Marine Innovation & Technology
2610 Marin Ave.
Berkeley, CA 94708
USA
Tel: 1-510-931-6135
Fax: 1-415-665-6045

Client:
The SeaStead Institute

Title:
ClubStead Preliminary Analysis:
Global Sizing

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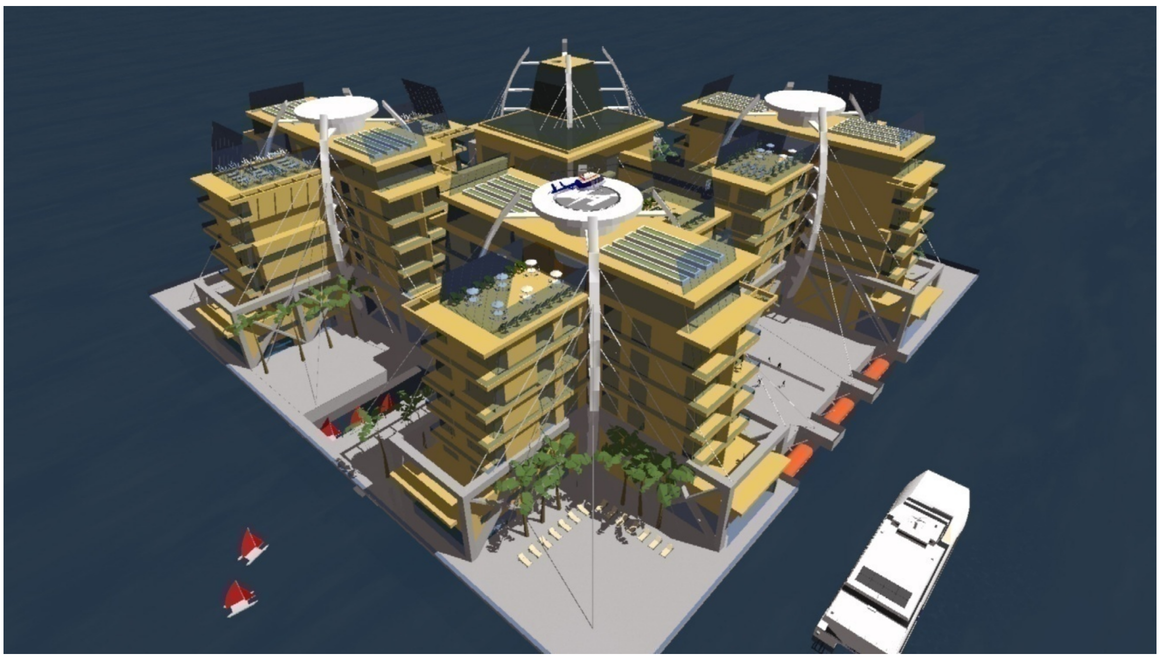
ClubStead Preliminary Analysis: Global Sizing



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1. Introduction

This document summarizes the main dimensions and particularities of the ClubStead. The ClubStead is a living ocean-going facility that can carry 270 people, including 70 staff members. It was designed by MI&T for The Seasteading Institute (TSI) to meet the criteria outlined in the attached design basis. The resulting platform is column-stabilized to optimize the hydrodynamic behavior and stay cables are used to suspend open areas off the deck to maximize the available living space.

2. General Dimensions

2.1. Global Sizing and Views

The general dimensions of the ClubStead are summarized in Table 1.

Table 1: General Dimensions of ClubStead

COLUMNS			
	Number of columns / units	**4**	
	Column diameter	41	ft
	Hard Tank Diameter	76	ft
	Hard Tank Height	20	ft
	Draft	75	ft
	Airgap	40	ft
DECK			
	Number of trusses	4	
	Width of truss	50	ft
	Height of truss	40	ft
	Distance column to column	200	ft
	Length of extension	100	ft

Figure 1 and Figure 2 illustrate the main dimensions of the platform. The bottom view shows the relative size and position of the columns with respect to the deck as well as the diameter of the footing at the bottom of column.
In the side view, the air-gap of 40 ft between the mean waterline and the bottom of the buoyancy module is shown.

