REVISION HISTORY

DATE	REV	SECTION	DESCRIPTION OF CHANGE
6/24/2010	-		ORIGINAL ISSUE

APPROVAL SIGNATURES	DATE
	25-Jun-10
Jennifer Snyder (Lead Engineer, SAIC)	
	25-Jun-10
William Christensen (Program Manager, SAIC)	

Customer: OSU

SAIC OCEAN TECHNOLOGY
26279 TWELVE TREES LANE, SUITE B
POULSBO, WA 98370
(360) 394-8850
"AN ISO 9001 REGISTERED FACILITY"

NEXT ASSY	USED ON

APPLICATIONS

CONTRACT NO.
SF143421C
AUTHOR
J Snyder
APPROVED

CONCEPT OF OPERATIONS – MOBILE OCEAN TEST BERTH

SIZE	CAGE CODE	DWG NO.	REV
A	OX4U3	0906-20-006	-

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1 Introduction

1.1 Project Description

Through a grant from the United States Department of Energy (DOE), Oregon State University (OSU) and the University of Washington (UW) have partnered to develop the Northwest National Marine Renewable Energy Center (NNMREC). NNMREC's purpose is to develop and maintain a full range of capabilities to support wave and tidal energy development within the United States. The Center's overall activities are structured to facilitate (support) device commercialization, inform regulatory and policy decisions, and close key gaps in the understanding of marine energy.

As part of NNMREC, OSU is designing and building an ocean-deployable mobile test berth, capable of testing a wide variety of Wave Energy Converters (WECs) throughout the Oregon, Washington, and California coasts. This test berth, known as the Mobile Ocean Test Berth (MOTB), will be located near the WEC and interconnected using a submarine power cable. Power generated by the WEC will be transmitted through this submarine power cable to the Test Berth for monitoring, recording, and dissipation.

The first MOTB will not be grid connected. Rather it will provide a mobile, floating capability for WEC evaluation allowing for full-scale demonstration testing. Only one WEC will be connected to the MOTB at any one time. However, multiple WECs and MOTBs may be located in close proximity to each other. Figure 1 is a preliminary layout of a single Test Berth with one WEC connected.

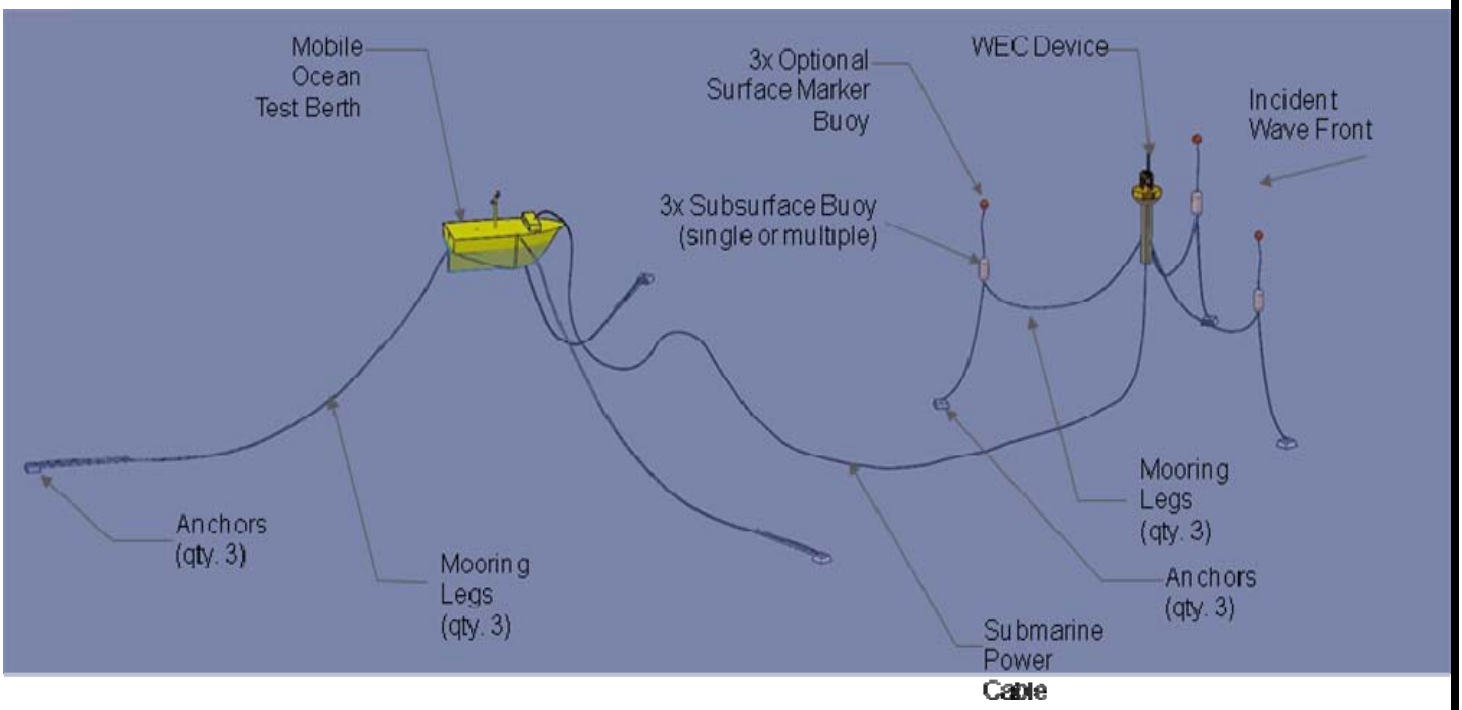

Figure 1 – Concept Sketch of a WEC Connected to the MOTB

In keeping with the strong OSU tradition of wave energy development, NNMREC will initially permit a one nautical mile square area off the coast of Newport, Oregon where WEC developers may operate in the rich Oregon resource. By obtaining general environmental and land permits, NNMREC lowers WEC developers' expense, shortens their application process, and accelerates their schedule to achieve field testing of their device. In time, multiple Test Berths will be located within this area, evaluating different WECs side by side in the same wave climate.

In addition to this fixed, permitted location provided by NNMREC, the Test Berth's mobility allows WEC developers to locate it at their own permitted location in support of their test and evaluation program. The use of a common tool to measure WEC power output at any location, for a variety of devices, will deliver precise technical results for device developers, utilities, regulatory agencies, and community stakeholders.

NNMREC's goals with the MOTB include providing important technical and environmental information so that WECs and installation sites may be evaluated without the attendant infrastructure costs and environmental impacts of an electrical grid connection. The MOTB will promote the NNMREC goals of providing wave energy developers with necessary facilities to field test, demonstrate, and advance sub-scale and full-scale systems, to inform regulatory and policy decisions, and to explore wave energy as a strong contributor to renewable energy portfolios.

NNMREC will work closely with WEC vendors to develop thorough test programs for their devices using the MOTB. This coordination will begin with a WEC assessment, continue with discussions on how to install and support WEC logistics, and extend through the deployment and testing of their WEC device with the MOTB. NNMREC itself will not operate the WEC devices during this period, rather they will provide oversight while maintaining and monitoring the MOTB. Results from the testing will be correlated with wave spectral data taken during the testing and certified by NNMREC.

1.2 Scope

This Concept of Operations (CONOPS) document describes the planned life cycle scenario of the OSU MOTB, covering construction, commissioning, test operations, maintenance, and eventual decommissioning. For the MOTB this includes the sea and land based infrastructure, maintenance (both routine and unexpected), response activities, logistics coordination, and anticipated staffing requirements. References (1) and (2) describe MOTB systems and sub-systems. Section 2 presents an overview of these systems and sub-systems.

The MOTB construction phase follows the engineering phase and includes placement of the MOTB mooring and anchoring system and the set up of the shore based receivers for data telemetry. Construction will start in January 2011 and complete in August or September 2011. After commissioning – a series of MOTB performance tests – NNMREC will install the MOTB and begin the operations phase, which is planned for ten (10) years from its first use with a WEC device attached. The operations phase will involve the testing of various WEC devices, MOTB maintenance, and significant on water activity, such as WEC installation, connection, and removal. The first significant event of the operation phase is the initial installation of the MOTB, which is planned for the fixed site at Newport, Oregon. The decommissioning phase covers the removal of the fixed moor components and any necessary restoration of the Newport site.

Figure 2 presents the general activities occurring in each of these phases. The CONOPS expands upon each phase in subsequent sections. This document is designed to serve as a decision guideline for engineering design and environmental planning. The CONOPS is the overarching document detailing the planned phases of the MOTB life cycle, with the exception of the design phase.

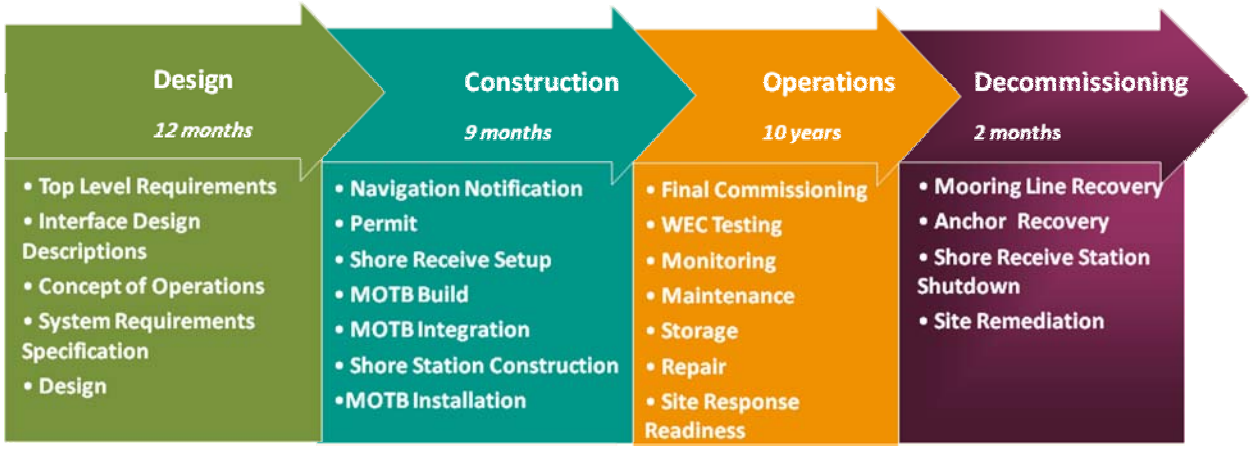

Figure 2 – Four Life-Cycle Phases of the MOTB

This document does not cover the installation or attachment of any particular WEC device or type of WEC device. NNMREC will develop detailed installation and connection documents with each individual WEC manufacturer. The CONOPS does describe the general steps for connecting the submarine power cable from WEC to the MOTB.

1.3 Document Organization

This document has seven sections and two appendices.

Section 1, Introduction, describes the project background, outlines the need, and relates the scope of the CONOPS, as well as defining the references and acronyms used throughout.

Section 2, System Overview, provides functional descriptions of the MOTB, its sub-systems, and the permitted site near Newport, Oregon. This section also discusses the opportunity for MOTB use at alternate sites.

Section 3, Construction, describes how the MOTB will be built, who will build it, what materials will use, and where they will build it.

Section 4, Final Commissioning and Installation, describes how the MOTB will be transported and what commissioning testing will be conducted. This section describes the installation of the MOTB mooring system and attachment of the MOTB to its mooring.

Section 5, Operations and Maintenance, details how NNMREC will operate and maintain the MOTB while it is deployed in its moor, how it will be monitored, what maintenance must be done pierside or in a drydock, and the emergency procedures recommended.

Section 6, Removal, reviews how to remove the MOTB from its moor.

Section 7, Decommissioning, describes the steps needed to decommission the permitted site and decommission or repurpose the MOTB.

Appendix A, WEC Device Installation, contains the general interface requirements and characteristics on WEC specific operations including possible construction guidelines, monitoring plans, and requirements.

Appendix B, Design of Record, lists the documents that are recommended for retention to preserve the historic background on the design of record.

1.4 References

The following documents are references that support the CONOPS for the NNMREC MOTB. The latest issue of each document should be used. The foundational documents have been developed in the design phase. Other documents will be as part of the MOTB construction phase.

1. Top Level System Requirements – OSU MOTB, SAIC document 0906-20-001
2. Interface Design Descriptions – OSU MOTB, SAIC document 0906-20-003
3. System Requirements Specification – OSU MOTB, SAIC document 0906-20-005
4. Test Plan – OSU MOTB, SAIC document 0906-20-007
5. MOTB Plans (all to be developed)
   a. Maintenance Plan
   b. Emergency Plan and Recall List
   c. Transportation Plan
   d. Safety Management Plan
   e. Security Plan
   f. Critical Spares List
   g. Logistics Support Lists and Inventories
6. MOTB Drawings and As-Built Updates
7. Permit Documents
   a. National Environmental Policy Act Documentation Package
   b. US Army Corps of Engineers Permit
8. Insurance Policies
9. Agreements and Contracts
   a. Build Contract (including turnover agreement)
   b. Central Lincoln Public Utility District
   c. Hatfield Marine Science Center
   d. Port of Newport
   e. WEC Developer Documents
      i. Contract, Installation, Monitoring, Maintenance, and Decommissioning
   f. Yaquina Head State Park
   g. FINE Surveillance Agreement

1.5 Acronyms Used

ABC	Above and Beyond Communications
AC	Alternating Current
CAD	Computer Aided Drafting
CONOPS	Concept of Operations
DATI	Data Acquisition and Telemetry Infrastructure
DC	Direct Current
DOE	Department of Energy
EA	Environmental Assessment
EIS	Environmental Impact Statement
FE	Facility Engineer
FINE	Fisherman Involved in Natural Energy
GPS	Global Positioning System
Hz	Hertz, cycles-per-second
IEC	International Electrotechnical Commission
MOTB	Mobile Ocean Test Berth

MTBCF	Mean Time Between Critical Failures
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NEPA	National Environmental Policy Act
NNMREC	Northwest National Marine Renewable Energy Center
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
ODOT	Oregon Department of Transportation
OSHA	Occupational Safety and Health Administration
OSU	Oregon State University
PII	Power Interconnect Infrastructure
PSI	Pounds per Square Inch
RECS	Renewable Energy Composite Solutions
RoHS	Restriction of Hazardous Substances
RPM	Revolutions Per Minute
SAIC	Science Applications International Corporation
SBI	Sea Based Infrastructure
SRS	System Requirements Specification
TLR	Top Level Requirements
USACE	United States Army Corps of Engineers.
USCG	United States Coast Guard
WEC	Wave Energy Converter

2 System Overview

2.1 Purpose and Safety

The primary purpose of the MOTB is to receive and characterize the electrical performance of a connected WEC device. Given that the MOTB will be designed to dissipate up to 1 MW of power and operate with AC voltages of up to 15,000 volts and currents up to 600 amps, personnel safety is a primary concern. Therefore, the MOTB will have a detailed safety management plan. All personnel shall be trained on all aspects of the CONOPS to protect themselves, the MOTB, and any WEC equipment.

