

Development Proposal for a 65-meter Private Luxury Submarine



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This document represents a proposal to further develop the design for a 213 foot, diesel electric luxury submarine. As proposed, the submarine would constitute the single largest private undersea vehicle ever built, and arguably, one of the most unique and interesting personal transportation devices of the century.

The submarine description is, in all ways, preliminary. Specifications, performance data and equipment are subject to change based on the owner's requirements. What follows is meant as a starting point for more serious discussions.

A Luxurious Undersea Vehicle

U.S. Submarines' management developed the concept of the luxury submarine with the *Nomad 1000* design back in 1993. However, the concept of luxury is often times synonymous with space, and by its nature, the interior space of the *Nomad* is limited, and provides less than optimal privacy.

This design, which we have named the *Phoenix* class, has ample space. The total interior area of the submarine is in excess of 5000 square feet. The significant volume, coupled with very large acrylic viewports, and the potential for relatively large, open spaces, results in a vehicle as luxurious as the finest of motor yachts.

Clearly, the *Phoenix* provides its owner with substantial capability - the opportunity to explore the depths of the world's oceans in perfect comfort and safety. The *Phoenix* is capable of making transatlantic crossings at 16 knots, yet can dive along the route and explore the continental margins of some of the most fascinating waters on earth. And unlike surface yachts, when the water gets rough, the submarine can submerge into a perfectly smooth and quiet environment, continuing on toward its destination with a ride unsurpassed in quality; unequalled by the finest motor coach or the most luxurious executive aircraft.

The Size Advantage

At 213 feet in overall length, the *Phoenix* is a vehicle of formidable size. Yet despite its 1500 ton displacement, the submarine is quite streamlined. Given the significant waterplane area and ample internal volume which allows for greater battery storage, the *Phoenix* will outperform smaller counterparts in surface speed, submerged speed and submerged endurance. Add the optional closed-cycle Stirling power system and the extended submerged range is truly remarkable. The large pressure hull diameter provides the opportunity to fit very large acrylic viewports, making the undersea viewing capability truly extraordinary. The interior space, with the noted absence of structural bulkheads provides for tremendous versatility regarding interior layout and space planning. And finally, the *Phoenix's* large size, coupled with its integrated roll stabilization system, makes surface transit quite comfortable in all but the worst conditions.

Preliminary Technical Specifications

General Specifications

Certification:	ABS +A1
Depth	1000 feet (305 m)
Length:	213 feet (65.0 m)
Beam:	26.3 feet (8.0 m)
Displacement:	1500 tons
Hull Diameter	
Bow:	13.1 feet (4.0 m)
Center:	22.0 feet (6.7 m)
Stern:	17.0 feet (5.2 m)
Aft Hemi:	13.1 feet (4.0 m)
Acrylic Deck Saloon Diameter:	7.0 feet (2.1 m)

Dynamic Characteristics

Max. Surface Speed:	17 knots
Cruising Speed:	15 knots
Max. Submerged Speed:	10 knots

Surface Propulsion

Surface Diesels:	2 x 1500 HP
Diesel Type:	MTU 12 V 396T or equiv.
Number of Shafts:	2

Sub-Surface Propulsion

Main Electric Motors:	2 x 500 HP, 360 V DC
Vertical Thrusters:	2 x 150 HP, hydraulic
Horizontal Thrusters:	2 x 150 HP, hydraulic

Endurance

Surface Range:	3500 + nautical miles
Submerged Endurance	
at 10 knots:	6 hours
at 5 knots:	50 hours
at 2.5 knots:	140 hours
at rest:	20 days minimum

Battery & Electrical System

Main Battery:	360 V DC - 8800 AH
Control Battery:	24 V DC - 2400 AH
Communication Battery:	24 V DC - 800 AH
Emergency Battery:	24 V DC - 1600 AH
Total Battery Capacity:	3280 KWH
Electric Generators:	2 x 370 KW

Gas Supply

Main Oxygen:	30 days, full load
Reserve Oxygen:	10 days
Main Air:	4000 psi in external tanks
Air Compressor:	4500 psi, 200 HP
Low Pressure Blower:	30 psi, 50 HP