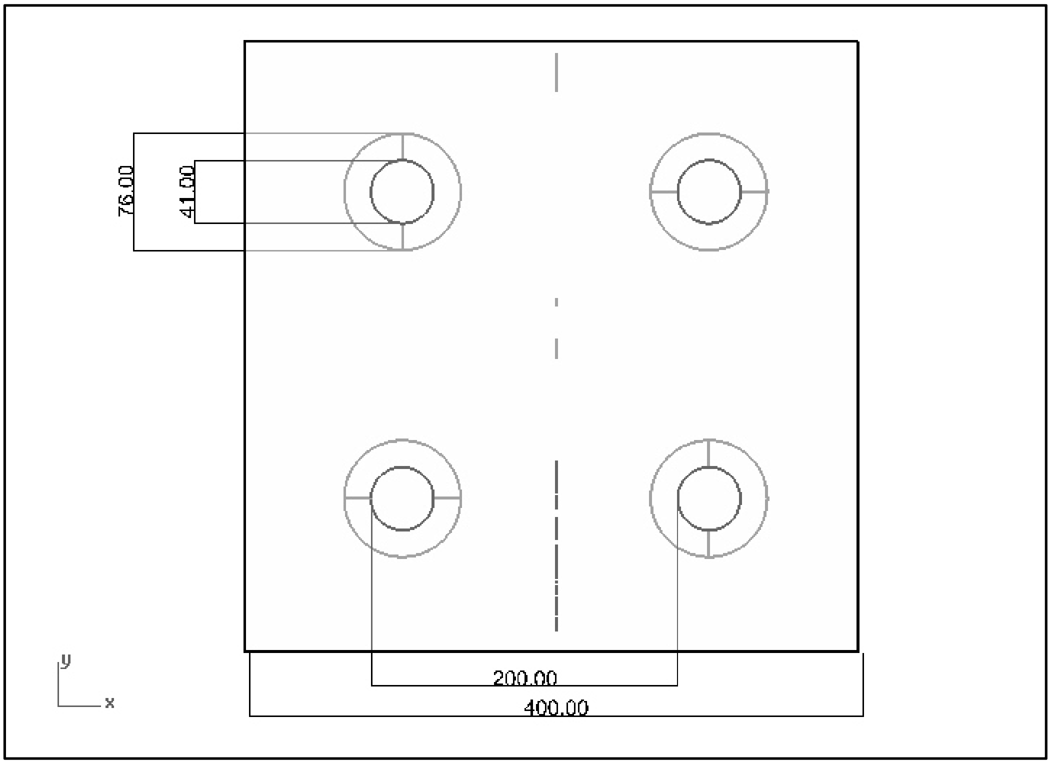

Figure 1: Bottom View of ClubStead

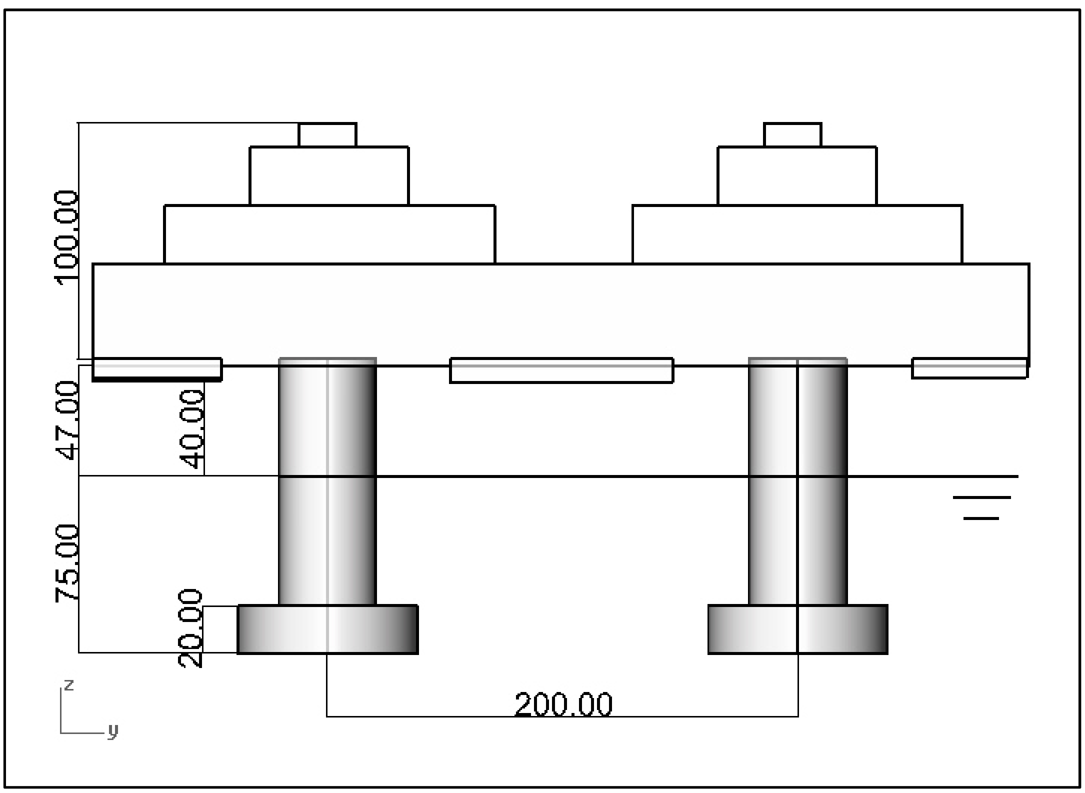

Figure 2: Side View of ClubStead

2.2. Mass Properties

Table 2 summarizes the weight of components of the ClubStead. They are divided into the main categories: structure, payload, live loads and ballast. The displacement of the platform is 20,908st.