While the MOTB serves as a research and development platform, which characterizes WEC electrical performance, dissipates WEC energy, and transmits performance data to shore, no purpose or function supersedes the overall safety of the MOTB, the personnel working with it, the species that may interact with it, or the community where it operates.

2.2 MOTB Description

The MOTB hull structure is based on the NOMAD style buoy (Figure 3), used in the North Pacific by the National Data Buoy Center (NDBC), a component of the National Oceanic and Atmospheric Administration (NOAA), for its stability through all weather types. In the case of the MOTB, a series of deck hatches on the exposed deck allow access to all three interior compartments. Each compartment will be outfitted with a small hatch for access while deployed. Maintenance personnel, small tools, and other gear can be carried through these hatches. Larger hatches will be installed and positioned at strategic locations to facilitate the change out of larger equipment, such as the transformer and input breaker. These larger hatches will not be removable when the MOTB is deployed. The MOTB must be pierside or in drydock to open these hatches and service larger, internal components. Figure 4 shows the conceptual deck layout, without the other topside gear (mast, ventilation piping, etc.) shown to highlight the hatch arrangement.

Figure 3 – NOMAD Buoy

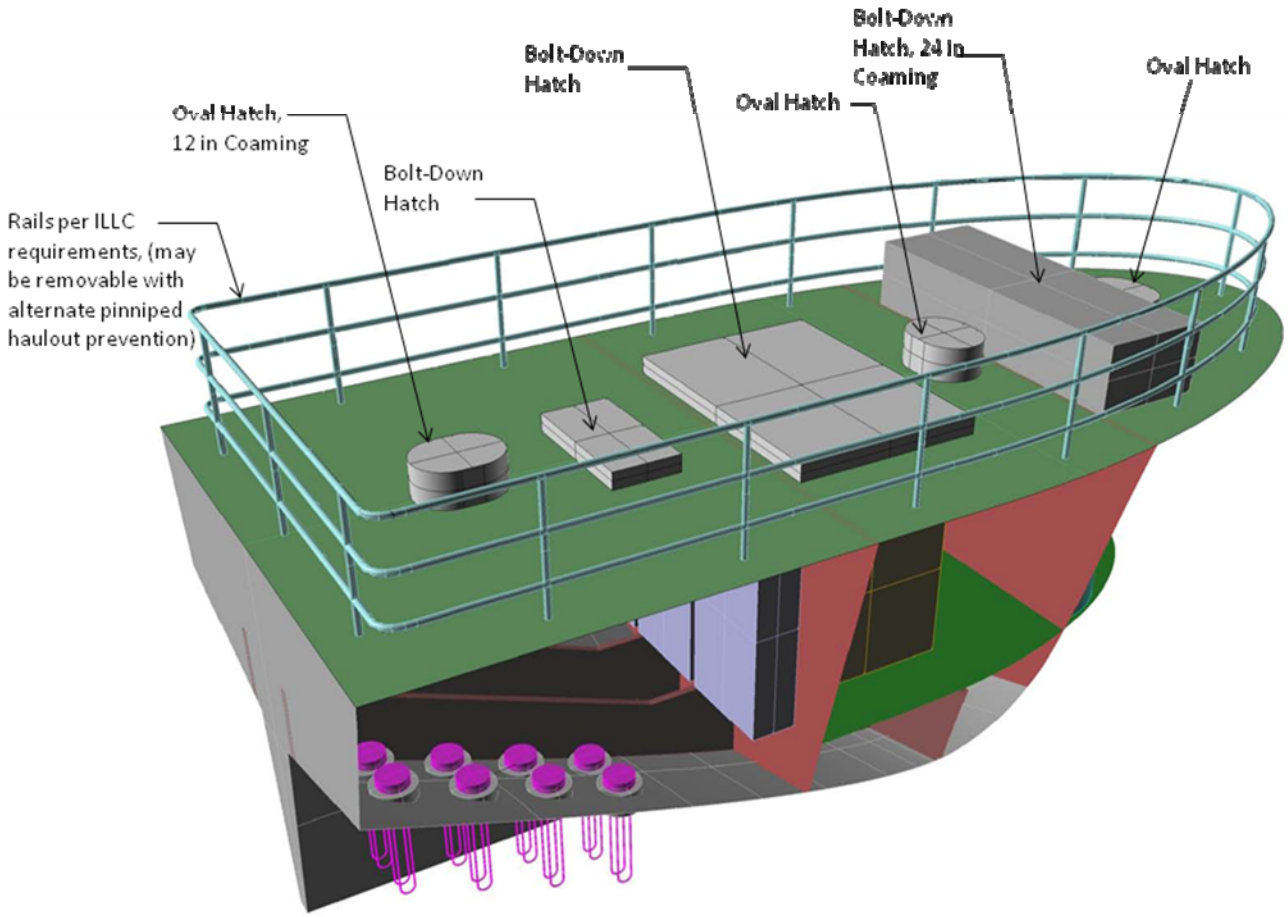

Figure 4 – MOTB Deck Layout (Masts not Shown)

The arrangement of the three interior compartments separates the voltage levels handled by the MOTB. The forward compartment will contain the input breaker, accepting the submarine power cable from the WEC. This compartment will contain the highest voltage components. The middle compartment will contain the transformer. The aft compartment will contain all the low voltage equipment such as the distribution panels, load dissipation controllers and elements, and data telemetry and acquisition sub-system. The aft compartment also reserves space for WEC data acquisition and telemetry equipment if required. Figure 5 illustrates the interior arrangement of compartment and major components. The figure excludes some elements, such as the protective covering around the load elements, for clarity of illustration. The protective coverings prevent unintended access by humans or marine mammals.

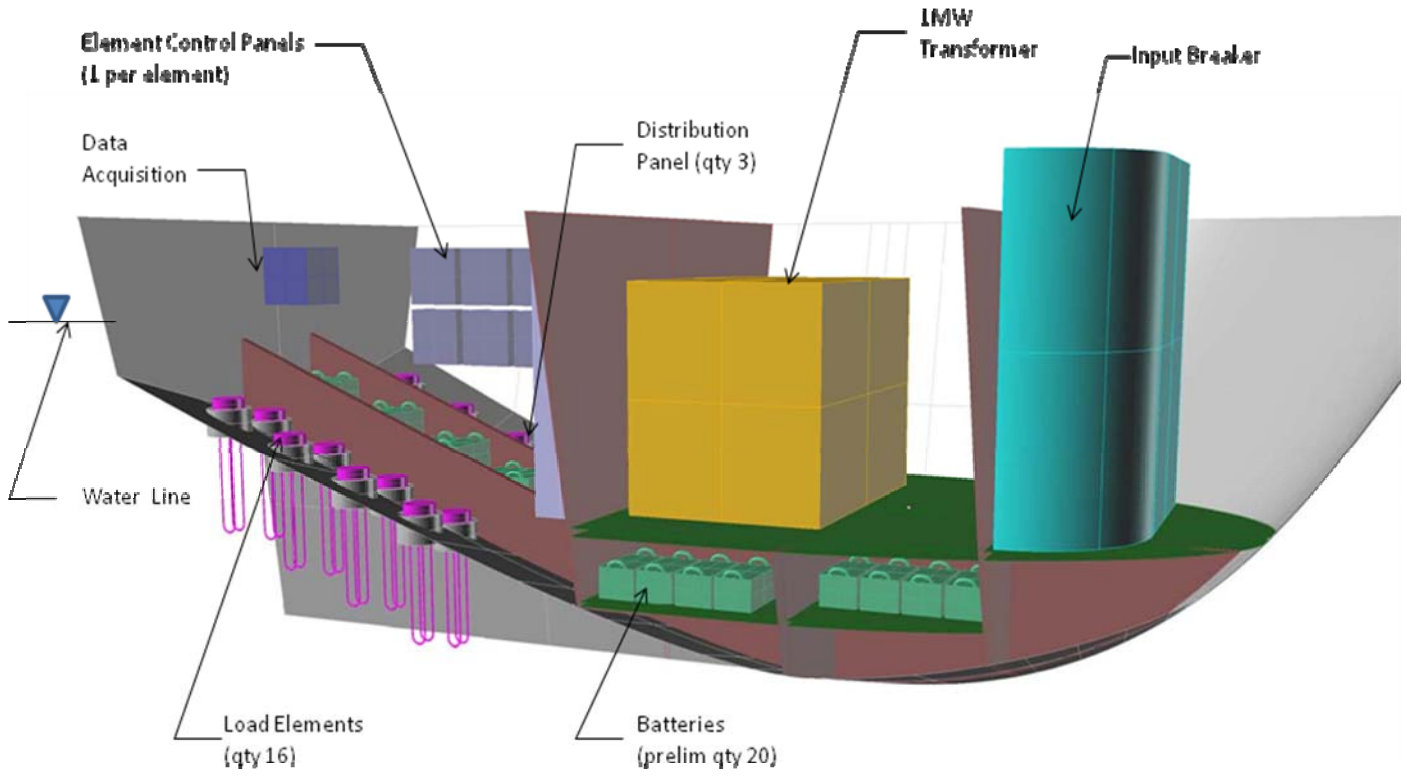

Figure 5 – MOTB Interior Layout (Simplified)

2.3 Locations

A distinguishing feature of the MOTB is its mobility, offering the prospect of bringing the test facility to a specific location. Normally, the MOTB will operate in a dedicated, permitted site.

2.3.1 Fixed Site – Ocean Facilities

The MOTB will initially be located within a permitted site off the coast of Newport, Oregon. This site will be marked on nautical charts. A Notice to Mariners will be issued advising boaters and fisherman of the area's restrictions and potential dangers. The main hazard is the potential entanglement of fishing gear with the mooring lines for the MOTB and WEC, as well as the subsea cables. The WEC will generate high voltages and transmit power to the MOTB, which can dissipate up to 1 MW. Therefore, the CONOPS will invoke redundant precautions to ensure that power is never shorted to ground. Keeping a respectful distance away from WEC and MOTB is recommended practice. The Notice to Mariners will emphasize the risk of entanglement and discourage transit in the area ("areas to be avoided".

The permitted site (Figure 6) is a one nautical mile square area, nominally 20-26 fathoms (36-47 meters) deep. The bottom type is nominally deep sand over bedrock throughout this area[1].

[1] NNMREC will conduct a site survey to verify and extend earlier survey results. The survey will consist of sidescan sonar to determine the bathymetric contours as well as core samples to determine specific soil characteristics.

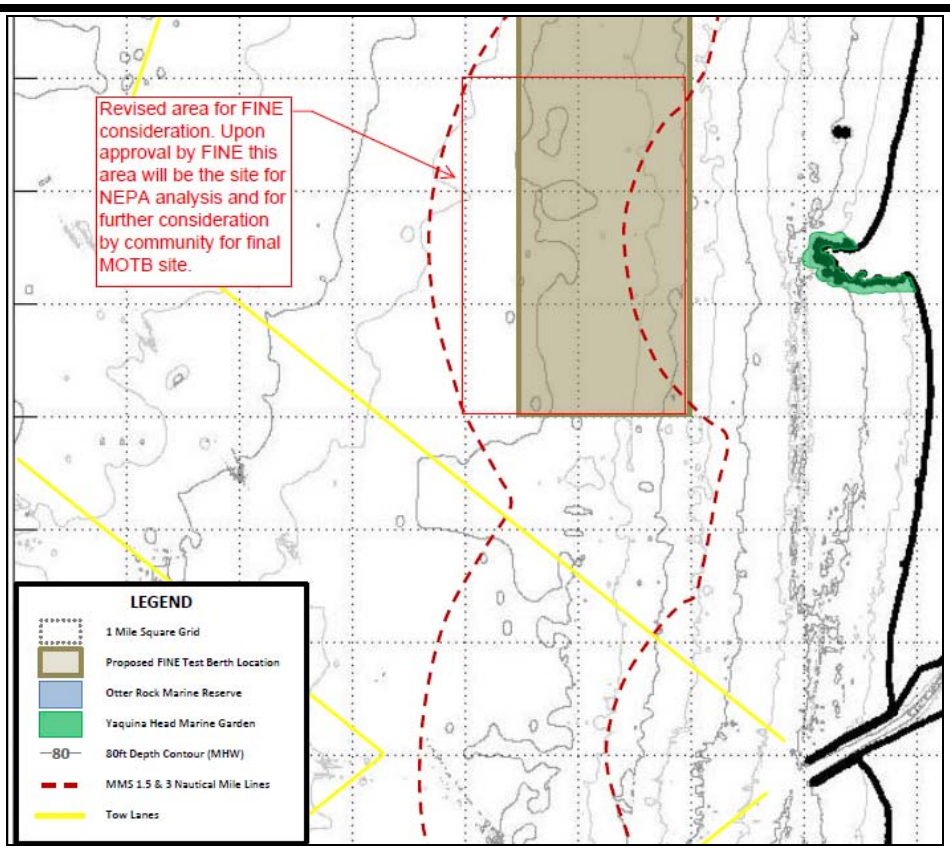

Figure 6 – Location of Permitted Site in Newport, Oregon

The permit will allow operation of one or two WEC devices, each with its own MOTB. The permitted area provides sufficient room for the four associated moorings to operate without interfering with each other. Further, the fixed site is large enough to eliminate the risk of one set of mooring interfering with deploying or recovering the other pair. Finally, the site layout must assure that each WEC has unobstructed exposure to the incident wave front. Therefore, the MOTB will be in the WEC lee and otherwise positioned to minimize the potential for cable entanglement. Figure 7 is a sample site layout with one MOTB-WEC pair. The CONOPS expects that the MOTB moorings will remain installed over the site's 10-year permit. Each WEC mooring and anchors will be removed when the device's test program is completed. This strategy reduces operating costs, while restoring the site after each use, as practical.

Supporting instrumentation will also be located within the permitted area. This equipment includes Wave Measurement Instruments (WMIs), such as Waverider buoys, bottom mounted wave measurement devices (Acoustic Wave and Current profilers (AWAC) or equivalent), and radars. For example, NNMREC plans to install WMI alongside each WEC. The WMI will be location outside of the WEC and MOTB watch circles. In this way, we prevent interference between the major components and measure the wave front accurately so it is the best possible representation of the wave field experienced by the WEC. Redundant wave measurement will be provided by OSU whenever possible.

