

## PRINCIPAL DIMENSIONS & CHARACTERISTICS

Length overall	355' - 0"
Hull diameter maximum	20' - 0"
Hull diameter minimum	12' - 6"
Draft horizontal normal	10' - 5"
Draft vertical normal	300' - 0"

Displacement	1,500 tons horizontal, 2,000 tons vertical
Displacement	800 tons (including concrete ballast)
Transverse Center of Gravity	0.4' below centerline axis of hull
Longitudinal Center of Gravity	182.0' forward of after end



## POINT OF CONTACT

Persons interested in learning more about the capabilities of FLIP, or its availability to support specific research, development, or test programs, should contact:

Capt. William A. Gaines, USN (Ret.), Assistant Director  
Marine Physical Laboratory  
Scripps Institution of Oceanography  
San Diego, CA 92152  
Telephone: (858) 534-1797 / Autovon: (619) 553-5852  
Fax: (858) 534-7039



# FLIP

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## FLoating Instrument Platform

MARINE PHYSICAL LABORATORY  
SCRIPPS INSTITUTION OF OCEANOGRAPHY, UCSD

## INTRODUCTION

In 1962, the need arose for a stable platform to measure fine-scale fluctuations in phase and amplitude of sound waves in support of the U.S. Navy's SUBROC program. Allyn Vine of Woods Hole Oceanographic Institution suggested a vessel that would have the stability of a long, narrow, buoyant object floating with the long-dimension vertical, as does a spar buoy. The original requirements established for the platform were:

- a. have a 300-foot draft to mount hydrophones;
- b. be acoustically quiet (this led to the requirement that the hull be completely flooded in the region near the hydrophones to avoid acoustic reflections);
- c. have a high degree of torsional rigidity so the position of hydrophones at the 300-foot depth would be known;
- d. have an electronics laboratory above the surface from which visual, radio, and radar contact could be maintained with a surface ship; and
- e. be capable of being berthed at a pier where the draft might be as shallow as 15 feet.

Several configurations for the vessel were considered. The final prototype was a single-welded unit that would be towed to station in the horizontal position and brought to the vertical position by flooding ballast tanks. Upon completion of at-sea experiments, the proposed vessel would be transitioned back to the horizontal position and towed to port or to another station. In addition, it would be capable of remaining on station for up to two weeks with a scientific party of four to six people.

The Marine Physical Laboratory (MPL) at Scripps Institution of Oceanography, under the direction of [XXXX scientist] Fred N. Spiess, took the lead and developed a design that indicated that such a craft was feasible. MPL research physicist Frederick H. Fisher was designated project officer. Along with Spiess and [XXXX scientist] Philip Rudnick, Fisher was largely responsible for developing the shape, size, and capabilities of this unique research platform. Fisher conducted painstaking experiments with models in test basins and finally with a tenth-scale operating version, which was tested in a lake near San Diego.

MPL proceeded on to design, conducted model tests, and supervised, with the assistance of the commercial naval architects L. R. Glosten & Associates of Seattle, Washington, the construction of the Floating Instrument Platform (FLIP). FLIP was constructed in just six months at the Gunderson Brothers Engineering Corporation yard in Portland, Oregon. Cdr. Earl D. Bronson, USN (Ret.), supervised construction and developed the operating techniques. The total initial construction cost was less than \$600,000.

FLIP was launched on June 22, 1962, and was accepted by the U.S. Navy on August 6, 1962, after successful builder's trials in Dabob Bay, Washington. Immediately after sea trials, FLIP was towed to San Diego; it commenced operations in September 1962.

## DOPPLER SONARS

The stability and size of FLIP make it possible to study the physics and energetics of surface and volume processes in the ocean and the atmosphere near the air-sea surface as well as surface processes just below the interface with Doppler sonar (frequencies from 75 to 200 kHz).

For example, it is possible to study internal-wave motion in about a cubic kilometer of the upper ocean in a very unique manner by using Doppler sonar developed by scientists at MPL. When mounted on FLIP, in 20-meter-range bins, the movement of the ocean can be measured to an accuracy of one cm/sec relative to FLIP in a cubic kilometer of the ocean if FLIP is drifting, or a larger volume if FLIP is moored. The 75 kHz sonar is rated at 35 KW and is made up of 1,720 elements assembled in trapezoidal modules that can be mounted individually or all together in a single, high-resolution, narrow-beam array. Surface-wave slopes or surface wavelengths can be measured from 40 meters at the lowest frequency down to five meters at the highest frequency with the various Doppler sonar. Measurements have been made of momentum flux, strain, Langmuir cell circulation, and wave-slope distribution. In the Arctic, these same sonars, mounted on the ice as a stable platform, are used to study internal waves and other phenomena under the ice as well as the energetics of heat exchange across the extreme temperature differences in open leads where the air temperatures can be 40 degrees Celsius lower than the Arctic Ocean waters.