Ballast & Trim Systems

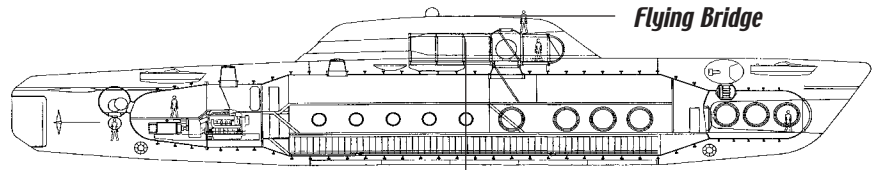
Main Ballast Capacity:	750,000 lbs buoyancy
Variable Ballast:	40,000 lbs
Trim Weight:	20,000 lbs, 78 foot travel
Drop Weight:	300,000 lbs, 5 sections

Looking at the *Phoenix* in more detail, we'll first describe the physical spaces, later moving on to the briefly discuss various systems required for operation.

Initially it is important to understand that the submarine consists of a few main components. The most important is the steel pressure hull that resists the hydrostatic pressure of the water and contains the interior decks and spaces. Connected to the pressure hull is the exostructure to which is attached external equipment like high pressure air and oxygen bottles, maneuvering thrusters, sonar transducers, etc. Also connected to the exostructure are the fairings that cover the equipment and the pressure hull and streamline the design

Flying Bridge

The uppermost level of the vessel is the flying bridge. This area is similar to its equivalent area on most yachts, with the exception of the fact that the materials selected are subject to immersion in water. Ample space exists for lounging, and cushions may be brought up from the area below. The flying bridge also houses the pressure compensated radar radome, GPS antennae, and satellite communications radome as well as radio aerials, running lights, etc. A remote steering station is also available.



Flying Bridge

Deck saloon is composed of transparent acrylic cylinders



Deck saloon

Deck Saloon

Immediately below the flying bridge and accessible through a large hydraulically operated hatch and a stairway, is the deck saloon. As proposed, this area would be composed of structural acrylic cylindrical sections seven feet in diameter and eight inches in thickness. The overall length of the pressure hull would be 40 feet.

The deck saloon would have a comfortably appointed interior, and would boast an incredible view for observation both on the surface and when submerged. By fitting transparent sections into the deck of the flying bridge, a view above would be possible as well.



The steel pressure hull of the Phoenix contains the three decks and various internal spaces and is penetrated by viewport forgings and entrance hatches as well as penetrator plates through which electrical, hydraulic and pneumatic connections pass externally.

In the forward portion of the saloon is the surface bridge. This area contains all the necessary control, monitoring, and navigation equipment to operate the submarine in the surfaced condition. The captain has a hemispherical sector acrylic viewport immediately in front, with the transparent cylindrical walls to either side.

The aft portion of the saloon has a large acrylic window providing a view astern that also acts as a large hydraulically operated hatch. A small automobile could be kept in the aft section if necessary.

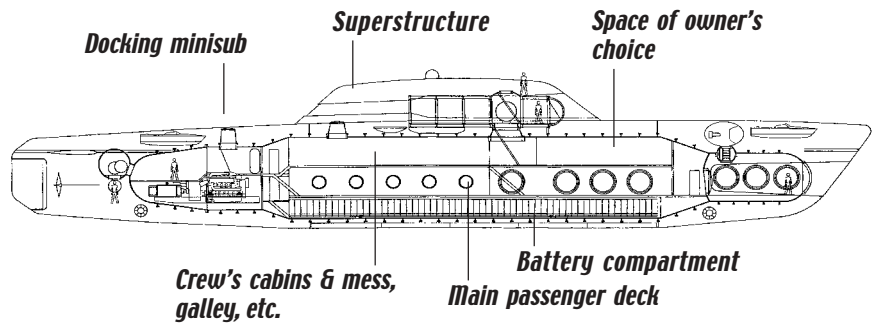
Superstructure

The superstructure itself is composed principally of aluminum (or GRP if the owner prefers) and it houses the deck saloon pressure vessel and provides the structural base for the flying bridge. There is a large degree of latitude possible with regard to the styling of the structure, with the caveat that its hydrodynamic efficiency will have a significant effect on the submerged speed of the submarine.

