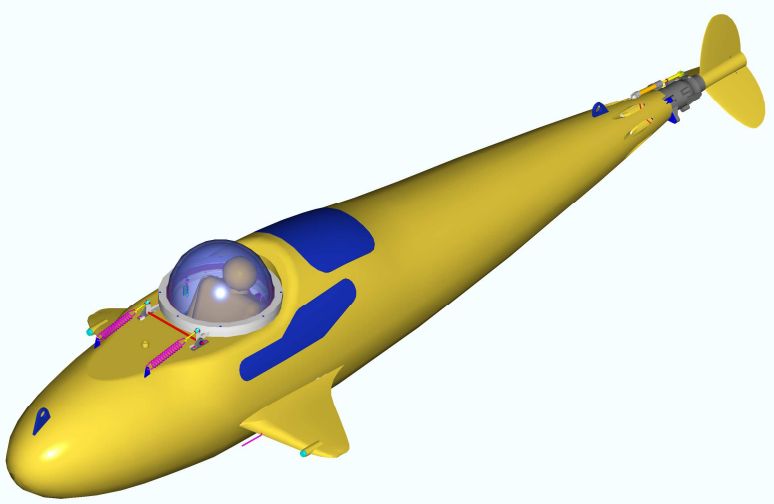
OPERATING MANUAL
V1.4

R300 Recreational Submersible



REDUS ENGINEERING

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I. VEHICLE CHARACTERISTICS

1. R300

a. General Capabilities

1. Operate at any depth from the surface to 300 fsw at a speed of 0-26 knots, and remain submerged for periods of up to approximately 7 hours (72 hours under emergency conditions).

2. Maneuver with flight control surfaces much like an airplane. Fly-by-wire control of pitch, roll and yaw enable underwater hydrobatics. Equipment is secured for temporary inverted orientation.

3. Hover at neutral buoyancy and/or rest on the bottom.

b. Specifications

Side and top views of the R300 are shown in Figure 1.

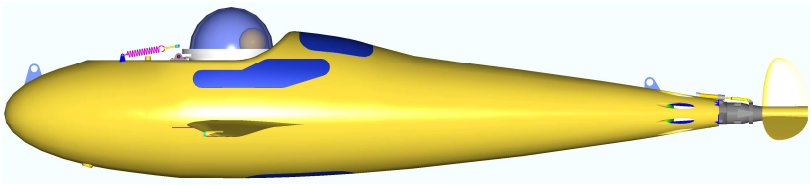


Figure 1a Side Profile, side view

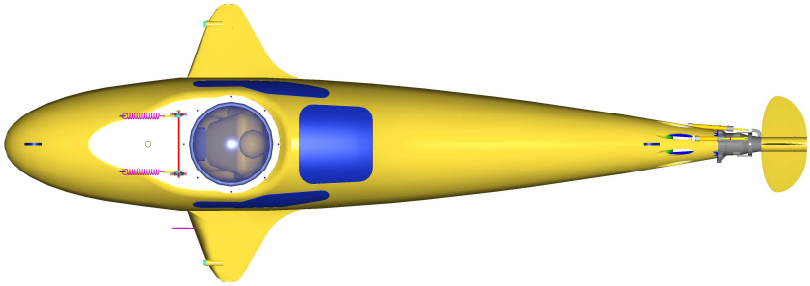


Figure 1b Top Profile, top view

MAIN DIMENSIONS	
Length	19' (5.8 m)
Beam	6'6" (2.0 m)
Height	4'1" (1.2 m)
Draft	2'7" (0.8 m)
Pressure Hull diameter	30” (76.2 cm)
Pressure Hull material	ASTM A516 Grade 70
Pressure Hull thickness	0.25” (6.35 mm)
Dry weight (excluding pilot)	4,234 lbs (1,920.5 kg)
Operational depth	300’ (91 m)
Payload capacity (with pilot)	220 lbs. (100 kg)
Drop weight	300 lbs (136 kg)
Hatch - ID	21.5” (54.6 cm) opening
Crew	1
PROPULSION & POWER SUPPLY	
Jet pump	Jet pump, axial flow, single stage
DC motor	13 hp DC motor with MOSFET motor controller
Total Power	12 kWh(120 VDC x100 Ah)
Main batteries	10 @100 Ah / 120VDC
Emergency battery	2 @100 Ah / 24VDC
Battery endurance	7 hrs (normal operation)
Emergency battery endurance	72 hrs (hotel load only)
GAS SYSTEMS	
Main ballast - Soft	7.6 SCF
Variable ballast - Hard	1.8 SCF
Air	76 SCF / 207 bar
Oxygen	78 SCF / 139 bar
Oxygen endurance	7+72 hrs
PERFORMANCE	
Normal speed	7 knots (8 mph) for 8 hrs
Max speed	26 knots (30 mph) for 9 min.
Range	66 miles (normal operations)

Pressure hull has been designed to conform to American Society of Mechanical Engineers (ASME) and Pressure Vessels for Human Occupancy (PVHO) codes[1].

The 220 lb payload listed above includes pilot. Any remaining payload is available for user equipment during the dive. This load includes internal and external equipment, subject to some restrictions. Internal equipment must pass through 21.5" hatch opening with adequate clearance.

Normal dive duration varies from 7 hours, but this time may be reduced by excessive power usage. The primary power consumers are propulsion motor, hydraulics and lights.

During any given dive, the percentage of time actually spent on the bottom or at desired depth depends upon the amount of time it takes to travel to and from that depth.

For more details on overall design and specifications, see the R300 Plans and Design[2].

2. Support Vehicle

The R300 is designed to be used without a dedicated support vessel. The transport vehicle will serve as the support vehicle and base of operations. The Submersible Operations Officer (SOC) will monitor the dive from this vehicle.

II. SHIP SYSTEMS

1. Life Support

a. Oxygen

High pressure oxygen is plumbed to a pressure reducing regulator coupled with an adjustable flow meter housed in the Air Management and Oxygen Control (AMOC) module within the cabin. Oxygen makeup can be either automatic (default) or manual. In automatic mode, the oxygen level is kept between 18 and 21 %. In manual or backup mode, it is bled into the compartment at the rate of 0 to 5 SLPM with the nominal rate being 0.5 SLPM.

The oxygen concentration is monitored continuously and displayed on the touch screen display. It is also shown with an analog gage as O2 (SLPM). If all electrical power is lost, then the backup oxygen dial should be adjusted so that approximately 0.5 SLPM is being introduced into the cabin. When the automatic mode is on, the backup O2 dial should be fully closed.

The O2 pressure in the external tanks is shown on the operator touch screen under the Gas screen. A backup display of the O2 pressure is displayed in the lower left front panel of the AMOC module.

b. Carbon Dioxide Scrubbers

1. Primary System

The scrubber is a filter canister that is packed with 3.4 lbs. of Sodasorb HP. The scrubber is mounted in front of the pilot joy stick about 4 inches off the hull for good air flow. The blower is mounted on the bottom of the canister and draws air in from the bottom and across the chemical bed. A fully packed scrubber will last 12 hours.

2. Emergency System

In addition to the 3.4 lbs. packed in the scrubber, the R300 carries 19 lbs. of Sodasorb in sealed bags for emergency use. The total endurance for 22 lbs. of Sodasorb is 80 hours (3.33 days) for pilot.

c. Atmosphere Analyzers

All life support sensors are installed in the AMOC module. These include the O2 pressure, O2 and CO2 concentration, relative humidly, cabin pressure, temperature and O2 flow rate. Their purpose of the O2 and CO2 sensors are to measure the partial pressure of oxygen and of carbon dioxide so that the PLC in automatic mode and the pilot in manual mode can make the adjustments necessary to maintain the O_2 and CO_2 levels within acceptable limits.

d. Thermal Protection

The submersible is subject to temperature changes. Long underwear, snowmobile type jump suits and chemical heat packs are provided to the pilot for protection in case of long exposure. It is advisable to carry a sweat shirt or other long sleeved shirt and wear long pants.

e. Food and Water

The submersible carries 2 quarts of potable water, plus enough vacuum sealed food sticks (USCG approved life raft rations) to provide 3 days life support.

2. Pneumatic System

a. Air

High pressure air is stored externally aft of the hatch in a single bank of scuba tanks. This bank consists of 4 aluminum S19 air tanks with a bank capacity of 76 SCF at 3000 psig (207 bar).

The high pressure air is only used for buoyancy control. Buoyancy is obtained by the use of the Main Ballast Tanks (MBT) which provide a total of 419 pounds of lift.

All controls are located on the pilots joy stick.

b. Oxygen

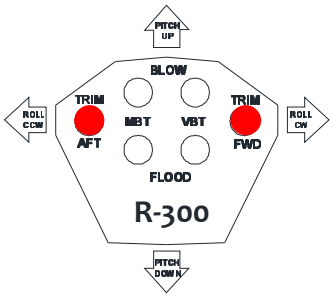
Oxygen is stored in two banks; port and starboard. Each bank consists of one Medical "E" size aluminum cylinder and one "D" size cylinder with a bank capacity of 78 SCF at 2000 psig (139bar). Both banks are connected together and available within the compartment. The oxygen endurance is 79 hours. This meets ABS rules[3] of 72 hours plus the normal mission period of 7 hours. Oxygen is used only for addition to the compartments atmosphere to replace that which is lost due to metabolic consumption by the pilot.

3. Hydraulic Systems

Hydraulic power is provided through a 24 VDC hydraulic trim pump. This hydraulic system consist of three components, positive displacement hydraulic pump driven off a 24 VDC motor, a 1 quart oil reservoir and a pressure relief valve. Hydraulic power is used to articulate the trim weight.

4. Longitudinal Trim

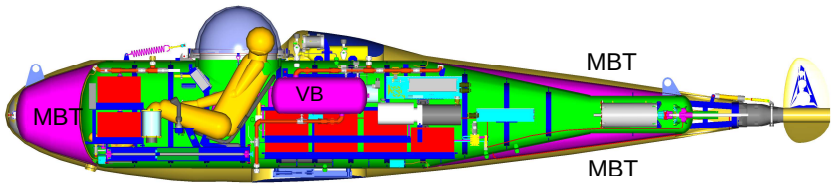
The operator can trim the R300 longitudinally. This is done by pressing trim buttons on joystick (shown to the right) which control a linear movement of 90 lbs of lead ballast located in the trim tube assembly. If the submersible is pitched upward while in a static condition, the

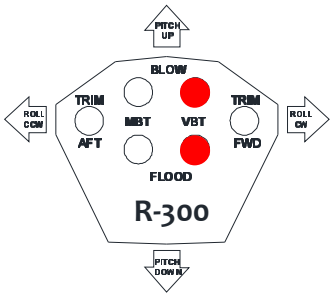


operator presses the trim-weight-forward switch on the joystick and watches an indicator on the touch screen display that tells him when the submersible is level. Likewise, if the submersible is pitched downward, the operator presses the trim-weight-aft switch and watches a gauge that tells him when the submersible is level. He then releases the button and the trim weight is locked in this position by the hydraulic control valve. This gives the submersible the ability to pitch upward or downward by 40 degrees.

5. VBT System

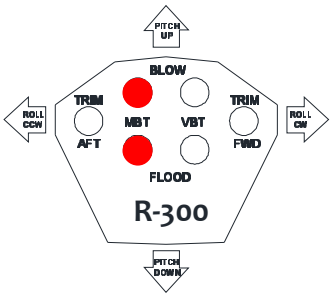
The Variable Ballast System (VBT) has 69 lbs (31 kg) H_2O capacity. The variable ballast tank is hard and is internally mounted at the boat longitudinal center of gravity.





This tank is filled and vented using three PLC controlled valves. Two electrically actuated ball valves are used for the vent and flood ports and one solenoid valve is used to supply air to blow the VBT. To descend, both the vent and flood valves are opened by pushing the VBT flood button on the pilot joy sick. To ascend, the air supply and the flood valves are opened by pushing the VBT blow button on the pilot joy sick. NOP is to start the dive with the VBT level at 80%. This is done by adjusting the fixed ballast. With this tank almost completely filled with water, blowing this tank gives the maximum lift.

