics as an endogenous determinant of engineering feasibility. Taiwan’s protracted South Star Project serves as a critical empirical reference, illustrating how political contestation, regulatory uncertainty, and social acceptance directly shape technological and spatial design outcomes.

By synthesizing comparative insights from international precedents—including Japan’s decommissioned Mega-Float and China’s emerging Dalian offshore airport—within a unified analytical framework, this study foregrounds the inherent trade-offs, risks, and adaptive pathways associated with floating airport development. Ultimately, it offers a forward-looking evaluative tool for policymakers, planners, and engineers seeking to navigate the trilemma of metropolitan expansion, ecological sustainability, and infrastructural resilience in densely populated coastal regions.

3. MODERN FLOATING AIRPORT PROJECTS

The concept of a floating offshore airport, an aviation facility constructed upon a Very Large Floating Structure (VLFS) positioned kilometers out to sea, represents a radical reimagining of transportation infrastructure. Utilizing advanced flotation technologies such as Pneumatic Stabilized Platforms (PSP), these structures aim to decouple major aviation hubs from land-based constraints. In an era of rapid urbanization, escalating land values, and heightened environmental awareness, VLFS-based solutions like floating airports are increasingly scrutinized as potential answers to persistent urban challenges: mitigating land-use conflicts, eliminating aircraft noise pollution over populated areas, and substantially reducing the community risk profile of aviation operations. The scope of this innovation extends beyond isolated infrastructure projects, intersecting with critical global discourses on sustainable urban expansion, blue economy development, climate change adaptation, and marine spatial planning.

The intellectual lineage of the floating airport traces back to the pioneering days of long-distance aviation. The January 1930 issue of Popular Mechanics featured a proposal for a stabilized, leg-supported platform in the Atlantic Ocean, resembling contemporary offshore oil rigs, intended as a mid-ocean refueling station for trans-Atlantic flights [15]. This was followed in 1935 by the famed aviator Louis Blériot's advocacy for "Seadromes" to enable economical trans-oceanic passenger travel [18]. Although technologically premature, these early visions established the core rationale: overcoming geographical barriers. The modern revival of this concept is driven by the recognized ecological and economic limitations of large-scale land reclamation—such as habitat destruction, sediment disruption, and colossal costs—coupled with the urgent imperative to develop infrastructure resilient to sea-level rise. Contemporary applications of VLFS technology now span floating cities (e.g., the "Oceanix" concept), floating solar and wind farms, logistics hubs, and even data centers, underscoring its transformative potential across sectors.

In 2000, the Japanese Ministry of Land, Infrastructure, and Transport sponsored the construction of Mega-Float, a 1000-metre floating runway in Tokyo Bay. After conducting several real aircraft landings, the Ministry concluded that floating runways' hydro-elastic response would not affect aircraft operations, including precision instrument approaches in a protected waterway such as a large bay. The structure has been dismantled and is no longer in use.

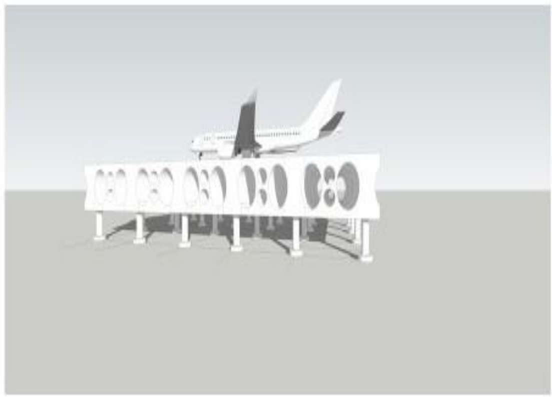

Fig.3 Parti view of aircraft moving on airport-ponton.

The pneumatic stabilized platform (PSP) was proposed as a means for constructing a new floating airport for San Diego in the Pacific Ocean, at least three miles off the tip of Point Loma. However, this proposed design was rejected in October, 2003 due to very high cost, the difficulty in accessing such an airport, the difficulty in transporting jet fuel, electricity, water, and gas to the structure, failure to address security concerns such as a bomb blast, inadequate room for high-speed exits and taxiways, and environmental concerns. Its primary lies in the systematic integration of advanced marine engineering solutions (such as PSP and hybrid VLFS configurations), dynamic environmental impact assessment grounded in recent life cycle assessment (LCA) scholarship, and the socio-political governance complexities inherent to contested coastal spaces.