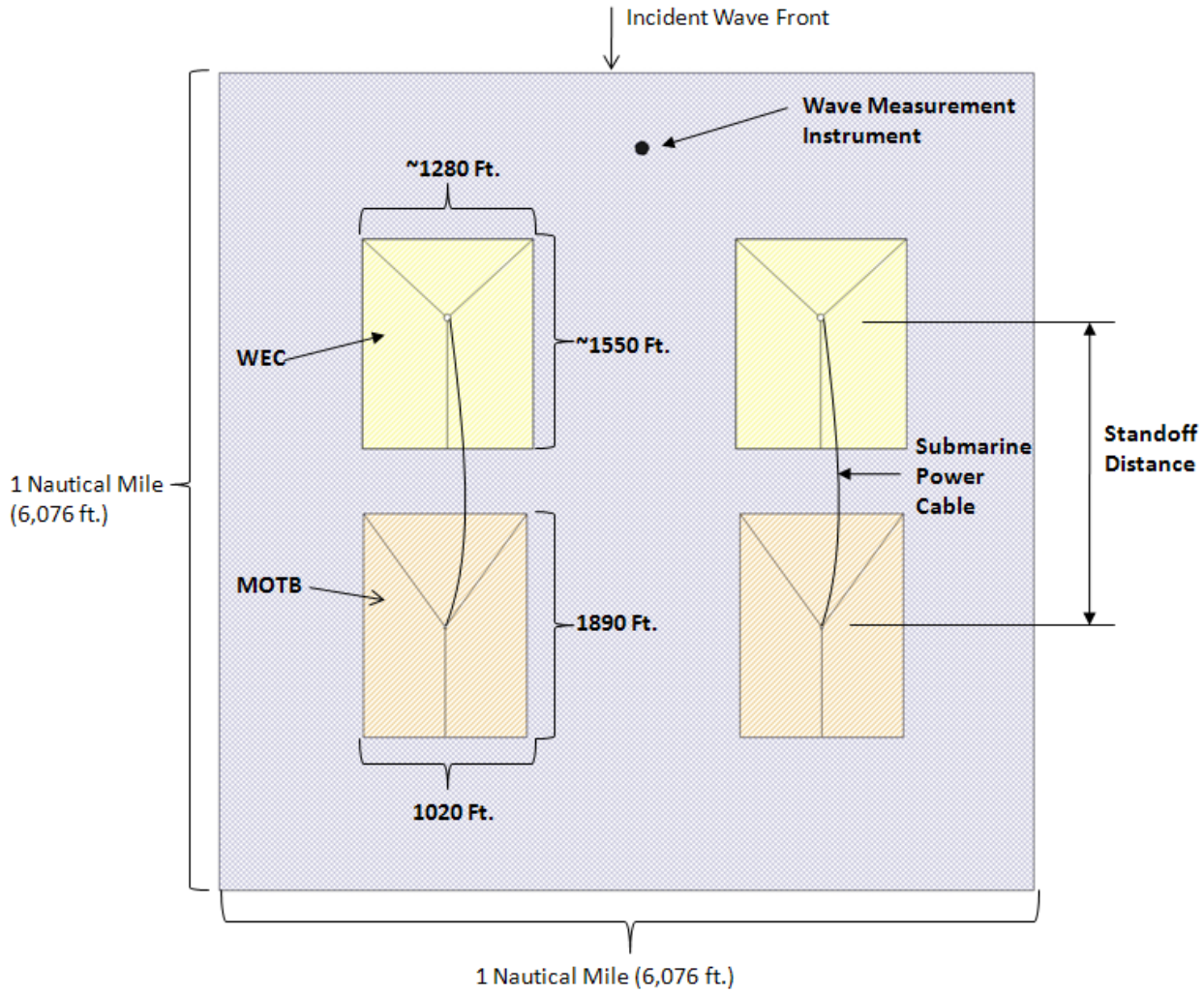

Figure 7 – Preliminary Site Layout with One Representative WEC and MOTB

2.3.2 Fixed Site – Shore Facility

An integral component of the fixed site is the shore facility, which may be located at the Port of Newport, the Hatfield Marine Science Center, or other suitable building. The shore facility would be the initial terminus for data telemetry and the local depot for MOTB logistics. Normal facility requirements (office and laboratory space, conference rooms, basic building utilities and services, storage and laydown areas, and shipping and receiving) will apply. Specialized facility requirements anticipated include support for electrical maintenance of MOTB components, pier access for MOTB docking, servicing and maintenance, access to crane services, and availability of towing charters.

2.3.3 Alternate Sites

As the MOTB demonstrates its utility and gains experience in the fixed site, NNMREC recognizes the potential for MOTB deployment at alternate sites to meet the requirements of specific WEC devices and their manufacturers. The ability to relocate the MOTB is a unique and distinguishing feature of the test facility. For each alternate site proposed, NNMREC will review the mooring requirements there and estimate the cost to relocate. The CONOPS expects that a new MOTB mooring system will be required, since the initial mooring system will remain installed at the fixed Oregon site. To assure that the MOTB will operate satisfactorily in an alternate site, NNMREC will examine the results of site characterization and the anticipated survival storm conditions to develop an adequate mooring

system. NNMREC will adapt the fixed site CONOPS for installation (Section 4), operations (Section 5), and removal (Section 6) to alternate sites.

2.4 MOTB Infrastructure

The OSU MOTB System has four major infrastructure segments, each of which contains sub-systems with technical elements, as described below. The four major infrastructure segments are:

- *Sea-Based Infrastructure (SBI),* which includes monitoring sensors for the marine environment, navigational markers and notifications, and the MOTB hull sub-system;
- *Anchoring and Mooring Infrastructure (AMI)*, which includes the mooring, recovery and release, and anchors;
- *Power Interconnect Infrastructure (PII)*, which includes electrical power conversion, conditioning, distribution, and protection elements of the System, and command and control elements of the electrical sub-system;
- *Data Acquisition and Telemetry Infrastructure (DATI)*, which includes data collection, transport, and local storage elements, data topology and encryption, the network interface to external elements and the shore monitoring station.

Beyond the physical infrastructure, the MOTB needs one additional segment to describe the MOTB fully: *Logistics*. The logistical element captures the support functions needed to conduct installation, operations, maintenance, and recovery of the infrastructure during the Operations Phase. Figure 8 is a system block diagram, which shows the relationship of these infrastructure elements.

Finally, while WEC devices create requirements for the MOTB, they are not part of the infrastructure. However, the CONOPS does describe how the MOTB will interface with WEC devices, how they are connected to the MOTB, how they operate with the MOTB, how they are disconnected from the MOTB, and how they are removed from the site. Thus, the CONOPS identifies the procedures for each of these events or series of events.

The governing authority for approving the interface procedures is NNMREC. As the permit holder for the fixed site and the MOTB owner, NNMREC is technical and programmatic point of contact for all questions or concerns about the MOTB and the WEC, as well as the ombudsman for any issues from the community. Therefore, the CONOPS provides general specifications (Appendix A) for WEC developers who wish to employ the MOTB as part of their test program. The appendix sets expectations for monitoring as well as requirements for WEC construction, installation, operation, and removal. NNMREC provides this guidance to protect the MOTB infrastructure and to qualify manufacturers according to the maturity of their design approach. In this way, NNMREC advances MHK technology development and promotes its acceptance throughout the Oregon by performing responsible WEC testing on devices that meet acceptable standards for construction, operations, and monitoring.

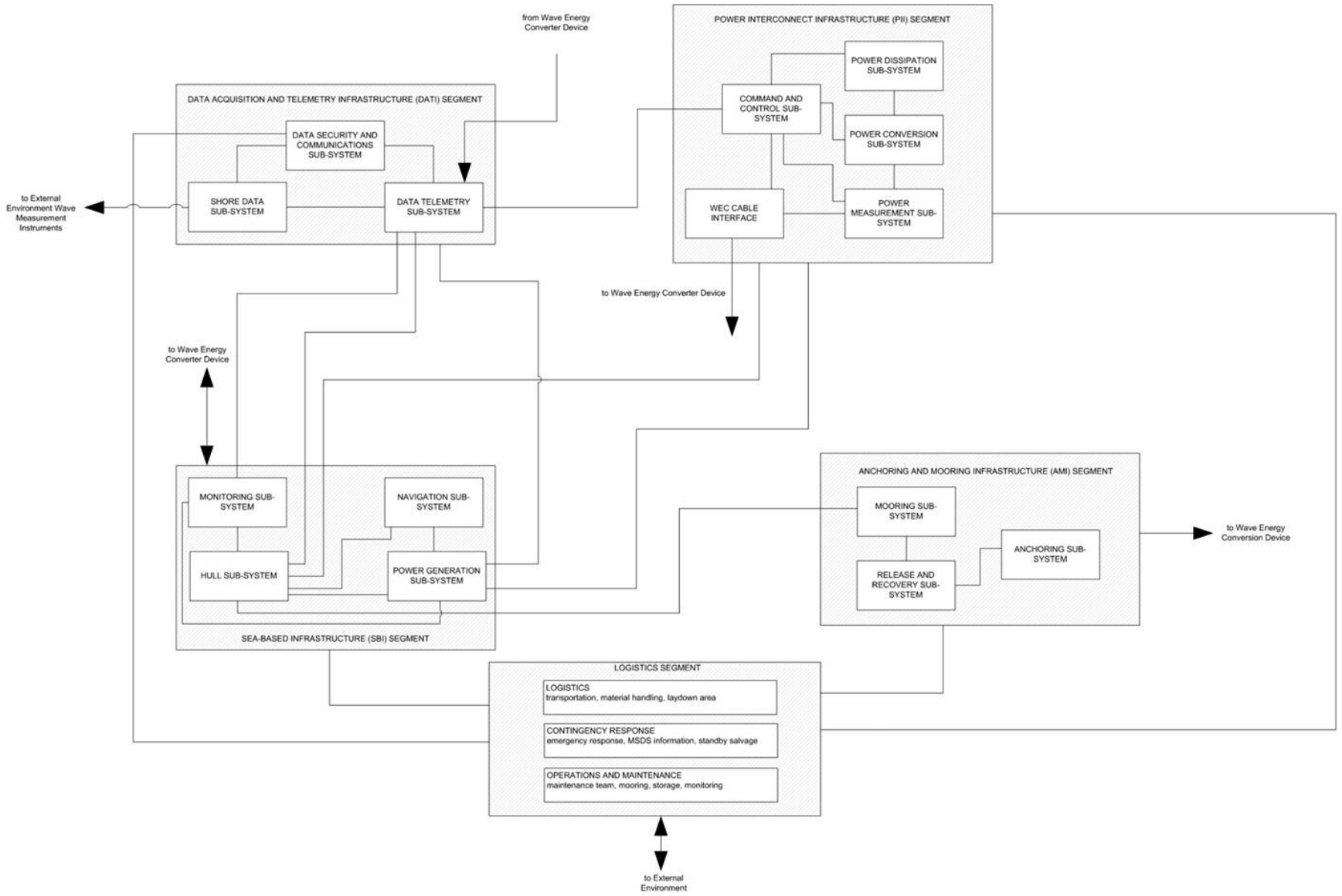

Figure 8 – Infrastructure Elements of the MOTB

The following sections briefly discuss the operational functions of each segment and the sub-systems within it. These descriptive introductions precede the detailed discussions of MOTB operations.

2.4.1 Sea-Based Infrastructure (SBI) Segment

The SBI segment includes the MOTB hull, monitoring, navigation, and low voltage power generation sub-systems. The next sections describe these sub-systems and their elements.

2.4.1.1 Hull Sub-System

The hull sub-system is the basic MOTB structure, the overall physical housing for the majority of the MOTB segments and sub-systems. The hull sub-system contains standard mechanical and outfitting elements, such as bilge pumps ventilation, and lighting. The sub-system includes safety features and protective equipment such as handrails and bumpers, watertight access hatches, mounting locations for all components, exclusion cages for subsurface load elements, and passive deterrence devices for marine mammals and waterfowl. Exposed hull surfaces will be painted yellow and marked in accordance with United States Coast Guard (USCG) requirements. The subsurface part of the hull and the load elements will be conspicuously marked to warn divers of the hazard. Reference (2) provides further details on these requirements and markings.

The hull sub-system uses two types of hatches to access the three interior compartments. Personnel will use small hatches to enter the compartments while pierside or deployed. There are no interior hatches between compartments. The hull sub-system will have larger hatches for equipment maintenance and replacement while pierside or in drydock. These larger hatches are not removable while the MOTB is deployed. See Section (TBD-01) for further details on hatches.

2.4.1.2 Monitoring Sub-System

The monitoring sub-system contains elements that sense, acquire, and report conditions on the MOTB. Data from this sub-system will require telemetry interfaces to distribute and store the monitoring data, which may be redundantly connected (by radio frequency or similar) to the shore facility. Certain monitoring elements may employ a store-and-forward (data logger) function, while others may require real-time throughput. Elements within this sub-system may include controllable assemblies like cameras, in-situ environmental sensors that monitor temperature, wind speed, and other specified variables, as well as sensors that monitor other sub-systems, such as ground faults, transformer temperature, and battery level.

2.4.1.3 Navigation Sub-System

This sub-system includes all of the aids to navigation (markers, signs, lights, etc) mounted on the MOTB. As well, the annotated charts, the Notices to Mariners, and other administrative notifications (such as the Federal Register), while not physically attached to the MOTB, contribute to the objectives of the sub-system. Reference (2) discusses these requirements and markings.

2.4.1.4 Power Generation Sub-System

The power-generation sub-system contains the batteries required to provide low voltage power to all sensors, communication devices, lighting, and other MOTB electrical loads. The sub-system includes the distribution wiring for the supply of low voltage power, and the re-charging modules for the batteries, which receive power from topside wind generators, solar panels, and, potentially, the WEC connected to the MOTB. The batteries will be tied together on a separate circuit such that when one cell is changed all cells in that circuit are changed to preclude unevenly loading any older batteries in a circuit. This sub-system will also be capable of supplying a limited amount of low voltage power to the WEC, if required for WEC startup or operation. Health information for this sub-system is sent to the shore facility via the Data Telemetry Sub-System (Section 2.4.4.1).

2.4.2 Anchoring and Mooring Infrastructure (AMI) Segment

The AMI segment includes the anchors and moorings required to position the MOTB securely in all expected or extreme weather conditions. The next sections describe the AMI sub-systems and their elements.

The AMI segment does not include the anchors and moorings specific to the WEC devices themselves. These sub-systems fall within the WEC device system and are outside the scope of the MOTB system definition.

2.4.2.1 Mooring Sub-System

This sub-system includes the mooring lines and connection components designed to keep the MOTB in its intended location when it is deployed. The MOTB connects to this sub-system upon installation.

2.4.2.2 Release and Recovery Sub-System

This sub-system includes the planned mechanisms to release and recover the mooring lines and anchors when the MOTB is temporarily removed from its fixed deployment site. This sub-system also includes the release and recovery mechanisms following WEC testing, as well as features planned for final recovery when decommissioning the site.