6. MBT System



The Main Ballast Tank (MBT) system is external and soft. There are two MBTs, one forward of the pressure hull and two saddle tanks wrapped around the aft part of the pressure hull. Air for blowing the MBT is supplied by four Catalina S19 scuba tanks. These tanks are filled to a maximum of 3000 psig and contain in total 76 scf of air. At 150 psig, the tank will hold 4.4 scf. Therefore, the volume of air available to blow the MBT from an initial pressure of 3000 psig down to 150 psig, is 72 scf. With the MBT volume being 6.4 ft^3, this gives the operator the ability to blow the MBT 11 times at the surface or one time at the maximum operating depth of 300 ft. See MBT Blow and Flood buttons on the diagram of the pilot joystick.

In the event that the joystick control of the MBT fails such as with loss of all electrical power, a manual MBT is available. On the pilots starboard side is the MBT air distribution panel (ADP). The ADP valve enables the pilot to selectively direct MBT blow air to the forward, aft or both MBTs. This valve should normally be set on both. At the bottom of the ADP is the manual MBT blow valve. Normally this is in the closed position. At any time, this valve can be opened to force air into the MBTs as per the ADP valve.

At the top of the ADP is the Built In Breathing System (BIBS) valve. When this valve is open, then air from the LP air is available for breathing by connecting an LP second stage scuba regulator to quick disconnect on the top of the ADP panel.

7. Electrical Systems

a. Main Battery

There are ten deep-draft, Absorbent Glass Mat (AGM) marine batteries connected in series that constitute the main bank. This bank is located within the pressure hull. The sealed AGM batteries were chosen primarily for safety reasons in that they can be operated at any orientation without spillage and they do not generate hydrogen gas during recharging. The main battery bank contains ten 12 VDC, 100 amp hour batteries connected in series to give 120 VDC.

b. Emergency Battery

Emergency battery is composed of two of the same AGM batteries connected in series. The “aux” position of the master switch activates only the emergency battery system. In this position, the onboard Programmable Logic Controller (PLC) is powered as well as life support and communication systems. Propulsion and the hydraulic systems are not online while the master key is in the “aux” position to preserve battery life in an emergency situation.

c. Touch Screen Display

The pilot utilizes a touch screen panel for all interfacing with the onboard PLC. By selecting different display screens, all ship systems can be viewed and integrated. All instrumentation for the boat is interfaced with the PLC and displayed on the operator panel. The operator panel is designed to be rotated back underneath the pressure hull when not in use. This facilitates entering and exiting the boat.

d. DC-Power Converter

A DC to DC converter is used to convert from 120 VDC to 24 VDC for running auxiliary equipment.

e. Motor Controller

The main propulsion motor controller works on the principle of varying the average motor voltage based on Pulse Width Modulation (PWM) technology. This controller requires a throttle potentiometer which is located in the master switch box to the starboard side of the pilot.

f. DC Propulsion Motor

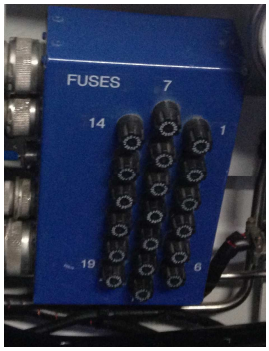
The main drive motor is model DC-L91-4003 manufactured by Advanced DC Motors. This is a Series wound brushless motor with an operating voltage of 72-120 VDC, an operating current of 130 amps continuous, 150 amps for 1-hr, and 500 amps intermittent. The motor is rated at 13 HP continuous, 15 HP (1-hr thermal rating), 43 HP peak using the 400-amp motor controller. The propulsion motor is reversible with proportional speed control.

g. On Board Battery Chargers

There are two on board battery chargers, one for the 120 VDC main battery pack and one for the 24 VDC emergency battery bank. To charge both bank 120 VAC plug rated for 50 AMPS can be plugged into a heavy duty 50 amp extension cord.

h. Fuse Box

The fuse box is located on the port side of the pilot seat. There are nineteen fuses with the function and max current of each shown below. A spare set of fuses is stored in the fuse box.



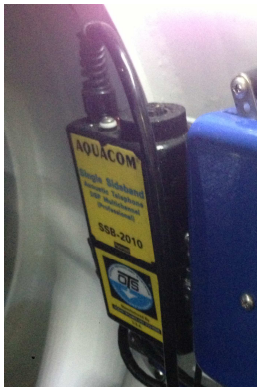
#	FUSE DESCRIPTION	CURRENT
1	5V POWER SUPPLY	2A
2	12V POWER SUPPLY	10A
3	AUX. BATTERY	20A
4	24VPOWER SUPPLY	30A
5	MAIN CONTACTOR	8A
6	EXTERIOR LIGHTS	8A
7	CHARGER INTERLOCK	2A
8	THROTTLE	1A
9	TRIM PUMP	15A
10	ROLL ACT. – STAR.	15A
11	ROLL ACT. – PORT	15A
12	PITCH ACTUATOR	15A
13	YAW ACTUATOR	15A
14	PLC	5A
15	INTERIOR LIGHTS	5A
16	INSCRUBBER FAN	1A
17	TOUCH SCREEN	1A
18	CIRC. FAN (AMOC)	1A
19	VHF RADIO	5A

i. Circuit Breaker

The Main Power Circuit breaker is located on the port side of the pilot seat. The purpose of the device is to limit the current to the main propulsion motor to less than 440 amps. It also enables the 120 VDC power from the batteries to be shut off. The circuit breaker is installed in a protective case as shown to the right.

8. Communications

The R300 is outfitted with an all channel marine VHF radio for surface communications. Also on board is an OTS underwater 2-way radio. Refer to the dive plan for the channel settings for both the VHF and OTS radios.



OTS Radio

VHF Radio

9. Navigation Aids

a. Depth

R300 uses an ambient water pressure transducer interfaced with the PLC to measure water depth. The depth is

displayed on the touch screen display. As a backup, the water depth is displayed for fresh water with a bourdon pressure gage shown in the picture.

b. Compass Heading, Pitch and Roll Angle

A single sensor system, packaged for submerged operations, is used to measure compass heading as well as pitch and roll of the submersible. The sensor package is located in the aft exostructure outside the pressure hull so that the effect by the hull on the magnetometer can be calibrated out. As a backup, bubble style roll and pitch gages are installed just below the lower hatch ring.

10. Lighting

Forward illumination is provided by two Deepsea Power Mini Sealite underwater lights. Each of these is a 120 VDC, 250 watt lamp that puts out 4750 lumens and has a maximum depth of 3,250 ft. The exterior lights are activated from the pilot touch screen display. Note that because these lamps require submergence for cooling, the PLC locks them out if the water depth is less than 1 ft.

III. OPERATIONS

1. Safety

Guidelines from American Bureau of Shipping "Rule for Building and Classing and Underwater Vehicle, Systems, and Hyperbaric Facilities" were used as a basis for the R300. Key safety features include:

- The pressure hull has been designed and tested to American Bureau of Shipping requirements of 1.25 times the rated design depth of the vehicle. The test depth is 375 fsw and R300's maximum operating depth is 300 fsw, well under the test depth.
- In order to ensure that no water leaks into the pressure hull, all penetrations for wires, pneumatic lines, view ports and hatches are designed in such a way that they actually provide a tighter seal the deeper the vehicle dives and these devices are inspected prior to each dive.
- While the vehicle weighs over 2 tons in air, when submerged it can be made exactly neutral by trimming with the variable ballast system so only a very slight force is required to move it up or down. It is therefore possible to ascend to the surface by blowing a small amount of compressed air into the variable ballast tanks.
- If for any reason additional buoyancy is needed, the main ballast tanks can be blown at any depth.
- A lead drop weight can be released mechanically giving an additional 300 lbs. of positive buoyancy.
- A maximum dive lasts about 7 hours, however, sufficient oxygen, water and supplies are provided to allow the submersible to remain submerged in an emergency situation for a period of up to 3 days.
- Emergency Procedures will be reviewed prior to each dive and are posted in the submersible.

2. Training Policy

Prior to the first time the pilot will be allowed to dive the R300, he/she must undertake and pass a rigorous training protocol that includes demonstration of his/her ability to operate all ship systems including,

ballast, longitudinal trim, life support (both automatic and manual), communications, emergency blowing of MBT at depth, emergency release of the drop-weight, and the emergency escape procedure.

Likewise, the SOC will undergo training in all ship systems with particular attention to emergency procedures and communications.

3. Submersible Operating Day

A submersible operating day is an 8 hour period (typically 0800-1600), depending on the type of mission. This is 8 consecutive hours and includes pre-dive checks, briefings, dive time, replenishment, down loading and debriefing. It may also run concurrently with undivable sea states and will not advance as the weather moderates.

The basic daily schedule will be established during the pre-mission communications.

4. Daily Dive Scheduling

Normally, two 3 hour dives per day are conducted typically starting at 0800 with surface replenishment at the end of the dive. The limiting factor is the battery which requires recharging between dives. The total dive time per day can not exceed 8 hours. Excessive and long excursions will drain batteries fast and will result in a shorter dive. If for any reason the State of Charge (SOC) for the main batteries has fallen below 50%, then mandatory surfacing for recharging is required. When planning your dive schedule, 8 hours as the maximum total dive time to be scheduled in any operating day. This is done so that maximum battery life is achieved throughout an operating year. It is recommended that the pilot meet each evening with the SOC to finalize the dive schedule and identify the names and weights of personnel and equipment to be on board the R300 the following day. Submersible Dive Planning Forms (Appendix C) will be provided for this purpose.

Notes:
1. Battery capacity is reduced by water temperature below 10^{o}C (50^{o}F) and can reduce dive time.
2. Dives covering long distances reduce battery capacity faster than dives remaining in a given area.
3. The pilot constantly monitors the battery condition and can elect to shorten a dive if conditions warrant.

5. Operations Guidelines

a. Operational Limits:

The R300 submersibles operate within various limits. These limits are based on safety, environmental, electro-mechanical and operational factors and were developed in order to provide the safest and most reliable submersible system in our class.

The limits listed below are not to be exceeded except in the case of a properly approved, preplanned mission or in case of emergency to ensure the safety of personnel.

1. The Pilot-in-Command will have the authority to terminate a dive by whatever means necessary at any time that he feels a hazard to the submersible or him/her self exists, without regard to mission success or completion.
2. R300 will not be operated where the bottom depth exceeds 300 fsw.
3. R300 will not be operated below a depth of 300 fsw.
4. R300 will abort any attempt to operate near wreckage, debris or natural terrain features which have entanglement or entrapment potential when visibility is low, current is high, or battery voltage is low.
5. R300 will remain clear of any explosive devices which may be sighted.
6. R300 will not work or be on station beneath or near a suspended load, or a towed array.
7. R300 will not transect in blackout conditions within 50' of the bottom or towards vertical walls or high relief areas.
8. R300 will not transect in a current strong enough to prevent stopping the submersible to avoid an obstacle.

b. Limiting Conditions

The submersible and its support vehicle are a matrix of systems. Each one has its own function and operating characteristics. Every attempt is made to ensure that all systems are fully functional. Some systems, if not functional, pose no threat to operating safety. It is up to

the SOC, and pilot to determine what, if any, effect loss of this equipment has on the success of the dive. Other systems, particularly that for life support, main power, and communications are indispensable and must be operational any time the R300 submerges. Loss of this equipment during a dive constitutes a reason to switch to back up systems and abort the dive.

The ability of the R300 to complete her mission successfully is also affected by conditions beyond any control; high current, low visibility, surge or heavy seas, rugged topography, overhangs or the over abundance of entangling artifacts such as commercial fishing gear. Any of the above may require a modification to the dive plan based on the pilot and/or the SOC assessment of the risk involved.

Weather and lake/sea condition play an important part of a successful mission. It is up to the SOC to determine that there is a reasonable fair weather window to ensure a successful launch, dive and recovery. Every situation is different, i.e., wave height, period, wind speed, height and direction of underlying swell, and weather forecast, so it is difficult to place a predetermined limit on launch or recoveries. However, the probability of a successful launch and/or recovery is low when the wind is above 20 knots or the sea state is higher than 2 (1.5-3 foot waves).