Aft of the deck saloon is a covered space that can be either fully or partially enclosed. The greater the degree of closure to the after portion of the structure, the less turbulence and the more efficiency. Hydraulically actuated after doors could be designed to open on command allowing fresh air to circulate. The area would be excellent for covered, informal, deck level dining.

Docking Minisub

Aft of the superstructure, or optionally, above the control cabin on the bow, is an area for a docking minisub.



Utilizing a special docking collar this vehicle is capable of leaving the *Phoenix* while submerged, and making excursions down to 2000 feet. With both top and bottom hatches, the minisub could also bring passengers from the surface, to the submarine lying at depth. The minisub could be designed to hold between two and eight passengers, depending upon the owner's preferences. Additionally, in the unlikely event of an emergency at depth, the minisub could be used to take passengers and crew to the surface.

Main Passenger Areas

The main passenger area consists of two decks, each 102' long and 20' wide. The upper deck is accessed from one of two hatches, either from the deck saloon, or from a hatch to the after portion of the superstructure. Two stairways, one in the center of the deck, the other in the after section, lead to the lower deck.

The upper deck is intended to provide space for an engineering workstation, a switch and contactor room, crew cabins and mess as well as the galley.

The forward portion, which ends at a bulkhead, is designed as a room of the owner's choosing.

The main deck is situated such that the forward portion, with eight 6' diameter acrylic windows, contains the living and dining areas while the section aft of the beam houses the owner's stateroom and guest cabins. Viewports, 35" in diameter, are situated on both port and starboard sides and can be placed wherever necessary.

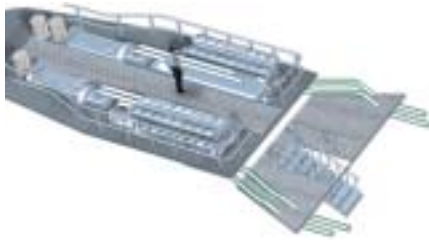
Below the passenger area is the battery compartment and bilge. A narrow manway allows access through the compartment for battery maintenance.



Engine Room

The engine room is accessed through doors at the after portion of both passenger decks. The space contains the





majority of the equipment necessary for the submarine's operation, including the main diesels, motor generators, drive systems, air compressors, hydraulic aggregates and life support systems. The upper level of the engine space provides access to the minisub and in the stern section, to a diver lock-out chamber. The bottom level allows maintenance of the main engines and related components.

Diver Lock out Chamber

A spherical diver lock out chamber, 8' in diameter is fitted above the shafts and attached to the aftermost section of the pressure hull. The chamber allows a diver to enter or exit the submarine from the area between the shafts at depths of up to 150 feet. The chamber can be fitted with decompression capability if required.