2.4.2.3 Anchoring Sub-System

The Anchoring Sub-System includes the physical anchors planned for use by the MOTB. These anchors and associated mooring chain will be used to secure the mooring lines to the seafloor. As with the mooring lines, the anchors will be designed to remain in place off Newport throughout the ten-year life span of the MOTB. By leaving the anchors in place for the project, costs associated with a repeated deployment and recovery of these heavy devices is reduced.

2.4.2.4 Wave Measurement Instruments

The installation, maintenance, and recovery of WMIs are outside the scope of this document. WMIs shall be maintained and operated using commercial best practices and shall be secured to ensure they do not become entangled within the moorings of the MOTB or WEC.

2.4.3 Power Interconnect Infrastructure (PII) Segment

The PII segment includes electrical power conversion, conditioning, distribution, and protection elements of the system, and command and control elements of the electrical sub-system. PII sub-systems are described in the following paragraphs.

2.4.3.1 Command and Control Sub-System

The Command and Control Sub-System controls operation of the power infrastructure, monitors status of the power interconnect sub-systems and provides routine status monitoring of all power elements. This sub-system feeds monitoring parameters back to the Data Acquisition and Telemetry Sub-System for transmission to shore.

2.4.3.2 WEC Cable Interface Sub-System

This sub-system contains the WEC cable interface (physical, power, and signal interface) as well as initial power protection devices for the MOTB components downstream of the WEC cable termination. These power protection devices are designed to disconnect the WEC from the MOTB, protect components, users, and environment. This sub-system also contains a grid mimic module. The grid mimic module should not be confused with a conventional power grid. Rather this module is designed to allow the WEC device to see a “soft” 50 or 60 Hz signal to which it may synchronize.

2.4.3.3 Electrical Power Measurement Sub-System

This sub-system contains the power measurement module(s) measuring the output power from the WEC device. The power measurement devices will communicate directly with the Command and Control Sub-System and the Data Telemetry Sub-System to collect, encrypt, transmit, and send the data to redundant secured storage.

2.4.3.4 Electrical Power Conversion Sub-System

This sub-system contains the power conditioning and formatting required to convert electrical power exported from the WEC device into a format suitable for distribution and dissipation into the Power Distribution Sub-System. WEC power is measured both before and after the conversion. Note: this sub-system is not to be confused with any required power-conditioning equipment required by a utility grid to receive power, but is instead used to convert the power to a form that can be readily dissipated.

2.4.3.5 Electrical Power Dissipation Sub-System

This sub-system contains electrical elements to receive, control, distribute, and dissipate the WEC electrical power. Electrical safety components will be contained within this sub-system for protection, to switch between loads, and to isolate loads between distribution points. This sub-system may also contain reactive load elements.

2.4.4 Data Acquisition and Telemetry Infrastructure (DATI) Segment

The DATI segment includes data collection, transport, and local storage elements, data topology and encryption, and network interface to external elements. Descriptions of the DATI sub-systems are provided in the following paragraphs.

2.4.4.1 Data Telemetry Sub-System

Like the Command and Control Sub-System, the Data Telemetry Sub-System interfaces with a multitude of other sub-systems and segments. While the Command and Control Sub-system represents the control signals required to monitor and control power aspects of the MOTB, the Data Telemetry Sub-System contains elements to receive, time stamp, distribute, and telemeter monitoring, performance, and control data within the system to a shore receiving facility. This sub-system employs a number of data telemetry implementations, including optical, wired, and radio-frequency communications. This sub-system also implements requirements of the Data Security and Communications Sub-System to achieve necessary data security functions during data sensing, transport, and storage. This sub-system also has the ability to manage data as needed and supply processed data and averages to the Shore Data Sub-System as needed. Finally, this sub-system will have the capacity to support data telemetry requirements for command and control functions for other system infrastructure sub-systems. For example, the data telemetry sub-system will have sufficient capacity to support receiving data inputs from the WEC device under test.

The Data Telemetry Sub-System will be redundant. At least two radio circuits will provide data transmission and communications to shore. An emergency radio, with a standalone power system, will be employed to ensure communications with the MOTB if it moves outside its watch circle and outside the transmit path of the high bandwidth data transmission radios. Hand held radios will be used for coordination of dockside, bay, and installation and removal activities.

2.4.4.2 Shore Data Sub-System

Data will be acquired and stored during system operation to ensure sufficient granularity for performance monitoring, failure analyses, and environmental monitoring. This sub-system receives data from system sensors via the Data Telemetry Sub-system, stores the information, and alerts

required personnel and systems to emergency signals. This sub-system also contains a user interface and remote access to review data collected. This graphical user interface will provide for representation of each deck and the associated sensors. An alarm will change colors and a separate box opens with details on the alarm. The alarm will remain the color indicated until acknowledged by the operator. The color conventions will be in accordance with utility industry conventions. For the majority of sensors green is good and red is bad with yellow being a less critical issue. For the WEC power output status and sensors the electrical utility industry standard will be used, thus sensors shown in red will be in the normal operating function. These will be displayed on a separate tab to ensure confusion between colors does not occur.

This sub-system implements requirements of the Data Security and Communications Sub-System to achieve necessary data security functions during data access and storage. This sub-system also contains elements for remote data access, analysis, and monitoring subject to access credentials authentication.

2.4.4.3 Data Security and Communications Sub-System

The Data Security and Communications Sub-System contains functional elements to ensure data security and integrity as well as protocols to determine importance of data. Due to the sensitive and competitive nature of the MOTB users, strict controls will be enabled to restrict access to confidential information. This sub-system contains elements to protect data access for such restricted information, but will also enable access to environmental data to all system users. Included within this sub-system are protocol definitions that determine the importance of data and move critical data through quickly. Also included in this sub-system are the physical security requirements for all DATI sub-systems.

2.4.5 Logistics Infrastructure Segment

The Logistics infrastructure segment is described in this section. Due to the abstract nature of this segment, a functional block diagram for this segment was not constructed. Each of the major logistical elements within this segment is described in the following paragraphs.

2.4.5.1 Logistics

This element includes all logistical matters related to infrastructure installation, training, operation, maintenance, and access during the planned life cycle. Such topics within this segment include the identification of local assets for material lifting, handling, towing, and staging of equipment within the Newport, Oregon area.

2.4.5.2 Operations and Maintenance

This final element of this segment contains functions required during the operational phase of the project. Operations include the deployment and recovery procedures for the MOTB, monitoring, safety, and security procedures for the deployed MOTB, and WEC connection device requirements. Maintenance includes the planned preventive maintenance requirements as well as maintenance manuals for commercial-off-the-shelf (COTS) and custom devices.

2.4.5.3 Contingency Response

A second element of this segment contains functions required to achieve an acceptable level of safety and risk within the project. This element contains planning matters, procedures, and infrastructure required to achieve emergency notification and response requirements in the event of a failed MOTB or WEC device or mooring, or due to a natural disaster or similar event. Items such as time-phased response, standby salvage, and other elements are also captured within this block.

3 Construction

3.1 Construction Team

The Construction Team for the MOTB will be comprised of a primary contractor and a number of subcontractors, all headed by the NNMREC Program Manager. Refer to Figure 9 for the planned reporting hierarchy of these support areas. Responsibilities for the different support areas are discussed below.

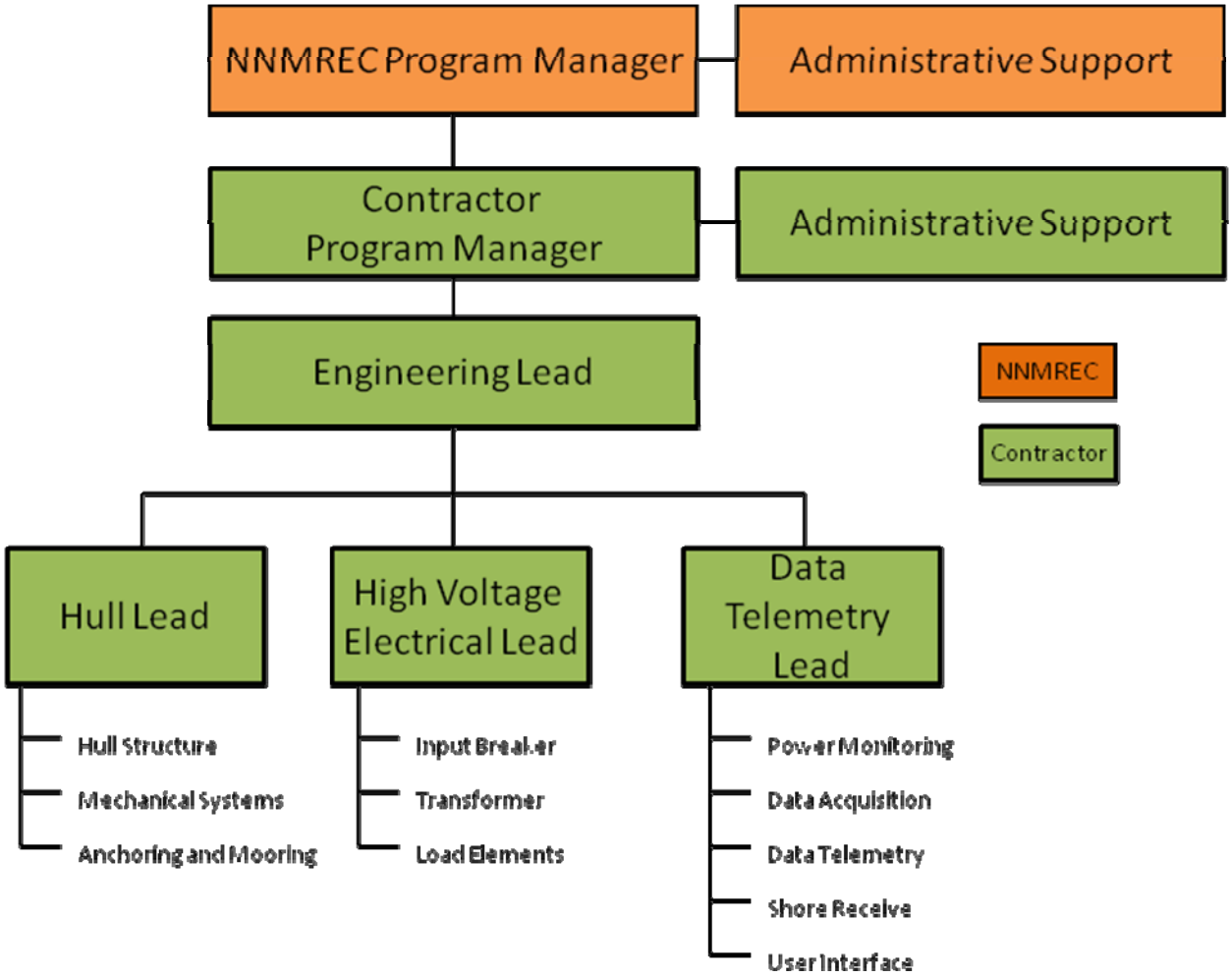

Figure 9 – Construction Team

3.1.1 NNMREC Program Manager

The NNMREC Program Manager (PM) shall be responsible for the overall management of NNMREC programs and projects, of which the MOTB is one. Administrative support such as contracts, marketing, and general admin support will be required.

3.1.2 Contractor Project Manager

The Contractor Project Manager shall be responsible for the overall management of the MOTB. Administrative support such as contract, finance, and general admin support will be required.

3.1.3 Engineering Lead

The Engineering Lead shall be responsible for all activities at all times during the final design and construction. The Engineering Lead is the primary point of contact for all activities concerning construction and installation of the gear. Both the Project Manager and the Engineering Lead assure the project operations are performed in a manner consistent with the Safety Plan.

3.1.4 Hull Lead

The Hull Lead is responsible for the hull construction of the MOTB and the associated mechanical systems. The hull construction shall be done in accordance with plans and designed completed during the design phase. Mechanical systems include the bilge pump, ventilation, handrails, and bumpers. Anchoring and mooing will be a subset of these mechanical systems.

3.1.5 Electrical Lead

The Electrical Lead is responsible for directing all systems associated with the WEC power receive, conversion, and dissipation. These components include breaker panels, load elements, and a transformer.

3.1.6 Data Telemetry Lead

The Data Telemetry Lead is responsible for coordination and construction of the data acquisition system on the MOTB as well as the data telemetry system both on the MOTB and on shore. Responsibilities include coordination with the shore station owner, network host facility, and other leads for MOTB construction.

3.2 Construction Location

The MOTB will be constructed in Vancouver, WA at the Renewable Energy Composite Solutions (RECS) facility. RECS, Hyak Electroworks, and Above and Beyond Communications are all located within a 10 minute drive of this facility. SAIC and OSU are both located within a few hours of this facility though from opposite directions.

3.3 Construction Materials

Construction of the MOTB will be done in accordance with the complete MOTB drawings developed during the design phase.

The hull structure shall be a molded sandwich core designed structure, with structural grade PVC core sandwiched between solid fiberglass and vinylester resin laminates. The keel will be constructed of solid fiberglass and vinylester resin laminates. Mechanical systems will be constructed from a variety of components including plastics, composites, and metals.

Electrical components will be constructed from metals such as stainless steel, copper, and aluminum as well as plastics and ceramics as needed. Dielectric fluid used in the transformer will be environmentally friendly seed oil. All high voltage cables will be copper core with adequate insulation to meet the criteria.

Data telemetry components will be commercially-off-the-shelf (COTS) components, which meet RoHS (Restriction of Hazardous Substances) regulations when possible. Components will be manufactured from a variety of materials including plastics, metals, and ceramics.

Mooring line components will be manufactured from synthetic line metal chain, and connection hardware. Anchor components will be manufactured from a variety of components including nylon line, anchor chain, steel shackles, and steel anchors.

3.4 Construction Testing

The MOTB shall be testing periodically throughout its construction and undergo extensive testing prior to initial installation. Systems will be individually tested using simulators and canned (or sample) data. For example, the data telemetry system test will use canned sensor data generated by an additional program to ensure receipt and processing by shore station. During the final stages of construction, the overall MOTB system will undergo a step-by-step testing to demonstrate readiness for commissioning testing and subsequent installation. These commissioning tests are defined in reference (3).