6. Pre-Dive Briefing

Every pilot is given a briefing by SOC inside the submersible prior to making his/her first dive. This briefing, which takes approximately 10 minutes, is done at the time of the individual's first dive just prior to launching. It details the location of controls, instrumentation, normal and emergency procedures. Emergency procedure cards are located in the cabin and are readily accessible to the pilot. This operator’s manual will be aboard at all times.

7. Off-Loading

The R300 is designed to be transported and off-loaded much like a conventional recreational motor boat. Shown below are different views of the R300 on its trailer. The Gross Vehicle Weight (GVW) of the sub and trailer is 5,300 lbs with a tongue loading of 500 lbs. A transport vehicle with the hauling capacity of at least 7,000 lbs GVWR is recommended. Always use caution when backing your sub into a

new launch and verify that the necessary depth exists to offload the sub. Recommended ramp depth at 25 ft from water's edge is 4 ft or greater.

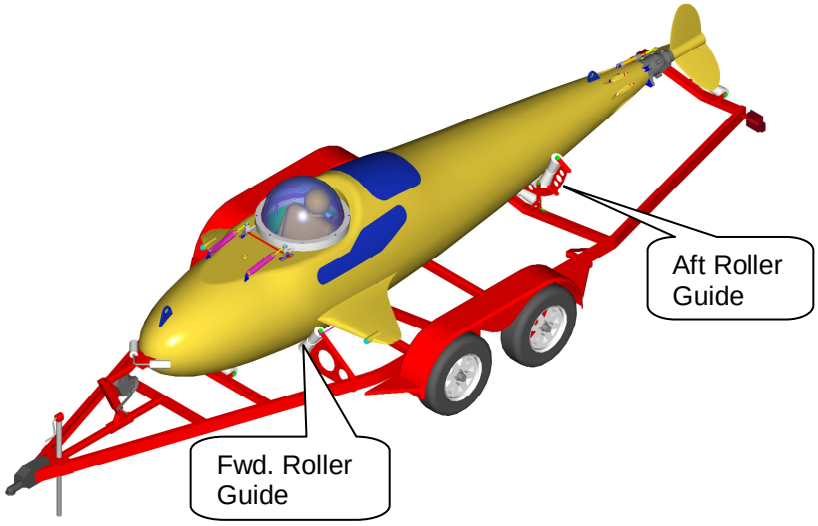
To expedite off-loading, prior to arriving at the ramp, the sub should be loaded with everything that is needed for the mission. Find a quiet spot in the parking lot away from the launch lane traffic. The Submersible Operations Coordinator (SOC) and pilot should go over the pre-dive check list and off-loading checklist given in Appendix B before traversing to the boat ramp. When you arrive at the ramp launch lane, all that is needed to do is launch the sub into the water.

Launching

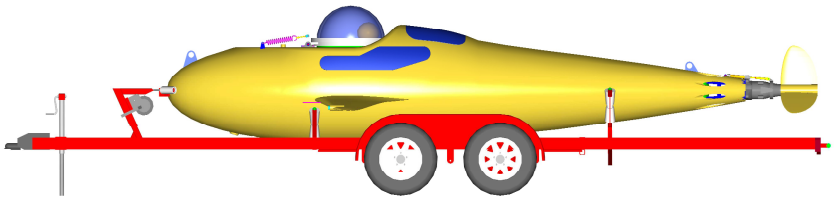
1. Chock trailer and install tongue extender.
2. Lower the aft roller guide just behind of the rear trailer axle.
3. Take off the trailer straps.
4. SOC confirms MBT flood plugs have been removed.
5. Pilot climbs into sub and turns on the main power switch.
6. SOC backs the sub and trailer into the water.
7. Once the sub is floating, SOC unhooks the winch hook attached to the bow eye of the sub.
8. SOC slowly pulls the trailer out of the water.
9. Pilot places the reversing switch in "reverse" position and slowly backs out of the launch area.

Retrieving

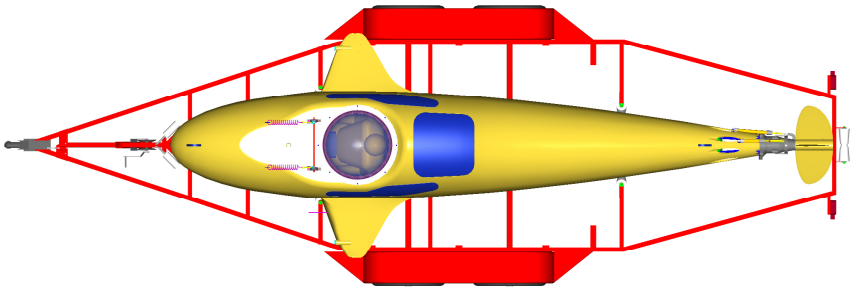
1. SOC makes sure aft roller guide is still in the lowered position.
2. SOC backs the trailer into the water using tongue extender.
3. With Main Ballast Tanks completely full of air, pilot maneuvers sub near the trailer.
4. SOC attaches winch strap to the bow eye of the sub and slowly winches the sub into position over the trailer.
5. SOC raises and locks the aft roller guide.
6. SOC slowly pulls the trailer out of the water. The sub will land first in forward then aft roller guides as the trailer is pulled out of the water. Make sure wings are level.
7. Pilot purges MBTs and VBT and powers down.
8. SOC/pilot pulls the rig to a quiet spot in the parking lot away from the launch lane traffic.
9. SOC secures the tongue extender and trailer straps.
10. Close air and O2 tanks valves, secure hatch.



R300 On Trailer – Isometric View



R300 On Trailer – Side View



R300 On Trailer – Top View

7. General Information

a. Submersible Dive Plan

Successful missions do not just happen; they are planned. This is possible only if Dive Plan is developed. It should not be based on assumptions; if a piece of equipment is essential to the mission, it must be stated in the Dive Plan. See Appendix B for the SUBMERSIBLE DIVE PLANNING FORM.

1. A complete dive profile, including day/night schedule, major gear changes, number and duration of dives, site locations, bottom conditions expected and number of revisits anticipated.

2. Equipment requirements and descriptions (dive by dive, if possible). Equipment, if provided by user or outside contractor, should be detailed by size and weight.

3. Name and phone number of pilot to be contacted regarding details of the dive plans.

b Clothing

It is important for R300 users to bring proper clothing along. The temperature on the bottom is often 30 degrees F colder than on the surface. Long pants, socks, sweat shirt and a sock-hat may be needed to stay comfortable.

c Scuba Diving

Only those certified scuba divers may dive in conjunction with R300 operations.

For safety reasons, scuba diving during submersible operations is limited to less than 100'. Also, no one will dive in the R300 for at least two hours after having completed a scuba dive that is greater than 100'. A scuba dive plan should be used for all dives.

IV. CONTROLS

1. Piloting

a. Entering and exiting the hatch

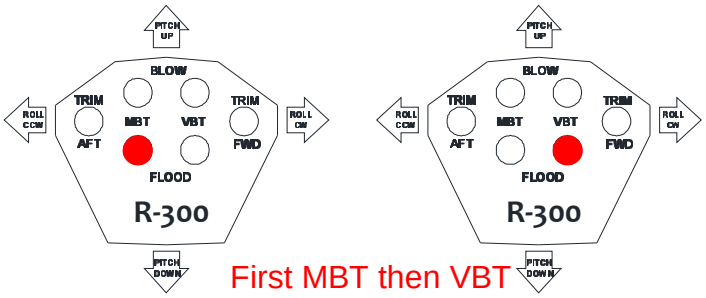
Entering and exiting the hatch should only be attempted with the MBT fully blown and with a sea state of 1 or less. If available, support personnel should stabilize the vehicle while the pilot enters or exits the boat. The pilot touch screen display should be folded back out of the way to facilitate entry.

b. Master Switch

To the starboard side of the pilot seat, against the hull is the master electrical box which contains the master key switch, throttle and the reversing switch. The keyed master switch as three positions, Aux-Off-On. In the “off” position, both the main and emergency batteries are disconnected from their electrical buses. In the “on” position (clockwise rotation), the main batteries are connected by energizing the main contactor. In this position all onboard systems are available. In the “Aux” position (counter clockwise rotation), the emergency batteries are connected. In this position only life support, interior lights and the touch screen panel/ PLC are on. Use this setting for extended wait for rescue if main batteries are dead.

c. Submerging

Submerging is a two step process, the first being to flood the MBT completely and the second to partially flood the VBT to achieve neutral buoyancy. Controls for submerging are located on the pilot joy stick. Note that the flood buttons for either the MBT or VBT are locked out if the hatch is open.

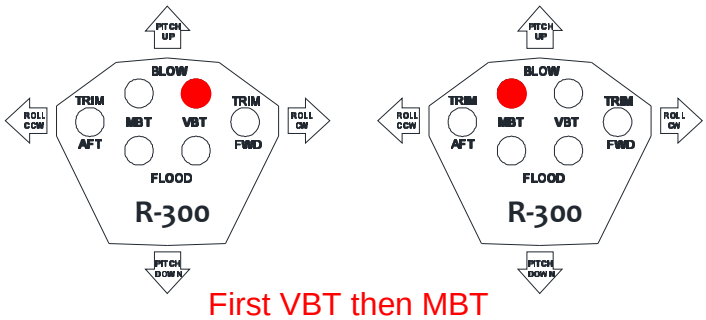


First MBT then VBT

The flood buttons for both the MBT and VBT are shown in the diagram. When flooding the VBT, do so until precisely the moment when the top of the dome is at the water's surface. This will leave the sub neutrally buoyant. The goal would be have adequate removable ballast so that the boat becomes neutral with a VBT level of 80-90%. This maximizes blows with the VBT at depth and minimizes the inrush of water into the VBT when opened at depth.

d. Surfacing

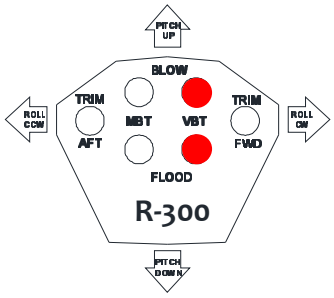
To surface the boat, the preferred way that minimizes air consumption is to use the propulsion motor to drive to near the surface. After making sure there are no surface vessels above, depress the VBT Blow button until the boat starts to ascend.



First VBT then MBT

To bring the hatch fully out of the water, the MBT needs to be blown dry. To do this, press the MBT Blow button until air starts to emerge from both the MBT flood holes. In an emergency, the MBT can be blown at depth. See Appendix A for how to use manual MBT blow valve in an emergency.

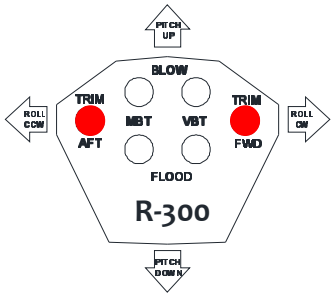
e. Depth Station Keeping



To maintain depth the boat buoyancy must be neutral. This is achieved with the VBT Flood and Blow buttons.

If the boat is slightly negative in buoyancy, depress the VBT Blow button momentarily to put a small amount of air into the VBT. Likewise, if the boat is slightly positively buoyant, then release a small amount of water from the tank using the VBT flood button. After neutral buoyancy is achieved near the surface, no further adjusting of the VBT should be necessary as this is a sealed tank. Exceptions to this include the boat passing through a thermocline, traversing between seawater and fresh water and an emergency situation in which the boat is taking on water from a leak.

f. Longitudinal Trimming



Operation of the trim weight system is controlled by the hydraulic system. Hydraulic fluid turns a reversible hydraulic motor that is connected to a lead screw which turns against a nut secured to the 90 lb trim weight which moves the ballast within the confines of trim weight tube situated under the pilot's seat and extending to his feet. On the operator joystick are forward and aft trim control buttons connected to the PLC through digital input module in the PLC. When the joystick trim switches are not pressed, the trim weight is locked in its current position. As the operator depresses the trim weight forward switch, hydraulic fluid turns the lead screw so that the trim weight moves toward the bow of the boat. Likewise, If the operator presses the trim weight aft switch, the trim weight moves

toward the stern of the boat. Limit switches prevent the trim weight from being dead headed. The trim systems can achieve a static pitching rotation of from 0 to +/- 40 degrees. Pitch inclination is shown on the home screen of the touch screen panel and on the pitch bubble gage on the pilots port side just below the lower hatch ring.

g. Speed Control

To control the speed of the boat, a throttle lever protruding from the top of the ignition box is used. To increase speed, move the lever aft. To prevent cavitation of the jet impeller, slowly increase speed. For the throttle control to work, the reversing switch directly above the keyed master switch needs to be in either the forward or reverse direction.

h. Reversing Switch

To go forward, move the reversing switch, directly above the keyed master switch, to the down position. Likewise, to reverse direction, move this switch to the up position. The throttle should be zeroed before reversing direction.

