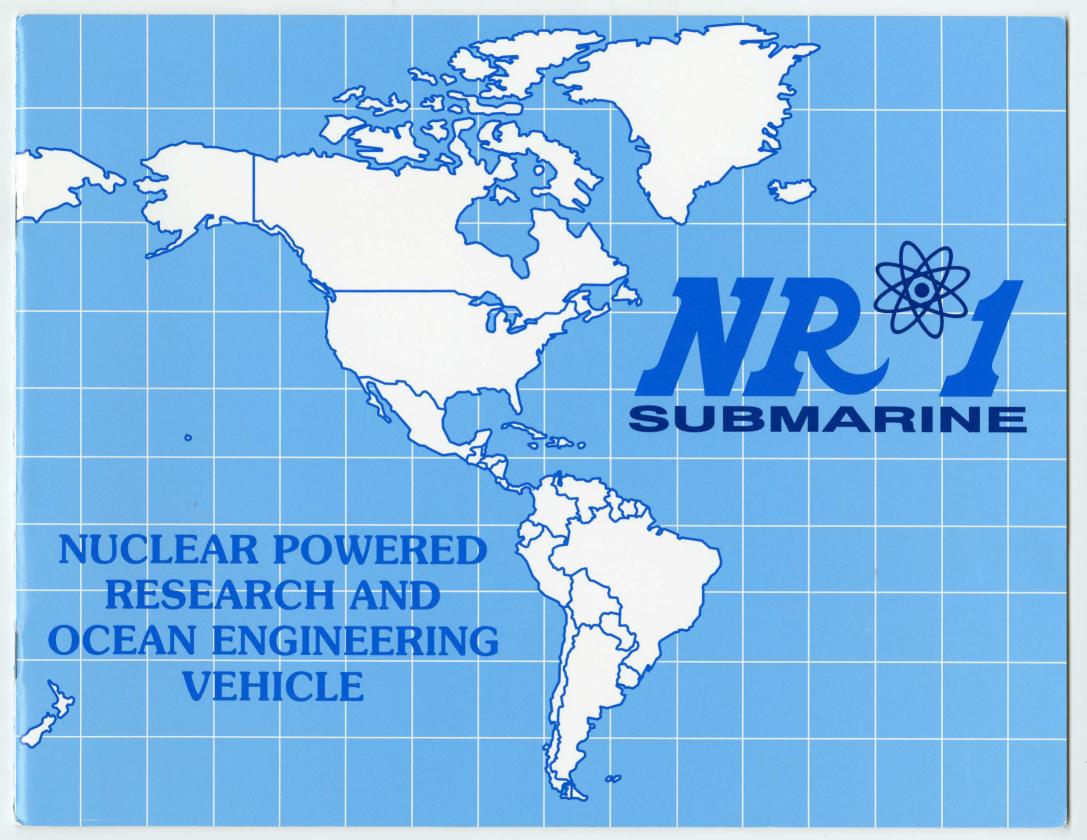
# SUBMARINE *NR-1*: NUCLEAR POWERED RESEARCH AND OCEAN ENGINEERING VEHICLE

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NMNW.2011.503.003





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NR:1

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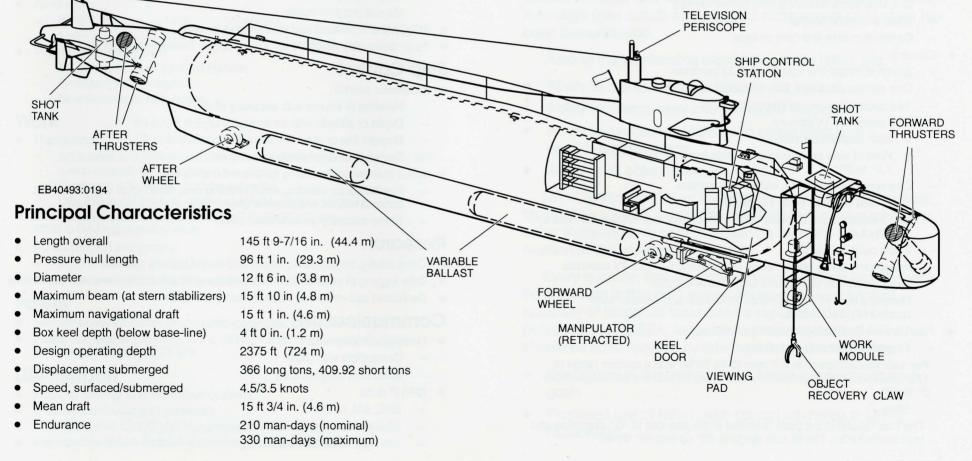
# **Summary of Features**

### **Missions**

- Search
- Large and small object recovery
- Geological survey
- Oceanographic research
- Installation and maintenance of underwater equipment

### Search Capabilities

- Side Looking Sonar
  - 600 ft (180 m) search width with 1 ft (30 cm) resolution or
  - 2,400 ft (730 m) search width with 4 ft (1.2 m) resolution
- Deep Submergence/Obstacle Avoidance Sonar (DS/OAS)
  - Compatible with Deep Ocean Transponder (DOT) for both bottom survey and local navigation
- Sub-bottom profiler
  - Variable power
  - Selectable frequency



## Summary of Features (Continued)

### Viewing

- Three 4 in. (10 cm) diameter viewports
- Nineteen 250 watt gas discharge lights (thallium iodide)
- Four 1000 watt thallium iodide lights
- Four 1000 watt variable intensity incandescent lights
- Two 500 watt incandescent lights
- Closed circuit television system, 500 line resolution (black and white)
  - Four 9 in. (23 cm) monitors
  - One color TV monitor
- Videotape recorder (VHS or 8 mm format)
  - 2, 4, or 6 hours recording time (either format)
  - Local or remote control
  - Continuous date and time on tape
- Cameras
  - Seven standard low light level (LLL) cameras
  - One standard low light level camera on pan/tilt unit
  - Two zoom TV cameras on pan/tilt units
  - One periscope TV camera
    - 360° azimuth coverage
    - Field of view continuously variable from 10° to 40° H by 7.5° to 30° V
  - One special mission LLL wide angle camera
  - Hand-held viewport color TV camera
  - One Electronic Still Camera (ESC) video switching system, 30 input by 10 output
  - Zoom color TV camera
  - Image processing unit for video enhancement of LLL TV cameras
  - Viewport 35 mm still camera with external strobe
  - Outboard dual 70 mm cameras (450 black and white or color exposures) and strobes
- Pan/Tilt units (forward, center, and stern)
  - Forward (free-flood) and center

Pan axis rotation speed is  $2.7^{\circ}$ /sec (0.45 RPM) with a rotation range of  $170^{\circ}$  clockwise and counterclockwise. In the tilt axis the unit ranges from  $0^{\circ}$  to  $90^{\circ}$ .