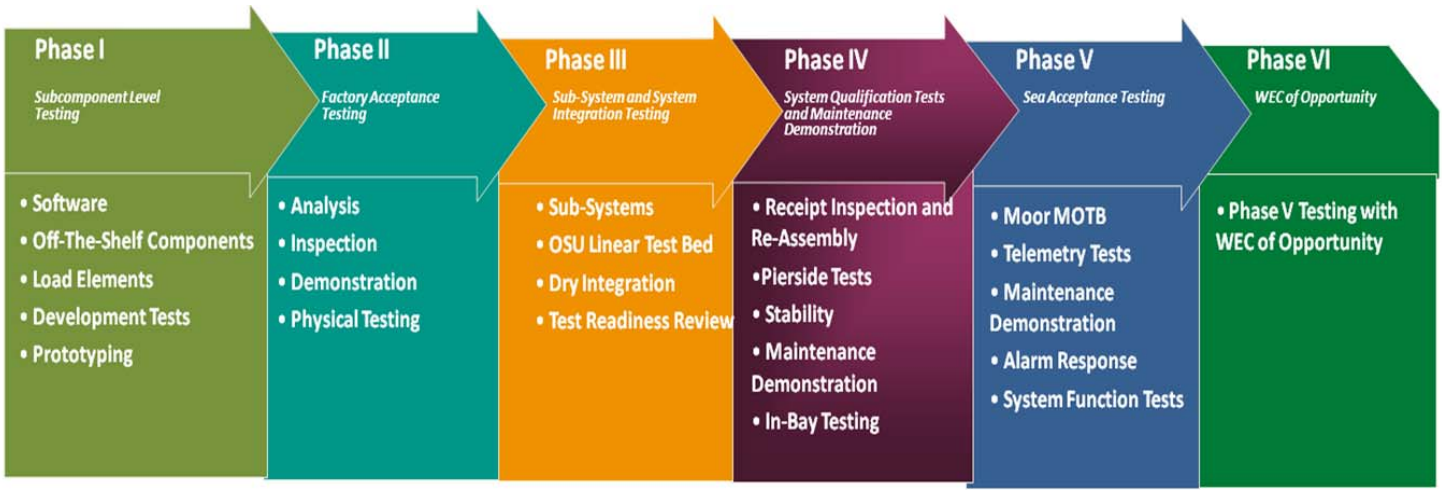

Figure 10 – Commissioning Plan Phases

4 Final Commissioning and Installation

The following sections discuss the deployment, towing, and installation of the MOTB into the moor as well as the initial mooring line and anchor deployment. Since the WEC connection to the MOTB will occur in the operational phase, this connection is detailed in Section 5.

4.1 Installation/Removal Periods

Planned installation and removal periods of the MOTB shall be between May and September. The months between October and April shall be avoided for any planned installation or removal since weather conditions are typically not favorable for safe marine operations. Installation or removal may occur during these periods if extenuating circumstances exist such as the forecast of a severe storm with the potential to exceed design requirements.

4.2 Installation Team

The Installation Team shall consist of a variety of subcontracted teams and assets. Many of these subcontracted teams and assets will be used each time the MOTB is brought to or from the permitted site mooring. The anchoring installation team is only needed for the initial installation of the MOTB since, as previously stated, the anchors shall remain in place at the permitted site during the 10-year lifespan of the MOTB.

The NNMREC Program Manager and Contractor Project Manager serve as the project leads, as the customer and project manager respectively. The installation team is comprised of a variety of subcontracted members, each serving under the direction of the engineering lead. Refer to Figure 9 for the planned reporting hierarchy of these teams. Responsibilities for the different team areas are discussed below.

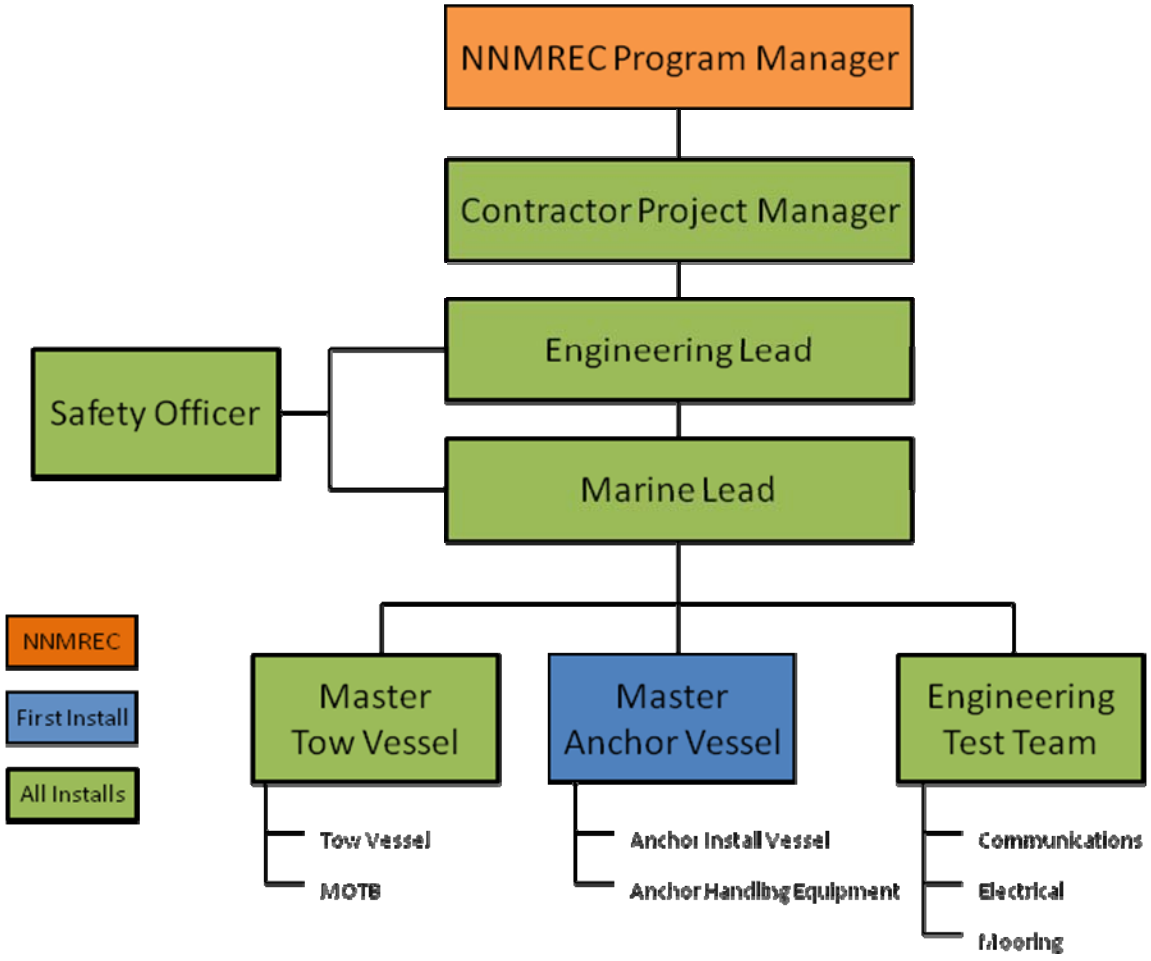

Figure 11 – Installation Team

4.2.1 NNMREC Program Manager

The NNMREC Program Manager (PM) shall be responsible for the overall management of NNMREC programs and projects, of which the MOTB is one.

4.2.2 Contractor Project Manager

The Contracting Project Manager shall be responsible for the overall execution of the Installation Plan for the MOTB. The Contracting Project Manager is responsible for the overall success, safety, and financial well-being of the project.

4.2.3 Engineering Lead

The Engineering Lead shall be responsible for all activities at all times during the final testing and installation of the MOTB. The Engineering Lead is the primary point of contact for all subcontractors and activities concerning the installation. Both the Contractor Project Manager and the Engineering Lead assure the project operations are performed in a manner consistent with the Safety Plan.

4.2.4 Safety Officer

The Safety Officer shall be responsible for safety during all on-water work. The Safety Officer will observe all operational actions of personnel, equipment, and machinery to maintain a safe working environment. The Safety Officer has the primary responsibility to review operational procedures and to observe at-sea operations, with the primary focus on identifying unsafe conditions that may be unnoticed during the course of deck operations. If unsafe conditions are identified, the Safety Officer

has the authority and responsibility to immediately stop operations, insure the MOTB is in a safe condition, and then bring these issues to the attention of the Engineering Lead for appropriate for determination of the facts, immediate corrective action, root causes, and longer term corrective measures. The Engineering Lead will ensure the facts and corrective actions are documented and provided to the Program Manager. After any order to stop operations, operations can resume only at the direction of the program manager in consultation with the SAIC division manager when cause and corrective action defined and agreed to by all parties.

4.2.5 Marine Lead

The Marine Lead is responsible for directing all deck procedures, specifically including equipment operations for use of cranes, winches, cable installation, etc. The Marine Lead is responsible for ensuring that deck operations are run safely within applicable regulations and has the duty to halt operations when hazardous conditions exist. The Marine Lead may or may not be the Engineering Lead. Specific qualifications for personnel will be the responsibility of the Marine Lead.

4.2.6 Master – Anchor Installation Vessel

The Master is responsible for the safety of the installation vessel and crew within the vessel. The Master takes direction from the Marine Lead but maintains the right to consider vessel and personnel safety before and during installation progress.

4.2.7 Master – Tow Vessel

The Master is responsible for the safety of the installation vessel and crew within the vessel. The Master takes direction from the Marine Lead but maintains the right to consider vessel and personnel safety before and during installation progress.

4.2.8 Others

All personnel not addressed in the above functional descriptions will report to one or more of the above described personnel and assist with duties concerning the installation of the MOTB. Personnel assigned with technician duties shall be properly trained and qualified to use the equipment necessary to perform required operations. Service personnel supporting operations shall understand the specific components they work on, including electrical, mechanical, and hydraulic, as well as basic service and repair procedures.

4.3 NNMREC Monitoring

A plan for periodic NNMREC additional monitoring and inspection shall be developed. This should include both announced monitoring and inspection and unscheduled monitoring and inspection during this phase. The results of this monitoring and inspections will be documented in the operating log and followed up with a formal report. See Section 5.5, Monitoring Plan for more information.

4.4 MOTB Installation Plan

4.4.1 Training

A series of training sessions and drill scenarios and conduct exercises will be performed prior to the installation of the MOTB. All personnel (contractors, OSU, NNMREC) working at-sea or on the MOTB shall be trained in the safe operation of high voltage. Periodic drills will be conducted. Drill scenarios including level of simulation, and acceptance criteria will be prepared for each type drill. See Section 5.3, Training for more information.

4.4.2 Transit to Newport-Truck

The MOTB will transit to Newport, Oregon via truck and lowboy style trailer. Permits will be required to transport the MOTB over land in accordance with the transportation plan. Required permits will be defined by Oregon Department of Transportation (ODOT) as well as any other state Department of Transportation that the MOTB will transit through to reach Newport. Transportation of the MOTB will be in accordance with these permits. Transportation of the MOTB may be in two or more packages to limit height and weight to allowable land transportation services. Initial weight estimates indicate that the input breaker and/or transformer may ship separate from the MOTB hull to meet with ODOT requirements. It is also expected that the dissipation load elements may be removed for shipment and re-installed on location.

The route planning will include a briefing to address checks of loose or vibration parts, breakdown, weigh stations, escort, expected rolling stop locations, safe haven, and personnel comfort breaks.

Prior to any shipment, an updated review of any local events will be completed to ensure planned evolutions do not conflict with local or regional community events along the route such as festivals, parades, regattas, tournaments, anniversaries, rallies, shows, contests, performances, conventions, fishing events, or celebrations; known traffic congestions; construction or outage detours; migration or other species related activities; or permit controlled activities.

4.4.3 Newport Outfitting

4.4.3.1 Staging Area Setup

Prior to receiving gear in Newport, the staging area shall be identified and prepared. Specific characteristics of the staging area are not yet known and will be added during the final design phase. General characteristics include the availability of power or generators, lighting, security, pier or dock capable of loads, identification of crane, crane counterweight assembly area, and crane pad area, and sufficient laydown area for logistics support boxes. Any contracted crane shall supply certified rigging gear, spreader beam, chaffing gear, taglines, and a dynamometer[2]. All lift loads shall be recorded.

A list of local suppliers, contact information, and hours of operation, and after hours contract will be developed.

4.4.3.2 Receive Gear

The MOTB, anchoring and mooring components, and associated gear shall be received in Newport. A crane and forklift of adequate rating shall meet shipments as needed. Anticipated gear is detailed below. This list, and the ratings of the crane and forklift, shall be refined as the design progresses. Detailed lifting requirements, clearances, and offload sequencing shall also refine as the design progresses.

1. Anchoring and Mooring Components
   a. Anchors
   b. Chain
   c. Connecting Hardware
   d. Buoys and floats
2. MOTB Hull

[2] Note: The crane will supply standard rigging gear. Any custom rigging gear needed for the MOTB will be provided. The crane operator will be provided with actual weight to be lifted and a diagram of centers of gravity.

a. Hull
b. Transformer
c. Input Breaker/Disconnect
d. Pier Mooring Line and fenders
e. MOTB simulator box

3. Shore Data Telemetry
   a. Shore Radios
   b. Shore Antennas (Central Lincoln PUD facilities may also be involved)
   c. Shore Computer
4. Test Equipment
   a. Load
   b. Cameras
   c. Sensors
   d. Probes
   e. Gloves
5. Safety Equipment
   a. Tag Lines
   b. Chaffing Gear
   c. Radios
   d. Float Coats
   e. Access Ramp
   f. Life Ring

4.4.3.3 Final Outfitting

Once in Newport, final outfitting the MOTB shall commence. Final outfitting shall primarily consist of components fit up during construction but removed for shipment. These components shall likely include power regenerations components (solar panels, wind birds), mast assembly, mast components (radios, antennas, and lights), load elements, and possibly the transformer and/or input breaker. Some components may not be installed until the MOTB has been launched and is located pierside in the water.

4.4.3.4 MOTB Launch

With final outfitting complete, the MOTB shall be launched. Multiple options exist for the launching of the MOTB. Options include the use of a crane to lift the MOTB into the water, the use of a marine railway to back the MOTB down a ramp, or the use of a marine travel lift to transport the MOTB into the water. Pictures of each of these options are included below in figures 10, 11, and 12 below. The launching method selected shall be dependent upon assets available in Newport, final size and weight of the MOTB, and operational safety considerations, including weather; winds, both steady and gusts, and sea state.

Figure 12 – Marine Railway (www.canada-photos.com)

Figure 13 – Marine Travel Lift (www.marineliftsystems.com)

Figure 14 – Land Based Crane (www.manitowoccranes.com)

4.4.3.5 Newport Testing

4.4.3.5.1 MOTB Dockside Testing

Final system testing shall be done pierside in accordance with the test plan. This test plan shall include testing of all components including: data acquisition from sensors, data telemetry, AIS function, lighting, alarm (fire and smoke, bilge, communications), bilge system, and remote breaker function. All systems will have previously been tested prior to shipment. These tests serve as a final check prior to installation.

4.4.3.5.2 MOTB Bay Trials

Bay trials may or may not be needed. The necessity of these tests will be determined and subsequently defined if needed during the build phase.