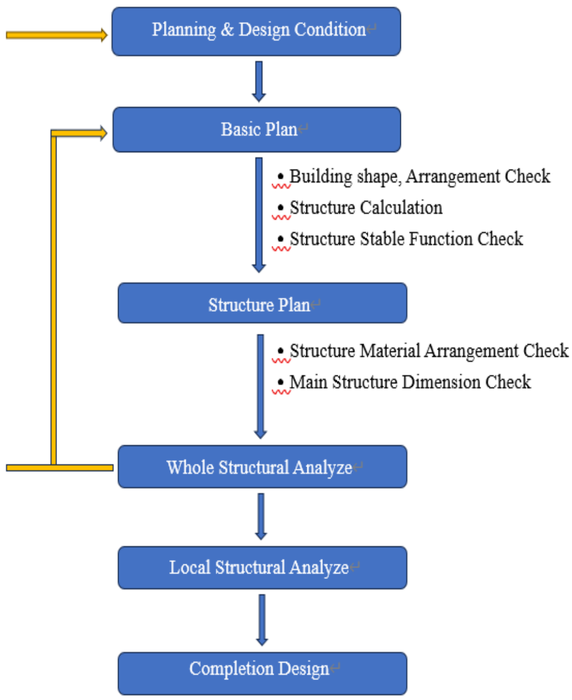

Fig.4 Planning and design flow chart of offshore airport.

Achmad Yani International Airport, the first floating airport in the world started construction on 17 June 2014, and had to be completed in 2016. However, only the passenger terminal and apron is floating.

Dalian Jinzhou Bay International Airport is mainland China's first offshore floating airport. The project was officially approved in October 2022 and is currently under construction.

Table 1: Comparative Analysis of Floating Airport Technologies

Technology	Cost (USD/ km²)	Stability	Environmental Impact
PSP (San Diego)	$12B	High (deep water)	Low seabed disruption
Reclamation (Kansai)	$20B	Moderate	High habitat loss
Hybrid (Dalian)	$8.5B	High	Moderate (turbidity)

4. COASTAL LANDS – TAIWAN CASE STUDY

Due to the fragility and sensitivity of coastal resources, once destroyed, they are extremely difficult to recover, in addition to reducing the value of water and product quality Ying want open outside, and environmental hazard, harm homeland security, the threat of people's lives and property, causing social problems. Therefore, the use and management of coastal zones require special care, under the principle of conservation of resources and development of both resources, according to the ecological characteristics and economic development needs resources, coastal resources for the overall planning and evaluation, are sequentially partitioned, so can the coastal zone be sustainably developed.

Coastal and soil erosion has always been a problem for many island countries like Taiwan [17]. In addition, many countries engage in massive reclamation (coastal modification) as a result of the rising awareness of population growth, trade development, and national defense. For example, Dubai engages in massive reclamations for trade and tourism, Japan built Kansai International Airport for transportation, China spent billions of RMB on land reclamation for military purposes and the constructions of airports (REF DALIAN), and the South Star Project (SSP) of Kaohsiung in Taiwan is being evaluated [27].

Due to the rise of environmental awareness in recent years, the objection of environmental groups and nearby residents, and fund shortages, SSP is still under construction after 30 years. We are facing several questions [18]. Should the SSP be continued? What should be done to cope with the incessant coastal and soil erosion of island countries (Taiwan)? Is land reclamation the only solution? How to manage coastal modifications on the long run? What are the funding sources for such a huge project? Should we consider and listen to the opinions of environmental groups and nearby residents? If so - how to gather their opinions? How many stakeholders should be considered? What should be done after listening to their opinions? All of these questions gradually emerge.

Taiwan's southwestern coast exemplifies tensions between infrastructure planning and environmental resilience. The South Star Project (SSP) delay underscores engineering-feasibility challenges in sediment management (Fig. 6–9) and environmental-impact conflicts with coastal communities [18]. Unlike Japan's Mega-Float, SSP's 30-year stagnation reflects inadequate stakeholder integration—a critical planning gap for floating infrastructure.

After understanding the geographical location and surroundings of Taiwan and the problems Taiwan is facing, we should start with the following:

(I)Finding examples of reclamation and labor-consuming and money-consuming projects that benefit future generations at abroad and learn from them.

(II)Understanding possible pollution and waste sources that come along with reclamation.
(III)Investigating the sources and flows of funds for reclamation and how the government invests in and solicit investments in such projects.
(IV)Investigating future trends of land reclamation in Taiwan or using coastal water surfaces in different ways.