Stern

The Pan/Tilt unit in the stern is limited in the pan axis to 45° clockwise and counterclockwise. The tilt axis range is 10° up and 60° down.

### Viewing (Continued)

- Data Logging Capability
  - Automatic data logging of all sensor data, ship control functions, navigation data and target positions at one or ten seconds and fifteen minute intervals.

### Navigation

- Dead reckoning with the digital computer, using ship's heading, ground speed (from Doppler or CVL sonar) or water speed (from Doppler sonar, acoustic log, or EM Log), with accuracy of 1% of the distance traveled
- Updating of dead reckoning local and geodetic position with:
  - Single transponder
  - Manual position inputs
- DS/OAS with forward and side looking arrays
- Four deployable AN/BQN-8A, Deep Ocean Transponders (DOT)

### **Ship Control**

- Automatic control
  - Heading or course with accuracy of  $\pm$  2°
  - Depth or altitude with an accuracy of  $\pm$  5 ft (1.5 m)
  - Straight line or ground track with accuracy of  $\pm$  2°
  - Transit to ordered position, or hover
- Aided manual-control using quickened display cues
  - Position error, heading error, heading rate, depth error and depth rate, ordered rudder, and plane angles
  - Same accuracy as automatic mode

### Research

- Conductivity, temperature, depth, and sound velocity sensors
- Data logging at variable time intervals (over 40 parameters are user-selectable)
- Dedicated rack-mounted scientific computer (PC)

### Communications

- Underwater telephone
  - Compatible with UQC
  - Automatic range display
- MF/HF radio
  - SSB, AM, or CW
  - 13,000 channels, 2 to 30 MHz
  - 125 watt voice, 25 watt average

### **Communications (Continued)**

- UHF radio
  - Wide band (data or secure)
  - ADF reception
  - 7,000 channels (225 to 400 MHz)
  - 10 watt output
- VHF radio
  - All US/Canada, international and weather channels
  - 10 expansion channels
  - 155 to 163.6 MHz
  - 25 watt output
- Antennas

\_

- GPS UHF Longwire
- Loran VHF
- Internal intercom system
  - Master station and six local stations
  - Emergency alarm signal
  - Sound-powered telephones

#### Work

- Manipulator
  - Articulated arm with shoulder, upper arm, forearm, wrist, and jaws, with seven controllable motions
  - Coverage: 9 ft (2.7 m) semicircular radius
  - Lifts 200 lb (90 kg) fully extended at full hydraulic pressure
- Two sample baskets, each about 2x3x3 ft (60x90x90 cm), 1000 lb (454 kg) capacity each
- Forward winch and grapnel
  - 1000 lb (454 kg) lift capacity
- Large and small object recovery systems

#### Power

- Nuclear-powered steam-driven turbo-generator; 450 v, 60 Hz, 3 phase
- Power conversion providing 115 v, 60 Hz, 1 and 3 phase, and limited 400 Hz and 28 vdc

### Life Support

- Heating, cooling, and ventilation systems
- Chlorate candle oxygen generator
- Catalytic burner for CO and H<sub>2</sub> removal
- Replaceable lithium-hydroxide canisters for CO<sub>2</sub> absorption

# Introduction

It is the policy of the U.S. Navy to make the nuclear-powered research and ocean engineering submarine NR–1 available to all qualified agencies of the U.S. Government, or accredited research organizations, for use in deep ocean research.

This synopsis provides interested parties with an overview of the capabilities and potential uses of Submarine NR-1. NR-1 can place a man on the bottom of the ocean with facilities unmatched by any other vehicle. The nuclear propulsion plant provides an endurance limited only by the provisions required to sustain the crew and scientific observers. An endurance of 330 man-days (one month with a normal complement of 11 men) has been demonstrated.

Among the outstanding capabilities of the NR-1 are:

- Ability to maneuver on or close to the seabed
- Ability to directly view and record the environs
- Ability to navigate precisely and sense objects at a considerable distance
- Ability to lift objects from the bottom

NR-1 is escorted by, or towed on her missions by a surface tender. The surface tender can also collect oceanographic data either independently or in coordination with NR-1 subject to mission and manning requirements.

Every question that any prospective user might have cannot be answered in this brief survey, however, the conceptual feasibility of proposed tasks can be rapidly evaluated by personnel in NAVSEA. Inquiries regarding the use of NR–1 should be accompanied by briefing information, including:

- Description of the project, its technical requirements and goals
- Proposed use of NR-1, with special reference to NR-1 capabilities

## Introduction (Continued)

- Any modifications to NR-1 or her equipment that might be necessary for the project
- Specific operating conditions anticipated
- The desired schedule
- The name and telephone number of a cognizant person in the project
- Other pertinent information

Inquiries are addressed to:

Chief of Naval Operations Department of the Navy Washington DC 20350 Attn: Director, Deep Submergence Systems Division (N873)

A copy should be sent to:

Naval Sea Systems Command Project Manager (PMS 395A3) Deep Submergence Systems Project 2531 Jefferson Davis Hwy Arlington, VA 22242-5160

Inquiries from investigators at academic institutions whose projects are sponsored by the Office of Naval Research should be processed through that sponsor. NR–1 operates as a unit of Submarine Squadron Two, from New London, CT. Responsibility for alterations to the ship rests with the Naval Sea Systems Command NAVSEA Project Manager (PMS 395) in Washington.

# **General Description**

NR-1 is a compact, nuclear-powered, electric-drive undersea research and ocean engineering submarine. Her operation depth encompasses all of the continental shelves and much of the continental slopes, while her nuclear power plant provides a far greater endurance than any other research submarine. NR-1 is capable of ocean search missions such as locating and identifying objects or ships lost at sea, and in situ examination and recording of ocean topographic and geological features. The ship is equipped and has the capacity for work near or on the seabed, performing sample gathering, recovery, implantation, or repair of objects in the ocean. The installed equipment can be supplemented by scientist-supplied sensors to conduct experiments and obtain knowledge of the ocean's chemical, thermal, optical, biological, and acoustical characteristics.

Hydrodynamically faired bow and stern structures beyond the ends of the pressure hull contain main ballast tanks and free flooding spaces, thrusters, emergency droppable lead shot tanks, oceanographic equipment, and miscellaneous items of ship equipment. The extreme bow of NR–1 is a separate structure that can be raised about a topside hinge to facilitate maintenance of components in the bow. Forward looking sonar and lights are installed on the hinged bow structure.