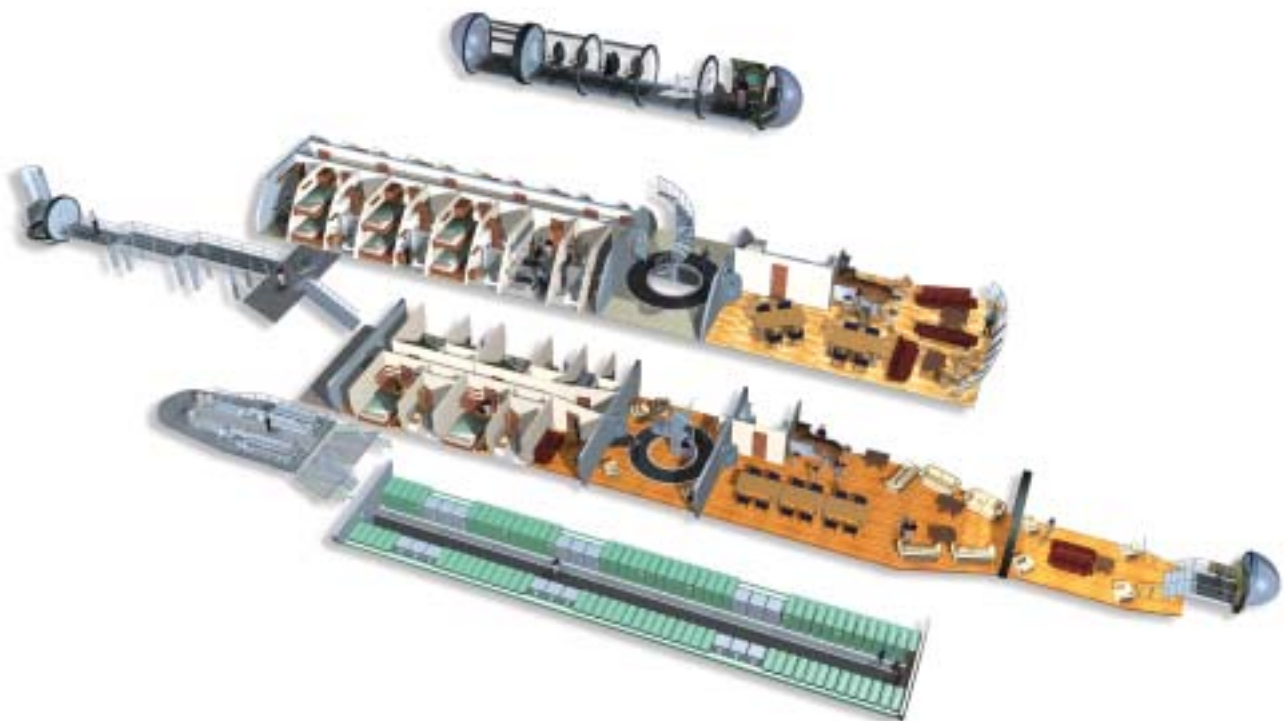


The pressure hull viewed from aft. The spherical diver lock-out chamber also has a dry transfer lock for entering the submarine at the top.

Forward Control Room

The forward control room is entered from the main deck through a water tight, pressure proof, door. The control room has an eight foot diameter hemispherical sector acrylic viewport forward, and three 6' diameter viewports on either side with the foremost pair angled slightly forward.

The control room contains all of the control and navigation equipment necessary to operate the submarine while submerged. The 26' x 13' area contains sufficient space to fit comfortable lounge chairs for passenger observation while underway.



The Phoenix hull configuration has been developed to provide ample interior space for its owners while maximizing the submarine's performance characteristics. A brief overview of the major operating systems follows:

Pressure Hull & Exostructure

The pressure hull will be composed of HY 80 fine grained high tensile steel approximately 50 mm in thickness (2.0 inches). HY 80 or its equivalent is commonly used in the construction of military submarines. External frames will be used to provide for maximum protection of the viewports and the frame spacing will be 4.6 feet.

Aluminium will be used for the deck, superstructure and flying bridge.

Ballast & Trim System

The main buoyancy tanks will provide 750,000 pounds of positive buoyancy and are comprised of eight conventional saddle tanks, four per side, as well as one bow and one stern tank. The bow and stern tanks are of an inverted design and are pumped dry by high volume pumps as opposed to

being air blown. The inverted tanks allow for the storage of two 16' run-arounds and the docking minisub. When the bow tank is drained on the surface the forward viewports can be accessed for cleaning.

Air for the ballast tanks is stored in high pressure air cylinders. A 200 HP, 4500 psi air compressor provides air for recharging the high pressure air system. A 50 HP, 30 psi, low pressure blower is used for topping off the conventional ballast tanks once the submarine reaches the surface.

The submarine's variable ballast system is composed of internal, one atmosphere tanks with high pressure ballast pumps. The variable ballast capacity is 20 tons.

A trim weight is located in the battery access tunnel and consists of a 10 ton weight that is track mounted for 75 feet of travel, producing pitch excursions of $\pm 9^\circ$.

A 150 ton emergency drop weight consisting of five 30 ton lead sections is mounted between the skids.