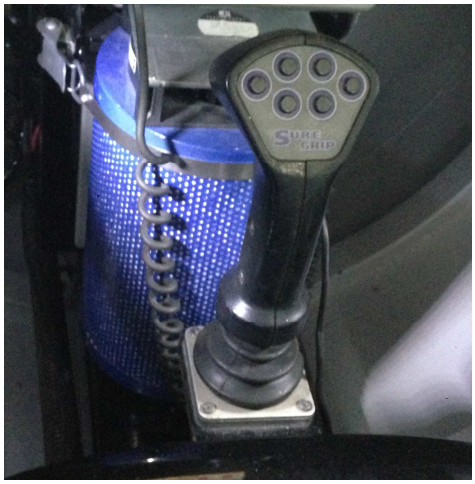
i. Braking

Breaking on the R300 is done by lowering the ailerons by pulling the joystick trigger switch. The position of the ailerons is directly proportional to how much the trigger is pulled. At low speeds, the jet impeller can aid braking by reversing the drive motor and applying the throttle.

j. Yaw Control

The rudder pedals are used for yaw control. As the pilot pushes the starboard rudder pedal the electric linear actuator connected to jet-ski thruster nozzle will produce a yaw in the submersible to the starboard side. Likewise, pressing the port rudder pedal causes the boat to yaw to the port side. As yaw control is fly-by-wire utilizing an electric actuator. This system is locked out if power is being supplied by emergency batteries.

k. Pitch Control



The pilot joystick is used to control the pitch. As the pilot pushes the joystick forward or the submersible pitches forward. If the pilot pulls back on the joystick, the boat will pitch upward. Movement is accomplished based on stroking a small electric actuator attached to the jet-ski articulated thruster nozzle. If the operator lets go of the joystick, it returns to central position and all control surfaces return to neutral positions.

l. Roll Control

To control the roll of the boat the pilot uses the joystick with port to starboard movement. With enough forward speed, it is possible to roll the boat. All equipment in the boat is secure for this reason. The pilot should not attempt a sustained inverted position as the fluid in the hydraulic reservoir could begin to leak. As the pilot moves the joystick in the starboard direction electric linear actuators on ailerons on either side of the submersible to generate a clockwise roll. The actuators are electrically linked and operate in opposite directions, i.e., starboard aileron moves up and port aileron moves down or in opposite directions for a counterclockwise roll. If the pilot removes his/her hands from the joystick, the ailerons return to a neutral position. Roll in the counter clockwise direction results from movement to the port direction of the joystick. The degree of roll is governed by both how far the joystick is moved and also by the boat speed. If the boat speed is to low, the pilot will not be able to roll the boat.

m. Changing CO2 Absorbent

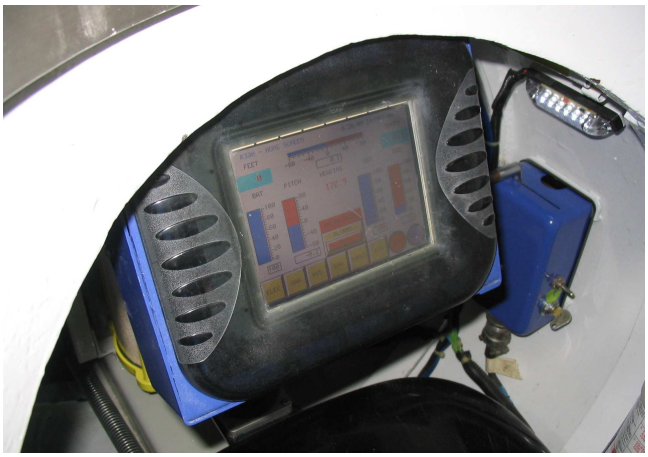
The scrubber is used to filter CO2 from the boat. After approximately 12 hours of use, the Sodasorb absorbent becomes saturated and needs to be changed. The scrubber is located between the pilot's legs

just forward of the joy stick as seen above. Spare Sodasorb is located in containers behind the pilot resting on the main batteries. To change out the absorbent, remove the top of the scrubber. It should not be necessary to disconnect the electrical connector to the scrubber blower. Discard the used absorbent onto the floor of the cabin and add fresh absorbent until the chamber is full. Replace the top of the scrubber and confirm that the scrubber blower is again functioning. There is enough absorbent for a total of 80 hours of life support. Secure the fresh absorbent container behind the pilot's seat.

2. Touch Screen Display

a. Home Screen

A touch screen display is used as the interface between the pilot and the programmable logic controller (PLC). It is mounted in the operator panel as seen below. This display can be rotated out of way to service the scrubber.

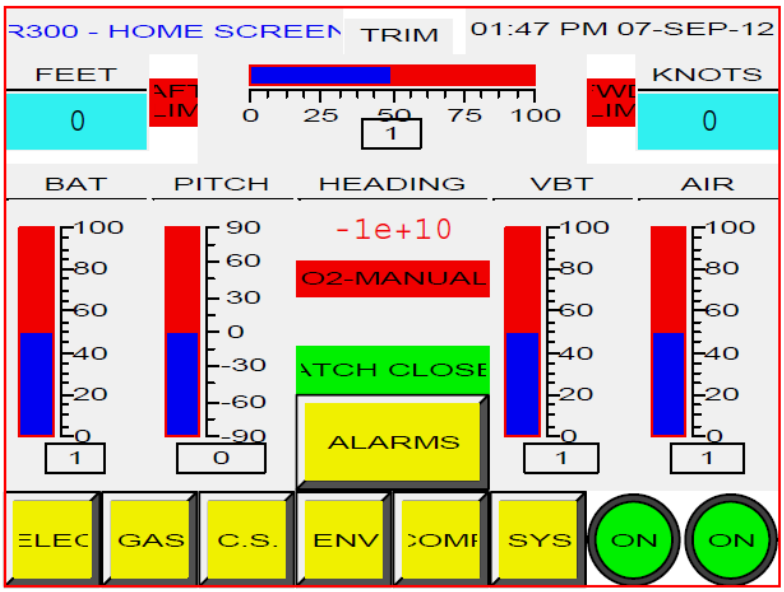


. All instrumentation displays are through the pilot selectable screens. The home screen is the primary screen to be displayed during dives.

The function of each item on the home screen is given below:

Hatch Status - A failsafe display is provided on the touch screen that clearly shows the position of the hatch cover. The display

just above the Alarms button changes from HATCH OPEN to HATCH CLOSED when the hatch is closed.



Alarms Switch – This is a navigation button to the Alarms Screen. From there, any alarm can be deactivated. As default, all alarms are active and an audible alarm will activate if any alarm condition exist. To silence the alarm, touch any place on the screen. See alarms database for details on alarm events. .

Depth – At the upper top of the home display is the depth of the boat shown in blue. The depth is calculated from the measured ambient water pressure.

Speed – At the upper right of the home display is the speed of the boat in knots shown in blue.

Trim Indicator – At the upper middle of the home display is the trim inclination indicator. The trim position is given both as a percentage with 100% being fully forward and as a gauge. .

Main Battery SOC – The state of charge (SOC) of the main batteries is shown on the left most bar graph. Pilot should surface immediately if SOC drops below 50%.

Pitch Indicator – To the right of the battery SOC indicator is the pitch indicator. The pitch is given both in degrees and as a gauge. Positive degrees are measured for an upward pitch while negative degrees indicate a downward pitch.

VBT Level – To the right of the alarm button is the VBT level indicator. 100% means the tank is completely filled with water.

Air Pressure – The right most bar graph is the Air pressure indicator. 100% means the four external air tanks are pressurized to their maximum level of 3000 psig. Zero means these tanks are empty or that all of the tank valves are closed.

Exterior light – At the bottom right of the screen, the right most round button is the Exterior light switch. Pressing the switch toggles the exterior lights off and on if the boat is in the water and the depth is greater than 1 fsw.

Interior light – At the bottom right of the screen, the left most round button (to the left of the exterior light switch) is the Interior light switch. Pressing the switch toggles the interior lights off and on.

Heading – Compass heading is measured in degrees. Zero or 360 is due north.

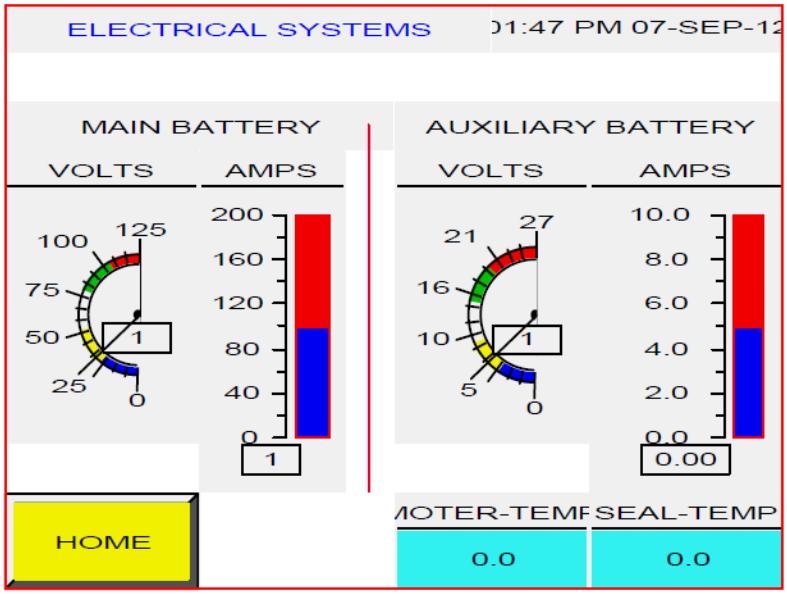
Screen Navigation Buttons – To navigate between screens, six yellow navigation buttons at the bottom of the home screen are shown. The buttons bring up the following screens:

1. ELEC – Electrical Systems
2. GAS – Air and Oxygen tanks pressures
3. C.S. – Control Surfaces
4. ENV – Environmental Systems
5. COMP – Compass Systems
6. SYS – System screen, Alarm history, charting, calibration

b. Electrical Systems

If the ELEC navigation button is pressed from the home screen, the Electrical Systems Screen is displayed as shown below.

The function of each item on the Electrical Systems Screen is given below:



Main Battery Voltage – The voltage on the main battery bank is shown both on a dial meter and as a digital value. A fully charged battery voltage is greater or equal to 128 VDC. The boat should be surfaced for recharging if this voltage drops below 100 volts.

Main Battery Current – The current in the main battery bank bus is shown both as a bar graph and as a digital value. The maximum current is 400 amps. However, operation at this level will drain the main batteries with in 10 minutes.

Auxiliary Battery Voltage – The voltage on the emergency auxiliary battery bank is shown both on a dial meter and as a digital value. A fully charged battery voltage is greater or equal to 27 VDC.

Auxiliary Battery Current – The current in the 24 VDC bus is shown both as a bar graph and as a digital value. The maximum current is 20 amps.

Motor Temperature – This indicates the temperature of the housing of the main drive motor in degrees F.

Seal Temperature – This indicates the temperature in the drive shaft seal circulation system after the coolant has passed through the seal and before it goes through the heat exchanger.

Home Navigation Button – Returns to the Home display screen.

