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Oil Rig and Superbarge Floating Settlements

Springer

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Preface

Floating cities have long been part of architectural and engineering history. Although contemporary versions have intensified in the last few decades, they are conceptually similar. They exist as structures built on modular platforms, which float directly on water and can be connected into larger surfaces. Unlike these typologies where the architecture exists above the raft and can be anything, this book explores the structures of oil rigs as elements of form to define space in new architecture.

An architecture of high-density configurations was made from megastructure vessels, which can be towed or sailed to locations with benign environments and anchored in a range of settlement forms to meet emergent need for human habitation in an age of rising sea levels. This book is an outcome of my design research studio with students in the Masters of Architecture Programme at the National University of Singapore.

I would like to thank my students—Christopher Wijatno, Davis Wong, Chen Qisen, Wang Yigeng, Sakinah Halim, Bek Tai Keng, Roy Tay, Nazirul Salleh, Judy Lee, Khairul Anwar, Cao Jinming, and Chen Shu Hua, without whose efforts this book could not have been written.

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Singapore, Singapore — Joseph Lim

Introduction

This study began with the idea of repurposing oil rigs. To contextualize the task beyond isolated conversions, a wider platform for investigation was used to garner design research propositions responding to emergent need in the light of climate change. Vessels from the oil and gas industry were repurposed to offshore and nearshore settlements as counterpoints to megacities in an effort to create ecological footprints that are more sustainable. The continued depletion of natural resources leading to land and resource scarcity has resulted in frequent displaced communities worldwide.

Questions concerning alternative forms of settlement have led to explorations at sea. What if we floated on water instead of consuming land inefficiently? And could we use wave energy instead of nuclear energy? Could we replenish food supply and regenerate marine eco-diversity? How would our lives be shaped by new offshore settlements? What would we use as structures for shelter, farming scaffold, and recreation?

Floating cities emerged in the 1960s with Buckminster Fuller's Triton City and Kenzo Tange's A plan for Tokyo. Current manifestations include Vincent Callebaut's Lilypad, the Seasteading Institute's Floating Cities, and the mile-long Freedom Ship accommodating 60,000 people. As an alternative to these examples, three types of vessels in the oil and gas industry, namely, the jack-up platforms, the semi-submersibles, and the superbarges are repurposed as small footprint habitable propositions to accommodate 20 percent of a projected global population of 8.1 billion people in 2025 (United Nations).

Floating settlements are spatially conceived with food and energy estimates for housing, recreation, and education at sea, as well as post-disaster healthcare and resettlement for nearshore deployment. Population densities of oil rig floating settlements exceed those of current proposals using modular rafts and are closer to a viable proposition addressing the issue of population growth.

This book explores the idea of repurposing oil rigs and barges for human habitation in nearshore and offshore marine settlements. It suggests developmental options to cold stacking or decommissioning oil rigs with serviceable physical structures or the immediate deployment of recently constructed oil rigs in a depressed market when operational costs will not yield returns.

Chapter "Industry Challenges as Basis for Repurposing Oil Rigs and Barges" discusses the environmental threat of the oil and gas industries at all stages of exploration, operation, and decommissioning, to marine ecosystems. The scale of the technical complexities and financial implications is a challenge to both environmentalists and industry seeking to protect the environment. The reuse of the abandoned structures to minimize disruption to marine ecologies is one alternative. However, the periodic occurrence of unused good condition rigs due to oil price fluctuations and time lags in construction is costly to owners. Thus, they may explore viable solutions through repurposing. This study focuses on the repurposing of jack-ups and semi-submersibles as they have tall structures and/or a wide range of deck areas to explore additional built-up areas. The implications of adding more useable floor area and increasing structural load pose challenges to capsizing. Design strategies depending on the type of rig are discussed to overcome instability and to give an idea on cost implications.

Chapter "Intensifying Food and Housing at Sea" portrays emergent need in the context of climate change and rising global population and proposes as counterpoints to megacities, resilient offshore and nearshore solutions to food production and supply, energy and wastewater management. Jack-ups, semi-submersibles, and barges are repurposed into specialized vessels. Of key interest is a typology of a high-density housing on jack-up or semi-submersible to meet the rising population in capacities that surpass cities on modular floating rafts. The spatial quality of the architectural conversions capitalized on the use of derrick and deck structure, moonpool and pontoons, to create spaces for communal gathering and for recreation. Infrastructure became architecture. The density and living quality of these propositions are explored through their range of communal recreation spaces. These are benchmarked with those of landed housing blocks in Singapore and landmark international examples.

Chapter "Optimal Settlement Size and Masterplan Strategies" studies the optimal sizes of flotillas, which attempt a circular economy involving aquaponics production and fish farming to support population sizes adequately sustained by renewable sources of technology. Estimates of capacity are made from specialized vessels designed for accommodation, food production, waste management, and medical care. These are then grouped into flotillas for 40,000 persons to be agglomerated into entire settlements. The vessels will each form elements of water-townscapes where city square is interpreted as a water court between vessels docked in specific configurations; water foyers beneath semi-submersible decks used as outdoor living spaces; and wharfs for recreation and commerce. Combinations of flotilla forms generate variants of entire settlements using jack-ups for up to 40 m depth of water and semi-submersibles for deepwater locations. The population densities of these settlements are compared with those of current floating cities, township densities in Singapore, and other high-density cities. Using UNESCO guidelines for offshore settlements to estimate the spacing between settlements, these autonomous settlement fleets conceived as sea cities occupy 38 sq. km of sea space and are an alternative to land-based mega cities accommodating 100,000 persons per sq. km. 20% of the projected population in the year 2025 can be accommodated on 6,510 oil rig settlements spaced 240 sq. km apart over 54.25 M sq. km of sea. Related to high-density settlements is the concern with environmental quality through the provision of public space. One indicator is the rate of recreational area per person. The space standards of each marine inhabitant—at 50 sqm recreational area per person—exceed 27 sqm in London, which is equivalent to Amsterdam, with one settlement type reaching 115 sqm per person equivalent to Vienna. Singapore by comparison has 65 sqm of recreational area per person.

