

A detailed technical line drawing of a submarine, showing its hull, conning tower, and various sensors and antennas. The drawing is overlaid with a grid and various callouts, giving it a schematic or blueprint appearance.

MODERN NAVAL WARFARE

SSN-774 Virginia Class



OPERATIONS MANUAL

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MODERN NAVAL WARFARE
SSN-774 Virginia Class
Operations Manual

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VIRGINIA CLASS - OPERATIONS MANUAL

TRAINING AND OPERATIONS FOR VIRGINIA CLASS SSN

Wave Ops

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THE VIRGINIA CLASS SSN

The Virginia Class fast attack submarine (SSN-774) is a nuclear-powered multi-mission attack submarine class operating with the United States Navy. Designed during the post-Cold War transition as a lower-cost, highly flexible successor to the Seawolf Class and a replacement for the aging Los Angeles Class, the Virginia Class was engineered to perform across deep-ocean (“blue water”) environments and shallow coastal regions (“littoral waters”). The design prioritizes acoustic stealth, sensor integration, flexible weapon payloads, and modular manufacturing techniques to streamline maintenance and capability upgrades throughout the ship’s 33-year service life.



Figure 1: Virginia Class Block IV surface transit

PROGRAM BACKGROUND AND MANUFACTURING STRATEGY

Following the collapse of the Soviet Union, the US Navy pivoted from deep-water blue-ocean anti-submarine warfare toward littoral access and multi-mission flexibility. The Seawolf Class, designed for high-speed deep-water dominance, proved too costly to procure in quantity, leading to program termination after three hulls. The New Attack Submarine (NSSL) program—subsequently named the Virginia Class—was established to balance acoustic superiority with operational affordability.

To maintain two domestic submarine industrial bases, construction was divided between General Dynamics Electric Boat (GDEB) in Groton, Connecticut, and Huntington Ingalls Industries – Newport News Shipbuilding (HII-NNS) in Newport News, Virginia. Rather than operating competing assembly lines, the two yards act as co-builders. Each yard constructs specific modules of every submarine, with final assembly, integration, testing, and delivery alternating between the two shipyards for each hull.

HULL ARCHITECTURE, PROPULSION AND SUBSYSTEMS

The pressure hull of the Virginia Class is fabricated from HY-80 high-yield steel, providing the structural integrity required for deep-submergence operations. Internal machinery and living spaces are built on isolated deck structures suspended within the pressure hull using rubberized acoustic mounts to reduce internal mechanical vibration transferred into the surrounding water column.

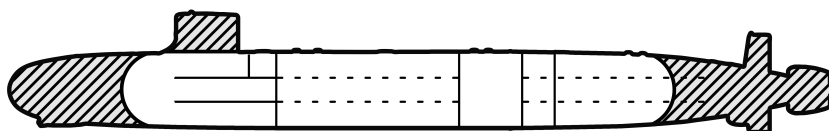


Figure 2: Virginia Class pressure hull and decks

PROPULSION PLANT

Propulsion is provided by a General Electric S9G nuclear reactor (Submarine, 9th Generation, General Electric design). The S9G is a pressurized water reactor generating approximately 210 megawatts of thermal energy, driving two steam turbines linked to a main propulsion shaft rated at 40,000 shaft horsepower (SHP).

- **Life-of-the-Ship Core:** The S9G core uses energy-dense nuclear fuel engineered to last 33 years without refueling. This eliminates the lengthy and expensive Engine Refueling Overhaul (ERO) required on previous generation submarines.
- **Natural Circulation:** At lower tactical speeds, the S9G reactor coolant circulates naturally without primary coolant pumps, eliminating a primary source of mechanical noise.
- **Pump-Jet Propulsor:** Instead of an exposed multi-blade propeller, the Virginia Class uses a shrouded pump-jet propulsor consisting of a stationary stator array and a rotating rotor enclosed within a duct. This configuration drastically delays the onset of cavitation at higher speeds, lowering the submarine's acoustic signature across all speed regimes.



Figure 3: Virginia Class pump-jet propulsor

SENSORS AND COMBAT SYSTEM

The Virginia Class integrates (around the AN/BYG-1 Tactical Control System) advanced digital sensors linked via commercial off-the-shelf (COTS) open-architecture processing units, allowing software upgrades to be fielded without major hardware overhauls.

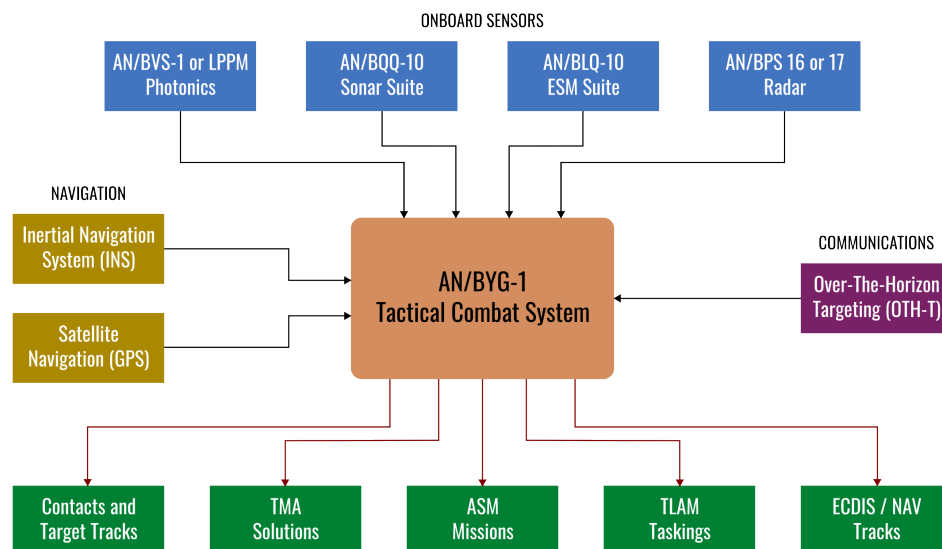


Figure 4: Virginia Class Combat System Block Diagram

PHOTONICS MASTS

The vessel replaces conventional optical periscopes with two Kollmorgen AN/BVS-1 photonic masts. These non-hull-penetrating telescoping stalks house multi-spectral optical sensors, transmitting high-definition digital signals over fiber-optic cables directly to displays in the Command Center. On later hulls one of the two AN/BVS-1 is replaced by the most discreet LPPM (Low Profile Photonics Mast).

Because the masts do not penetrate the pressure hull via long physical tubes, the Command Center was moved down one deck (to Deck 2), where it occupies a larger operational space detached from the sail footprint.

No longer a simple observation device each photonics mast features the following sensors:

1. High-definition color camera
2. Black-and-white short-wave infrared camera
3. Mid-wave infrared (MWIR) thermal camera
4. Laser rangefinder (LRF)
5. Early warning radar intercept receiver
6. GPS receiver

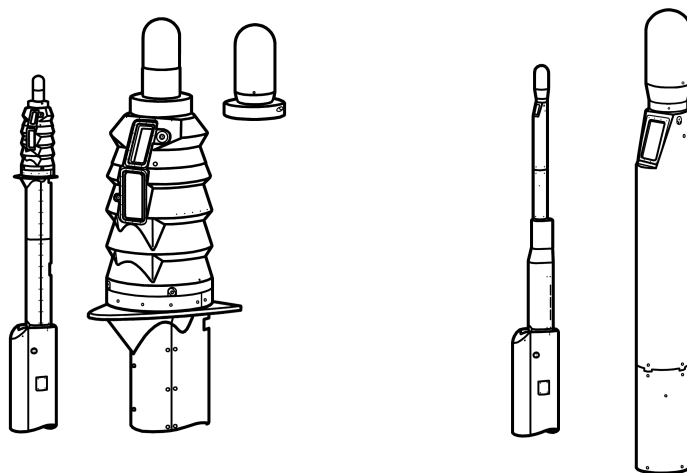


Figure 5: The two types of photonics masts. AN/BVS-1 left and LPPM right

AN/BQQ-10 SONAR SUITE

Acoustic data is captured and processed by the AN/BQQ-10 (ARCI) integrated sonar system, which combines several distinct arrays:

1. **Bow Array:**
 - *Blocks I-II:* Air-backed spherical sonar array.
 - *Block III onward:* Large Aperture Bow (LAB) array featuring a passive acoustic array with hydrophones backed by a passive structural reflector, significantly reducing maintenance requirements while expanding low-frequency detection ranges.
2. **Flank Arrays:** Light Weight Wide Aperture Array (LWWAA) mounted along the port and starboard sides of the hull, utilizing fiber-optic acoustic sensors for passive line-of-bearing target localization. Due to the ability to passively return the range to a track (under certain conditions) the system is also known as RAPLOC.
3. **Towed Arrays:** Deployed from stern tubes, utilizing both thin-line arrays (TB-23 on Block I and TB-29A on later blocks) and fat-line array (TB-16 on Blocks I and II and TB-34 on later Blocks) for long-range passive detection and tactical target motion analysis (TMA).
4. **High-Frequency Sonar:** Chin-mounted and sail-mounted high-frequency arrays utilized for active mine detection, obstacle avoidance and under-ice navigation.

5. **Acoustic Intercept Receiver:** The, AN/WLY-1 with antennas located at different locations around the hull (the most prominent one at the top of the sail), intercepts, detects, classifies and tracks a wide range of under water acoustic emissions.

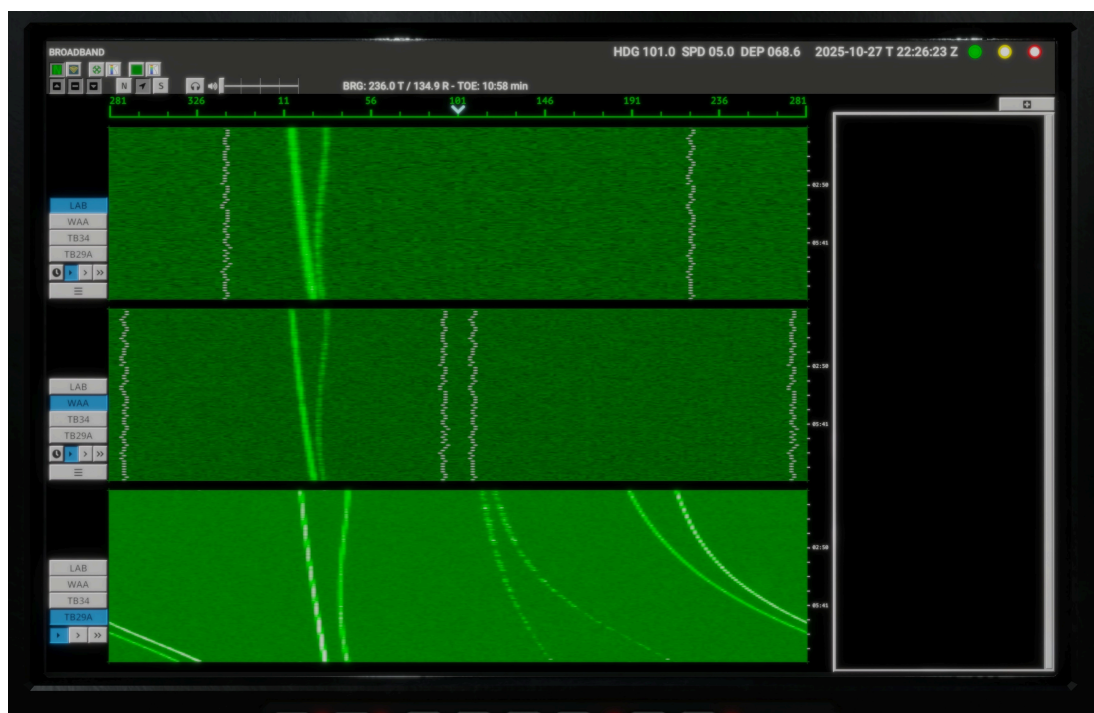


Figure 6: Broadband display on a Block III SSN showing signals from LAB (top), WAA (middle) and Towed Array (bottom)

AN/BLQ-10 ELECTRONIC WARFARE SUITE

Electronic Support Measures (ESM) are provided by the AN/BLQ-10 system, an integrated radar warning and signal intelligence suite designed for radio frequency (RF) surveillance in dense threat environments. Utilizing the dedicated non-hull-penetrating AN/BSD-2 masts deployed from the sail, the AN/BLQ-10 automatically intercepts, detects, classifies, and geolocates radar, communications, and navigation signals across a broad frequency spectrum.

The system functions surfaced or at periscope depth to provide early warning of adversary surface, airborne or coastal radar emissions, enabling the submarine to maintain situational awareness and execute threat avoidance without compromising its own acoustic stealth.

AN/BPS-16 AND AN/BPS-17 RADAR SYSTEMS

Surface search and precision navigation are performed by the AN/BPS-16 (upgraded to the AN/BPS-17 digital baseline on later hulls) X-band navigation radar system. Housed on a retractable non-hull-penetrating mast within the sail, the radar is primarily deployed during surface operations, harbor transits and restricted water navigation to prevent collisions and map surface contact tracks.

To mitigate the risk of hostile counter-detection while operating near enemy shores, the system incorporates low probability of intercept (LPI) wave-shaping modes that spread radar energy across variable frequencies. Radar track data feeds directly into the submarine's electronic Contact Management System (CMS) and tactical combat network to maintain target geometry alongside sonar and ESM tracks.

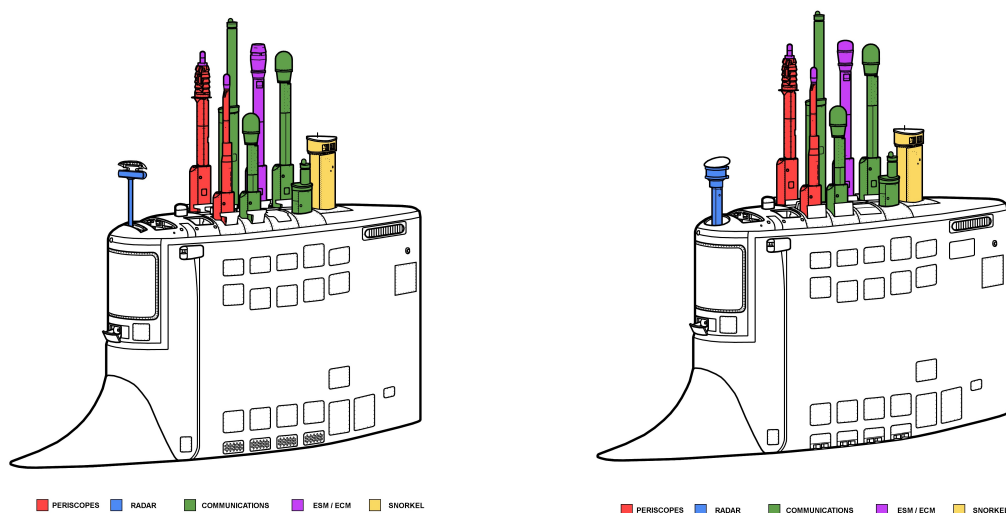


Figure 7: Virginia Class masts arrangement (Blocks I-III left, Blocks IV+ right)

TACTICAL COMBAT SYSTEM

Combat control is managed by the AN/BYG-1 Tactical Control System (TCS). AN/BYG-1 synthesizes tactical data from the sonar suite, electronic support measures (ESM), photonics, radar and external communications to calculate target motion analysis (TMA), manage target tracking and generate firing solutions for heavy torpedoes, anti-ship and strike missiles.