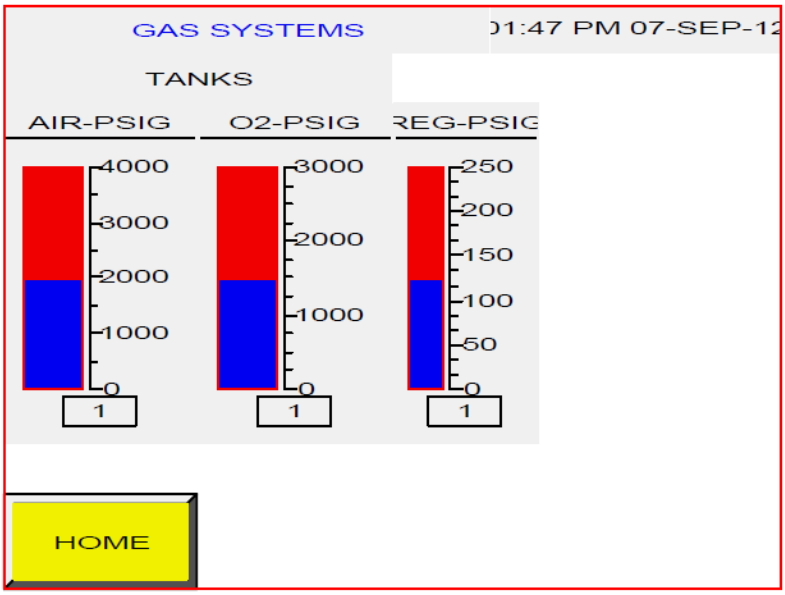
O2 Pressure – To the right of the Air pressure gage is the gage for the O2 pressure. This is the manifold pressure of the four external oxygen tanks. The maximum pressure is 2000 psig. Zero means these tanks are empty or that all of the tank valves are closed.

Reg Pressure – This is the regulated air pressure in psig as measured from the low pressure (LP) port on the air scuba regulator. This regulator is set to deliver regulated air at a fixed differential pressure above ambient water pressure. At the surface, this will read what this differential pressure is set at. Regulated air is used to blow ballast tanks.

Home Navigation Button – Returns to the Home display screen.

c. Gas Screen

If the GAS navigation button is pressed from the home screen, the Gas Systems screen is displayed as shown below.



The function of each item on this is given below:

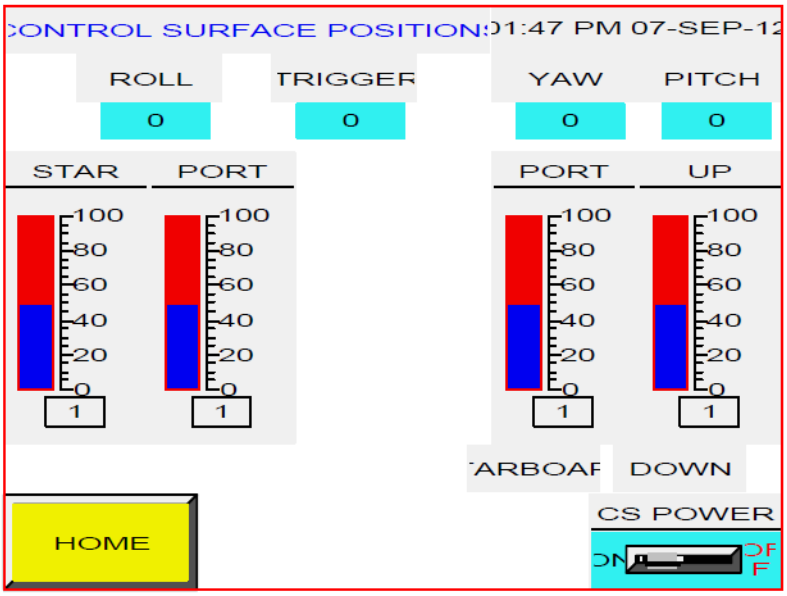
AIR-PSIG – The air pressure indicator displays the gage pressure of the external HP air tank. The scale is 0 to 4000 psig. The maximum air pressure is 3200 psig.

O2-PSIG – The oxygen pressure indicator displays the gage pressure of the external oxygen air tank. The scale is 0 to 3000 psig. The maximum O2 pressure is 2000 psig.

REG-PSIG – The regulated or LP air pressure indicator displays the gage pressure of the pressure from the LP side of the first stage scuba regulator. Note that this pressure floats approximately 40 psi above the ambient water pressure. The scale is 0 to 250 psig.

d. Control Surface Position Screen

If the CS navigation button is pressed from the home screen, the Control Surface Position screen is displayed as shown below.



The function of each item on this is given below:

ROLL – The blue box under ROLL is the joy stick roll position given as a percentage from full port to full starboard.

TRIGGER – The blue box under TRIGGER is the joy stick trigger position given as a percentage from full un-pressed to fully pressed.

YAW – The blue box under YAW is the rudder position sensor given as a percentage from fully port to fully starboard.

PITCH – The blue box under PITCH is the joy stick forward and aft position given as a percentage from fully aft to fully forward.

These four sensors are used to establish the set point for the PID controllers for each function.

STAR INDICATOR – Bar graph and associated digital text shows the relative position of the starboard aileron. Zero would indicate the starboard aileron is fully down while a 100% would indicate the starboard aileron is completely up.

PORT INDICATOR – Bar graph and associated digital text shows the relative position of the port aileron. Zero would indicate the port aileron is fully down while a 100% would indicate the port aileron is completely up.

YAW INDICATOR – Bar graph and associated digital text shows the relative position of the yaw control surface. Zero would indicate the aft control surface is fully to the starboard side while a 100% would indicate the aft control surface is fully to the port side.

.

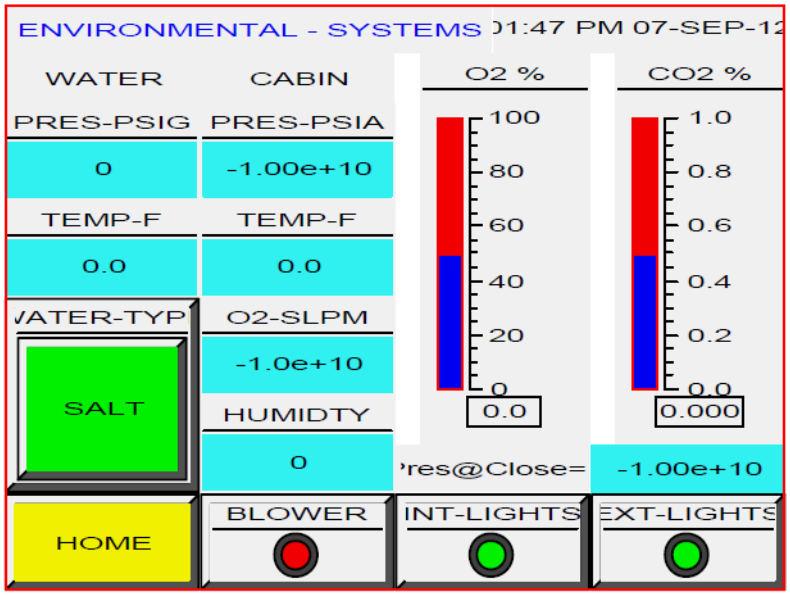
PITCH INDICATOR – Bar graph and associated digital text shows the relative position of the pitch control surface. Zero would indicate the aft control surface is down while a 100% would indicate the aft control surface is fully up.

CS POWER SWITCH – This switch is used to activate (default) or deactivate the control surfaces.

Home Navigation Button – Returns to the Home display screen.

e. Environmental System Screen

If the ENV navigation button is pressed from the home screen, the Environmental Systems screen is displayed as shown below.



The function of each item on this is given below:

WATER PRES – This shows the ambient water pressure measured in psig.

WATER TEMP – This shows the ambient temperature measured in degrees F.

CABIN PRES – This shows the cabin absolute pressure measured in psia. Typically around 14.7 psia for atmospheric air.

CABIN TEMP – This shows the cabin temperature measured in degrees F.

WATER TYPE SWITCH – This is a wwitch that toggles between sea water and fresh water. This is used to select the correct water density to calculate the water depth from ambient water pressure. The default is fresh water.

O2 (SLPM) – This is gage that displays the oxygen flow rate in SLPM being supplied to the cabin when in the automatic life support mode.

HUMIDTY – This shows the cabin relative humidity (RH). Zero indicates the air is completely dry and 100% indicates the air is completely saturated with water vapor.

O2 % – This shows mole percent of oxygen in the cabin. Normal air contains 21 mole % of oxygen.

CO2 % – This shows mole percent of carbon dioxide in the cabin.

PRES @ CLOSE – This shows the cabin absolute pressure measured in psia at the last time the cabin hatch was closed.

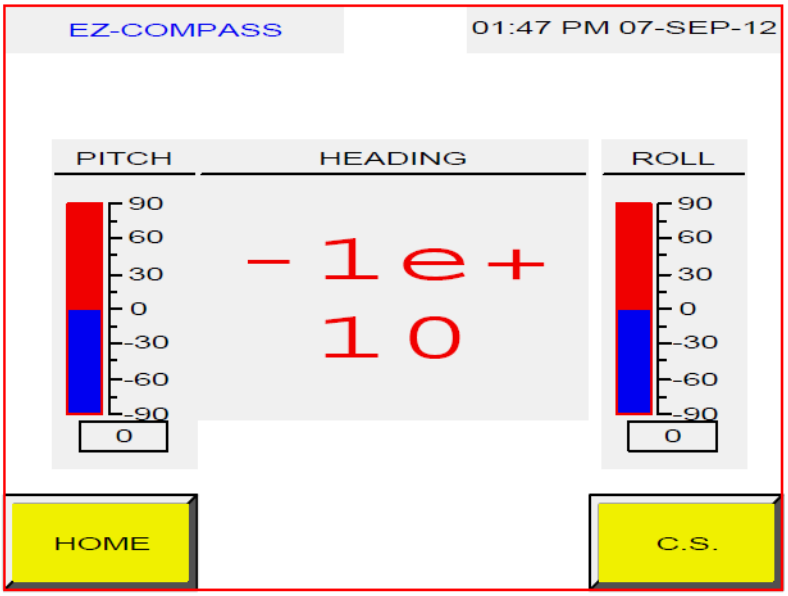
BLOWER – This button activates the scrubber blower. Green indicates that blower is on (default).

INT-LIGHT – This button activates the interior lights. Green indicates that lights are on. Off is the default position.

EXT-LIGHT – This button activates the exterior lights. Green indicates that lights are on. Off is the default position. Note that an interlock with depth sensor locks out use of the exterior lights if the boat is on the surface.

f. Compass System Screen

If the COMP navigation button is pressed from the home screen, the Compass Systems screen is displayed as shown below.



The function of each item on this is given below:

PITCH – This is an indicator of the pitch position coming from the compass pitch sensor. A positive number indicates the bow is up while a negative indicator is for bow down.

ROLL – This is an indicator of the roll position coming from the compass pitch sensor. A positive number indicates the boat is listing to the starboard while a negative indicator the boat is listing to the port side.

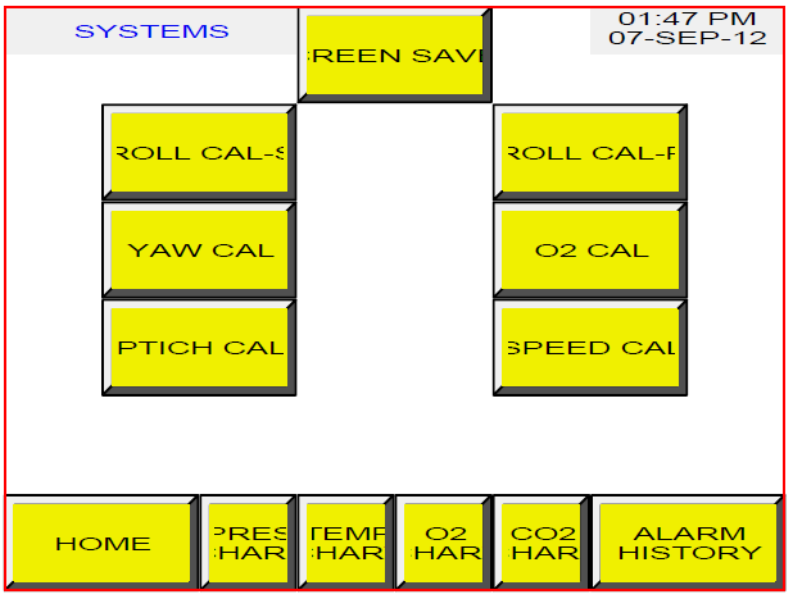
HEADING – This is an indicator of the compass heading coming from the compass heading sensor. Zero or 360 degrees is due north.