Chapter "Post-Disaster Applications for Displaced Populations" generates a separate fleet of floating settlements for post-disaster relief operations. Given an increase in the frequency of natural disasters caused by climate change, there is a corresponding increase with the number of displaced populations. For both climate and political refugees, the timeliness of aid for survival is not the only issue. Beyond the immediate need of restoring damaged infrastructure and providing medical aid for survivors is their long-term rehabilitation and recovery. The United Nations (UN) guidelines for post-disaster and humanitarian aid are adopted for response times in providing aid with a flotilla comprising semi-submersibles converted into a 1,500-bed hospital. UN space standards for post-disaster housing are fitted in superbarge accommodation units with additional units for cremation, parks, and farm plots to enable survivors to start up activities for self-subsistence. The idea is not only to create a fully deployable fleet for immediate disaster relief, but also to provide housing, production, and communal facilities for establishing and maintaining a settlement in the long term.

Chapter "Other Forms of Repurposing" explores six specific applications when repurposing oil rigs into specialized vessels. The proposals are premised on nearshore/offshore prototypes which improved by design, the challenging issues of inefficient land plot requirements (e.g. prisons, funeral facilities, resorts) or unsustainable business models (e.g. Olympic stadia) or which improved industrial workflow (e.g. LNG bunkering). This leads to a streamlining of processes saving time and land resources. A jack-up funeral complex integrates wake halls,

chapels, funeral parlors, and crematorium in a single nearshore facility. With the exception of religious burial practices, cremation is a land-saving option with the advantage of resource recovery.

A prison on a semi-submersible is a solution to unsanitary conditions of many prisons worldwide that are operating in severe overcapacity. An offshore prison obviates the need for land set aside for incarceration of future convicts. It is designed for the rehabilitation of inmates involved in daily routines of farming production and acquiring skills for communal integration upon release. Design strategies provide higher cell capacity with fewer prison staff in a compact form. This facility uses waterscapes for recreational sporting activities and moats as escape prevention.

The construction of sports stadia for the Olympics and the FIFA World Cup series in separate cities is often a risky financial investment when stadia were underutilized in post-event scenarios. The proposal is for a fleet of semi-submersibles converted into floating stadia capable of staging international sporting competitions involving games, courts, and fields and which can be mobilized and reused at sea. The facility can be leased intermittently to organizations that may not have the means for large capital investment, but that can rent a number of semi-submersible stadia and recover costs through ticket sales.

Conventional port planning separates bunkering facilities from transshipment hubs, which sort out container cargo for re-exports. This proposition uses jack-up oil rigs arranged radially to integrate LNG bunkering with wharves in a nearshore facility to reduce time taken for loading and unloading cargo separately from time needed for bunkering. This facility is designed with the turning radii of tankers and cargo ships to maximize the number of berths in a single facility with a sizeable cargo TEU turnover. It can be conceived as a satellite facility to improve port efficiency.

With jack-up rigs, recreational parks requiring large amounts of water can be placed nearshore so as to free up coastal land for strategic and essential developments. Larger deck and airspace come from combining two jack-ups. A water treatment facility minimizes the high volume of water and energy usage by designing the layout of water rides in ways to minimize water pumping. Most significantly, the large ecological footprints can be avoided in the proposed jack-up waterpark.

Resort developments on coastal land risk damage to sensitive marine ecosystems. The proposition of offshore resort to mitigate environmental impact is explored with a semi-submersible rig and a jack-up rig of 5,000 sqm deck area, to accommodate the number of hotel rooms and a range of facilities recommended in the hospitality industry. Accessible by sea vessels, these studies have capacities larger than the Seaventures Dive Resort on a converted jack-up rig off Sipadan, Borneo in the Celebes Sea.

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About the Author

Dr. Joseph Lim is Associate Professor and Director of the Masters of Architecture Programme at the Department of Architecture in National University of Singapore. He has a special interest in prototypical structures addressing emergent spatial and environmental need. His design projects have won SIA Design Awards and international awards including an Honorable Mention for Lee Treehouse at the Kenneth F. Brown Asia Pacific Culture and Architecture Design Award in 2003; and a Merit Win for Dragon Bridge in URA Southern Ridges Bridge International Design Competition in 2004. Joseph's focus in Industry and Infrastructure explores land intensification through architectural investigations, which have significant implications on the planning of future settlements, townships and infrastructure. In 2008, he pioneered corporation-funded design research studios, collaborating with Jurong Town Corporation in 2008–2010. Maritime and Port Authority of Singapore-funded research studio followed in 2014, which explored an urban design study for Tuas Port 2027 and was exhibited at the Singapore Maritime Week Exhibition and SG50 NUS Exhibition in 2015. The research studio was also featured in a Channel News Asia documentary—Futuropolis Episode 2: Keeping Afloat televised in 2017—on the effects of rising sea levels and the viability of floating settlements. Joseph is the author of Bio-structural Analogues in Architecture (2010) and Eccentric Structures in Architecture (2012); both publications are in their third reprint and have been translated in Korean and Chinese languages. His latest publication, Skybridge investigates forms of air rights structures built over Ayer Rajah Crescent, Singapore and the research conclusions were presented at the Jurong Town Corporation i3C Symposium on Industrial Infrastructure Research in 2017.

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