Figure 8: The control room of a Virginia Class Block III SSN

NOTE: All Virginia Class SSNs receive regular upgrades and most of the hardware and software are in-line across the fleet. However for gameplay purposes in Modern Naval Warfare the blocks are modelled with their initial fit.

WEAPONS SYSTEMS AND PAYLOAD CAPACITY

Primary offensive armament is split between the forward torpedo room and vertical launch structures integrated into the bow and mid-body (later blocks).

Block	Torpedo tubes	Torpedo room weapons	VLS tubes x weapons	VPT tubes x weapons	VPM tubes x weapons	Total vertical launch weapons
Blocks I-II	4 x 21"	26	12 x 1	-	-	12
Blocks III-IV	4 x 21"	26	-	2 x 6	-	12
Block V	4 x 21"	26	-	2 x 6	4 x 7	40

TORPEDO ROOM

Four 21-inch (533 mm) hydraulic torpedo tubes are located amidships, angled outward to accommodate the bow sonar arrays. The weapons room stores up to 26 weapons, which can include:

- **Mk 48 Mod 7 CBASS Torpedoes:** Heavyweight wire-guided acoustic homing torpedoes designed for high-speed anti-submarine and anti-surface engagement.
- **UGM-84 Harpoon:** Submarine-launched anti-ship cruise missiles.
- **Naval Mines:** Mk 67 Mobile Mines.



Figure 9: Weapons carried by Virginia Class SSNs (MK-48 HWT, UGM-84 Harpoon ASM, UGM-109 Tomahawk LAM)

VERTICAL STRIKE SYSTEMS

- **Blocks I-II:** 12 individual Vertical Launch System (VLS) tubes integrated into the bow forward of the pressure hull, exclusively dedicated to UGM-109 Tomahawk Land Attack Missiles (TLAM).
- **Blocks III-IV:** Two large-diameter Virginia Payload Tubes (VPT) replacing the 12 individual VLS tubes. Each VPT houses a revolver-style launch mechanism holding six Tomahawk missiles, simplifying maintenance and reducing individual hull penetrations.

- **Block V (Virginia Payload Module):** Integrates four additional large-diameter payload tubes in an 84-foot mid-body plug. Each VPM tube holds seven Tomahawks, expanding total strike missile capacity from 12 to 40 missiles per hull. The large diameter of the VPM tubes also supports the future deployment of intermediate-range Conventional Prompt Strike (CPS) hypersonic glide vehicles.

BLOCK VARIANT BREAKDOWN

The production of the Virginia Class is executed in iterative blocks, incorporating manufacturing adjustments, maintenance optimizations, and structural capacity upgrades across the fleet build cycle.

Block	Hull numbers	Count	Key technical modifications and innovations
Block I	SSN-774 – SSN-777	4	Initial production baseline. Features 12 bow VLS tubes, spherical bow sonar array, photonics masts and modular construction architecture.
Block II	SSN-778 – SSN-783	6	Manufacturing processes streamlined. Construction modules reduced from 10 to 4 per hull, achieving significant cost reductions and shorter build cycles without changing core combat systems.
Block III	SSN-784 – SSN-791	8	Major bow redesign. Replaced 12 VLS tubes with 2 large Virginia Payload Tubes (VPTs). Replaced spherical bow sonar with the fiber-optic Large Aperture Bow (LAB) array.
Block IV	SSN-792 – SSN-801	10	Maintenance availability tuning. Design changes extend operational periods between major depot overhauls, reducing planned lifetime depot maintenance cycles from 4 down to 3 per hull.
Block V	SSN-802 – SSN-811	10+	Integration of the 84-foot Virginia Payload Module (VPM) mid-body insert, adding four large payload tubes. Expands land-attack strike capacity from 12 to 40 Tomahawk missiles and enables hypersonic weapon carriage.

SPECIAL OPERATIONS FORCES (SOF) AND UNMANNED INTEGRATION

The Virginia Class was engineered to support Special Operations Forces (SOF) deployments without requiring external structural adaptations or loss of combat performance.

- **Lock-Out Trunk (LOT):** A integrated pressure chamber located on Deck 1 within the pressure hull. The trunk can flood and pressurize rapidly, allowing up to nine Navy SEALs or special operations personnel to exit or enter the submarine simultaneously while submerged.
- **Dry Deck Shelter (DDS) Capability:** Provisions on the upper hull casing aft of the sail allow attachment of a removable Dry Deck Shelter (DDS) or Shallow Water Combat Submersible (SWCS) garage for launching swimmer delivery vehicles (SDVs).

- **Unmanned Systems Integration:** The 21-inch torpedo tubes, Virginia Payload Tubes, and VPM structures are configured to launch, track, and recover Unmanned Underwater Vehicles (UUVs) such as the Razorback and REMUS platforms for littoral survey, intelligence gathering, and mine countermeasures.

OPERATIONAL MISSION PROFILES

Virginia Class boats perform six primary tactical missions across regional and global theaters:

1. **Anti-Submarine Warfare (ASW):** Denying water space to hostile attack and ballistic missile submarines through long-range passive sonar detection, target tracking, and Mk 48 heavy torpedo engagement.
2. **Anti-Surface Warfare (ASUW):** Conducting surface ship surveillance and anti-surface strike using Mk 48 torpedoes and anti-ship missile payloads.
3. **Strike Warfare (STK):** Executing precision long-range land-attack operations using land-attack Tomahawk cruise missiles and hypersonic kinetic weapons against high-value target networks.
4. **Intelligence, Surveillance, and Reconnaissance (ISR):** Deploying passively in contested or denied coastal waters to monitor electronic emissions, track maritime movements, and feed tactical intelligence back to joint force command networks.
5. **Special Operations Support:** Inserting, supporting, and recovering special operations forces in sensitive coastal environments via the Lock-Out Trunk or Dry Deck Shelter.
6. **Mine Warfare (MIW):** Mapping hostile underwater minefields, deploying defensive mine arrays, and launching autonomous unmanned platforms to clear sea lines of communication.

PRIMARY TECHNICAL SPECIFICATIONS

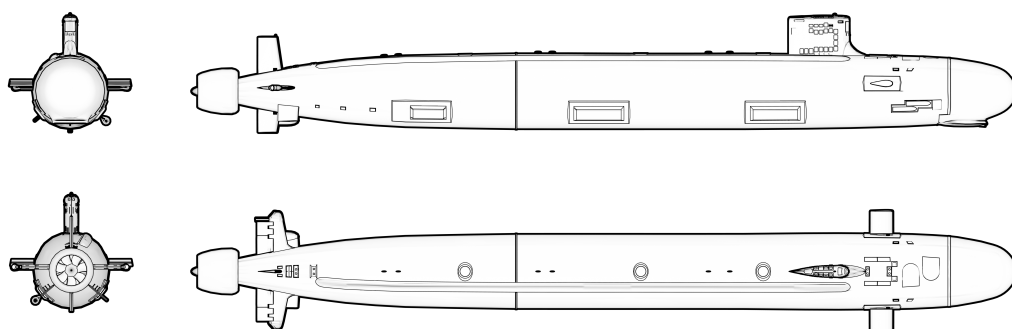


Figure 10: Virginia Class Block 3 diagram

GENERAL CONFIGURATION

Parameter	Blocks I–IV	Block V
Overall Length	377 ft (115 m)	460 ft (140 m)
Beam	34 ft (10.4 m)	34 ft (10.4 m)
Draft	32 ft (9.7 m)	32 ft (9.7 m)
Keel to Sail	60 ft (18 m)	60 ft (18 m)
Submerged Displacement	7,800 tons	10,200 tons
Complement	132 (15 Officers, 117 Enlisted)	132 (15 Officers, 117 Enlisted)

PROPULSION

Parameter	Blocks I–V
Reactor Plant	Westinghouse S9G Pressurized Water Reactor (210 MWt)
Turbines	2 x Steam turbines 40,000 SHP (29.8 MW)
Screw	Single shaft Pump-Jet propulsor

PERFORMANCE

Parameter	Blocks I–IV	Block V
Maximum Operational Speed	34 knots (submerged)	32 knots (submerged)
Maximum Operational Depth	1,200 ft (366 m)	1,200 ft (366 m)
Crush Depth (est.)	1,550 ft (472.5 m)	1,550 ft (472.5 m)

SUBMARINE SCHOOL

Welcome to Submarine School. This chapter will help you learn the basics of controlling a Virginia Class submarine through a series of 13 missions. Each mission is designed in such a way that will teach you to accomplish specific tasks and here you will find the necessary instructions to complete them. The missions are organized in three groups:

Group	Missions
Control room, ship control and navigation	Missions 1-3
Sensors and target classification	Missions 4-9
Fire control and weapon employment	Missions 10-13



Figure 11: Virginia Class Block 1 Control Room

Keep in mind that this whole training campaign is using a build block approach. This means that although all missions are unlocked each mission is based on knowledge gained on previous ones.