Home Navigation Button – Returns to the Home display screen.

C.S. Navigation Button – Returns to the Control Surfaces display screen.

g. Systems

If the SYS navigation button is pressed from the home screen, the Systems screen is displayed as shown below.



The function of each item on this is given below:

SCREEN SAVER – The button turns off the display screen. Hitting any key restores the screen.

ROLL CAL-STAR – This button takes you to calibration screen for the starboard roll remote sensor.

ROLL CAL-PORT – This button takes you to calibration screen for the port roll remote sensor.

YAW CAL – This button takes you to calibration screen for the yaw remote sensor.

PITCH CAL – This button takes you to calibration screen for the pitch remote sensor.

O2 CAL – This button takes you to calibration screen for the oxygen sensor.

SPEED CAL – This button takes you to calibration screen for the speed paddle wheel ensor.

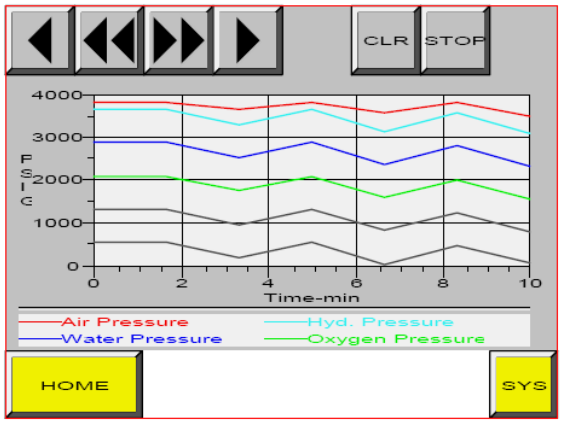
Screen Navigation Buttons – To navigate between screens, six yellow navigation buttons at the bottom of the home screen are shown. The buttons bring up the following screens:

1. HOME – Go to Home Systems
2. PRESS CHARTS – Go to Pressure charts
3. TEMP CHARTS – Go to Temperature charts
4. O2 CHART – Go to Oxygen chart
5. CO2 CHART – Go to CO2 chart
6. ALARM HISTORY – Go to Alarm history

h. Pressure Chart

If the PRES CHART navigation button is pressed from the System screen, Pressure Charting screen is displayed as shown below.

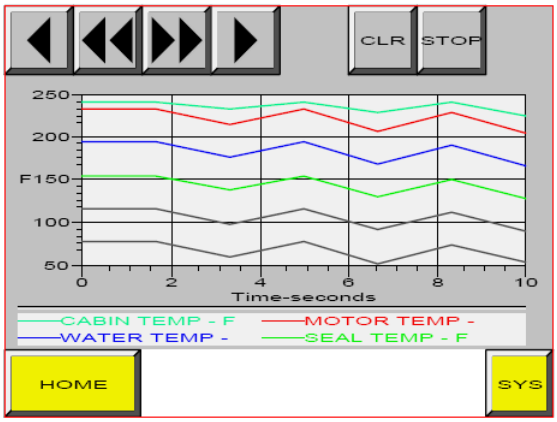
Pressing the HOME navigation button returns the user to the Home screen while pressing SYS returns user to the System screen.



i. Temperature Chart

If the TEMP CHART navigation button is pressed from the System screen, Temperature Charting screen is displayed as shown below.

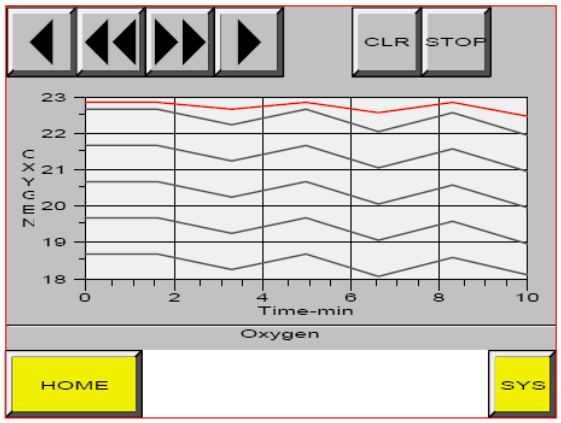
Pressing the HOME navigation button returns the user to the Home screen while pressing SYS returns user to the System screen.



j. Oxygen Chart

If the O2 CHART navigation button is pressed from the System screen, Oxygen Charting screen is displayed as shown below.

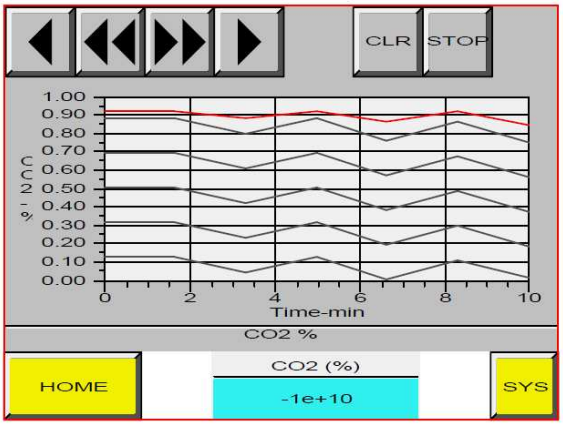
Pressing the HOME navigation button returns the user to the Home screen while pressing SYS returns user to the System screen.



k. CO2 Chart

If the CO2 CHART navigation button is pressed from the System screen, Carbon dioxide Charting screen is displayed as shown below.

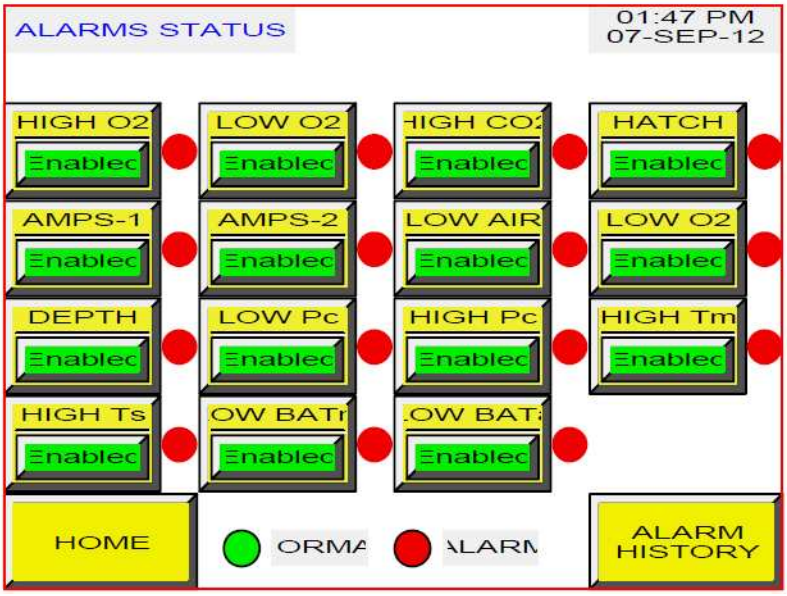
Pressing the HOME navigation button returns the user to the Home screen while pressing SYS returns user to the System screen.



I. Alarms Database

There are a number of alarms that will activate with both an audible sound and message across the bottom of the screen regardless of which screen is displayed. These alarms are:

Alarm	Description
1	High Oxygen Level, > 23%
2	Low Oxygen Level, < 18%
3	High CO2 Level, > 5000ppm
4	Hatch Open on Dive
5	High Main Current, > 300 Amps
6	High Aux Current, >20 Amps
7	Low pressure in Air Tank, <25% in tank
8	Low pressure in O2 Tank, < 25% in tank
9	Depth Exceeds 300 ft
10	Low Cabin pressure , < 12 psia
11	High Cabin pressure , > 20 psia
12	Motor field winding > 248 F
13	Seal Barrier Fluid Outlet Temp >200 F
14	Low Main Battery Voltage
15	Low Aux Battery Voltage



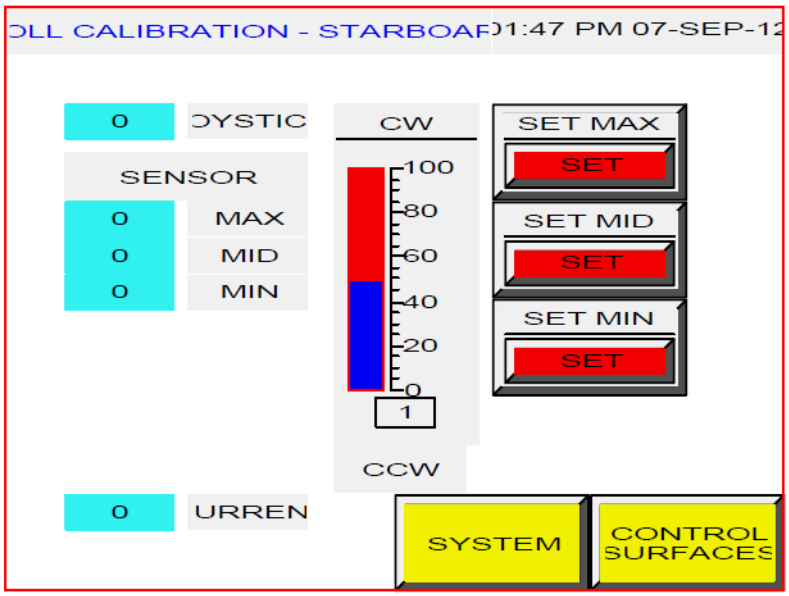
If an audible alarm is on, a red button will indicate which alarm(s) is set. To deactivate an alarm, press the button and the indicator should go green.

Home Navigation Button – Returns to the Home display screen.

ALARM HISTORY Navigation Button – Returns to the Alarm history display screen.

j. Roll Calibration – Starboard Screen

From System screen, if the Roll Calibration – Starboard Screen is pressed, the following screen is displayed. The purpose of the screen is to calibrate this remote sensor:



JOYSTICK – This is a zero to 100% value that corresponds to the position of the joystick while in roll movement. This is used to establish the set point for the proportional, integral and differential (PID) loop controller dedicated to the starboard aileron movement.

SET MAX With this control surface being manually moved to the maximum position, when this button is pressed, the value of the remote sensor is stored under the MAX field to the left.

SET MID With this control surface being manually moved to the centralized position, when this button is pressed, the value of the remote sensor is stored under the MID field to the left.

SET MIN With this control surface being manually moved to the minimum position, when this button is pressed, the value of the remote sensor is stored under the MIN field to the left.

CURRENT This field shows the current reading from the sensor.

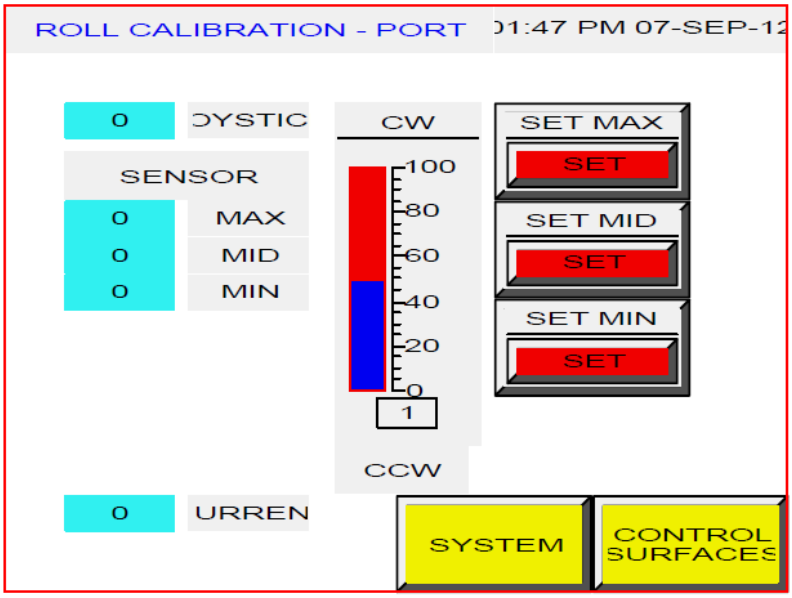
BAR INDICATOR The current position of the starboard aileron normalized to zero to 100% of the span is shown.