Table 2: Weight Summary of ClubStead

Structure:			
Column steel (below deck)		3458	st
Tower steel (including cable supports)		591	st
Truss and deck steel		1944	st
Cables		84	st
Appurtenances		10	st
Buoyancy module		928	st
	Total structure	**7016**	**st**
Payload:			
Machinery (electrical, auxiliaries, propulsion)		414	st
Living Areas + Open areas		7705	st
	Total	**8118**	**st**
Live loads:			
Passengers		25	st
Operators		9	st
Diesel		541	st
	Total	**575**	**st**
Ballast:			
Water in columns		2091	st
Variable (including water stored for consumption)		3109	st
	Total	**5200**	**st**
Total weight:		**20908**	**st**
Total structure:		**15100**	**st**
Hull + Primary Structure:		**7016**	**st**
Ballast + future extension		**5200**	**st**

The center of gravity of the platform is computed based on the center of gravity of its components. The distance of the center of gravity from the keel is KG and is 94.5ft. The upward distance of the center of gravity from the mean waterline is referred to as OG and is equal to 19.5ft.

Table 3: Center of Gravity of ClubStead

APPARENT CENTER OF GRAVITY HEIGHT KG		
columns/appurtenances	43.4	ft
truss and deck	133.0	ft
towers and cables	175.0	ft
live loads (except diesel)	163.7	ft
buildings and living facilities	163.7	ft
ballast and diesel	4.9	ft
buoyancy module	120	ft
KG	**94.5**	**ft**
OG	19.5	ft

3. Architectural Features

The ClubStead is designed to provide housing to 270 people as well as extensive recreational and business spaces. The architecture is described in the accompanying report “ClubStead Preliminary Analysis: Architecture”. A total of 368,200 ft^2 are available on the platform, including indoor and outdoor space. Assuming buildings weigh 50lb/ft^2 and outdoor spaces weigh 30lb/ft^2, the total payload on the ClubStead is 7,705st.

4. Stability in Installation and Operations

The installation process described in the “Construction and Installation” report takes a modular approach to construction and installation. The stability of each module before installation is required. In calm seas, it means that the metacentric height must be positive. The column standing upward on its footing has a metacentric height (GM) of 0.7ft. The draft of a column in transit is 16ft, which provides the 20ft-high footing with a 4ft freeboard. The GM of the deck modules supporting the buildings is 0.6ft for the small ones, with a draft of 6.8ft and a 3.2ft freeboard on the 10ft high buoyancy module below the deck.

In operations, the GM is 13.8ft. The robustness and stability of the design in operations is validated by time domain numerical analysis. The distance between the tip of the deck, at the bottom of the buoyancy module, and the top of the wave crest is always larger than 5ft off the coast of San Diego, CA. The heave natural period of the ClubStead is 17 seconds.

To comply with safety requirement for passenger vessels [1], the columns are compartmented. If damage occurs at one compartment, due to collision for instance, the platform must remain stable. Vertical bulkheads and watertight flats limit the amount of flooding in a column so the metacentric height remains positive in all damage conditions.

5. Structure

The sizing of the primary structure of the deck with a finite element model is described in the report "Structural Analysis". The analysis goal is to determine the amount of steel needed to support the payload and the squeezing and prying modes of the columns in waves. Tubular elements are used for the trusses and the flat open areas.

Table 4 summarizes the weight of trusses and supporting beams on the deck upper structure.

Table 4: Weight Summary of Primary Upper Structure

Description	Number per ClubStead	Total Weight (st)	Total Weight for Design (+10%) (st)
Primary Deck			**1911**
Main truss between columns	4	1145	
Cantilevered truss	8	397	
Corner open surface area	4	37	
Side open surface area	4	132	
Center open surface area	1	57	
Towers			**591**
Central Towers	4	353	
Vertical pipes for cable support	16	185	
Cables	96	76	**84**
	TOTAL	**2381**	**2620**

The structural weight of the columns and buoyancy module is based on volumetric ratios from similar structures. The column is assumed to weigh 8lb/ft^3 of displaced volume, which results in 3,458st. The buoyancy module weighs 4lb/ft^3 of displaced volume, and represent 928st of the structural weight.