Atop the hull, a bridge fairwater with plastic windshield protects a two-man bridge and the ship's access hatch, and encloses the diving planes mechanism. A fiberglass superstructure deck, housing pipes and cables, extends the length of the top of the pressure hull. A box keel extends most of the length of the ship below the pressure hull and serves as a fairing for tanks and various services and components, and as a platform for resting on the seabed. A pair of wheels can be extended from the keel for traversing firm bottoms.

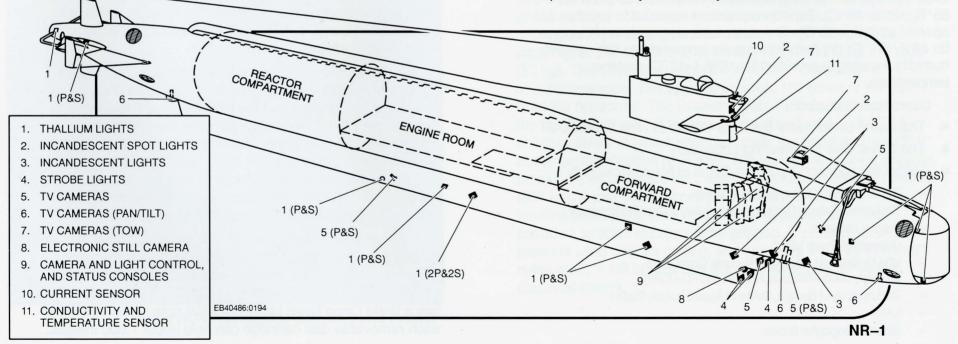
Pressure hull penetrations have been minimized in NR-1. They include one 25 inch (63.5 cm) diameter access hatch, three acrylic viewports, and valves for variable ballast water and depth sensing. Hydraulic piping penetrations are ganged in six-valve manifolds. Electrical hull penetrations are of the multiple connector type. Spare electrical and hydraulic hull penetrations are available for new equipment.

The NR–1 has two AN/UYK-44 military digital computers. The main computer is normally used for navigation, ship control and guidance, and the auxiliary computer is used as a backup or scientific computer, depending on user needs or mission requirements. In addition, a 80486 PC serves as an interface with the main and auxiliary computers for data reduction and graphics. The terminal is designed for dedicated scientific use, and is user programmable. The navigation system uses a digital computer and sonars. Various electronic systems include:

DS/OAS Sonar with forward and side arrays with several ranges

- A Doppler sonar and correlation velocity log integrated into the ship's computer for measuring ground and water speed and drift for dead reckoning
- Acoustic log for measuring cross currents
- Sonars for measuring the distance of the ship from seabed and surface
- An underwater telephone and radio transceiver are provided for voice or CW communications
- GPS and Loran for surface position fixes

NR-1 is equipped with Bernoulli drives for logging data from various sensors, navigation and ship control data, and ship's functions. NR-1 is also equipped with special research, oceanographic, and work gear, including the three viewing ports, exterior lights, TV, anchoring system, bottoming wheels, a manipulator, an object recovery claw, and a work module



### **General Description (Continued)**

(sample basket). The manipulator can pick up objects and deposit them in the sample basket to be carried to the surface. Different gripping and cutting tools may be used in the manipulator. The manipulator also positions the object recovery claw. A portable control box, operable from either the ship control station or from a viewing port pad in the forward compartment, controls the manipulator. A variable lead ballast compensating system is used to release lead shot in controllable quantities to offset the weight of lifted objects.

On extended missions, NR–1 accommodates the crew and two passengers in air-conditioned comfort. An atmosphere control system circulates oxygen through filtered air-conditioned vents, and removes harmful gasses. A frozen foods locker, warming oven, hot drink dispenser, and hot water heater are provided, as well as sewage disposal and amenities for washing up.

NR–1 is designed to operate in water densities of 63.6 to 64.3 lb/cu ft (1.016 to 1.029 sg) and water temperatures of 28° to  $85^{\circ}$ F (–2° to 29°C). Topside equipment exposed to weather will operate at 0°F (–18°C). The air conditioning system is designed for 88°F (31°C) dry bulb weather air temperature, 70% relative humidity. Heating is provided for 10°F (–12°C) weather temperature.

Users have included:

- The Naval Underwater Systems Center at New London, CT
- The Naval Civil Engineering Laboratory
- Under the sponsorship of the Office of Naval Research
  - The Woods Hole Oceanographic Institution
  - The Lamont–Doherty Geological Observatory of Columbia University
  - Rutgers University
  - University of Rhode Island
  - NOAA's National Underwater Research Center at the University of Connecticut at Avery Pt. (NURC–UCAP)
  - The University of Georgia, Center of Applied Isotope Studies
  - NASA
  - National Geographic Society

# Ocean Research and Work Capabilities

NR–1 was designed with emphasis on working on or near the seabed. Three acrylic viewports in the forward hemi-head of the pressure hull provide a direct view of the primary forward work zone. Each viewport is of 4 inch (10 cm) minor inside diameter, 90° conical frustum. Nineteen 250 watt thallium iodide, four 1000 watt thallium iodide, two 500 watt incandescent, and four variable intensity 1000 watt incandescent lights provide external illumination. The incandescent lights are used primarily for color photography, closed circuit TV viewing, and close-in viewing closer than 15 ft (4.5 m). The thallium iodide lights are used for distant viewing, television, and photography.

The closed circuit television system includes Low Light Level (LLL) cameras, LLL zoom cameras, a color camera, color and black and white monitors, a VHS video recorder, an image processor unit, an Electronic Still Camera (ESC), pan/tilt units, and a video switching system.

The center zoom LLL camera mounted on a pan/tilt unit is used for viewing the manipulator work zone and is a viewfinder for the 70mm cameras and the ESC camera. The periscope TV camera mounted on the bridge fairwater is used for surface viewing and safe surfacing. The video switching system enables the operator to select any one of 30 video inputs for output to any TV monitor, or the video recorder unit. All video recordings are time and date annotated, and all pan/tilt mounted camera outputs are annotated with the pan/tilt position data.

A pair of 70-mm film cameras with motorized drive and strobe lighting provides a photographic record of the seabed and objects of interest. The camera can take up to 4 frames per second, and has a film capacity of 3,300 exposures. The ESC has a Write Once Read Many (WORM) optical disk drive and each removable disk cartridge can hold about 1,600 images.

