Draft Science Support Requirements for a Manned Spar Buoy Laboratory

Introduction

Needs for a manned spar buoy laboratory/stable ocean platform were articulated as early as 1959 by the National Academy of Sciences Committee on Oceanography (National Research Council, 1959) and several craft in this category were built and used in the 1960s (Bouee Laboratoire, FLIP, SPAR, POP). Only one of these (FLIP) had the mobility and versatility to carry out a wide range of research functions and has continued to support seagoing work up to the present time. The appendix lists a number of research projects for which FLIP has been used over its 26-year life. Like the bulk of the conventional ocean research craft, also built in that decade, FLIP is becoming increasingly expensive to maintain, while at the same time new research requirements have emerged beyond her present capabilities. Given the long history of fruitful use of FLIP, it appears appropriate that consideration be given to her replacement with a new vehicle.

As in other similar instances, the UNOLS Fleet Improvement Committee has sponsored the compilation of this draft set of science requirements for consideration by the ocean science community as it moves toward design and construction of an updated version of a craft to meet the needs of the 1990s and beyond. Most of the requirements presented below were assembled during a 1987 workshop at the Marine Physical Laboratory (Fisher and Bishop, 1988).

Three communities have found this type of craft to be useful in the past and look forward to broadened capabilities: marine physicists (acoustics, optics, radar), physical oceanographers (surface and internal waves, turbulence), and atmospheric scientists (low-altitude marine meteorology, air-sea interaction). Beyond these, examples of new uses include providing ground truth for satellite observations (e.g., satellite altimetry, surface roughness) and in geodesy, as well as occasional uses in biological oceanography and sea floor studies.

In physical oceanography and atmospheric science, the principal utility of this type of craft is in providing laboratory space and a rigid, stable mounting structure for sensing, recording, and analyzing conditions in the vicinity of the platform. This involves rigging of booms and platforms above the water to hold instruments or provide support points for sensors suspended in the water. It also implies use of remote sensing systems-acoustic under water and optical or microwave above. Primary parameters of concern are local velocity, density, temperature, and sea surface configuration (wave height, slope, etc.). In many types of research visualized in this category one is interested in near-surface conditions and thus one need not moor; however, it often is necessary to maintain a particular orientation (e.g., relative to the wind). The essential design requirement is for minimal disturbance in the surrounding water and air.

Underwater acoustic research, on the other hand, makes substantial use of the platform as a laboratory from which hydrophone arrays can be suspended and monitored deep in the ocean. This implies minimal heaving motion and ability to be moored (in the same manner as FLIP now is) in deep water in order that translation caused by wind and near-surface currents will not drag hydrophones through the more nearly stationary deeper layers. Ability to maintain orientation is also often desirable. Because acoustic conditions in stormy areas are of interest, the platform should be able to operate in relatively heavy weather. The same minimal heaving motion could be exploited in handling of ROV's or seafloor work systems in support of studies of phenomena at the ocean floor.

More detailed consideration of various science missions, along with the major items noted above, leads to a variety of requirements on the type of platform needed for these several research communities.

General Configuration

The combined requirements of minimal disturbance of the surrounding water and low response to surface wave motion lead to choice of a long slim structure, with axis oriented vertically. The combination of draft and variation of cross-section area vis-à-vis depth should be chosen to achieve the necessary payload and minimal response to the spectrum of a well developed sea. Payload requirements will result from consideration of various capabilities developed below. Heave response to the seaway should be less than 5% of the rms wave height for sea state 6 with a superposed 15-18-second period swell of 10 m (crest to trough). Roll response should be less than 2° rms.

The above water section should be able to cope with 30-m waves and should provide substantial structure for supporting booms. It should have a topmost deck capable of being cleared for operation of small helicopters (two man) or for landing and lifting of loads from large helos. It should provide for working platforms close to the sea surface during periods of low sea state, as well as external decks on which small winches and other overside equipment-handling gear can be mounted.

Mobility

The platform should be capable of being towed to and from station at a speed of at least 8 knots. It should be capable of transiting the Panama Canal. Towing would use conventional seagoing tugs or offshore supply boats capable of carrying the gear necessary for mooring, and would assist in deploying and recovering the moor.

It is clear that this towing speed cannot be achieved with the craft in its research operating mode (axis vertical). Since it is undesirable to be forced to make personnel transfers at sea, this craft, like FLIP, must be capable of being manned while in some other attitude (e.g., axis horizontal) and under tow.

While propulsion for transit would not necessarily be provided, limited thruster capability (perhaps dual use of the azimuth control system) should be installed to allow maneuvering close to piers without the need for harbor tugs.

Station Keeping

The platform should be capable of being held in a three-point moor with ability to be rotated in the moor and moved laterally over a limited area (radius approximately 5% of water depth) by shortening or lengthening mooring legs using on-board equipment.

It should be provided with a thruster system capable of maintaining an arbitrary orientation to within $\pm$ 5° in l5-knot winds without mooring. Since operation of thrusters will disturb the surrounding water, there should either be multiple sets (e.g., three) at different depths, or the system should be movable in depth so that investigators can minimize the effects at depths of particular interest to them.

Ballasting capability should be provided to allow trimming so that mean tilts associated with load deployed asymmetrically (particularly on booms) can be compensated.

Environmental Disturbance

There should be adequate holding and processing tanks such that discharges from heads, showers, etc., will be in accordance with current best research ship practice. Garbage compacters should be provided such that trash will not have to be disposed of on station for at least 30 days. Cooling water discharges from engines, air conditioners, etc., should have multiple outlets so that investigators can choose the depth of discharge. Exhaust stacks should be arranged to allow venting in controlled directions. Major pieces of machinery (e.g., engines) should be mounted to minimize transmission of noise to the water.