We went to great lengths to make Modern Naval Warfare the most realistic submarine simulator ever made. Given that you will not learn how to fight in the Virginia SSN overnight but if you take the time and effort we promise it would be a rewarding experience.

1. SHIP CONTROL 101

MISSION DESCRIPTION

The purpose of this mission is to familiarize yourself with the pilot station and the basic controls of the submarine. By the end of the mission, you should be able to:

- Helm the submarine
- Dive and surface
- Control the various masts and antennas
- Set pilot depth alarms
- Control the submarine through the autcrew feature

The submarine for this mission is a Virginia Block 1, but the processes are identical for all blocks of the Virginia family. So, let's get started.

MISSION PARAMETERS

- Virginia Class Block 1 ownship
- Deep water location
- Surfaced starting depth
- No civilian traffic
- Day
- Good weather
- No winning condition (this means you can exit the mission at any time and still receive a "Success" report at the end)

A NOTE ABOUT TIME COMPRESSION

Many of the procedures discussed in the guide can be time-consuming. In order to solve this problem, there is a *Time Palette* which is toggled by clicking ESC or Right Click and is located on the bottom-right corner of the screen (*mnw-control_guide*, p6). The right-most control of the palette sets the time compression for the game using the mouse wheel. If the system allows it and the FPS don't drop too low, it is possible to increase time compression and make the procedures take less time. However, if the FPS drop too low, it will automatically return to 1x speed.

OVERVIEW AND PROCEDURES

First thing we need to do is familiarize ourselves with the pilot station of the submarine, because this is where the bulk of the handling of the submarine's movement happens. To go to the pilot station, simply left-click on one of the two monitors at the front of the platform, or press F2 (*mnw-control_guide, p1*).



Figure 12: Pilot steering panel

This figure shows what we will be looking at when we enter the pilot station; this is the **Steering** Panel of the Pilot station. All the functionalities regarding steering are located there. Clicking on the *Masts* tab in the bottom-left corner will open the panel responsible for handling everything pertaining to the deployment of Towed Arrays, Blowers, and Masts & Antennas.

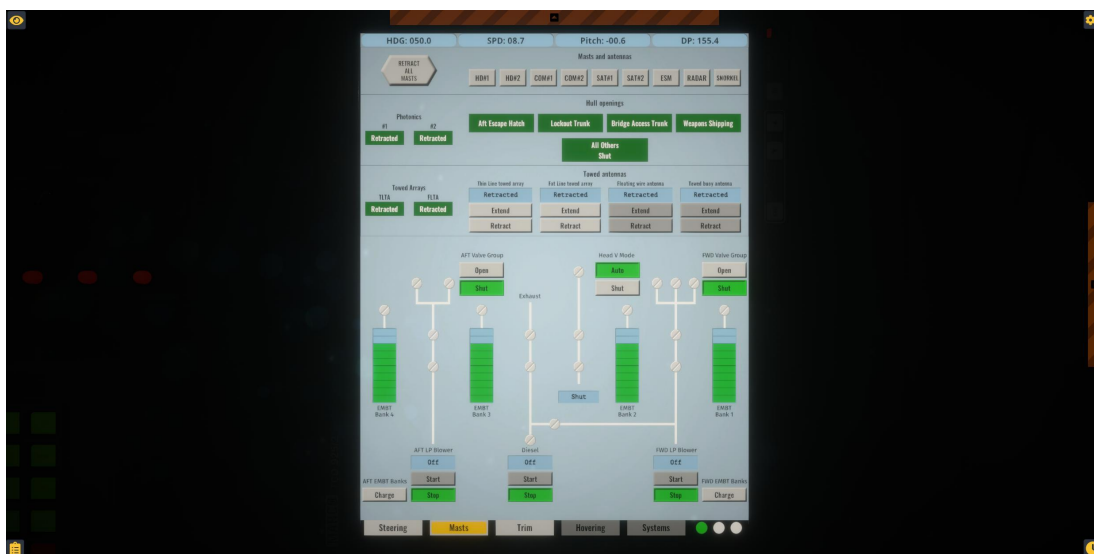


Figure 13: Pilot masts panel

Starting with the *Mast Panel*, at the top we can see all the different masts and antennas that can be deployed from there (these can also be deployed at their respective stations). Right under them, there are buttons responsible for deploying the Thin and Fat Line Towed Arrays, which will be used when we take a look at the sonar.

Going back to the **Steering Panel**, it's time to practice handling the submarine.

At the middle of the panel, we see three buttons, one under the other; these are the *Trim*, the *Depth*, and the *Heading*. Pressing any of them will open a num-pad (Figure 3), and the corresponding field (*Ordered Trim*, *Ordered Depth*, and *Ordered Heading*) will be filled with the number we input after pressing *Order*.

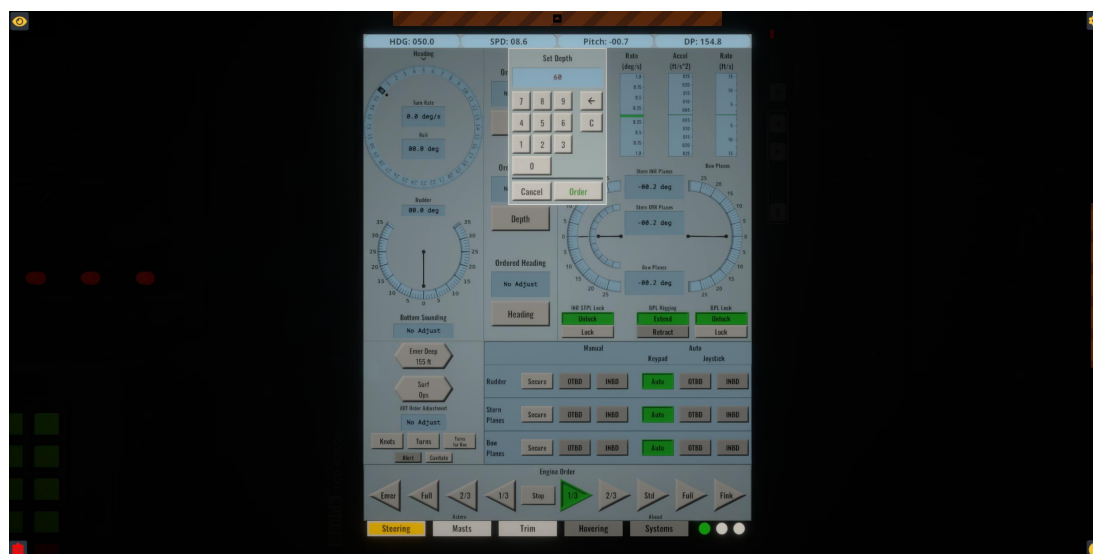


Figure 14: Pilot station num-Pad

■ How to set your speed (EOT order)

The speed of the submarine can be controlled with the engine order fields at the bottom of the Steering Panel, with each order corresponding to a different speed in knots (*virginia_qrh*, p1-3). For example, if we press the 2/3 button, after a few seconds (depending on the starting speed), the speed will be around 10 kt if submerged and 8 kt if surfaced. As with the previous systems, oscillations are to be expected at first around the target speed.