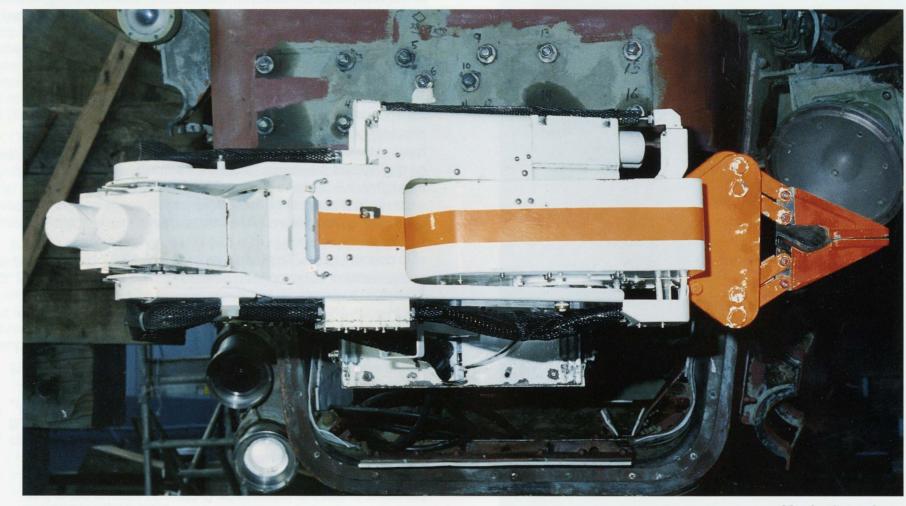


**AN/UYK-44 Computer Complex and Printer** 

A color-compatible hand-held video camera may also be used at the viewports. Conductivity, temperature, sound velocity, and depth sensors provide basic ambient data, which in combination with user-supplied software, may be processed in the auxiliary computer, or the data can be logged on disk. Ambient seawater samples may be obtained from the ship's depth gauge system.

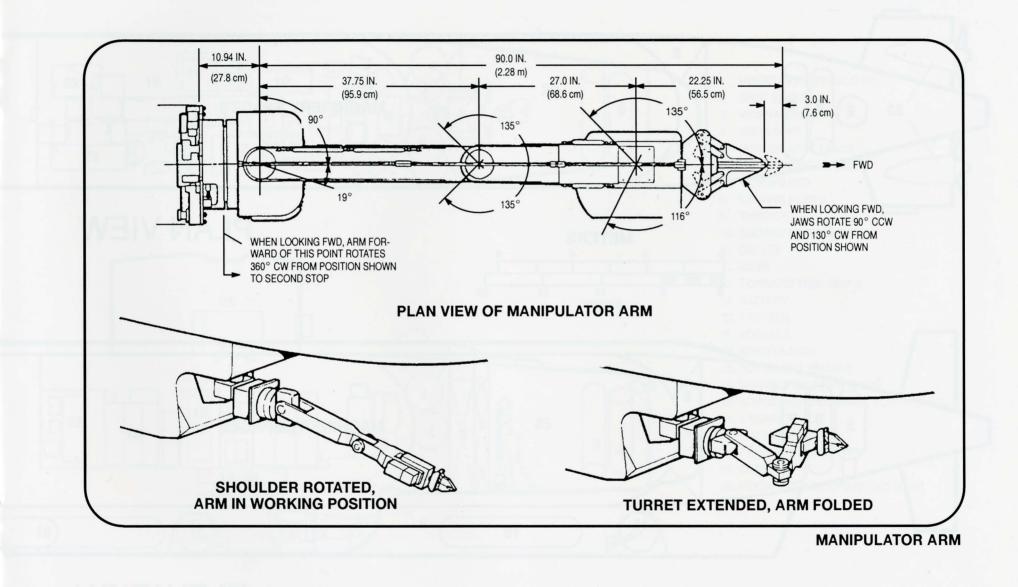
NR-1 has a hydraulically powered general purpose manipulator with six degrees of freedom and seven motions: shoulder pivot and rotate, elbow pivot, wrist pivot, wrist rotate, hand extension, and jaw open/close. With the submarine resting on the seabed the manipulator has a semicircular work zone of about 9 ft (2.7 m) radius, which allows it to place objects in the work module (sample basket). When not in use, the manipulator is housed in the forward end of the box keel. It is controlled from a portable control box usable at either the viewing ports or the ship control station. The manipulator can pick up objects having one dimension not exceeding 8 inches (20 cm). In seawater, at full hydraulic pressure, the manipulator can lift objects that weigh up to 200 lb (90 kg), or at minimal pressure, up to 110 lb (50 kg). The shoulder rotates the arm 360° clockwise or counterclockwise. The upper arm pivots 19° down or 90° up from the horizontal. The forearm pivots 135° up or down from the longitudinal axis of the upper arm. The 5,000 in.-lb (57.6 m-kg) capacity wrist actuator can rotate the hand and jaws 220° about the longitudinal wrist axis. The jaws have knurled gripping faces on their outboard end, and cutting force from 0 to 1,300 lb (591 kg). A pair of soft-faced jaws and a pair of hard, knurled-faced jaws, both without cutting blades, are also provided, to suit the object to be gripped. A second set of jaw plates is used only for cutting, and can cut a 1-3/4 in. (4.4 cm) nylon rope, 1-1/8 in. (2.8 cm) diameter wire rope, or similar electrical cables.