Screen Navigation Buttons – The buttons bring up the following screens:

1. SYSTEM – Go to the Systems Screen
2. CONTROL SURFACES – Go to the C. S. Screen

k. Roll Calibration – Port Screen

From System screen, if the Roll Calibration – Port Screen is pressed, the following screen is displayed. The purpose of the screen is to calibrate this remote sensor:



JOYSTICK – This is a zero to 100% value that corresponds to the position of the joystick while in roll movement. This is used to establish the set point for the proportional, integral and differential (PID) loop controller dedicated to the port aileron movement.

SET MAX With this control surface being manually moved to the maximum position, when this button is pressed, the value of the remote sensor is stored under the MAX field to the left.
SET MID With this control surface being manually moved to the centralized position, when this button is pressed, the value of the remote sensor is stored under the MID field to the left.

SET MIN With this control surface being manually moved to the minimum position, when this button is pressed, the value of the remote sensor is stored under the MIN field to the left.

CURRENT This field shows the current reading from the sensor.

BAR INDICATOR The current position of the port aileron normalized to zero to 100% of the span is shown.

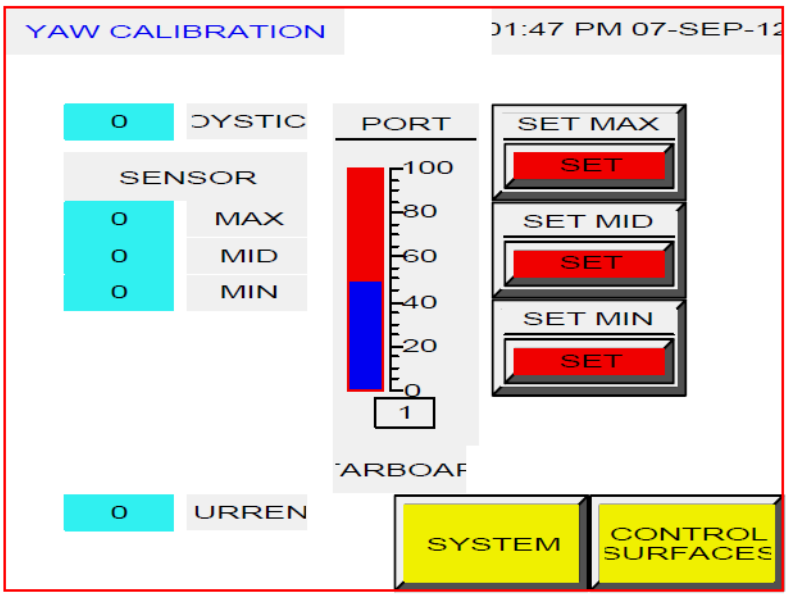
Screen Navigation Buttons – The buttons bring up the following screens:

1. SYSTEM – Go to the Systems Screen
2. CONTROL SURFACES – Go to the C. S. Screen

I. Yaw Calibration Screen

From System screen, if the Yaw Calibration Screen is pressed, the following screen is displayed. The purpose of the screen is to calibrate this remote sensor:

RUDDER– This is a zero to 100% value that corresponds to the position of the rudder pedals. This is used to establish the set point for the proportional, integral and differential (PID) loop controller dedicated to the yaw control surface movement.



SET MAX With this control surface being manually moved to the maximum position, when this button is pressed, the value of the remote sensor is stored under the MAX field to the left.

SET MID With this control surface being manually moved to the centralized position, when this button is pressed, the value of the remote sensor is stored under the MID field to the left.

SET MIN With this control surface being manually moved to the minimum position, when this button is pressed, the value of the remote sensor is stored under the MIN field to the left.

CURRENT This field shows the current reading from the sensor.

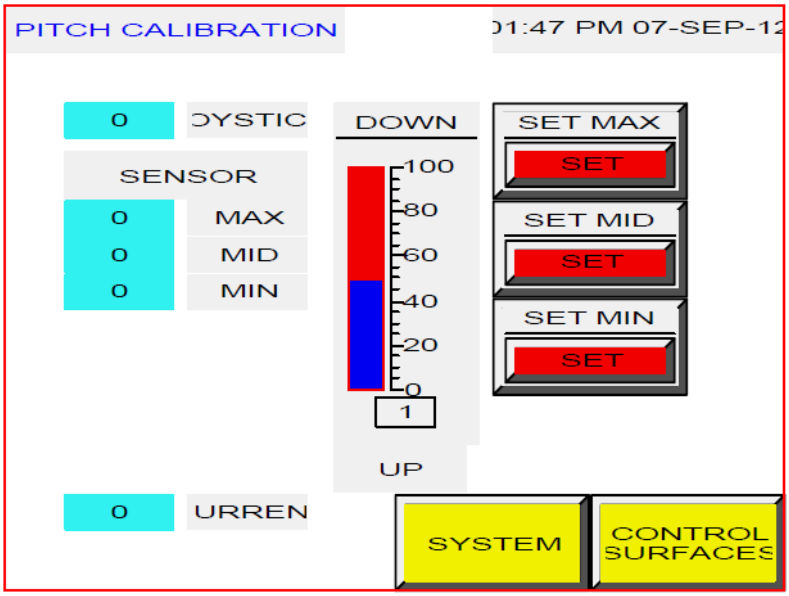
BAR INDICATOR The current position of the yaw control surface normalized to zero to 100% of the span is shown.

Screen Navigation Buttons – The buttons bring up the following screens:

1. SYSTEM – Go to the Systems Screen
2. CONTROL SURFACES – Go to the C. S. Screen

j. Pitch Calibration Screen

From System screen, if the Pitch Calibration Screen is pressed, the following screen is displayed. The purpose of the screen is to calibrate this remote sensor:



JOYSTICK – This is a zero to 100% value that corresponds to the position of the joystick while in pitch movement. This is used to establish the set point for the proportional, integral and differential (PID) loop controller dedicated to the pitch movement.

SET MAX With this control surface being manually moved to the maximum position, when this button is pressed, the value of the remote sensor is stored under the MAX field to the left.

SET MID With this control surface being manually moved to the centralized position, when this button is pressed, the value of the remote sensor is stored under the MID field to the left.

SET MIN With this control surface being manually moved to the minimum position, when this button is pressed, the value of the remote sensor is stored under the MIN field to the left.

CURRENT This field shows the current reading from the sensor.

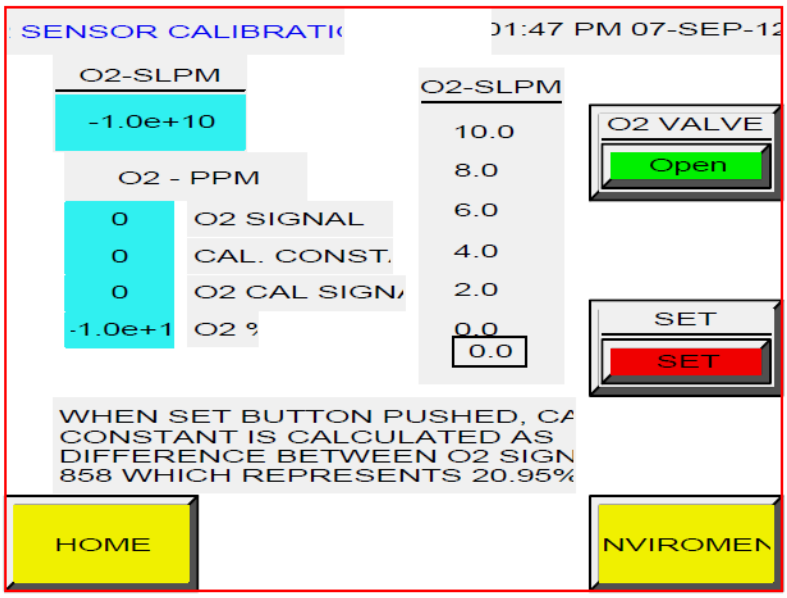
BAR INDICATOR The current position of the pitch control surface normalized to zero to 100% of the span is shown.

Screen Navigation Buttons – The buttons bring up the following screens:

1. SYSTEM – Go to the Systems Screen
2. CONTROL SURFACES – Go to the C. S. Screen

I. O2 Calibration Screen

From System screen, if the O2 Calibration Screen is pressed, the following screen is displayed. The purpose of the screen is to calibrate Oxygen sensor. From this screen the O2 control valve can be opened:



O2-SLPM – This display shows the current oxygen flow rate in SLPM. During automatic life support mode, when the PLC detects that the oxygen level has dropped below 20%, a signal is sent to the O2 controller to set the rate at 4 SLPM. When the O2 concentration exceeds 22%, this rate is set back to zero.

SET – When this button is pushed, a calibration constant is calculated as the difference between the O2 sensor reading and 20.95%, the normal concentration of O2 in the air. This is used to calibrate the sensor back to 20.95%.

O2 VALVE – When this button is pushed, the O2 controller is opened and directed to flow at 4 SPLM. This is used to test the function of the controller.

Screen Navigation Buttons – The buttons bring up the following screens:

1. HOM – Go to the Home Screen
2. ENVIORMENT – Go to the Environmental Systems Screen

V. CHAIN OF COMMAND

The duty assignments which follow constitute the formal delegation of authority to persons assigned those duties. In addition, they provide a description of responsibilities and accountability for the management and operation of the R300.

The Submersible Ops Coordinator and the Pilot are required on all dives. It is up to them to use their experience and expertise to coordinate the successful completion of the mission. Their duties are as follows:

Submersible Operations Coordinator (SOC)

The SOC is responsible for the safe and efficient operation of the submersible and its associated systems. He is responsible for scheduling dives, interfacing mission related gear to the submersible and determining if conditions are favorable for a successful launch and recovery. His authority is absolute.

The SOC must know the capabilities and limitations of the submersible, and balance that against the needs of the Pilot. The SOC will be responsible for maintaining an overview of the entire operation.

Pilot

The operator of the R300 is designated as the pilot. The pilot will work closely with the SOC to develop an acceptable mission plan to include location, depth, tasks, equipment required. In matters of operational safety, the SOC must always defer to the pilot of the vehicle. In practice, the pilot informs the SOC of what he/she desires and unless it is unsafe, illegal, or against accepted procedure it will be carried out.

REFERENCES

1. “ASME PVHO-1b-2000 ADDENDA to ASME PVHO-1-1997 Safety Standard for Pressure Vessels For Human Occupancy” September 22, 2000.

2. Redus, C.L.: “R300 Plans and Design”, Redus Engineering Technical Report, August 20, 2005.

3. “Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities” American Bureau of Shipping & Affiliated Companies, 2002, Second Printing October 1993.