6. Energy Needs and Propulsion System

To avoid the expenses of a mooring system and preserve the philosophy of the ClubStead, free from government control, the ClubStead is equipped with a dynamically positioning (DP) system.

The propulsion forces are generated by two thrusters, each on a different column, positioned under the bottom of two columns.
The thrusters are powered by electric diesel generators. Two 2MW Diesel generators provide the platform with utility and propulsion power. The Diesel generators are marine type generators. According to industrial data, such generators consume about 0.2st of fuel per MWhr of energy produced. Table 5 summarizes the expected power consumption on board the ClubStead. The utility consumption is based on energy consumption per capita

in the USA[1]. The propulsion power reflects the amount of energy required to move the ClubStead at 2knots during a quarter of the time.

Table 5: Fuel Consumption for Utility and Propulsion Power

	Consumption per year (MWhr/year)	Fuel Consumption per year (st/year)	Fuel Consumption (st/3 months)
Utility	3780	748	187
Propulsion	7155	1417	354
Total (st)		2165	541

In the weight summary, it is assumed that the ClubStead carries enough fuel for 3 months at a given time. Supply boats are expected to come in at least every month. As the fuel gets used, the weight is adjusted with incoming ballast water.

7. Cost Estimate

The main components of CAPEX (Capital Expenditure) are the construction of the primary steel structure, the construction of the buildings and the installed equipment and auxiliaries. The capital cost of the ClubStead is estimated to $114,333,000. This cost doesn't reflect potential future cost saving optimizations.

The cost estimate is based on a parametric approach: each component of the cost is determined as a function of weight of the element or square footage. These numbers include material cost as well as labor cost for construction and setup.
The cost of the primary structure depends largely on steel market price. However labor cost can represent up to 60% of the cost of construction of the steel hull. Based on recent bids from shipyards, the cost of built steel for the primary structure is taken at $5000/ton in the following analysis.
The cost of the living areas is chosen at the high end of the ranges for hotel prices. Built and ready to use hotel rooms in the US vary between $100 and $160 per square foot[2]. This includes leasing and other irrelevant costs. However, it does not include the necessity for light materials. The $160/sq.ft cost basis is therefore used in the subsequent analysis for interior spaces. This price is lowered to $100/sq.ft for open areas.
The parametric cost of purchasing and installing auxiliary and mechanical equipment is estimated to be $20,000/st. To reflect the various spending categories, a break-down is attempted in the table below.
Installation and deployment represent 15% of the cost. Future engineering developments toward detailed design and construction are estimated to be 1.5% of the CAPEX.

[1] According to the Human Development Report by the United Nation Development Program, in 2004, the average consumption per capita in the US was 14MWhr
[2] Hotels and Resorts by Fred R. Lawson

Table 6: Summary of CAPEX for the ClubStead

COST ESTIMATE		
PRIMARY STRUCTURE		$34,946,000
Hull	$17,292,000	
Primary Deck	$14,362,300	
Cable Structure and Tower Support	$3,291,000	
BUILDING AND ARCHITECTURAL FEATURES		$49,672,000
Hotels and Living Areas	$40,672,000	
(includes building modules, outfitting, furnishing)		
Open Areas	$9,000,000	
PROPULSION & ELECTRICAL		$4,350,000
Diesel Generator	$1,375,000	
Thrusters	$500,000	
Navigational Equipment	$500,000	
Diesel Generator	$1,375,000	
Installation of electric network	$500,000	
Auxiliary energy sources (solar panels)	$100,000	
AUXILIARY SYSTEMS		$6,500,000
Fire Safety	$1,000,000	
General Ventilation	$2,000,000	
Fresh water, plumbing system	$2,000,000	
Sewage and garbage disposal	$1,000,000	
Ballast System	$500,000	
INSTALLATION		$17,150,000
Towing		
Assembling and Welding		
ENGINEERING		$1,715,000
TOTAL		**$114,333,000**

Maintenance costs are part of the OPEX (Operational Expenditure). They represent typically about 5% of the CAPEX per year. Lower maintenance costs may be used when the mechanical components on the platform, which are costly to maintain, do not represent a large part of the payload. Also, the design of the structure can be optimized for maintenance. The maintenance costs on the Clubstead will represent about 3% of the CAPEX per year of at sea, i.e $3,430,000 per year.

References

[1] “Safety Of Life At Sea”, revised version 2004, SOLAS’04, International Maritime Organization

[2] “Human Development Report”, United Nation Development Program, 2004

[3] “Hotels and Resorts”, Fred R. Lawson,