## Ocean Research and Work Capabilities (Continued)

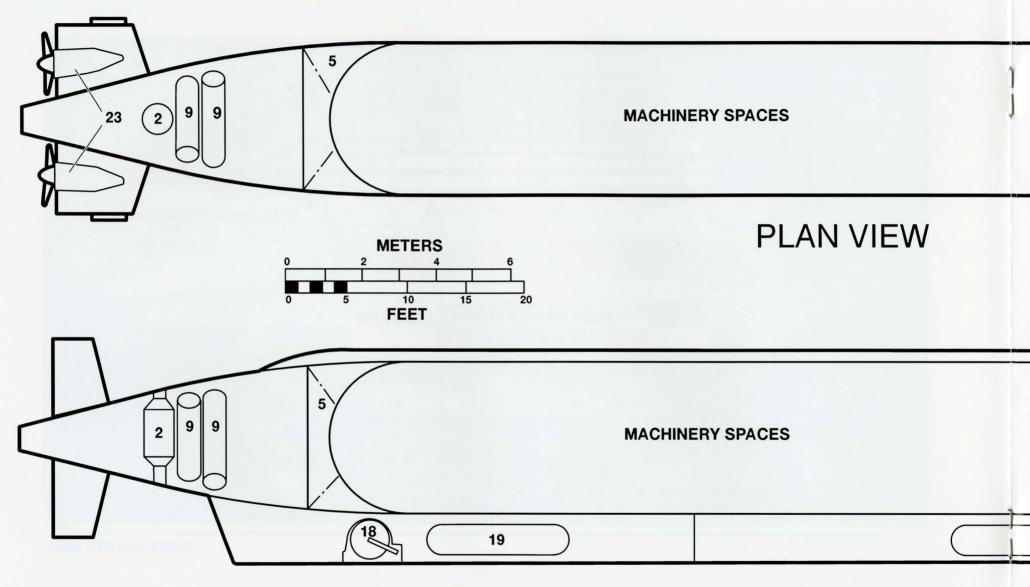


Manipulator Arm

Seneral Arrangement

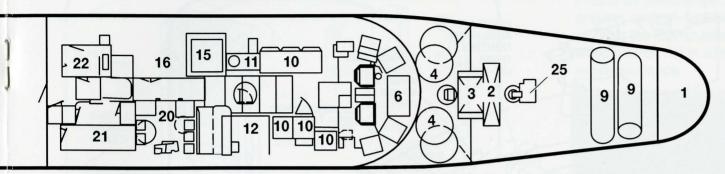


# General Arrangement

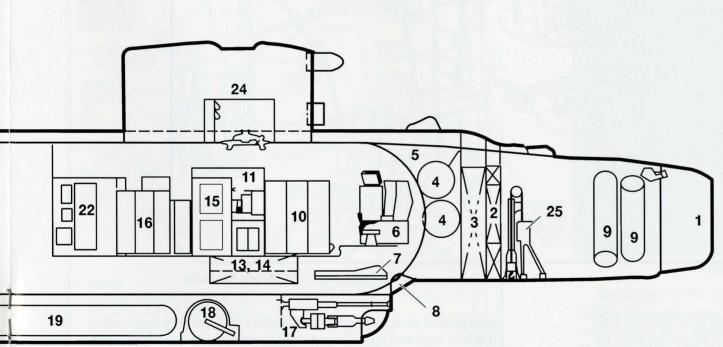


**ELEVATION** 

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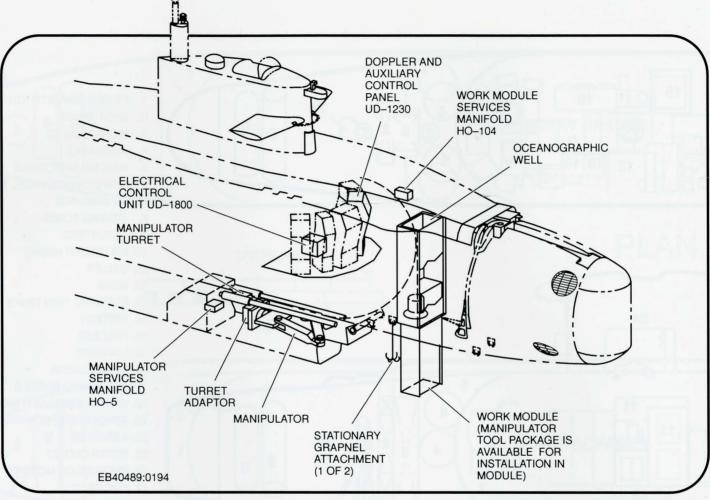


#### 1. HINGED BOW STRUCTURE

- 2. SHOT TANKS
- 3. WORK MODULE
- 4. AIR FLASKS
- 5. MAIN BALLAST TANKS
- 6. SHIP CONTROL PANEL
- 7. VIEWING PAD
- 8. VIEWING PORTS
- 9. THRUSTERS
- 10. EQUIPMENT RACKS
- 11. GALLEY
- 12. MESS
- 13. FORWARD TRIM TANKS
- 14. BATTERY
- 15. FREEZER
- 16. LOCKERS
- 17. MANIPULATOR
- **18. BOTTOMING WHEELS**
- 19. VARIABLE BALLAST TANKS
- 20. ATMOSPHERE CONTROL EQUIPMENT
- 21. 4 BERTHS
- 22. WATER CLOSET
- 23. PROPULSION MOTORS
- 24. BRIDGE
- 25. HOOK/GRAPNEL OPERATING GEAR

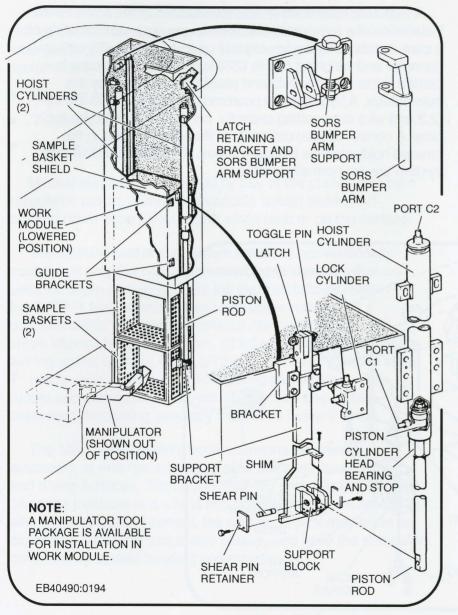
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## Ocean Research and Work Capabilities (Continued)



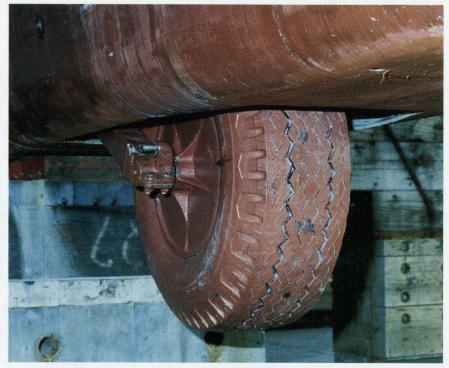
**Manipulator and Work Module** 

The bow contains a hydraulically operated work module with two sample baskets, each 19-1/2 in. deep by 29-1/2 in. wide by 36-3/4 in. high (about 50x75x93 cm), and capable of holding objects weighing 1000 lb (450 kg) in air. The work module can be extended 6 ft (1.8 m) below the bow for collecting objects gathered by the manipulator, or for temporary installations of special test or oceanographic equipment. It retracts flush with the box keel when not in use, and is removable from topside by a portable davit with a 1-1/2 ton (1,364 kg) hoist. A shot tank for 2,000 lb (909 kg) of lead shot, adjacent to the sample baskets, permits weight compensation as objects are gathered. The shot hopper has a hydraulically operated metering valve.



Work Module Arrangement

Two retractable rubber-tired bottoming wheels provide a means for maintaining a fixed distance between the box keel and the seabed, facilitating movement on the bottom and while working the manipulator. Wells in the keel accommodate the wheels when not in use, and allow the wheels to retract under excessive loads.