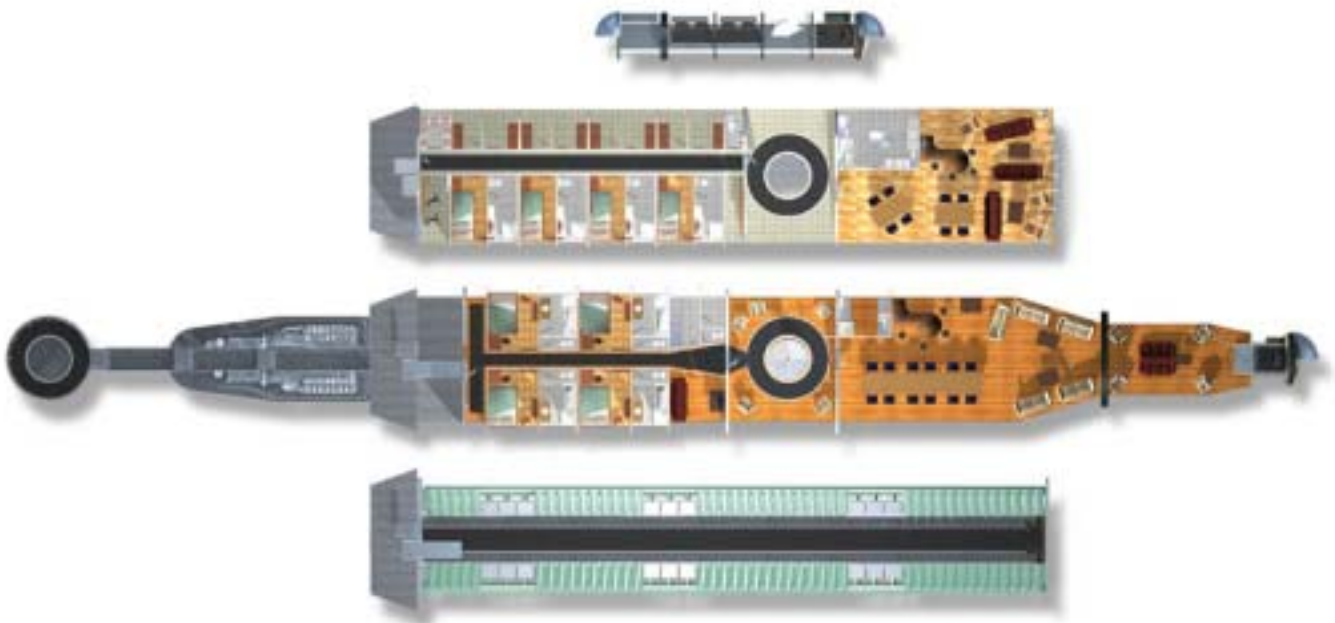
Hydraulic System

Three separate hydraulic systems are used aboard the submarine. The main system is composed of two 150 HP constant speed, variable displacement pumps on a closed system charged to 30 bar. This aggregate powers four, 150 HP hydraulic maneuvering thrusters, two vertically oriented, and two laterals, one each mounted in the bow and stern.

Two smaller 20 HP hydraulic units are pressure compensated for use with external equipment, and a third system consists of two 20 HP pumps at one atmosphere to drive internal machinery.

Life Support System

The life support system is comprised of high pressure oxygen tanks stored outside the pressure hull, two high volume CO₂ scrubbing systems, two air conditioning/heating units and twin automated oxygen injection systems linked to atmospheric monitors. A Haskell pump is provided to transfer oxygen from shore based bottles when necessary.



Plan view of the four decks. Numerous different interior configurations can be implemented.

The life support system is sufficient for a minimum of 30 days of submerged time for a full complement of passengers and crew. A separate reserve oxygen system will provide an additional 10 days of life support.

Electrical System

The submarine's electrical system is divided into separate battery banks weighing a total of 189 tons. The main battery consists of two banks of 180 cells per bank for 8800 AH at 360 V DC. The two 500 HP electric motors are powered by this battery bank. Smaller motors are operated by 120 V DC. A separate motor generator converts 360 V DC to 120 V AC current for the hotel load.

The two 500 HP (370 KW) motor-generators are designed to charge both the main battery banks while the submarine is underway on the surface. During extended stays in port without shore power or at anchor, the batteries can be charged by a single generator run by one of the diesel engines. The massive battery capacity insures

that recharging need only occur at significant intervals.