■ How to turn the ship

The rudders handle the turning of the submarine, which can be done by inputting a heading in the *Ordered Heading* field; this will instruct the rudders to start turning in order for the submarine to reach the ordered heading (at which point the rudders will return to their resting positions).

For example, if we input 60 in the *Ordered Heading* field, after about a minute (depending on the heading the submarine was at when we started), the heading of the submarine will be 60 degrees.

■ How to adjust your depth

The planes are responsible for handling the depth of the submarine, which can be done by inputting a depth in the *Ordered Depth* field (in ft). This will cause the planes to turn to specific angles until the submarine reaches the ordered depth (at which point the planes will return to their neutral positions).

For example, if we input 90 in the *Ordered Depth* field, after approximately three to five minutes (depending on the starting depth), the depth of the submarine will be around 90 ft.

It should be noted that changing the depth of the submarine is a mechanically complex procedure, with a variety of different forces that are applied; that means that it will be slow, and oscillations are inevitable. The range of the oscillations depends on a number of factors, namely the speed of the submarine and the difference between the starting and the target depth.

■ How to set your bubble (pitch)

The *Ordered Trim* field can be used to order the submarine to catch a bubble equal to the number in the field.

For example, if we input 5, that means that the submarine will pitch (or turn vertically) 5 degrees after a few seconds. It's important to note that due to the strong external forces, the process cannot be done perfectly, and there will be oscillations around the 5-degree value until the submarine manages to stabilize itself.

Finally, it should be noted that there are other ways to control the planes and the rudders with the three sets of buttons next to the *Heading* button; these lock and retract the planes. The general rule is, if we are going above 15 kt while in great depths (for example, over 500 ft - *virginia_qrh, p1-3*) or we are in the process of diving/surfacing, we should be unlocking the planes to ensure better control over the submarine.

■ The pilot station secondary displays

Pressing the orange arrow at the very top of the screen turns to the pilot secondary displays. Here you can find various controls and features like:

- Ship Alarms
- Adjustable Depth Alarms
- Rigging sets
- System logs

For now we are interested in the Ship and Depth alarms panels.

The ship alarms The *Alarm* button opens the panel housing instant access to the activation of alarms for many different situations, with every single one of those situations written on the button of each alarm as shown below.

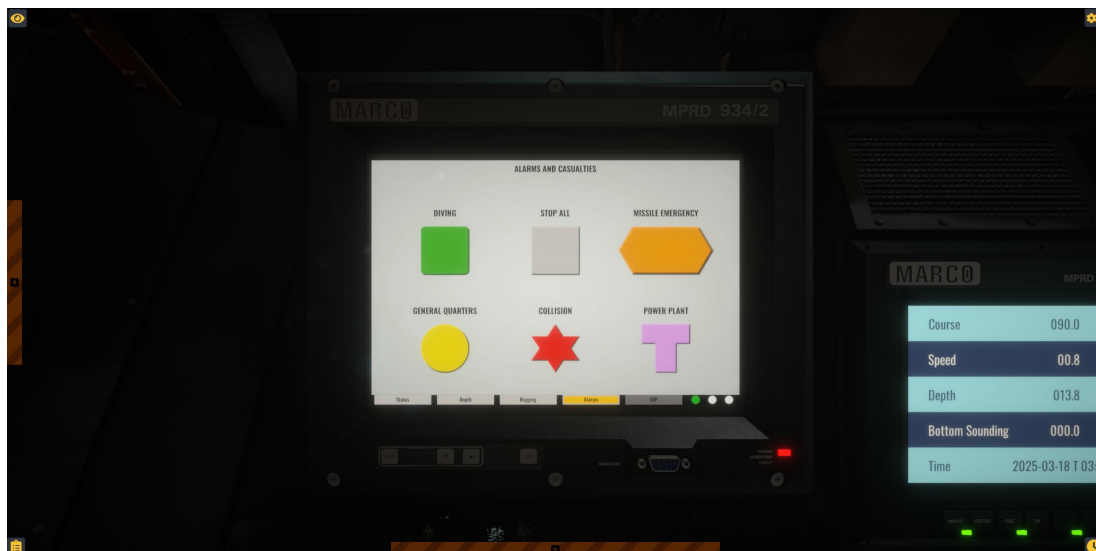


Figure 15: Alarms panel

The adjustable depth alarms Depth Alarms can be set and used as a audible warning when we reach specific depths (for example, test depth). Clicking the *Depth* button at the bottom of the screen opens the panel with all the alarms and their enable/disable buttons and a display showing the ships position and pitch within the water column. Each alarm has a depth field which we can fill and, after enabling it, the alarm will be activated when the submarine reaches (or crosses) that depth.

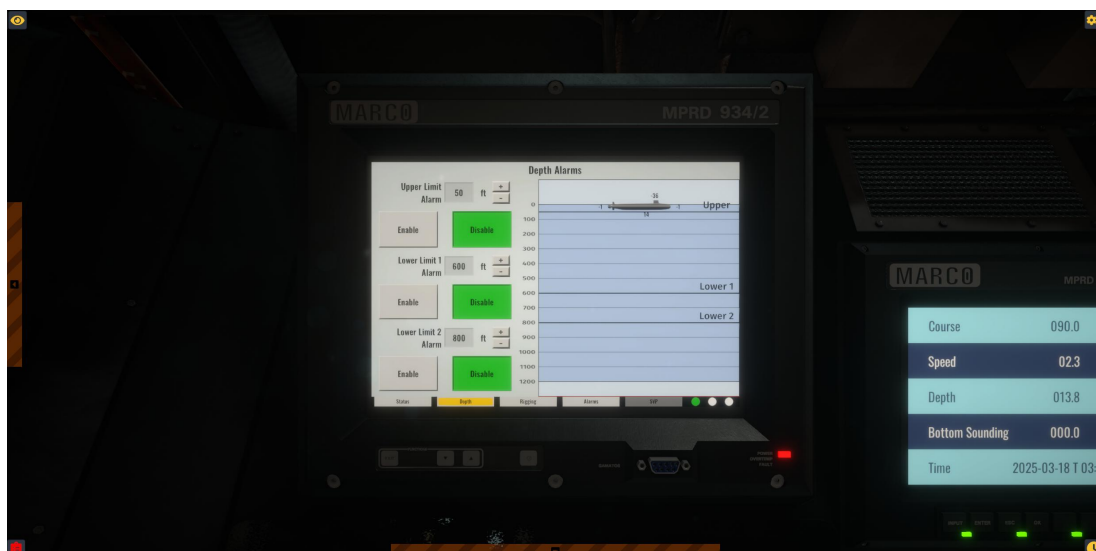


Figure 16: Depth alarms panel

■ How to dive (or submerge) the ship

Now that we are more familiar with the controls of the submarine, we can explore different useful procedures, namely the **Dive Process** and the **Surface Process**. These are highly convoluted and dangerous procedures.

The *Dive Procedure* is necessary to be done while surfaced, in order to submerge the submarine and enable it to dive to the ordered depth (*virginia_qrh, p2-2*). The process is as follows:

- Start by setting a speed of 2/3 ahead and waiting for the submarine's speed to stabilize to that value
- Ensure the inner stern planes (INR STPL) and the bow planes (BPL) are unlocked
- Go to the *Alarms* panel of the Pilot Station Secondary displays and press the *Diving Alarm*
- Go to the *Masts* Panel and click both *FWD* and *AFT Valve Group Open* buttons (this will start the process of filling Main Ballast Tanks with water and make the process of diving possible)
- Order a depth of 150 ft
- Keep an eye on the depth and on the pitch of the submarine; when the depth is stabilized around 150 ft and the pitch is approximately 0, the process is complete

■ How to surface the ship

The *Surface Procedure* is necessary to be done while submerged, in order to surface the submarine. The process can be done in two ways, depending on whether we want the surfacing to be done quickly (due to an emergency), or in a controlled and slow manner.