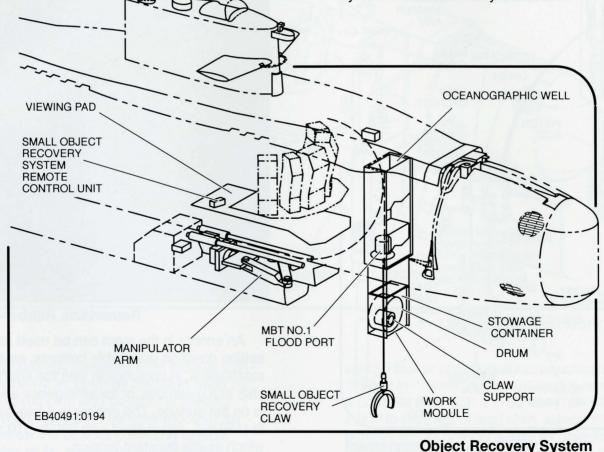


**Retractable Rubber-Tired Bottoming Wheel** 

An anchor in the stern can be used as an alternative to setting down on unsuitable bottoms, as a depth-keeping mechanism, in conjunction with the ship's thrusters to tether the ship at a given site, or for emergency anchoring when the ship is on the surface. The anchor is a two-fluke design, weighs 350 lb (159 kg), and is fitted with 360 ft (110 m) of line. A hydraulic winch exerts constant tension.

## **Ocean Research and Work Capabilities (Continued)**

One general purpose hydraulic winch is located in the bow forward of the work module on center line of the ship. The winch can lift 1000 lb (454 kg), and with drum lock engaged, holds 4,500 lb (2,045 kg). It is equipped with 150 ft (45 m) of line and an end fitting for hooks or grapnels. A hydraulic control valve and foundations in the bow permit installation of a removable object recovery system, consisting of a claw capable of grasping objects up to 14 inches (35 cm) in diameter and weighing 500 lb (226 kg) in water. The claw is carried in the work module and placed on an object by the manipulator. A hydraulically powered cable cutter, with 7/8 in. (2.2 cm) wire rope cutting capacity, can be substituted for the claw. A control device, ordinarily at the viewing ports in the forward hold, controls the claw forces. The recovery claw and system are not normally installed.



# **Ship Control**

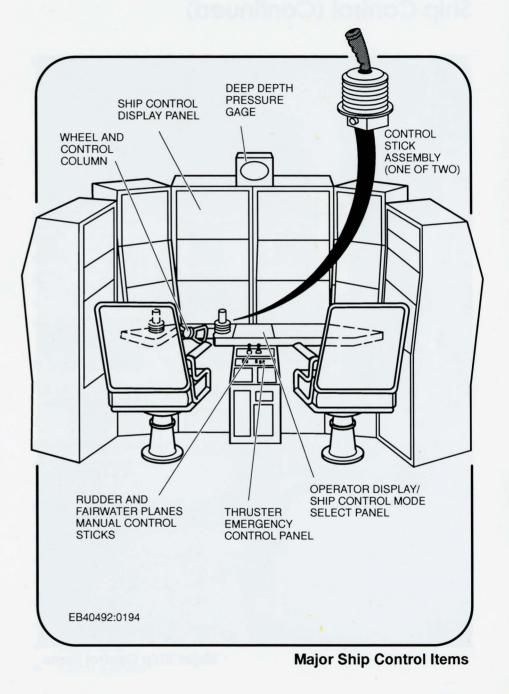
NR–1 has three systems for producing depth and course changes in addition to compressed air de-ballasting and emergency jettisoning systems. The three normal control systems are:

- Steering and diving
- Thrusters
- Variable ballast pumping

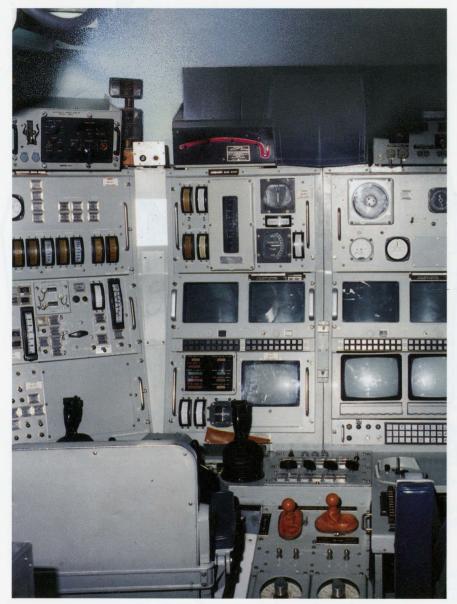
Normal surfacing is achieved by use of the planes and main propulsion power, pumping of variable ballast water, and blowing down main ballast water when near or on the surface.

The steering and diving system functions conventionally except that only the diving planes on the bridge fairwater are used for depth changing, while the stern stabilizers remain fixed. NR–1 has balanced lower and upper rudders on a common stock. The control surfaces are powered from the ship's internal hydraulic system. At full speed the submarine's turning radius is about 900 ft (275 m). A sustained trim of about 7° can be achieved by use of the diving planes alone. The rudder and planes have decreasing effect as ship speed decreases, becoming generally ineffective below 2 knots.

The ship control station provides means for manual, automatic, or emergency control of all thrusters and steering and diving surfaces. The ship is normally controlled by the pilot using the joysticks or a wheel and column control. As an alternative to manual control, the pilot or co-pilot may lay in an expanding square or serpentine course, and have the computer continuously update heading commands.



## Ship Control (Continued)



**Major Ship Control Items** 

The thrusters are used for ship control at speeds slower than 2 knots. Each of the forward and after free flooding spaces has two 7 hp (5.2 kw) thrusters in an X–arrangement, consisting of a 24 in (60 cm) diameter duct with a submersible motor-driven impeller. Each thruster can be controlled from 0 to 300 lb (136 kg) of thrust. Using the thrusters, the ship can be pitched 7°, or turned in its own length. Using the thrusters in combination with main propulsion power, the ship can be "crabbed" over the ocean bottom in side currents, while tracking straight on the bottom. The thrusters will keep the ship's position in a 1/4 knot broadside current, as is desirable for following submarine cables or pipelines. The thrusters can be proportionally controlled, or operated at full power in an emergency, from joysticks at the control station.

A pumped water variable ballast system provides the normal method of changing depth, and an auxiliary variable ballast system is used during special missions. The variable ballast system compensates for ship weight changes and also can take on up to 1000 lb (450 kg) of water at depth, to adjust the ship's weight on the seabed. The system is used to achieve neutral buoyancy for hovering. It has external tankage of sufficient capacity to provide neutral buoyancy from surface to test depth, in seawater of 63.6 to 64.3 lb/cu-ft density (1.016 to 1.029 sg), which encompasses all densities that might be encountered in the open sea.