4.1 Overview of coastal Taiwan Land Use

The marine environment is an invaluable property of mankind. Land reclamation is one way of making use of coastal shallows which can be developed to different types of economic use, such as for accommodation, cultural, conservation, but also for industrial and purposes of infrastructure. The reclamation of land by building an artificial island is achieved by the construction/repair of bank revetments around the perimeters before combining those with existing islets with sand or landfill. An artificial island is primarily used as a site for shallow water petroleum exploration or the reception of large tank ships or transportation of minerals. Floating cities (seasteadings) are basically large steel constructions that are partially submerged in the ocean [10]. They are usually modified from naval vessels that were formally used for marine development activities (i.e. floating cities above large deep-sea mines that serve as multifunctional complexes to provide accommodation, shopping and event entertainment for miners) [11].

The development of offshore airports has been an ongoing trend worldwide. Examples of offshore airports on reclaimed land include the Honolulu International Airport of Hawaii [26], and Japan's Nagasaki Kansai Airport [14]. In fact, the government actually planned the construction of an offshore airport before the Taoyuan International Airport was built. However, due to rigorous protests by local elected representatives, concrete development of the project has yet to take place.

Fig.5 Japan's Nagasaki Kansai Airport

4.2 Offshore land reclamation

In 2009, the typhoon, Morakot brought a lot of mud which sedimented in the river estuary of Kao-Ping River, Taiwan government and local Kaohsiung government planned to use the sediment for the Nanhsing project area. Therefore, Taiwan government hopes to re-promote Nanhsing project in order to develop the urban area of Kaohsiung. Because of the heavy sediment brought by Morakot, the downstream of Kao-Ping river was sedimented, these sands could be used for land reclamation to develop harbor, offshore airport and bigger industries. It could also increase the financial development and be used as the base of Kaohsiung airplane.

The SSP project is proposed to be built near the existing Kaohsiung airport and the second harbor, which is 3 km by 1 km. It was expected to be built at 3 square kilometer and was planned to be replacing the existing Kaohsiung airport and become the international airport of the South. However, since no funding was received from the government, the plan was postponed.

Fig.6 South Star Project (SSP) of Kaohsiung in Taiwan

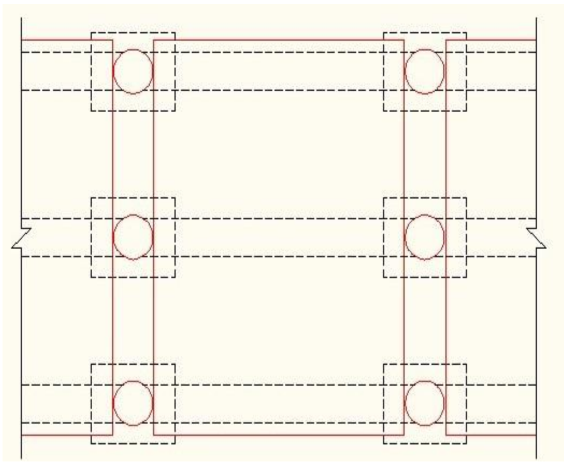

Fig.7 Plan -South Star Project (SSP) of Kaohsiung in Taiwan

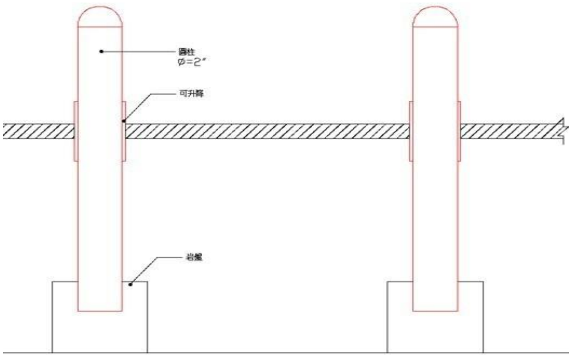

Fig.8 Elevation-South Star Project (SSP) of Kaohsiung in Taiwan

Fig.9 South Star Project (SSP) of Kaohsiung in Taiwan

4.3 Advantages of an Offshore Airport

Developing Offshore airports is a trend in the world, and we concluded three merits as follows: Firstly, the plane could take off or land at night, because the offshore airport is far away from the city and could fly or land at anytime without disturbance by the night. Second of all, because of the long distance between offshore airport and the city, the noise and air pollution could be reduced [10,13]. In addition, it could make the flyway clear which could reduce the judgment error about the plan landing (Take the event happened in Da-yuan & Singapore as examples.) PLUS land space use! More and more construction space is needed and becomes a major problem all over the world. Namely, how to use the spaces more properly has become the major point in the transportation design. The bigger space the more quantities, efficiency and more importance. the floating airport was under precise calculation and integrated with several techniques.