## EQUIPMENT DEPLOYMENT

FLIP is uniquely configured to deploy a wide array of scientific equipment and sensors. The two scientific laboratory spaces on FLIP have approximately 500 square feet of area. There is significant flexibility in installing equipment on FLIP and most installations can be accommodated. Where necessary, equipment may also be placed on the external working decks for easy access. Sensors can be attached to the hull on existing or custom-made foundations; they can also be deployed by lowering them from booms mounted on the bow section. Depending on weight, the sensors can be installed at any location along the submerged hull and even below the 300 drafts by attaching short extensions to the hull.

For deploying sensors from booms mounted on the external working decks, FLIP has available a variety of booms and winches for loads up to 1,000 pounds. For unique requirements, the MPL shop can construct special equipment to assist in the deployment of sensors. Winches with load capabilities up to 15,000 pounds are available. Through a fairlead at the bottom of FLIP, acoustic arrays as long as 3,000 meters have been deployed.



FLIP designers Phillip Rudnick, Fred Fisher, and Fred Spiess holding the first model of FLIP, made from a Louisville Slugger baseball bat.

## TECHNICAL DESCRIPTION

The Research Platform FLIP is a 355-foot-long manned spar buoy designed as a stable research platform for oceanographic research. FLIP is towed to its operating area in the horizontal position and through ballast changes is “flipped” to the vertical position to become a stable spar buoy with a draft of 300 feet. FLIP has been used principally for acoustics research. It has also been used in a variety of other programs, including geophysics, meteorology, physical oceanography, non-acoustic ASW, and in laser propagation experiments. FLIP has operated in both the Atlantic and Pacific Oceans.

For more than 40 years, FLIP has served as a valuable oceanographic research platform for the Navy, NSF and other agencies. FLIP is uniquely stable in rough seas where other research vessels experience difficulty. Carrying a research team of 11 people and a crew of five, FLIP can sustain research operations for up to 30 days without resupply and can operate either drifting or moored.

FLIP is constructed of approximately 700 tons of Tri-Ten steel, a product of the U.S. Steel Corporation. The diameter of the hull is 6.5 meters from the 91-to-49 meter depth, tapering to four meters at the 20-meter depth. This change in diameter makes FLIP less responsive to wave motion; in 10-meter waves FLIP’s total vertical motion has been less than one meter.

FLIP has no propulsion power. It has a small hydraulically operated orientation propeller located below the vertical water line that can rotate the vessel about its vertical axis. The propeller can be servo-controlled from the gyro compass to maintain a heading. Three diesel generators supply 340 KW electrical power for ship and scientific needs. The engines are gimballed for operation in either the horizontal or vertical position.

Freshwater is carried in a 1,500-gallon tank and replenished daily by a 30 gal/hour reverse-osmosis water maker. About 3,000 cubic feet of air at a maximum pressure of 250 psi is stored in eight storage flasks located inside the ballast tanks.

## MAINTENANCE PROGRAMS

In 1994, the Office of Naval Research funded a \$2 million major phased Maintenance Availability of FLIP. The FLIP Maintenance Availability commenced at the Campbell Shipyard in San Diego on December 12, 1994, and was officially concluded with the completion of a successful sea trial on January 18-19, 1996. The Maintenance Availability was conducted in phases, with FLIP supporting research operations between maintenance phases.

During planning for the Maintenance Availability, priorities were established for the accomplishment of repairs, upgrades, and maintenance. The established priorities were: structural repairs, safety requirements, upgrades to meet federal and state regulations, habitability improvements, and material reliability. The established priorities were successfully met.