Endurance

The platform should have 60 days endurance without need to refuel or re-provision. This requirement is based on providing the ability to remain on station, taking data, through a succession of weather fluctuations. Although landing of large helicopters is not required, deck and mast arrangements should allow for transfer of people and equipment by this means.

Habitability

The craft should accommodate a science party of up to 16 under conditions approaching those of today's conventional research ships (no more than four people per stateroom, nor more than eight per head/shower facility). Sleeping spaces should be adequately air conditioned and insulated from machinery noise. Operation in all ocean areas (except where ice would be encountered) should be anticipated, and habitability requirements should be met in both operating and towing attitudes.

Laboratory Space

About 1,000 sq ft of laboratory space should be provided, at least half of which should have the ability to maintain temperature at no more than 21°C and humidity less than 90% for operation of electronics and computers. Space should be capable of being subdivided to accommodate several separate research groups and should be usable in both horizontal and vertical attitudes. Separated working or wet lab space should be available for equipment repair and for working with water samples. Uncontaminated water should be drawn from various depths with plumbing running to the wet lab. (Cool water from the bottom of the platform might be used for air conditioning).

Equipment mounting systems (e.g., Unistrut) should be provided. Dockside access to laboratory spaces should allow instrument packages with dimensions up to 4x8x8 ft to be lowered directly in.

Space should be allocated for science storage so that supplies, spares, and packing materials need not be kept in the working lab. This space could be remote from the labs, in a part of the ship not desirable for other use. Means (lifts, davits, elevators) should be provided for moving gear between decks and into position for deployment.

Booms and Masts

The platform will be used to deploy arrays of instruments in the water and the air. Boom and mast complexes are required to support and maintain the sensors, antennas, etc. Some should reach beyond the zone in which the vehicle itself significantly perturbs the air (order of 3 times the platform's widest dimension, but to distances to be determined by tests on models using wind tunnels). This places a premium on designing the superstructure to produce minimal disturbance. Other booms, able to support substantial loads, should be available to hang payloads in the water without the instruments or their cables fouling on the underwater portion of the vehicle.

The booms should be installable in any quadrant of the vehicle and should be easily rigged once the ship is in the vertical position. Use of six or more booms simultaneously may be anticipated. Telescoping booms and masts, hydraulically extended, should be considered. For longer booms, active compensation for vehicle tilt should be considered

The number of options in this category is quite large. It would thus be appropriate to convene a group of representative users to determine what booms/masts might be considered as general purpose, and what other options could be accommodated by installing mounting foundations for special-purpose units.

Hull Mountings

A flippable hull provides unique opportunities while alongside the pier for mounting equipment that will, after flipping, be located at the desired depth and position below the surface. To take full advantage of these opportunities, foundations for heavy equipment (e.g., large acoustic transducers-up to 10 tons) should be built into the ship. "Bolt-on", "bolt-to" mounting rails or similar structures should be provided for fastening lighter units, and for movable instruments that could be shifted from one depth to another, or brought up to laboratory level for adjustment, calibration, or repair. Cableways should be provided to accommodate connecting wiring protected from the wash of the sea over the hull.

Winches and Handling Gear

At least one major winch, installed in an enclosed area, is needed to handle 6,000 m of electromechanical cable of at least 10-mm diameter. The capability of installing alternate winches, e.g., to handle 4,000 m of O.68-in diameter electromechanical cable, should be included. One or more tracks should be provided to move equipment along the hull while at sea in either the vertical or horizontal position. In the vertical, this should allow payloads to be assembled in the laboratory and moved down to operate at any depth along the hull. These tracks would also provide movable guides to prevent cables for suspended instruments from fouling on the hull.

Electric Power

At least 100 kw of clean power should be available for scientific party use, plus power (- 1000 kW) for housekeeping, thrusters, winches, etc. There should be sufficient redundancy to provide continuous power for 50 days on station, yet permit shutdown of some prime movers for maintenance. Multiple circuits should be provided so that activities in separate spaces can be isolated from one another, with clean power available for sensitive equipment (computers, etc.). Capability should be provided for installation of storage batteries to provide minimal housekeeping and laboratory power for silent ship operations.

Communication and Navigation

A versatile communication suite is necessary, particularly because in this compact type structure it is desirable to be able to select appropriate antennae and frequency bands to avoid interference with research equipment. Data transmission links for passing digital information, including satellite imagery, at 9600 baud or better should be included. Work with aircraft is anticipated, and communication is needed appropriate for such operations. GPS and Loran C systems should be available, with digital (RS 232) output for logging by the scientific party during drifting operations. Thought should be given to minimizing the number of antennae to reduce interferences with other topside activities.

Underwater acoustic communications and warning beacons are needed to facilitate work in the vicinity of submarine operating areas or transit lanes. Transducers and processing equipment should be available to permit using acoustic transponder navigation to document sma1l-scale motions when moored. There also should be capability for tracking ROV's operated from the platform.

References

National Research Council, *Oceanography* 1960-1970, 1959.

Fisher, F.H. and Bishop, C.B., editors. *Stable Research Platform Workshop,* SIO Reference 87-29, Apri1 1988.

Sea State		*Height*	
	Description	*Feet*	*Meters*
0	Calm-glassy	0	0
1	Calm-rippled	0 to 0.5	0 to 0.1
2	Smooth-wavelets	0.5 to 1.5	0.1 to 0.5
3	Slight	1.5 to 4	0.5 to 1.25
4	Moderate	4 to 8	1.25 to 2.5
5	Rough	8 to 13	2.5 to 4
6	Very rough	13 to 20	4 to 6
7	High	20 to 30	6 to 9
8	Very high	30 to 45	9 to 14
9	Phenomenal	Over 45	Over 14