4. “Naval Ships’ Technical Manual Chapter 594 Salvage – Submarine Safety Escape and Rescue Devices”, US Navy S9086–T9–STM–010/CH–594, 31 January 1995

5. HBOI Research Vessels, CLELIA Operating Manual, Aug. 2001.

GLOSSARY

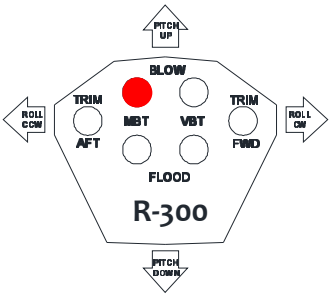
Term	Description
ABS	American Bureau of Shipping
AGM	Absorbent Glass Mat (battery type)
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
BCD	Scuba Buoyancy Compensation Device
CO2	Carbon Dioxide
DCS	Decompression Sickness
FSW	Feet Sea Water
GPM	Gallons Per Minute
GPS	Global Positioning System
GVW	Gross Vehicle Weight
MBT	Main Ballast Tank
O2	Oxygen
PD	Positive Displacement Pump Type
PD	Positive Displacement Pump Type
PID	Proportional, Integral and Differential loop controller
PLC	Programmable Logic Controller
PSIA	Pounds Square Inch Absolute
PSIG	Pounds Square Inch Gage
PVHO	Pressure Vessels for Human Occupancy
PWM	Pulse Width Modulation
ROB	Reserve of Buoyancy
SCF	Standard Cubic Feet (at Standard T & P)
SOC	State of Charge
SOC	Submersible Operations Coordinator
USCG	United States Coast Guard
VBT	Variable Ballast Tank
VDC	Voltage Direct Current

APPENDIX A – EMERGENCY INFORMATION

Step a. Don't panic; there is 3 days life support in the submersible (water, food, etc.). The submersible electronics will automatically power up from emergency batteries if power from the main batteries is lost.

Step b. You can bring the submersible to the surface by using the following procedure:

1. Depress MBT blow button on pilot joystick until sub starts to move upward then secure. Sub will then surface on its own.



2. If all power is lost, open manual MBT blow valve until sub starts to move upward then secure. Sub will then surface on its own.

3. The the drop-weight can be released with the hydraulic hand pump on the pilot's starboard side. Locate handle near the forward starboard interior light. Insert handle and pump several times until the weight is released.

4. Once on the surface, you can use VHF radio to communicate with the support vehicle.

Step c. At this point, the pilot is stranded on bottom, and all means of surfacing have failed. Because the submersible is designed with provisions to stay 3 days in an emergency, the preferred next step in this situation is to wait for rescue in which a diver would attach a lifting cable to the lugs on the submersible and the submersible would be hoisted to the surface.

WHILE WAITING FOR RESCUE

1. Monitor the O2 and CO2 levels from the Environmental Systems Screen and keep in communication with OTS radio on the channel called out in the dive plan.

2. Scrubber blower should be left in the “ON” position (Red).

3. Turn off the CS from the Control Surfaces screen.

4. O2 makeup should be in the “Auto” mode. While in this mode, the O2% will slowly drop to below 20 % and the O2 Makeup light will turn green. O2 will then start bleeding into the cabin. The O2 level should then increase until it reaches 22%. At that time, the O2 control valve will close. The O2 level will continue to rise to about 22.5% and then begin dropping. This cycle will continue as long as there is O2 available.

5. If, for any reason, the O2 level drops below 19%, switch to the “Manual” O2 makeup valve on the AMOC module. Closed is full clockwise as viewed from back of valve. Monitor the O2 level and keep it between 20 and 22% by adjusting the valve.

6. Monitor the CO2 level. The scrubber should keep the CO2 level below 5000 ppm. A fresh package of CO2 absorbent should last approximately 12 hours. When the CO2 absorbent is consumed, the CO2 level will begin to increase. At this time, the absorbent should be replaced.

7. If stranded on the bottom due to entanglement, the pilot can signal the boats location by releasing a small stream of bubbles from the forward MBT using the manual MBT blow valve partially opened.

8. The pilot should tap the pressure hull periodically to signal divers of the boats location.

There are situations which would favor escaping the submersible while at depth.

Criteria Supporting the Decision to Escape:

Escape should be considered if one or more of the following criteria are met[4]:

1. Uncontrolled flooding or fire exists.

2. The carbon dioxide concentration is approaching 1 percent (10k ppm) and is continuing to increase after all means to control carbon dioxide buildup have been used. Waiting until the carbon dioxide levels are intolerable will give survivors only a few extra hours to safely remain on board and will greatly complicate the escape sequence as the survivors' mental capacities deteriorate.

3. The oxygen concentration is approaching 13 percent and is decreasing after using all onboard reserves.

4. The internal atmospheric pressure of the boat is increasing and rescue is not immediately anticipated. Escape should be made before the internal pressure reaches 20 psia to minimize the risk of DCS in survivors when they reach the surface.

5. Persistent toxic atmosphere exists.

6. Surface support is present to retrieve and care for survivor, especially in colder waters.

7. Escape operations are conducted at a depth of 450 feet of seawater (fsw) or less. Successful escapes from greater depths are possible but are riskier.

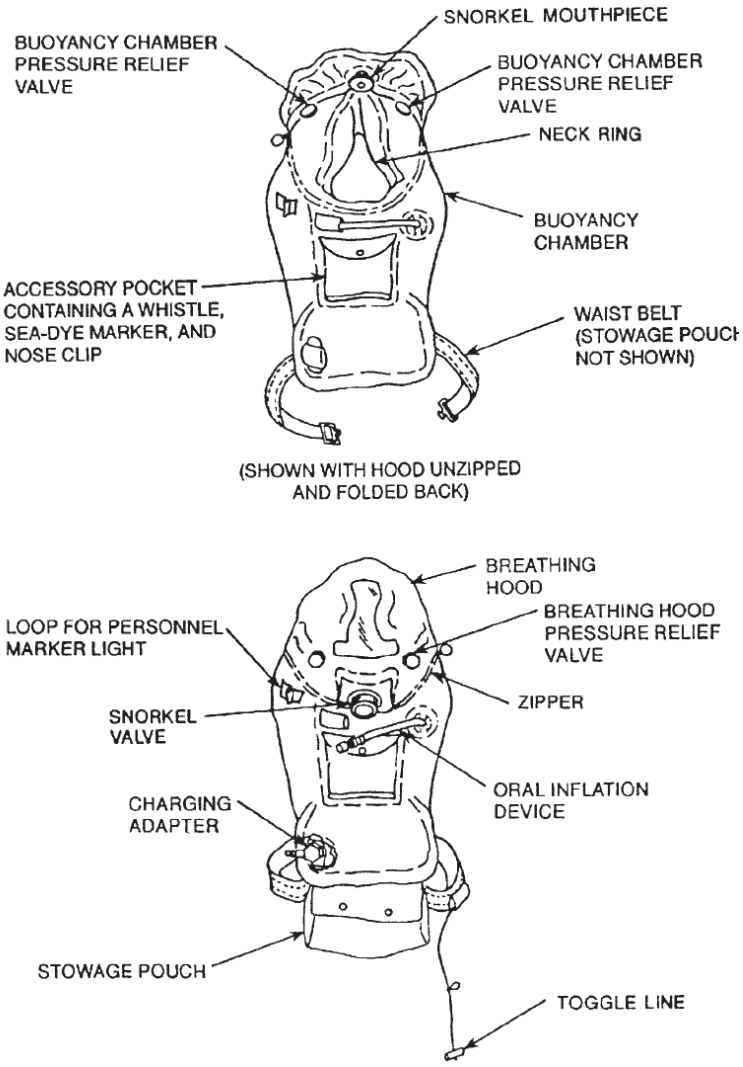
8. The pilot's physical condition will allow survival in the open water until rescue personnel arrive.

If it becomes necessary to exit the submersible at depth (300' max), the pilot should:

1. Release seat buckle and hatch latches.
2. Turn on the dive light attached to life jacket.
3. Locate "Steinke hood", set snorkel valve to "open position" and place hood over head and bite down on mouth piece.
4. Orally inflate the "Steinke hood" ballast chamber.
5. Turn off both the master switch and the circuit breaker.
6. Fully open scuttle valve.
7. When water level reaches level A (approximately chest level), repeat oral inflation of Steinke hood ballast chamber, close snorkel valve on Steinke hood and grip hatch handles.
8. When hatch opens, launch yourself upwards through the hatch. Breathe normally during ascent to prevent lung over inflation.
9. On surfacing, open snorkel valve to breathe surface air then inflate (embedded CO2 cartridge) life jacket to increase buoyancy. If calm sea state, remove Steinke hood.
10. Once on the surface, you can use VHF radio to communicate with the support vehicle

Notes:

1. Step 1 - high differential pressure will prevent hatch opening at this point.
2. Step 3 - open Snorkel valve enables pilot to breath cabin air without building up CO_2 in hood.
3. Step 4 - oral inflation of the "Steinke hood" ballast chamber occurs twice to account for increasing pressure in the cabin compressing air in the appliance.
4. Step 7 - Level A: Pressure in boat has reached 44.3 psia (3 atmospheres) assuming boat was stranded at 300'. This should take 64 seconds if scuttle valve is fully open.
5. Step 8 - hatch opens at 94 seconds assuming a fully opened scuttle valve.
6. Assent rate will be approximately 425 ft/min with fully inflated Steinke hood.



Detail View of Submersible Escape Appliance Features

APPENDIX B – PRE DIVE CHECK LIST

OFF-LOADING CHECK LIST

(1) Main Circuit Breaker ON
(2) Batteries Charged
(3) Fresh CO2 absorbent
(4) Air tanks full and ON
(5) Oxygen tanks full and ON
(6) Scuttle Valve CLOSED
(7) Weight Position 80%
(8) Hatch CLOSED

PRE-DIVE CHECK LIST

(1) Main Circuit Breaker ON
(2) Master (Key) Switch ON
(3) Interior Lights ON
(4) Scrubber Blower ON
(5) Control Surfaces ON
(6) O2 Makeup on AUTO
(7) Alarms all ON
(8) Main Ballast Blow Check
(9) Rudder Range Check
(10) Aileron Range Check
(11) Communications Check
(12) Hatch CLOSED

ON-BOARD EQUIPMENT LIST

(1) Emergency Medical Kit
(2) Emergency CO2 Absorbent
(3) Scrubber Wrench and cross point screwdriver
(4) Dive Light
(5) Fire Extinguisher
(6) Steinke Hood
(7) Life Jacket
(8) Hand warmers (chemical pack only)
(9) Spare Fuse Set
(10) OTS Radio
(11) 2 quarts of potable water, plus rations for 3 days
(12) Towel
(13) R300 Operating Manual
(14) Small Note Pad and Pencil
(15) Human Element Range Extender (HERE)

IMPORTANT ITEMS TO BE FAMILIAR WITH BEFORE DIVE:

(1) Main ballast tank (MBT) flood and blow controls.
(2) Emergency MBT manual blow valve location.
(3) Emergency hand-pump for drop weight - location.
(4) Emergency CO2 scrubber container - location
(5) Emergency Oxygen make-up valve location
(6) Emergency Steinke Hood - Location
(7) Location of OTS &VHF radios and channel settings.

BACKUP PARTS AND EQUIPMENT	
Emergency Phone Numbers	Tools box
Spare R300 Operating Manual	Log Book
Towels	R300 documentation
Flash Lights (2)	Hydraulic Oil
Flash Light Batteries	Hydraulic Oil Funnel
Key (Backups)	Acrylic Window Cleaner
Spare hatch O Ring	Multimeter
Tie Wraps (Assorted)	50 Amp Extension Cord
Spare SodaSorb	Extra Ballast Weight
Spare Fuses set: 1A(4), 2A(3), 5A(3), 8A(2), 10A(1), 15A(5), 20A(4), 30A(1)	Note Pad (water proof)

SCUBA EQUIPMENT CHECK LIST	GENERAL CHECKLIST
Tanks	
Extra Tank O Rings	Sun Screen
Regulators	Sun Glasses
Masks	Hat
Mask Straps	Swim Suite
Mask Clear	Clothes
Snorkel	Deck Shoes
Scuba BCD	Lawn Chairs
Weight Belt	Road Maps
Fins	Drink Cooler
Swim Suit	
Wet Suit	
Scuba Marker Float	
Chem. Lights	

APPENDIX C - SUBMERSIBLE DIVE PLANNING FORM

DATE	DIVE #	PERSONNEL	LOCATION		DEPTH (FSW)
		FORWARD WT# WT# WT#	SITE NAME	LAT. LONG.	

TASKS (PRIORITY)	OBJECTIVES	LOCATION (PRE DIVE WAY POINT) LAT.	LOCATION (PRE DIVE WAY POINT) LONG.	GEAR REQUIRED TYPE