4.4.4 Anchor and Mooring Installation[3]

The anchors and mooring lines shall be installed separately from the installation of the MOTB. It is anticipated that the anchors and mooring lines can remain deployed throughout the 10-year life span of the MOTB.

The anchors and mooring lines shall be loaded on the installation vessel in Newport, Oregon and transit to the installation site. A mooring installation prerequisite list will be completed prior to loading. Using pre-defined coordinates for anchor location the installation vessel shall lower each anchor into place with the mooring lines and anchor chain attached. An acoustic release or similar shall be used to recover the lowering line. The mooring lines shall be tied off to a properly lit surface and/or subsurface buoy for temporary storage. Exact installation location shall be recorded and kept for future reference.

A detailed anchor and mooring installation plan shall be developed during the detailed design phase and shall be approved prior to installation. Features of the installation plan shall include anchor handling vessel requirements, additional assets required for install, and suggestion of possible anchor installation vessels. This plan must coordinate with the WEC mooring design and the plan for installing independent wave monitoring instruments.

[3] This is an external interface point with the WEC developer. To minimize mobilization costs, it may be advisable to coordinate the initial anchor and mooring line installation with the first WEC developer to minimize mobilization cycles and the risk of entanglement due to more than one installer of the anchors and mooring lines.

4.4.5 Towing of MOTB

With the final testing and checkout of the MOTB complete (including the completion of a separate tow readiness prerequisite list), the MOTB will be connected to a tow vessel and transported from the pier to the mooring installation site.

A detailed towing plan shall be developed during the detailed design phase and shall be approved prior to installation. Features of the tow plan shall include details of the MOTB connection to the mooring lines, load-handling gear, and associated requirements for this gear. The tow hawser will be a minimum length of TBD-02 for maneuvering and control and a length of TBD-03 for catenary for tow.

Temporary towing lights and day shapes will be installed on the MOTB and support vessel as required by the US Coast Guard. A tow hawser will be connected to the bow of the MOTB for towing to the mooring site.

Features of the tow plan shall include the above as well as minimum tow vessel requirements, tow attachment points, tow speed, towing components (shackles, tow hawser, safety lines, etc), and suggestion of possible tow vessels.

4.4.6 Installation of MOTB in Three Point Moor

A detailed installation plan shall be developed during the detailed design phase and shall be approved prior to installation. Once the tow vessel reaches the installation site, the MOTB shall be connected to the moor. The tow vessel shall facilitate this connection with the assistance of a smaller work skiff. The work skiff shall recover and clean the first mooring line. The tow vessel shall locate the MOTB near this mooring line and the work skiff shall make the connection. The work skiff shall then proceed to recover and clean the second mooring line. The tow vessel shall reposition itself on the MOTB if needed to locate it near the second mooring line and the work skiff shall make the connection. Finally, the work skiff shall then proceed to recover and clean the third mooring line. The tow vessel shall again reposition itself on the MOTB if needed and locate it near the final mooring line. The work skiff shall make the final connection and vessels can stand back as needed.

4.4.7 Final Commissioning Testing

Once installed in the moor, initial commissioning testing will be in accordance with a test plan. This test plan shall be developed during the final design phase. Bay Trials may be conducted prior to leaving Newport Bay as described in Section 4.4.3.5. Final at-sea commissioning testing shall be conducted to ensure shore communications, operations of the MOTB in the moor, and critical system operation.

4.4.8 Securing for Unmanned Deployment

Once testing is complete, the MOTB shall be secured for unmanned deployment. A detailed plan shall be developed to ensure all components are checked and secured prior to leaving the MOTB unmanned in the moor. This plan shall include checklists to confirm all systems are functioning and shore has the necessary communications signals as well as a list of items to be secured.

4.4.8.1 System Function Checks

- Confirmation of AIS transmission
- Confirmation of Radar Reflector
- Confirmation of Marker Lighting
- Danger and Warning Signs and Placards
- Verification of Alarm System

- Verification of Telemetry (critical sensors, cameras, and control features)

4.4.8.2 Items to be Secured

- Ventilation Screens
- Deck Hatches
- Deck Rails Removed
- Pinniped Haul Out Prevention Installed and Activated (if needed)
- Removal of all Tools
- Removal of all Interconnecting Lines
- Removal of Access Plank (if needed)

Once the MOTB is installed in the mooring and unmanned NNMREC must immediately implement the monitoring plan as detailed in Section 5. Safety of the MOTB, marine animals, and the surrounding community depends on a thorough monitoring plan that is followed diligently.

5 Operations and Maintenance

The operations and maintenance period of the MOTB is planned for ten (10) years. During this period a number of different operations will occur including monitoring, alarm system checks and acknowledging the alarms, training, verification of data receipt and storage, data archiving, dispatch of response, logging operations and checks, any out of specification conditions or unexpected conditions, and reporting. In addition, there is support of on water operations to remove, install, MOTB and monitor WEC installation and start up and continuing operations. This concept of operations document will detail the above operations and point to other documents as applicable for more detailed operations.

5.1 Operations and Maintenance Team

A standard team will be used during the operations and maintenance period of the MOTB. This team shall be comprised of NNMREC staff, subcontractors, and WEC developers. These team members, along with brief descriptions of their functions, are included below.

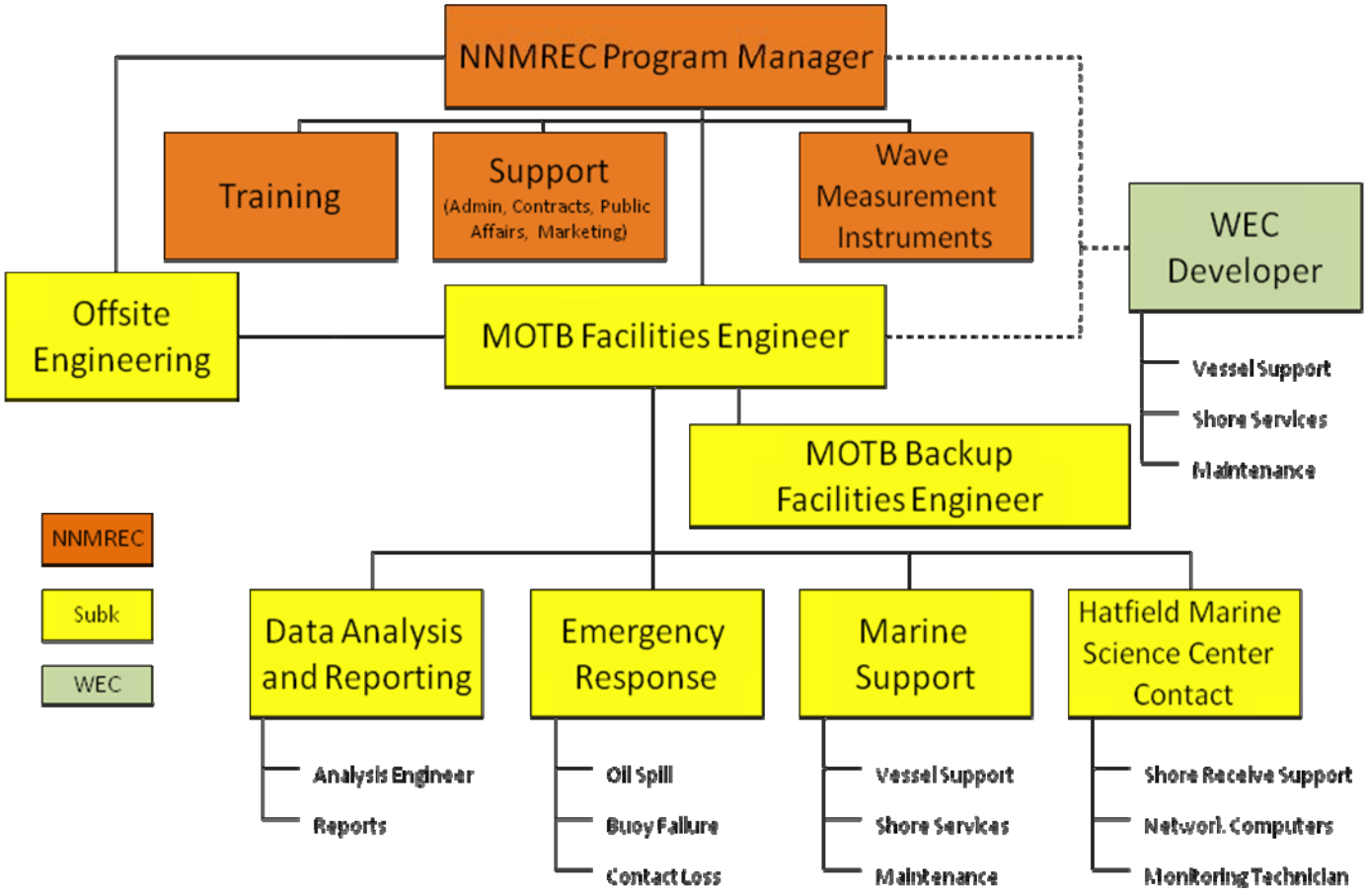

Figure 15 – MOTB Operations Team

5.1.1 NNMREC

NNMREC shall serve as the primary resource and contracts source for the MOTB. A program manager with a support staff including administrative support, contracts, and marketing will be needed to ensure the WEC vendors coordination, marketing to potential vendors, and agreement of terms and conditions.

5.1.1.1 Program Manager

The Program Manager (PM) shall be responsible for the overall management of NNMREC programs and projects, of which the MOTB is one. The PM shall oversee all activity related to the operation of the MOTB. The PM, together with the Facilities Engineer, shall assist with coordination between the MOTB and the US Coast Guard as well as between the WEC and MOTB, the local community, US Coast Guard, and required shore services.

5.1.1.2 Training

NNMREC shall complete training for all personnel maintaining or working on the MOTB. This training shall include MOTB specific training (including high voltage, sensors, reporting, and maintenance logs) as well as WEC specific training (specific to each WEC). This training may be conducted by the offsite engineering subcontractor and WEC vendor in lieu of NNMREC.

5.1.1.3 Support

A variety of support functions will be needed to support the NNMREC Program Manager including administrative, contracts, public affairs, and marketing.

Administrative support will be required for the PM to support procurement needs for the site, site scheduling, WEC coordination, and other duties as needed.

Contract support shall assist the PM in the placement of contracts with subcontractors for operations and maintenance activities, marine and land support, as well as with contracts with WEC vendors. Contract support, with outside support from an engineering team, shall be in charge of ensuring the WEC vendors meet the minimum requirements and MOTB terms and conditions are agreed to. Contracts shall also support WEC vendor understanding of the site operations, site terms and conditions, and available MOTB schedule.

Marketing and Public Affairs support shall have a dual function to market the MOTB to both WEC vendors and the local community. This support shall assist the PM by supplying marketing personnel and materials to the WEC community and assist with planning regular community outreach events during the initial construction and operations of the MOTB.

5.1.1.3.1 Wave Measurement Instruments

Additional instrumentation to measure the wave height, period, and direction, known as Wave Measurement Instruments (WMIs), may be deployed at the site in addition to the WEC and MOTB. These instruments will be deployed, maintained, and monitored by NNMREC. The deployment of these devices will serve to assist in the analysis of the WEC power output. Placement of these instruments in the permitted site will be in accordance with existing and planned installation activities and devices.

5.1.2 Subcontractor

Various subcontractors will be used to assist NNMREC with the operations of the MOTB. These subcontractors include monitoring staff, engineers, marine support, and emergency response.

5.1.2.1 Offsite Engineering

An offsite engineering team will be used to conduct a review of WECs prior to their acceptance for testing at the MOTB, address configuration control for varying MOTB layouts, and provide maintenance support as needed. WEC acceptance analysis will include WEC structural analysis, WEC mooring design, and review of WEC monitoring plans. See Appendix A WEC Device Installation Interface Requirements and Characteristics for further details.

5.1.2.2 MOTB Facilities Engineer

The Facilities Engineer (FE) will be responsible for maintaining the MOTB including deployment/recovery options, maintenance reporting and tracking, and most importantly acknowledgement and response to alarms and emergency conditions. The FE shall be the primary point of contact for all the subcontractors assisting in any operation surrounding the MOTB. A backup FE will be available for when the FE is unavailable.

5.1.2.3 Data Analysis and Reporting

TBD-04

5.1.2.4 Emergency Response

TBD-05

5.1.2.5 Marine Support

A marine support contract will be needed to support the various types of at-sea maintenance. The marine support contractor will need to include on-call vessel support. The contracted vessel will need to be capable of withstanding local sea climates, safely mooring next to the MOTB, carrying small payloads, etc. Specific characteristics of this vessel have not yet been determined.

Since the marine support vessel will be needed for regularly scheduled maintenance trips, as well as unplanned maintenance trips, NNMREC shall contract with a local vendor to provide vessel services. These services will come with a planned, short notice, and immediate charter rate.

5.1.3 Hatfield Marine Science Center Contact

The Hatfield Marine Science Center (HMSC) will be used as a host facility for the MOTB database and internet server. Basic power and high-speed internet access shall be supplied through the agreement. Specifications of this agreement, cost shares, and requirements will need to be finalized. A monitoring technician may or may not be included in this contract.

5.1.4 WEC Developer

TBD-06

5.2 WEC Installation and Connection to MOTB

5.2.1 MOTB Configuration, WEC Specific

The MOTB may need to be configured for specific WECs. The MOTB shall be designed to accommodate as many different types of WEC input as possible. To accomplish this, some configuration may be needed from manufacturer to manufacturer.

5.2.2 WEC Installation

The installation of the WEC is not the responsibility of NNMREC. However, NNMREC shall have a representative present during all WEC installation activities to ensure boundaries are respected, clearance is given to the MOTB and any other deployed equipment, and procedures are following according to best practices.

5.2.3 WEC Cable Connection to MOTB

- Submarine power cable installation
- Submarine power cable connection
- WEC power on

5.3 Training

NNMREC and WEC developer will develop a series of training drill scenarios and conduct exercises at least once prior to a WEC deployment and prior to any return to the test site. In addition, NNMREC and the WEC developer will conduct a training drill once a quarter. Drill scenarios and evaluation criteria will be agreed to prior to the drill. Periodic drills will be conducted. Drill scenarios including level of simulation, and acceptance criteria will be prepared for each type drill. Drills include:

- Fire
- Flooding
- Arc Flash
- Divorce from WEC electrically
- Intrusion detection, unauthorized access
- Wildlife haul out or roosting
- Position; exceed expected watch circle or GPS position, mooring failure, anchor drag
- AIS
- Emergency Shutdown
- Collision
- Entanglement in fishing gear

All personnel associated with operations of the MOTB and associated WEC will be trained in accordance with the safety management plan. Topics include:

1. Medium voltage electrical safety;
2. Cardio-Pulmonary Resuscitation (CPR),
3. Automatic External Defibrillator (AED),
4. Hypothermia and First Aid;
5. Personnel protective equipment and fall protection;
6. MOTB access procedures;
7. Confined space access and control, gas free, and ventilation procedures+;
8. Shutdown and isolation procedures and tools including lock out and tagout; work authorization procedures;
9. Security; evacuation; rescue procedures;
10. Towing and Mooring Procedures;
11. Boat operation requirements will be addressed for each vessel employed.