Emergency surface This is the procedure when there is an emergency or to minimize the exposure of the submarine when operating in hostile environments (*virginia_qrh, p2-4*).

- Set the speed to 2/3 ahead or higher
- Exit the pilot station and look up the *Manual Control* overlay (Figure 6)
- Open the overlay shows two switches (the *Emergency Blow Activators/Chicken Switches*)
- Click both of them starting with the right (fore) first and then the left (aft) 5 seconds later
- Go back to the Pilot Station and click on the *Surface Ops* button on the bottom-left; this resets all orders regarding ordered trim and depth
- Wait a few seconds and the submarine will be surfaced



Figure 17: Manual control overlay (chicken switches)

Standard surface This is the proper procedure when returning to port at the end of a patrol (*virginia_qrh, p2-3*).

- Set the speed to 2/3 ahead and wait for the submarine to stabilize to that value
- Order the submarine to reach *Periscope Depth*
- Wait until the current depth is approximately equal to the Periscope Depth
- Click on the *Surface Ops* button on the bottom-left
- Open the Snorkel (this is done by going to the *Masts* Panel and pressing the Snorkel button on the top-right of the screen)
- Wait for the snorkel to be out of the water
- Go to the *Masts* Panel and click *Start* at the *FWD* and *AFT* LP Blower on the bottom left and bottom right of the panel respectively
- Wait for the blowers to empty the MBTs
- Wait for the ship to surface
- Process complete

WARNING: It must be noted that the standard surfacing procedure, while controlled, can be very time-consuming, so don't expect it to be completed quickly.

■ The autocrew system

The final thing to learn is the use of autocrew regarding its use to pilot the submarine. The autocrew are NPCs that can be activated, which can be ordered to perform multi-step procedures of their corresponding station with a single order.

For example, the pilot autocrew can be ordered to perform the aforementioned diving and surface procedures, change depth/heading/speed, the fire-control autocrew to load weapons, the sonar autocrew to track targets, etc.

To activate the autocrew, exit the pilot station and press right-click on the pilot station and then *Autocrew* on the dropdown. Things to keep in mind regarding the autocrew are the following:

- The autocrew function will always be active for the pilot station and cannot be deactivated.
- Not all stations have it available.
- There can only be one autocrew active per station.

To gauge which stations have autocrew available, simply pay attention to the icon when hovering over them:

- A *Keyboard* indicates that autocrew is **not** available and everything has to be done manually.

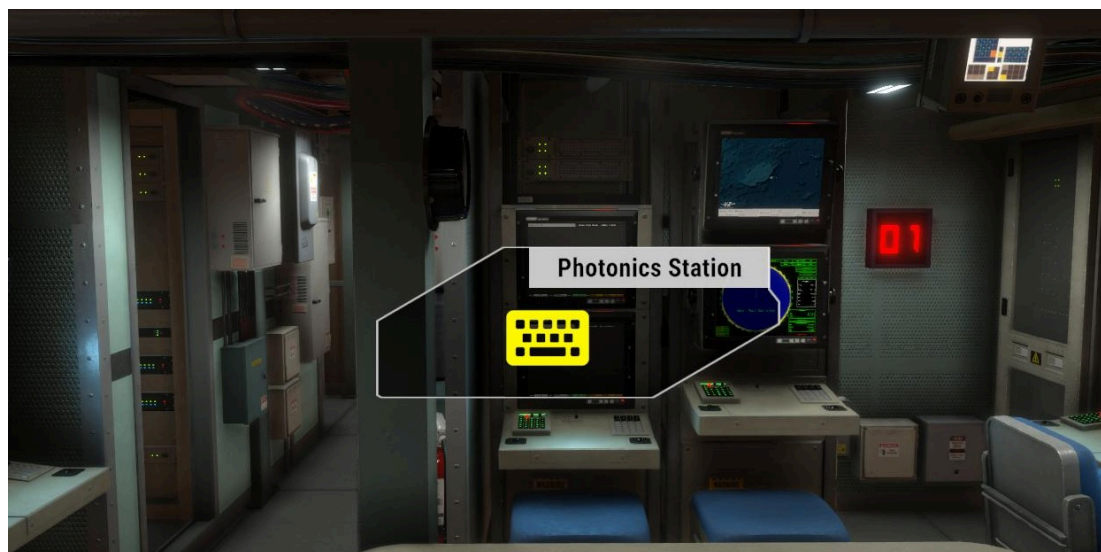


Figure 18: Autocrew unavailable

- An *Arrow* indicates that autocrew **is** available and can be activated by right-clicking on it.

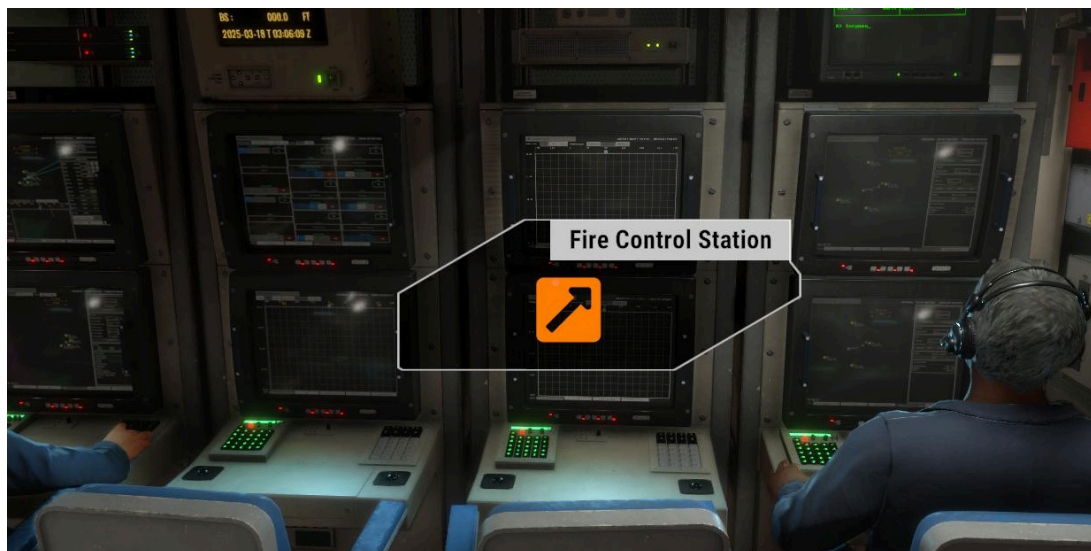


Figure 19: Autocrew available

- A *Human* indicates that autocrew **is** available and is currently active.