Structural deficiencies reported by Carderock NSWC engineers following a 1993 inspection were corrected with repairs to the interior hull structure, replacement of exterior deck sections, and replacement of six sea chests, as well as numerous sections of interior air and water piping. Safety was significantly increased with a major electrical upgrade, installation of an escape hatch from tank 10, boom and winch repairs, installation of a machinery monitoring system, and a reliable fathometer system. FLIP was brought into compliance with existing regulations with the installation of an approved sanitation system, fire main system, machinery monitoring system, general announcing system, and the removal of wooden structures throughout the platform. Material reliability was enhanced with the overhaul of all engines and generators, overhaul of the air compressors, overhaul of the air-conditioning system, replacement of the radar and fathometer, overhaul of all valves and piping systems, and replacement of the water maker. Habitability improvements included all new galley equipment, new bunks with Coast Guard-approved mattresses, replacement of all wooden lockers with light-colored aluminum lockers, new deck tile, and new improved insulation in all living compartments.

Following the completion of the Maintenance Availability in 1996, FLIP was a safer, more efficient platform from which to conduct oceanographic research. Most importantly, though FLIP remains an uninspected research platform, FLIP now meets major Coast Guard regulations for oceangoing platforms. With the continuing, aggressive preventative maintenance program, the operational life of FLIP has been extended for an indefinite period.

Since completion of the Maintenance Availability in 1996, an aggressive inspection and preventative maintenance program has been in place, including annual tank inspections and refurbishment of two ballast tanks each year. The preventative maintenance program has been successful in maintaining FLIP in a high state of material readiness.

Although FLIP has performed far beyond expectations, constant upgrades are required to keep pace with new technologies for this valuable research tool.



## OPERATIONAL EXPERIENCE

FLIP's stability, 300-foot draft, and low acoustic noise levels have made it uniquely suitable for a wide variety of research experiments. Hydrophones can be positioned at a variety of depths for listening to acoustic signals, and the same applies for other instrumentation such as pressure sensors for measuring wave heights, tilt and depth of FLIP, and temperature sensors for measuring thermal structure in the ocean. In order to study the horizontal extent of thermal variations in the ocean, three booms can be extended so that temperature sensors can be lowered simultaneously at known distances from one another. Density variations in the upper levels can be studied with high-resolution Doppler sonar. Meteorological instruments mounted on a vertical mast that can move up and down at the end of a boom enable measurements immediately above the sea surface. FLIP's deep-sea winch can lower instrumentation packages to a depth of 4,000 meters. Booms below the waterline can also be mounted on the hull for obtaining horizontal separation of sensors.

The early demonstration of FLIP's unique capabilities as an oceangoing measurement platform with very low motions has led to its use for many other programs. Research conducted on FLIP has included studies of:

- the relation of temperature variations in the ocean to fluctuations in intensity and direction of sound waves
- waves generated from storms in the South Pacific, for which FLIP was stationed between Hawaii and Alaska
- turbulence and thermal structure of the ocean
- amplitude and directionality of internal waves
- energy transfer between the ocean and atmosphere in which wind velocity, humidity, and temperature profiles immediately above the ocean surface were measured
- ambient noise intensity and direction using vertical hydrophone arrays suspended from FLIP and horizontal arrays (DIMUS) at the bottom of FLIP
- long-range sound propagation
- variation in properties of the earth's crust, for which FLIP was used as a listening platform for explosive sound signals launched from four ships going away from FLIP in four different directions
- the depths to which whales dive
- effects of pressure on sound attenuation
- scattering of sound from the sea surface and reverberation

## OPERATIONAL CAPABILITIES

FLIP can be used in either a drifting or moored mode, based on the science requirements, and can remain on station in the vertical position for substantial periods of time. For research requiring a stationary rather than drifting platform, a deep moor capability has been developed. The first mooring made from a single moor was in 5,500-meter waters north of Hawaii in 1969. Subsequently, a multiple anchor capability evolved. It is now possible to place FLIP in a three-anchor mooring in virtually any depth of water; in September 2001, FLIP was moored in a water depth of 4,242 meters, 250 miles southwest of Oahu, Hawaii.

Deep-water moorings usually take one day, from first light to past dusk, in waters 4,000-5,000 meters deep. A deep mooring requires about 80 tons of gear aboard the tow vessel. Moorings in 4,000-meter water with a mooring scope of 1.5 have had watch circles in the range of 80-200 meters, depending on currents. The mooring lines are recovered and reused whereas the anchor and anchor chain (10 tons per leg) are left on the bottom. Three-point moorings in the deep ocean are routine operations, especially for deployment of acoustic arrays in which flow noise must be minimized and acoustic navigation of array elements is required. The transponder system for Array Element Location (AEL) can be surveyed in and tied to the GPS navigation system with the GPS receiver aboard FLIP.