NNMREC will determine the refresher training frequency and schedule.

5.4 Operational and Testing Periods

Short Duration Testing

Initial Monitoring Period: Few days to few weeks
Longer Term monitoring
1-2 months
Winter over period-extended

Access to the MOTB during operations testing. There is no planned entering of the MOTB spaces once installation and commissioning are complete.

Access using the personnel access hatches while at sea is not a planned event. Space ventilation and splash protection for the hatches would be too difficult to achieve. If access during very calm seas was considered, a detailed access plan would have to be developed and approved and detailed time targeted training completed to ensure the minimum exposure time.

There may be times when the onboard hard drive needs to be replaced. Access will be only to the hard drive.

External maintenance access: For periods when the Test Berth is removed from the mooring and brought into Newport for servicing or reconfiguration, access will be governed by confined space access requirements.

5.5 Monitoring Plan

Monitoring may include a variety of areas including the data analysis, alarm monitoring, and website maintenance. The type and frequency of data analysis and reporting has not yet been determined.

5.5.1 Initial Monitoring

5.5.2 Long Term Operations

The site will be monitored on an uninterrupted basis through the Data Acquisition and Telemetry Infrastructure. To ensure uninterrupted monitoring the data telemetry system will have a redundant radio and receiver set as well as emergency batteries separate from the primary low voltage power system. Alarms from the MOTB will be fed to DATI network and viewable through a secured network login to an internet based user interface hosted at the Hatfield Marine Science Center (HMSC).

Alarms will receive inputs from two sources: (1) the MOTB and (2) 1-800 phone call from outside source. The facilities engineer will actively monitor the MOTB when deployed, checking the health of the system at least twice a day, six hours apart. In addition to the manual monitoring system, an automated alarm system will notify the facilities engineer if needed. The 1-800 number will be set up and specifically designated for MOTB issues. This number will be posted on the MOTB and published on NNMREC's external website, ensuring the community has a means to reach NNMREC in the event of an issue.

5.5.3 Shore Station Monitoring System

A network based graphical user interface for monitoring the MOTB shall be developed as part of the MOTB design. This interface shall be hosted at HMSC and broadcast through the internet. Users shall be able to log into the interface from any computer connected to the internet using usernames and passwords to view data, make changes to the system, and address alarms. Varying levels of access shall be granted to this interface based on the user's needs.

5.5.3.1 Hatfield Marine Science Center

A secure room at HMSC shall be used to host the MOTB monitoring system. The room shall be locked and have an access control system in operation that validates authorized personnel. This is necessary to protect the sensitive nature of the WEC power output data. The room shall be nominally sized, allowing for three rack computers and a small air conditioning unit. Basic 110V power and a dedicated internet port (possibly T-1 or equivalent) will be needed. Uninterruptable power supplies and a backup generator shall be used to ensure data is backed up and communications with the MOTB are not lost.

The telemetry data will be backed up daily. Data will be archived periodically (TBD-07) and stored separate from the back up. All electronic storage media will be conspicuously marked, logged, and controlled at receipt and transfer to or from the HMSC location. Media with WEC data shall be

removed from the HMSC location at the conclusion of a WEC vendors lease and stored at an offsite NNMREC location. This marking and offsite storage ensures no outside WEC vendor obtains access to another WEC vendor's data.

5.5.4 MOTB Access Control

Three types of access will be available through the MOTB graphical users interface (GUI). These are full access, full read access, and read only access. Varying levels of access are needed to ensure safety and adequate monitoring of the MOTB, access of data to parties with the need, and public outreach access. The varying levels of access and what is allowed through each access is described below.

5.5.4.1 Full Access

Full access shall be granted to the facilities engineer and an offsite engineering contractor with system expertise. Full access shall allow a user to reconfigure the system as needed, log and note alarms, and note any maintenance issues.

5.5.4.2 Full Read Access

Full read access with limited sensor check shall be granted to NNMREC personnel and any additional selected personnel. As this access contains the WEC power output information access shall be limited to protect WEC vendor proprietary data. Users with this access level shall be able to select sensors and determine their health but will not be able to reconfigure any components within the system. Users shall be able to see, but not update or modify, MOTB maintenance and alarm logs. WEC vendors shall likely be granted this access.

5.5.4.3 Read Only Access

Read only access shall be granted to those personnel that have a community interest in the project. Read only access shall only allow the user to see the sensors are functioning "within normal parameters" and will not have any interactive features. This access shall be granted to primary community stakeholders such as a FINE representative.

5.5.5 Joint Monitoring

In accordance with the agreement with the WEC developer, joint monitoring of the WEC is expected both during the initial operating/test period and throughout the testing period. The exact method of joint monitoring will be determined on a case-by-case basis. Monitoring may be through the submarine power cable and transmitted through the NNMREC shore station. Alternately, monitoring may be through a WEC specific telemetry system and provided with minimal delay to the NNMREC servers through an internet interface. Requirements for WEC monitoring parameters are further discussed in Appendix A.

5.5.6 Security Plan

A security plan may be developed that defines the access control requirement for the telemetry system and data. This security plan would define the access password control requirements, administrator access, and frequency of change of passwords. The security plan will define the intrusion detection and tamper resistance features and identify appropriate responses to intrusion detection alarms to be included in the response plan.

5.5.7 Additional Monitoring

Multiple national laboratories and research institutes are developing sensor suites to monitor additional parameters including a wide range of environmental, ecological, and engineering parameters. These sensor suite space, weight, power, telemetry bandwidth, mounting, and

operational requirements have not been defined at this time for incorporation into MOTB design. As such, these sensor suites will not be incorporated the initial insulation of the MOTB but may be included in future technical refreshes. Some of these sensor suites are described below.

The Pacific Northwest National Laboratory (PNNL) is developing a sensor suite to monitor marine mammals, birds, and endangered fish and whales.

The National Renewable Energy Laboratory (NREL) is developing a sensor suite to monitor WEC health and environmental parameters such as acoustic noise, water temperature, and salinity.

5.5.8 Data Analysis and Reporting

Electrical Performance Summary
- Hours of Operation
- Voltage Range-High, Low, Average (TBD-08)
- Current
- Power
- 24 hour plot (WEC vendor access)

5.5.9 Alarms

A detailed alarm response manual will be developed as part of the monitoring plan to address alarms. Alarms will be categorized into four areas: (a) basic, (b) moderate, (c) critical, and (a) WEC alarm automatically by the DATI. The alarm response manual will provide a series of decision trees to assist the FE in determining the next step, logging procedures, and points of contact.

All alarms will be logged by the system and must be acknowledged by the FE, the response initiated or dispatched, and again logged with the corrective action taken. Alarm logs will be periodically reviewed to assist in determining faulty sensors or problematic systems.

WEC representatives shall monitor their alarms and will advise the MOTB FE that they have received, acknowledge, and addressed their alarm in accordance with the WEC alarm response manual (see Appendix A).

Some of the alarms anticipated are:

- WEC Based Alarms
- Exceed Watch Circle (Failed Mooring)
- Bilge
- Power Output
- Sensors
- Basic Alarm
- System Condition
- Environmental
- Sensor Offline
- Moderate
- Storage Disk Failure
- Communications Failure
- Unauthorized User (Data Access)
- Critical
- Ground Fault
- Exceed Watch Circle (Failed Mooring)
- Bilge Pump
- Intruder Alarm (Physical)

Entanglement by fishing gear or mammals

Different level alarms will result in a varying automated responses. These responses are detailed below.

5.5.9.1 WEC Based Alarms

The MOTB will monitor selected WEC alarms. The exact monitoring path will depend upon agreements between NNMREC and the WEC vendor. Monitoring path options include the WEC sending select data to the NNMREC monitoring system or the NNMREC monitoring system monitoring the WEC alarms directly and sending the WEC vendor the information.

A WEC vendor shall maintain monitoring control of their device at all times. WEC based alarms will result in a SMS text message being sent to the facilities engineer. The FE will have 2 hours to log into the system, log the alarm, and address the issue. Response from the WEC manufacturer shall be in accordance with their approved WEC alarm response plan (see Appendix A).

5.5.9.2 MOTB Basic Alarms

Basic alarms will be displayed on the monitoring console and will result in a SMS text message being sent to the facilities engineer. The FE will have 2 hours to log into the system, log the alarm, and address the issue. If the FE does not address the alarm within the allotted time frame, an automated phone call will be sent to the FE. If the FE still does not log into the system within 30 minutes, the backup FE will receive both an SMS text message and automated phone call.

Basic alarms can typically be addressed during the next MOTB servicing, may require resetting, or may need to simply be logged.

5.5.9.3 MOTB Moderate Alarms

Moderate alarms will be displayed on the monitoring console and will result in a SMS text message being sent to the facilities engineer. The FE will have 30 minutes to log into the system, log the alarm, acknowledge the alarm, and address the issue. If the FE does not address the alarm within the allotted time frame, an automated phone call will be sent to the FE. If the FE still does not log into the system within 5 minutes, the backup FE will receive both an SMS text message and automated phone call.

Moderate alarms may result in an early MOTB servicing, may be serviceable at the next outing, may require resetting, or may simply need to be logged.

5.5.9.4 MOTB Critical Alarms

Critical alarms will be displayed on the monitoring console and will result in a SMS text message, e-mail, and automated phone call being sent to the facilities engineer. The FE will have 10 minutes to log into the system, log the alarm, and address the issue. If the FE does not address the alarm within the allotted time frame, a SMS text message, e-mail, and automated phone call will be sent to both the FE and backup FE.

Critical alarms require either monitoring (bilge pump), active reaction at the soonest weather window (ground fault, exceed watch circle), or additional data uploading (intruder, relocate camera and upload additional images). A critical alarm cannot simply be re-set. It must be monitored and addressed. A critical alarm will typically require an onsite response team outfitted to deal with fire and flooding conditions. Intrusion detection response will also include notification of local law enforcement and US Coast Guard, Newport by the FE.

5.5.9.5 Master Alarm

A master alarm occurs when multiple critical alarms occur at the same time. An example of such an occurrence may be activation of multiple bilge pumps, exceeding of a watch circle, and an intrusion alarm. These series of alarms may indicate a vessel strike or other catastrophic event.

Master alarms will be displayed on the monitoring console and will result in the immediate notification of the FE and the US Coast Guard. Master alarms require immediate investigation through the user interface, contact of the US Coast Guard to activate them if required, and likely an active on-site response at the soonest weather window.

5.6 Maintenance Plan

5.6.1 Maintenance Team

- Facilities Engineer
- Backup Facilities Engineer
- Technician
- Tow Assist Team
- Procurement

5.6.2 Development of Maintenance Plans

A maintenance plan shall be developed to support the MOTB. This maintenance plan shall be organized into a plan that can be supported by NNMREC. The maintenance plan shall address the details of maintenance types detailed below, maintenance manuals, configurations,

5.6.3 Types of Maintenance

Three types of maintenance will occur:

Inspection: The MOTB is inspected visually through the camera and through regular maintenance trips on a pre-determined schedule. The inspection will determine maintenance requirements.

NNMREC will conduct both announced and unannounced safety inspections. If pierside, this inspection may include internal wiring and ground system.

Scheduled Maintenance: Maintenance is done based on length of operational use or at pre-determined intervals of time. The results of the maintenance will provide an understanding of future maintenance requirements.

Solar panel cleaning
Anemometer and wind bird inspection
Inspection and cleaning of marine growth build-up
Evidence of bird or marine mammal presence
Hull marine growth diver inspection
Hull inspection is not expected until TBD-09 years
Load element inspection
Thermal image inspection during operations
Mooring lines

Condition-Based Maintenance: Monitoring of equipment condition is used to analyze operational status and trends. Operational parameter limits, warnings and alarms serve to initiate investigative and/or corrective maintenance.

Corrective Maintenance: This maintenance is when required and may be between scheduled maintenance. The change in schedule could be due to:

Failure of equipment or hardware,
Predicted failure during an inspection, or
Accelerated maintenance to be available during a specific time frame, when normal maintenance would be done.

Hands on visual inspection shall occur on a regular basis to replace batteries, retrieve hard drives, clean solar panels, and complete routine cleaning. This hands on visual inspection shall take no more than four hours and shall likely occur on a monthly basis.

All equipment used on the MOTB will be provided with an operations and maintenance manual. Two copies of the manuals will be available and will provide:

- Safe operation of the equipment,
- Schedule for inspection and maintenance, and
- Spares list.

In addition to the above, maintenance that can be done while in the moor shall be identified as well as maintenance that must be done pierside and in drydock identified.

5.6.4 On-Site Maintenance

Initially, weekly visits to the MOTB will be conducted. These visits will serve to visually inspect the exterior of the MOTB for signs of premature wear, excessive biofouling, or to address minor modifications desired by the team that cannot be modified from shore. These visits will be 1-2 hours in length. Additional visits will be dependent upon the testing duration and the weather. In general, interior access is not planned while installed in the mooring.

Inspection of the load elements and cage on port or starboard side may be accomplished with video cameras but no at sea maintenance is planned, TBD-10.

Once operational and functioning the MOTB will require very few maintenance trips. Regularly scheduled maintenance trips will be required to retrieve data storage devices, replace batteries (TBD-11), clean solar panels, replace broken wind turbines, and any other corrective maintenance specifically authorized for accomplishment . It is anticipated that these maintenance trips will take 4-6 hours and be needed every 4 weeks. If weather precludes visitation, additional video surveillance, data compression, and backup batteries (TBD-12) may be utilized.

Inspection and maintenance of the mooring system for fouling or other condition will be TBD-13

All WEC inspection will be conducted in accordance with the approved WEC maintenance plan. Refer to Appendix A.

Additional surveillance by FINE will be in accordance with their agreement.

5.6.5 Dockside Maintenance

NNMREC shall have a slip in Newport for the storage of the MOTB for periods of maintenance as well time between testing.

Some maintenance shall require the MOTB to be moored dockside in calm weather to complete. This maintenance may include the change of load elements, re-routing of electrical wires, etc.

5.6.6 Dry-dock Maintenance

Some maintenance shall require the MOTB to be dry-docked to complete. This would result from in unexpected and likely catastrophic in nature such as a collision, damaged hull, etc.