A freshwater trim system inside the pressure hull can compensate for, or induce a 15° trim angle under normal submerged conditions. The system consists of forward and after trim tanks connected by piping and a positive displacement pump. The trim system can change ship pitch angle at 1.7°/min, and is controlled from the control panel.

# **Command and Control**

NR–1 has standard navigational capabilities for geodetic position fixing. The dead reckoning position of the ship is provided automatically by the computer, from data entered by the Doppler sonar system and gyrocompass. Dead reckoned tracks and position fixes are shown on an X–Y display. Based on the navigational data, the computer produces guidance intelligence, including:

- Current computation
- Course or track keeping
- Terminal point acquisition
- Thrust prediction

The ancillary functions of the computer are:

- Data logging of important parameters
- Startup, test, performance monitoring
- Speed of sound computation

The system can accept manually entered position information, and extrapolate ship position in either geodetic or arbitrary local bottom reference coordinates, based either on sensed ground speed when the ship is within 600 ft (180 m) of the bottom, or on sensed water speed, plus manually entered data on the set and drift of the current in which the ship is operating.

Listed below are the command and control displays, and the communication features of NR-1.

### **Command and Control Displays**

- Ordered heading or course (digital)
- Actual heading (digital)
- Heading error (analog)
- Ordered and actual depth (digital)
- Depth rate
- Depth/altitude error (analog)

### Command and Control Displays (Continued)

- Position X/Y (digital)
- Position along and across track, or hover reference point (digital and analog)
- Navigational graphic plot
- Target position
- Obstacle avoidance sonar displays
- Pitch and roll
- Bow and stern height above seabed (digital)
- Speed relative to the bottom in three directions (X,Y,Z)
- Water speed (ahead and astern)
- Thruster force (individual)
- Variable ballast system valve positions, pump status (ON or OFF), discharge pressure, and system flow totalizer
- Compensating shot valve position
- Winch cable tension and length paid out (one for each winch)
- Manipulator status
- Bottom wheels raised or lowered
- Ship system control and position displays

### Communications

- MF/HF radio transceiver
- UHF fixed radio transceiver
- VHF fixed radio transceiver and portable units
- Underwater telephone
- Sound-powered telephone
- Voice tube
- Alarm system

# **NR-1 Sonar Systems**

### DS/OAS, Side-Looking, and Doppler Sonars

NR–1 has sonar systems that enable her to navigate precisely, communicate, detect, and ascertain the position of objects in the water and on the seabed. Certain of the systems are integrated into the ship's control and display console and the ship's computer. The table below summarizes the characteristics of the principal sonar systems.

SONAR	RANGE (yds)	FREQ (kHz)	POWER (watts)	FORM OF OUTPUT
DS/OAS HF	Short	Classified	Classified	Video
DS/OAS LF	Long	Classified	Classified	Video
DS/OAS DOT	Long	Classified	Classified	Video
SIDE-LOOKING	100 or 400	177.5	200 (min)	Dual-Channel Dry Paper Recorder & Video
DOPPLER	* 2 to 200 Bottom Track	300	130	N/A
DEPTH & ALTITUDE	0 to 2,000	25	360 (min) 1,400 (peak)	Strip Chart Recorder
AFT ALTITUDE	0 to 400	50	70 (min) 165 (peak)	Strip Chart Recorder
UNDERWATER TELEPHONE	5,000	8 to 11	200	Audio/CW
SUB-BOTTOM PROFILER	8,000	3.5 or 7.0	Variable to 10,000	Strip Chart Recorder & Video
RESCUE/ PINGER BEACON	_	3.5	-	N/A
CVL	100 to 5,000	18	Booster	N/A

<sup>t</sup> Doppler will also lock on water backscatter for velocities with respect to water, at altitudes greater than 8.75 yd (8 m)

The primary sonar system in NR–1 is the Deep Submergence/Obstacle Avoidance (DS/OAS). It is a high resolution search sonar which is used to detect and ascertain the position of objects during surfacing and submerged operation. A side-mounted, low and high frequency array provides long range upward and downward-looking detection over a broad sector port and starboard of the ship. A bow-mounted, high and low frequency array provides high resolution downward-looking detection and classification for objects on or above the seabed. The DS/OAS has been used to identify, close on, track, and maneuver in close contact with off-board experimental equipment.

Bottom-moored AN/BQN–8A transponders are available. They are designed for launching from four AN/BQN–8A canisters located in the stern. These transponders respond to the DS/OAS DOT mode frequencies, and are used by the ship when running search patterns. The ship returns to the predetermined location where the transponder beacons were deployed. This system is effective either in midwater or on bottom targets. Four DS/OAS monitors display range and bearing information.

A side-looking sonar, for locating and classifying objects on or near the seabed to either side of the submarine, transmits and receives sonar information in a long range 1,200 ft (366 m) mode, and a high resolution 300 ft (91 m) mode. The display assembly contains a dual-channel paper recorder and controls for range mode selection, paper speed selection, and recording of sonar information on the video recorder. High probability-of-detection search rates for the side-looking sonar are 1 sq nm/hr for objects 4 ft (1.2 m) in diameter and larger, and 1/14 sq nm/hr for objects 1 ft (30 cm) in diameter that have adequate target definition.

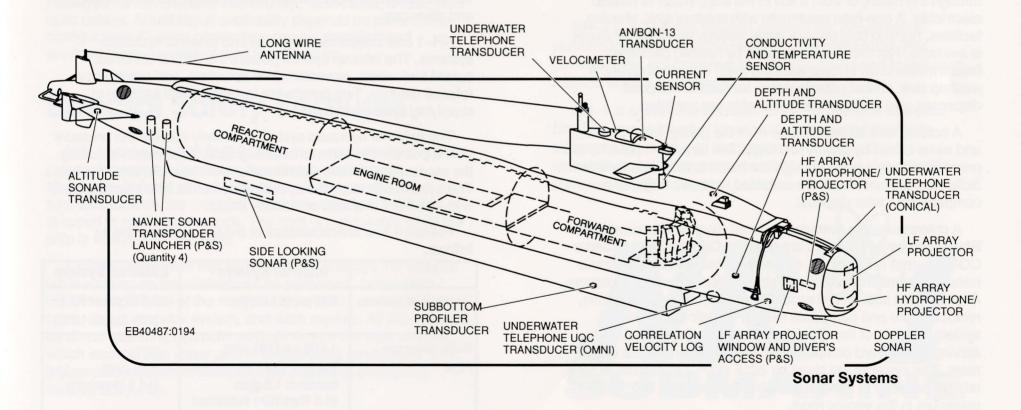
A Doppler sonar set measures ship's speed with respect to ground and water. The range of velocity measurements are: fore/aft 0 to 15.0, port/starboard 0 to 7.0, and up/down velocity from 0 to  $\pm$  5.9 knots. The Doppler sonar works in conjunction with the ship's computer for navigation by dead reckoning.