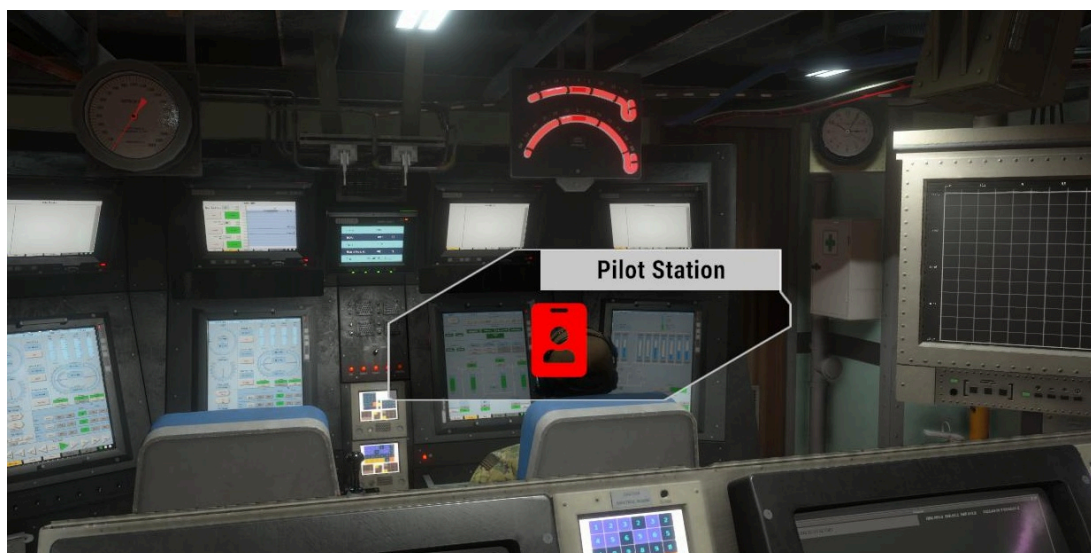


Figure 20: Autocrew active

All previous procedures can be done using autocrew, except for the setting of the alarms. Simply choose the command in the dropdown (top figure) and then enter the corresponding depth or heading (middle figure). Furthermore, diving and surfacing procedures can be completed by pressing the corresponding command on the dropdown and then choosing the type (standard or emergency - bottom figure). The autocrew member will automatically carry out all the necessary steps.

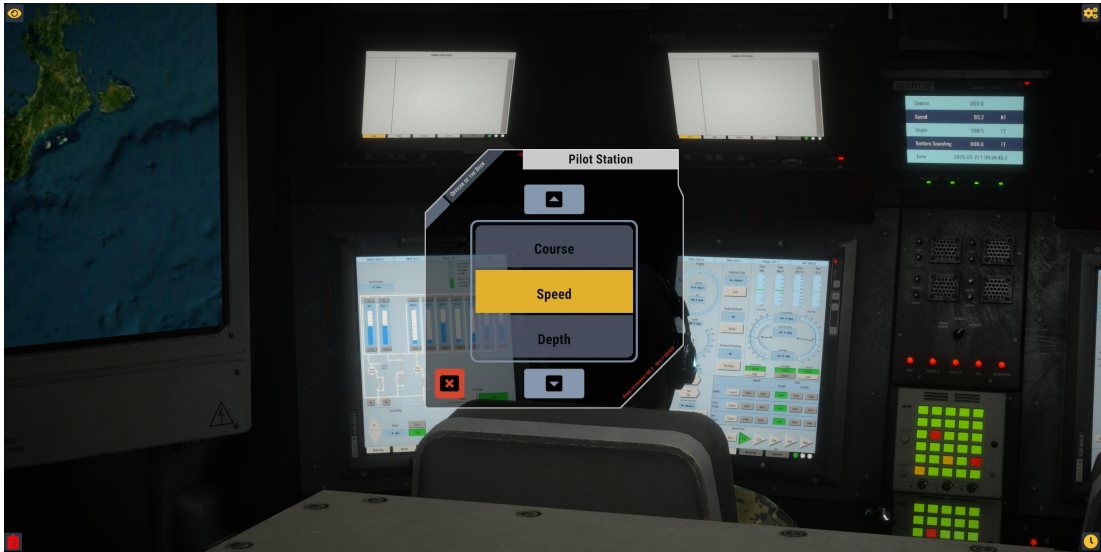


Figure 21: Autocrew dropdown

Note: In order to set a depth using the autocrew, the ship needs to have gone through the diving procedure and be submerged, if surfaced; this can be done either manually or through the *Dive* order to the autocrew.

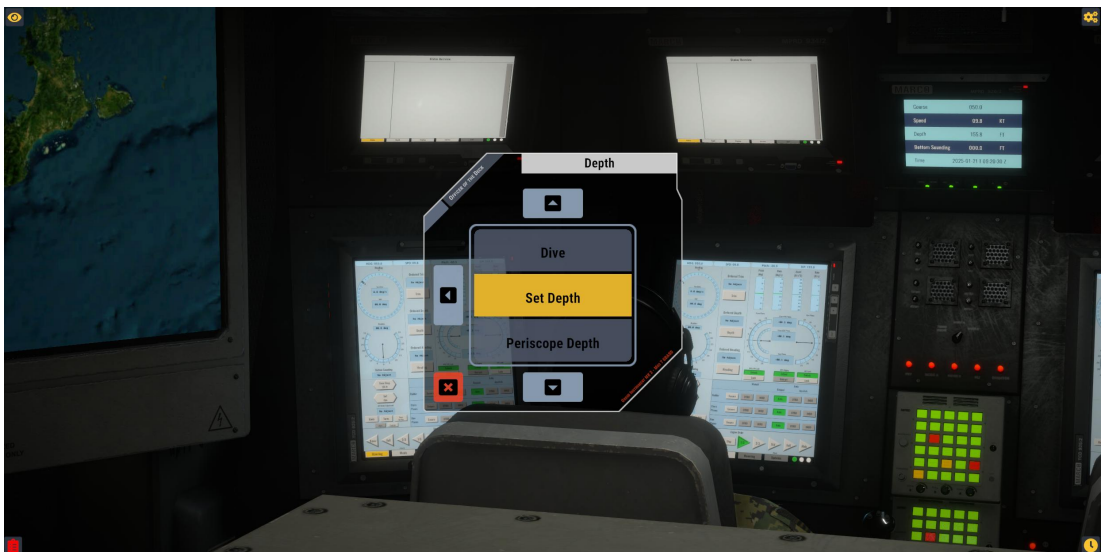


Figure 22: Autocrew depth

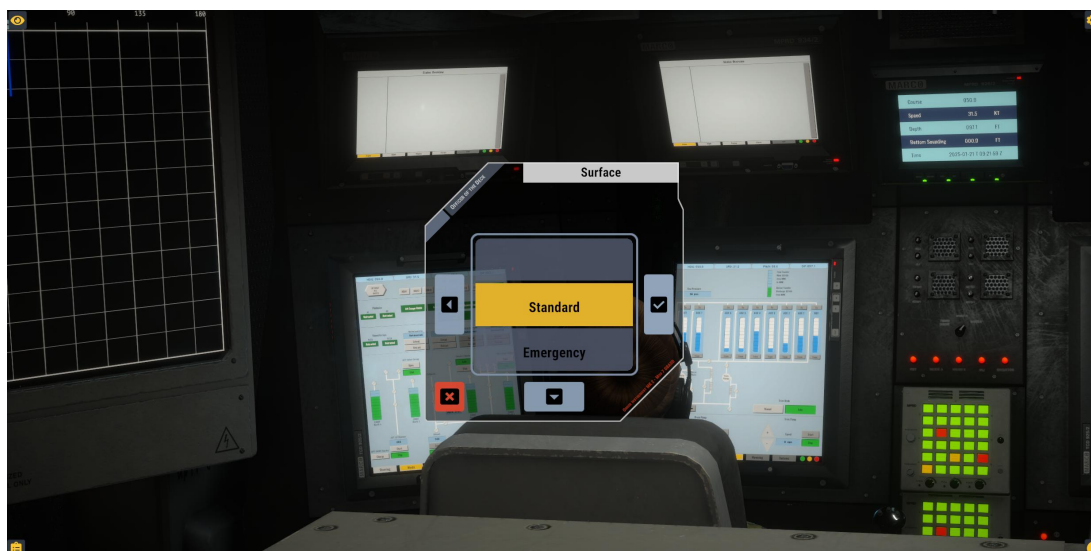


Figure 23: Autocrew surface ops

WALKTHROUGH

It's time to put everything we learned to the test. The first mission itself does not have any objectives; this means that you can exit it at any point and have it be classified as successful. However, you shouldn't move on to the next until you are confident you have understood all the concepts that are outlined in this guide. For this reason, the next section of the guide is a "checklist", containing all the things you should be able to do, as well as what these actions look like when done properly.