5.6.7 Maintenance Reporting

Three types of maintenance reports will be generated: (1) Inspection Reports, (2) Scheduled Maintenance, (3) Condition-Based Maintenance, and (4) Corrective Maintenance. Each of these forms will be located in the Maintenance Plan along with guidelines for completing them. Each maintenance report shall be given a unique serial number following a pre-designated plan and tracked according to that number.

5.6.8 Operations and Maintenance Training

All maintenance personnel will receive training specific to the MOTB. This training will include high voltage training, safety training required for on-water work, MOTB specific systems, and any other pertinent training deemed necessary.

Each WEC vendor shall give WEC specific training to the FE and any applicable technicians. While NNMREC will not be responsible for WEC operations and maintenance, it may become a necessity for the FE to assist with WEC emergency operations and thus should be familiar with the WEC operations.

5.7 Extreme Events

Extreme events that occur at or outside the design requirements will require thorough evaluation of the MOTB prior to resumption of normal operations. These events included unusually high waves, high winds, earthquake, electrical fault, automatic protective action, master alarm, or tsunami.

5.8 Contingency Response

5.8.1 MOTB response

TBD-14

5.8.2 WEC response

TBD-15

5.9 Self-Evaluation

OSU/HMSC will conduct an annual self-evaluation of operations and maintenance and conduct a safety, corrosion, structural integrity, tamper seals and locks, and attachment point inspection of the MOTB, preventive maintenance schedule and any deferred items, and supporting facilities. Attribute list attached (TBD-16).

NNMREC will review the self-evaluation and will formally document the results and any findings. MOTB will utilize the Minerals Management Service (MMS) conventions for reports: a Potential Indication of Non conforming Condition (PINC) or Indication of Non-Conformance (INC). The response will be based on the severity of the finding. Any INC will be thoroughly evaluated to ensure the complete facts are documented and corrective actions identified. All action items will be tracked until completed and the action taken.

6 Removal (This entire section remains to be completed TBD-17)

6.1 Removal Team

- Tow Vessel
- Work Skiffs

6.2 WEC Connection

- WEC power off
- Submarine power cable disconnection
- Submarine power cable buoy off?

6.3 MOTB Removal Plan

- Validation of WEC power off
- Removal and buoy off of mooring lines
- Connection to tow vessel
- Transportation to Yaquina Bay
- Moorage in Newport or storage

6.4 Reconfiguration of MOTB

6.5 Alternate Location

- Survey Requirements
- Tow Plan
- Land Transportation
- Anchor Installation
- MOTB Setup

7 Decommissioning

7.1 Site Decommissioning

Per the permit guidelines, the site shall be decommissioned after 10 years. Decommissioning includes the removal of all items placed in the water and on the seafloor. All buoys and anchors shall be removed.

7.1.1 Anchor and Mooring Line Removal

Prior to the removal of the anchoring and mooring lines, the MOTB shall be removed according to the removal procedures (initially outlined in Section 6.3). The MOTB anchors and mooring lines shall be removed by a vessel with adequate assets and load handing capabilities. The anchors and mooring lines shall be removed by attaching a recovery line to the anchor (likely using an ROV) and then winched to the surface. It may be possible to recover the anchors through the mooring lines, if this is the case and ROV will not be needed. Anchors and mooring lines shall be properly disposed of.

7.2 MOTB Decommissioning or Repurposing

This section is to be determined later (TBD-18). Some considerations are as follows:

- Cancel AIS identification
- Change in Nautical Charts
- Cancelation of Notice to Mariners
- Cancelation of Agreements with Local Vendors, Port of Newport, etc
- Disposition of Hull and Major Components.

Appendix A: WEC Device Installation Interface Requirements and Characteristics

1 General

All WEC manufacturers looking to test at the MOTB shall enter into contract agreements and negotiations with NNMREC. Many factors shall be considered, parameters and requirements addressed, and agreements reached during these negotiations. The below sections address just some of the technical factors that should be discussed during this period.

1.2 WEC Requirements

Each WEC will have specific requirements and interfaces for testing at the MOTB. These requirements include, but are not limited to, the below stated:
Power Output
Submarine Power Cable Interface
Data Transport
Power Supplied to WEC
Grid Mimic Module

1.3 Acceptance Requirements

Prior to acceptance for installation, each WEC shall be individually evaluated to address design and construction standards, marking, installation, maintenance, and decommissioning plans, and monitoring plans. This section will define the minimum standards that are expected to be met by the developer. The developer will be allowed to recommend alternate standards that are justifiable. New standards may be added based on operational experience in the industry.

1.3.1 Hull and Structural Design

The developer shall provide calculations for the design of the hull and supporting structure. The following ABS Rules may be used for guidance for the hull design:

1. "Rules For Building And Classing Steel Vessels 2010, Part 3, Hull Construction And Equipment."
2. "Conditions Of Classification – Offshore Units And Structures, 2008, Part 1."
3. "Guidance Notes On Spectral-Based Fatigue Analysis For Floating Offshore Structures," March 2005.
4. "Commentary On The Guide For The Fatigue Assessment Of Offshore Structures (April 2003)," Updated June 2007.

Alternate offshore industry rules may be proposed by the developer. These will be reviewed on a case-by-case basis by NNMREC, offsite engineering, and any permitting authority as needed and their applicability determined.

The developer shall submit the following:

1. Structural analysis of the WEC. The analysis should include:
   a. Deployed condition, including the mooring connections
   b. Handling conditions, including lifting points used
2. Deployment conditions, including towing points
   a. Structural drawings with the following information:
   b. Plate thickness
   c. Main structural member
   d. Stiffeners

e. Mooring, lifting, and towing connections
f. Connection and welding details
g. Sea chest and through hull openings
h. Re-enforcement plates and rings, and doubler plates
i. Material specification

3. Weight estimate
4. Stability calculation for deployed and deployment conditions
5. Corrosion Control plan and cathodic protection
6. Watch Circle and expected GPS coordinates
7. Danger and Warning signs, placards
8. Visible features for video surveillance
9. Lights

1.3.2 Marking

1.3.2.1 Lighting

All WEC devices shall be outfitted with lighting in accordance with the NNMREC permit requirements. This lighting may be in accordance with the IALA Recommendation O-139 "The Marking of Man-Made Offshore Structures." The USCG is typically requires their approval for all lights and lighting plans and shall be consulted by NNMREC on the preferred approach for the WEC vendors.

1.3.2.2 Audible

All WEC devices shall be outfitted with a sound signal in accordance with NNMREC permit requirements. This sound signal may be in accordance with the IALA Recommendation O-139 "The Marking of Man-Made Offshore Structures." The USCG is typically requires their approval for all sound signal devices plans and shall be consulted by NNMREC on the preferred approach for the WEC vendors.

1.3.2.3 Radar and Radar Reflector

Individual WECs shall be fitted with a passive radar reflector mounted above the waterline. An AIS beacon may be required in addition to a passive radar reflector.

1.3.3 Piping Systems

The developer shall provide design information for the piping systems used on the WEC. The minimum piping systems are:

1. Bilge system
2. Vent piping

The following ABS Rules can be used for guidance "Rules for Building and Classing Steel Vessels 2010 Part 4." The following additional requirements shall be included in the design:

10. Through hull valve shall reach rods to allow for operation from outside the hull
11. Discharge lines for the bilge system shall have double check valves
12. Vent piping shall have a float style ball check and a lockable gate/ball valve

The developer shall provide the following:

1. Calculation for each the piping systems
   a. Head loss for systems with a pump

b. Pump curves and reason for the selection of the bilge pump
c. Available bilge pump operation time based on battery operation
d. Pressure calculation for the selection of pipe sizes and components

2. Piping Instrumentation and Diagram with the following information
   a. Pipe size and routing
   b. Material schedule for the components

Alternate offshore industry rules may be proposed by the developer. These will be reviewed and their applicability determined on a case-by-case basis by NNMREC, offsite engineering, and the permitting authority if needed.

1.3.4 Electrical Systems

The developer shall design information for the electrical and electronic systems used on the WEC. The design of the electrical system shall be in accordance with IEEE Standard 45 "Recommended Practice for Electric Installations on Shipboard." Wires and cable shall have protective covers or be routed in protective conduit to prevent damage from marine animals. Power cable shall be routed separately from electronic and monitoring wiring.

The developer shall provide the following information:

1. Expected performance
2. Electrical load analysis
3. Battery life based on the electrical load analysis. The battery shall be capability of operating for 24 hours with the highest load requirement without charging.
4. Protective features settings

1.3.5 Criteria for Power Take Off Design

The piping, electrical, and electronic systems shall meeting the requirements listed in Sections 1.3.2 and 1.3.4. The developer shall supply enough information to allow for the verification of the safety of the systems.

1.4 Installation Plan

1.4.1 General

The developer shall provide an installation and recovery plan for the WEC. The plan will include all aspects of both operations. Contingencies shall be included in the installation plan.

1.4.2 Mooring System

1.4.2.1 Design of the mooring system

The mooring system shall be design for deployment off Newport, Oregon. The deployment design shall be for a minimum of one continuous year. NDBC Buoy 46050 may be used as method to determine the environmental conditions. The design shall use a 50-year storm for the maximum loads. The calculation shall include failure modes.

NNMREC will provide the bathymetry for the site.

The mooring system calculation should be done using API RP 2P, "Analysis of Spread Mooring Systems for Floating Drilling Units." Alternate methods are acceptable provided they are used in the offshore industry. The developer shall provide the calculation to NNMREC for review and acceptance.

1.4.2.2 Mooring system components

The developer shall provide drawings of the mooring system that was designed in Section 1.4.2.1. The drawing shall include the following information:

1. Anchor type and number required
2. Anchor chain length for leg, size and material
3. Anchor line length for each leg, size and material
4. Interconnection hardware
5. Mooring Attachment Points

1.4.3 Installation Plan

The developer shall provide an installation plan for the WEC. The installation shall include the operation from the Upland Site until it is in its mooring system. The plan shall include the following information:

1. Assets to move the WEC on land
2. Assets to transfer the WEC from land to water
3. Marine assets to handle the WEC
4. Marine asset and equipment to handling the installation of mooring system
5. Description of the Installation method and sequence, and expected schedule
6. Equipment for handling the WEC at each stage of transportation
7. Listing of key individuals and their responsibilities
8. A systematic description of the following processes:
    9. Installation of the mooring system and mooring footprint
    10. Transferring the WEC from land to water
    11. Towing the WEC to the site
    12. Connection the WEC to the mooring system

The procedure shall include a contingent section, which will address:

1. Points of Contact and Recall List
2. Weather impact and requiring stoppage of the procedure
3. Possible failure of equipment during the operation
4. Opportunities during the procedure when work can be suspended
5. Salvage plan for failed WEC.

The plan shall be submitted to NNMREC for comment and acceptance.

1.4.4 Maintenance and Monitoring Plan

1.4.4.1 Training

WEC manufacturers testing at the MOTB shall complete a training session on the maintenance of their WEC device for their local maintenance crew as well as for NNMREC and subcontracted personnel that will be maintaining the MOTB. This training is required for overall system safety. This training was previously discussed in Section 4.4.1.

1.4.4.2 Maintenance Plan

A maintenance plan shall be developed by each WEC manufacturer. This maintenance plan shall address types of maintenance, when maintenance should occur, and a local maintenance crew that will be responsible for the WEC. This plan shall be submitted to NNMREC for comment and acceptance.

1.4.4.3 Monitoring Plan

Safety parameters, including buoy safety and human safety, for the WEC shall be monitored continuously. These parameters shall be either fed back to the NNMREC monitoring system at Hatfield Marine Science Center or fed through the MOTB DATI Infrastructure. These parameters will be made available on a secure network for external viewers with proper access credentials. If the WEC sends the signals to the NNMREC monitoring system, the WEC monitoring path shall have a redundant backup. Example parameters include:

1. Location of WEC
2. Bilge Pump Alarm
3. Bilge Pump Operation
4. Battery Condition
5. Battery Charging Rate
6. Mooring Tension

A monitoring plan shall be developed by each WEC manufacturer and submitted to NNMREC for comment and acceptance. The monitoring plan shall include the local point of contact for the WEC manufacturer that will be maintaining the WEC if the manufacturer is not located in the immediate area.

1.4.4.4 Alarm Response Manual (Emergency Response Plan and Agreements)

An alarm response plan and manual shall be written by each WEC manufacturer and submitted to NNMREC. This alarm response manual shall cover alarms within the WEC and the required response. The necessary NNMREC personnel or their subcontractors shall be trained by the WEC manufacturer in alarm response for the manufacturers WEC device.

1.4.5 Decommissioning Plan

The decommissioning plan shall include all the required information that is listed in installation plan, Section 1.4.3. The plan shall cover the removal and recovery all the equipment installed during deployment. The WEC shall be returned to shore. The plan shall be submitted to NNMREC for comment and acceptance.

Appendix B: Design of Record

The below documents shall be maintained as the design of record with the NNMREC Program Manager, Facilities Engineer, and Offsite Engineering. This information provides critical background for use as needed during operations, contingency response, design modifications, and future builds.

1. Design Drawing Package
2. TLR
3. IDD
4. SRS
5. Test plan and completed test procedures
6. Bill of Material
7. Technical Manuals and Vendor Cut sheets
8. US Army Corps of Engineers Permit
9. Insurance Policy
10. Spares Lists and Logistics Support Box Inventory'
11. Maintenance Plan and Maintenance Schedule
12. Safety Management Plan
13. Transportation Plan
14. Installation Plan
    a. Connect and Disconnect Procedure
    b. Wiring and Ground Inspection Plan
    c. Periodic Inspection Checklist/Attribute List
15. Quality Plan with Reliability and Availability Determinations
16. Salvage Plan
17. Decommissioning Plan
18. Training and Qualifications Plan
19. Emergency Response Plan and Procedures
    a. Battery Charge
    b. Fire Bill
    c. Flooding
        i. Emergency flotation
        ii. Grapple and Tow to shallow water
    d. Intrusion Detection/Boarding/Temporary mooring along side
    e. Mooring Failure
    f. Collision
    g. Mooring fouling by fishing gear
    h. WEC casualties
    i. Marine Wildlife-Birds, Marine Mammals
20. Work Authorization Log
21. Operation Plan

a. Line ups
b. Lock Out Tag Out Procedure
c. WEC Cable Connection and Disconnect
d. Battery Charge from Servicing Vessel

22. Reliability and Availability Determinations

Appendix C: To Be Determined Items

Table 1 – To Be Determined Items

TBD Number	Page #	TBD Number	Page #
TBD-01	16	TBD-11	41
TBD-02	29	TBD-12	41
TBD-03	29	TBD-13	41
TBD-04	34	TBD-14	42
TBD-05	34	TBD-15	42
TBD-06	34	TBD-16	42
TBD-07	36	TBD-17	43
TBD-08	38	TBD-18	44
TBD-09	40		
TBD-10	41		