A depth/altitude sonar recording system measures the distance to the seabed or to the surface from the forward end of the submarine. A separate altitude sonar set measures altitude from the after end, and also serves as a backup for the depth/altitude sonar system. Reflected sonar signals are marked on CRTs to show distance from the seabed. Ranges may be selected between 0 and 6,000 ft (1,829 m), on five scales, for the forward depth/altitude sonar, and between 0 and 1,200 ft (366 m), on three scales, for the after sonar.

A sub-bottom profiling system provides a high resolution profile of the sedimentary layers below the seabed. For deep penetration, the system emits a narrow-beam, high intensity, vertical signal. Good records are simultaneously produced for both near and deeper sub-bottom layers. The echoes are recorded on 9.5 in. (24 cm) wide paper.

A correlation velocity log (CVL) system provides ship's velocities from surface to bottom.

NR-1 also has an underwater telephone for communicating with surface ships or submarines having similar equipment.



# Accommodations, Stores, Endurance

Fixed berthing is furnished for four persons. Two more can sleep on the viewing pad in the forward compartment and one in a portable hanging bunk. Seven personal lockers of 3 cu-ft (85 cu-dcm) each are provided. Stores and supplies can be carried for 330 man-days maximum. Frozen 0°F (–18°C) food storage of 32 cu-ft (900 cu-dcm) is provided. Consumables, vital spares, safety equipment, basic test gear, and tools necessary for 30-day missions are usually carried.

A potable water tank is provided. It is filled from dockside through the hatch, or from a still in the ship. Water is heated electrically. A one-man washroom with lavatory sink, shaving facilities, hot and cold potable water outlets, and a water closet is available. Hot meals are prepared by heating packaged frozen meals in an electric warming oven in a small galley. A washup sink, chilled potable water, an electric hot drink dispenser, and a three-man mess table are provided.

A holding tank accepts waste from the galley, sink, lavatory, and water closet by gravity drainage. The tank is emptied by low pressure air, via a hose through the hatch to dockside facilities. Solid wastes from meals are collected in plastic bags, and compacted for later disposal.

A chlorate candle furnace produces oxygen. Standard USN lithium-hydroxide canisters are used for  $CO_2$  absorption, and a  $CO-H_2$  burner is furnished. An electric atmosphere analyzer is installed, supplemented by portable equipment when necessary. Absolute and activated charcoal filters, with recirculating fans, remove odors and particulate matter. The air conditioning system consists of two cross-connectable subsystems, one serving the forward compartment, the other serving the engine room. The systems are sized for  $80^{\circ}F$  ( $27^{\circ}C$ ) maximum at 50% relative humidity in living and control spaces, and  $100^{\circ}F$  ( $38^{\circ}C$ ) maximum in the engine room.

# Service Systems and Spare Capacity

NR–1 has a 4,500 psig (306 atm) compressed air system for blowing main ballast tanks, recharging scuba compressed air flasks, and emergency air breathing. The air is stored outside the pressure hull. The ship is supplied compressed air by a portable shore-based air compressor rated at 29 scfm at 4,500 psig (14 liters/sec at 306 atm).

An emergency air breathing system provides a reduced pressure supply to 13 conveniently placed outlets. Face masks with demand regulators and hoses are located at each outlet. The air system has external connections topside for charging and diver use.

NR–1 has independent internal and external hydraulic systems. The internal system powers the control surfaces, ballast tank vents, seawater valve actuators, and emergency release devices. Two pumps are installed, each capable of supplying system demand.

The external hydraulic system is entirely outside the pressure hull. It powers the external oceanographic equipment, including the manipulator, wheel mechanisms, work module, and winches. The system can meet the operating demands of the largest user, with all others in a hold or standby mode.

Pressure flow characteristics of the two systems are as follows:

erepainery devicers. The night for i	Internal System	External System
Dynamic pressure	900 psi (61 atm)	2,575 psi at 50°F (175 atm at 10°C)
Static pressure Flow	1,500 psi (102 atm) 5.0 gpm (22.7 liters/min) transient 1.5 gpm (6.8 liters/min) sustained	 3.25 gpm (14.8 liters/min)

Spare electric circuits presently available in NR–1 include six 15 amp, and one 25 amp, 450 volt, 3-phase circuits. There are also 115 volt, 60 Hz, 1- phase, 10 amp circuits with wall receptacles. In addition, 115 VAC or 250 VDC circuits can be made available by installing AC/DC inverter power supplies in some of the 440 VAC circuits. A junction box, accessible via the forward main ballast tank flood hole, has three 5-pin connectors available to supply AC or DC power to outboard loads, or circuit connections to devices anywhere in the submarine.

NR–1 has 21 electrical hull penetrators having from one to 12 receptacles. These penetrators have the following circuit capabilities: multi-wires (various gauges); twisted shielded pairs; coax (RG 58 and 59); and 100/140 nm, multi-mode, 8-fiber, fiber optic cables. Actual circuit availability depends on current ship configuration. Custom penetrators can be manufactured provided there is sufficient lead time to do so.

## **Special Safety Features**

NR–1 carries 22,000 lb (9,980 kg) of expendable lead shot to provide emergency buoyancy. The shot is contained in shot-tanks, forward and aft. Primary and secondary backup hydraulic controls are provided to release the shot, which is dropped in about ten seconds. The shot is replaceable while the ship is waterborne, dockside.

External equipment that might become entangled or trapped while working on the seabed can be jettisoned. Jettisonable equipment consists of the manipulator, wheels, anchor, winch hook, object recovery system, and work module. All are released by direct-operating hydraulic controls except the work module, which incorporates shear pins in its operating mechanism. The jettisonable equipment also provides additional emergency reserve buoyancy. The main seawater and variable ballast system hull and backup valves have remote control hydraulic actuators.

NR–1 has an international orange bridge fairwater to improve her visibility at sea. If a casualty results in inability to surface, a standard AN/BQN-13 rescue pinger beacon is used to aid in locating her. Salvage lifting pads forward and aft facilitate raising the ship. For depths where self rescue is feasible, Steinke escape hoods are provided.

# Conclusions

NR–1 is a versatile, flexible, economical, experimental platform for oceanographic research and exploration. Her potential uses are unlimited; she can be configured to suit each mission unique requirement.

NR–1 is a one-of-a-kind submarine for one-of-a-kind jobs. She is a unique blend of lessons of the past and the most advanced technology of the present. NR–1 provides the technical and platform resources that well serve the scientific community in the undersea arena.