Three additional 24 V DC battery banks are also present. One of these is an isolated bank set aside specifically to operate communications equipment. The second larger bank is designed to run all the control and monitoring equipment and instrumentation, while the third isolated bank is reserved for emergency use.

Propulsion & Maneuvering

Surface power is provided by twin diesel engines (MTU 12V 396T or equivalent) generating 1500 HP each and driving twin propeller shafts through F/N/R transmissions with a 4:1 reduction ratio. Also clutched to the transmissions are two 500 HP, 360 V DC double armature motor generators. These units, powered by the battery banks, provide submerged propulsion. Alternately, the motors are used as generators to charge the battery banks when the diesels are operating.

It is estimated that the propulsion system will provide surface speeds of 16 knots, and maximum submerged speeds of 8-10 knots.

Maneuvering is accomplished with four 150 HP hydraulic thrusters. Two thrusters are vertically mounted abeam and propel the submarine up and down in the water column when there is little to no forward speed. A third thruster is mounted transversely on the bow, a fourth on the stern. The lateral thrusters allow for both side and rotation of the submarine while surfaced or submerged.

Control, Navigation & Communication

An integrated control and monitoring system is operated from touch screen, animated graphic workstations. The system, composed of two industrial processors for full redundancy allows for convenient control and monitoring of all the major systems of the submarine. Alarm setpoints are included as well as automated maintenance flagging. Manual backups for all major systems are also available.



Surface navigation is accomplished with conventional electronic equipment including differential GPS, radar, chart plotters, depth sounders, etc. Submerged navigation is aided by high resolution active sonar. Passive sonar is included for surface obstacle avoidance when surfacing. A navigation buoy with DGPS can be towed on the surface behind the submarine when operating submerged. Inertial navigation systems will also be investigated.

Communication is accomplished with an Inmarsat M satellite system, SSB and VHF radios and a dual frequency underwater telephone with pinger. A buoy can be deployed from the submarine at depth to allow for full spectrum communication.

Optional Equipment

The *Phoenix 1000* is fully equipped and the only option is a closed cycle Stirling power system. The Stirling system provides submerged power from a diesel burning external combustion engine that recirculates and scrubs exhaust gases while injecting liquid oxygen into the front-end of the combustion process. The result is power system that can operate autonomously and will allow the submarine to operate submerged for days or even weeks at a time.

Safety

The submarine is designed to be classified *+A1 Manned Submersible* by the American Bureau of Shipping. The ABS has classified the majority of the world's operating manned submersibles and tourist submarines, and there has never been a serious injury or fatality in any ABS classified vessel. In one year alone nearly 2 million passengers are carried on the world's tourist submarine fleet.



Control and monitoring system screen.



Closed cycle Stirling system.

The Phoenix will have full redundancy in critical systems. Life rafts, life jackets, reserve oxygen and scrubbing compound, emergency rations, water and space blankets are included on board. Lung powered portable re-breathers are available for use in an oxygen deficient or contaminated atmosphere.

Passive and active fire systems are installed, including exane cables and an automated Halon based fire suppression system. Electrical fires will self extinguish when an emergency trip switch is activated, isolating power to all electrical systems in the vehicle.

Emergency surfacing can be accomplished by four methods including blowing the main ballast tanks, evacuating the variable tanks, releasing the 150 ton drop weight and powering to the surface with thrusters. Over 1,000,000 pounds of positive buoyancy is available.

The docking minisub can be used to evacuate the submarine, and the NATO style skirt will allow undersea docking by the DSRV or other military submarine rescue vehicle. A watertight, pressure proof bulkhead is installed between the forward control room and the main passenger areas, and the deck saloon is also an isolated space.



Clearly, the Phoenix will be the safest civil submarine ever constructed.

Design & Construction

A number of potential approaches can be considered in the design, engineering and construction of the Phoenix. First stage design and engineering cost is estimated at \$230,000 with the second stage costs being approximately \$450,000. Total project cost is estimated at \$80 million with a design and construction period of at least 3 years.