5. GLOBAL WARMING, CLIMATE CHANGE, AND SEA LEVEL RISE.

In light of global warming and climate change, NOAA (National Oceanic and Atmospheric Administration) is predicting that, by 2050, most coastal cities in the U.S. likely will be threatened by at least 30 days of fooding each year.3 That is for coastal cities on the Mainland. Islands in the Pacifc (including Hawaii) will likely have it much worse. Moreover, reputable scientists are saying that, by 2100, the oceans will rise between 2.5 and 6.5 feet feet (0.8 and 2 meters), which is more than enough to food many U.S. coastal cities. That is enough for a lot of concern and worry[25].

This research will review existing knowledge on global warming and climate change, particularly in terms of sea level rise. It will examine how much of a threat global warming really is, and suggest that it is, in fact, serious enough that major preparations should begin now. It will look at the causes of global warming and consider the reasons for the controversy that has surrounded it. The research will report on what might happen in the future and take a look at what has already started happening around the world, and here in Hawai‘i, as a result of global warming and climate change. It will present what the international community has recommended be done to slow down the process of climate change, and look at comments made by the president of the U.S. as he speculates on what might be coming up in the future.

Unfortunately, short of eliminating all greenhouse gasses from the atmosphere, the literature tells us that there are no permanent solutions to the problem of climate change and sea level rise. There are, however, various recommended strategies to manage or mitigate global warming, and they will be examined here, culminating in a focus on foating development, not as a solution to the problem, but as one strategy among a number of strategies to mitigate the problem.

This research document briefly reviews existing knowledge of global warming and climate change, along with the consequences. It examines sea level rise, and briefly discusses the controversy that still lingers, allegedly because of what oil companies have done. It goes through strategies for mitigating sea level rise, with a final focus on floating development, not as a solution, but as one of a number of suggested ways to mitigate the problem of sea level rise.

6. CONCLUSION

This comprehensive synthesis of literature spanning from 1930 to 2025 has critically examined the multifaceted concept of floating offshore airports, analyzing their planning paradigms, engineering feasibility, environmental trade-offs, and governance dynamics. The findings underscore that the development of such infrastructure represents not merely a technical challenge, but a complex, interdisciplinary endeavor situated at the intersection of marine engineering, environmental science, urban planning, and socio-political governance. Key conclusions can be articulated across four interconnected dimensions, providing a holistic framework for future decision-making.

(1) Planning: Floating airports mitigate urban noise but require integrated transport links (water taxis/undersea tunnels). (2) Engineering: PSP technology suits deep-water sites; reclamation remains cost-effective for <30m depths. (3) Environment: Artificial reefs enhance marine biomass, but dredging elevates turbidity (Taiwan's SSP case). (4) Policy: Taiwan's experience urges early engagement with NGOs/residents in Environmental Impact Assessments.

7. FUTURE DIRECTIONS AND RECOMMENDATIONS

Floating offshore airports present a visionary, adaptive response to the converging pressures of urbanization, climate change, and sea-level rise. However, their pathway forward necessitates a decisive shift from siloed, techno-centric planning to an interdisciplinary, multi-criteria decision-support framework. Future research should prioritize: (1) Developing integrated assessment models capable of simultaneously evaluating structural performance, full lifecycle environmental costs, socio-economic impacts, and climate resilience;(2) Enhancing long-term monitoring and data collection on the operational performance and environmental effects of existing or emerging offshore airports (e.g., Dalian); (3) Exploring innovative financing models and public-private partnerships tailored for large-scale floating infrastructure; and (4) Conducting comparative studies on governance models and stakeholder engagement effectiveness across diverse geopolitical and cultural contexts.

In summary, the realization of a floating offshore airport is not only a test of marine engineering prowess but also a profound exercise in how societies navigate the trilemma of development, ecological stewardship, and social equity. It demands a collaborative endeavor where planners, engineers, policymakers, and communities work in concert to forge resilient and responsible pathways amidst uncertainty. The floating airport, therefore, stands as a symbol of both the immense potential and the profound responsibility inherent in humanity's future engagement with the ocean.

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