First thing to do is go to the pilot station and figure out the status of the submarine. Opening the pilot station, we get the following information:

- The heading of the submarine is 90 degrees
- The depth is at 13.9 ft, meaning it is surfaced
- The current EOT Order is 1/3 ahead; if the speed is not already at approximately 4 kts, it soon will be

■ Mission steps and maneuvers

- Give an order for 2/3 ahead. If done correctly, after a few seconds the speed is expected to be at 8 kt
- Give an order for 120 degrees heading. If done correctly, the rudder should turn to 15 degrees, then start slowly reducing the angle until it is at 0 degrees. Meanwhile, the heading will start to move from 90 and then, after 2-3 minutes, it should be at 120
- Give an order for 1/3 speed. The speed should then be reduced to approximately 4 kts.
- Go to the alarms and set two depth alarms: The Lower Limit 1 to 600 ft and the Lower Limit 2 to 800 ft
- Engage the diving procedure. After a few minutes, the submarine should be stabilized at 150 ft and the EOT Order should be 2/3
- Give an order for Std ahead. After a few seconds, the speed is expected to be at approximately 15 kt

- Give an order for 700 ft depth; if done correctly, after approximately 3 minutes, the submarine should be oscillating between 699 and 702 ft and then, after a couple of minutes, it should be stable at 700 to 700.5 ft
- Give an order for 20 degrees heading. The rudder should be turned the other way (at -15 degrees) and then, after approximately 3.5 minutes, the heading of the submarine should be 20 degrees heading
- Order Periscope Depth. After approximately 4 minutes, the submarine should be oscillating slightly around 56 ft.
- Give an order for 1/3 speed. The speed should then be reduced to approximately 5 kts.
- Lastly, simply raise the snorkel from the masts panel.

MISSION COMPLETION

At the end of the mission, the submarine should:

- Be at 20-degree heading
- Have a speed of 5 kt
- Have a slight pitch around 1 degree due to oscillations
- Be between 54.5 and 56 ft depth
- The snorkel should be raised.



Figure 24: Pilot at the end of the mission



Figure 25: Submarine at the end of the mission

Congratulations! You can now exit the mission.

2. CONTROL ROOM AND RADIO 101

MISSION DESCRIPTION

Now that you're able to control the submarine, it's time to familiarize yourself with the Control Room, as well as the basic operation of the submarine's Radio Station. By the end of the mission, you should be able to:

- Have complete knowledge of the position of every station and auxiliary screen
- Cycle through station displays on the Large Displays
- Effortlessly operate the submarine's light controller
- Send and receive messages

The submarine for this mission is a Virginia Block 1, but the processes are identical for all blocks of the Virginia family. So, let's get started.

MISSION PARAMETERS

- Virginia Class Block 1 ownship
- Deep water location
- 150 ft starting depth
- No civilian traffic
- Dusk
- Good weather
- No winning condition (this means you can exit the mission at any time and still receive a "Success" report at the end)

OVERVIEW

Before diving into the specifics of the mission, it's important to get an overview of the entire Command Station. Pressing (and holding) Tab will create an overlay over each station, with the station's name displayed above it, as shown in the pictures below.

It's worth noting that these overlays are color-coded:

- Light Blue for Stations
- Green for Auxiliary Screens
- Red for Chicken Switches
- Yellow with black stripes for rooms



Figure 26: Station overlay 1

For the stations, starting from the Pilot Station and proceeding clockwise, these are:

- **Pilot Station**

Responsible for conning the submarine, controlling the depth, managing ballast tanks and handling antennas and wires.

- **Fire Control Station**

Responsible for creating fire control solutions, plotting missions and handling the weaponry of the submarine.

- **ESM Station**

Responsible for detecting and analyzing electromagnetic, radar and communication emissions to help identify and track potential threats without actively transmitting.



Figure 27: Station overlay 2

- **Radio Room**

Responsible for voice and data communications between the submarine and the external world.

- **Photonics**

Responsible for handling the different photonics masts and their multi-spectral optical sensors.

- **Radar**

Responsible for actively detecting and tracking contacts and assisting navigation while surfaced.

- **Sonar**

Responsible for using underwater sound to passively detect, locate and classify other vessels and actively avoid obstacles.



Figure 28: Station overlay 3

At the center:

- **Command Station**

Used by the captain and officer of the deck and provides quick access to a number of different stations, information displays and documentation.

- **ECDIS**

Used as a tactical display, navigation chart and for plotting courses.

■ Auxiliary Screens

In order to have easy access to information regarding the status of the submarine without needing to directly access a station, a number of different screens have been placed around the Control Room, each displaying a variety of information. Starting from the Pilot Station and proceeding clockwise, these are:

- **Anglemeters**

Analog backup instruments that show roughly the number of degrees the submarine is pitched and rolled.



Figure 29: Anglemeters

Note: There are two identical Anglemeters: one that is placed horizontally (in relation to the rest of the Control Room) over the Pilot Station and shows the degrees the submarine is rolled, and one placed vertically and to the left of the Pilot Station that shows the degrees the submarine is pitched.

- **Mission Clocks**

They tell the time in Zulu (UTC timezone), as this is the standard used by American submarines.



Figure 30: Mission Clock

- **Large Displays**

They can be set to display data from different stations; specifically, the ECDIS, Time Bearing Plot and Situational Awareness.



Figure 31: Large display

- **Info Displays**

They show the current Course, Speed, Depth, and Bottom Sounding of the submarine. (Note: The bottom sounding returns data only if the Fathometer is active.)



Figure 32: Info display

- **Ammo Status Displays**

They show the current status of the submarine's weapon loadouts including the torpedo tubes.



Figure 33: Ammo status display

- **Sierra Contact Led Display**

A screen to the left of the Sonar Station displaying the ID of the next sierra (Sonar) contact to be tracked (this will be explored further in the Sonar chapter).

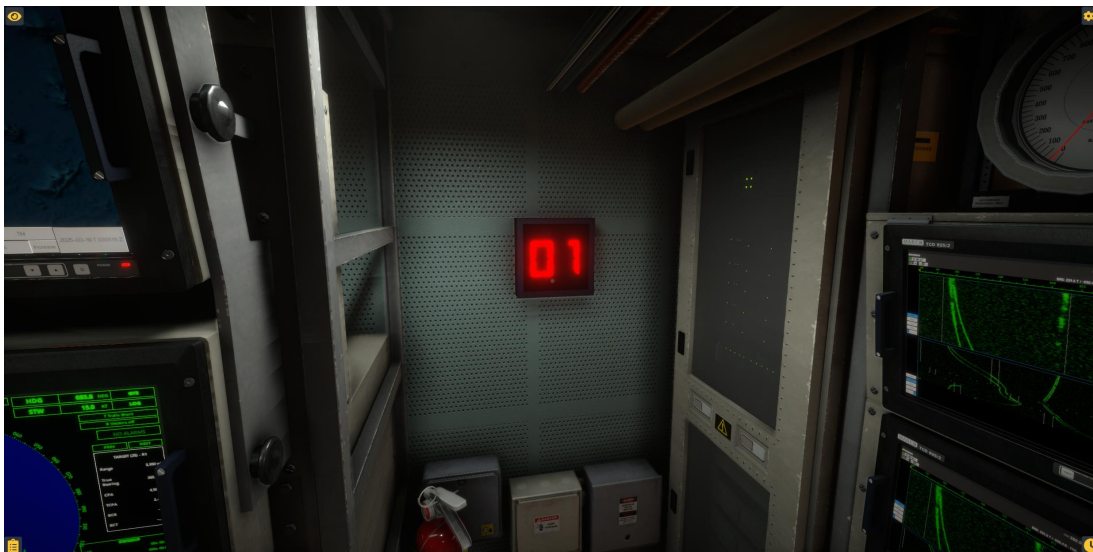


Figure 34: Next sierra contact ID

- **Depth Gauges**

Another analogue backup instrument that displays the current depth of the submarine.

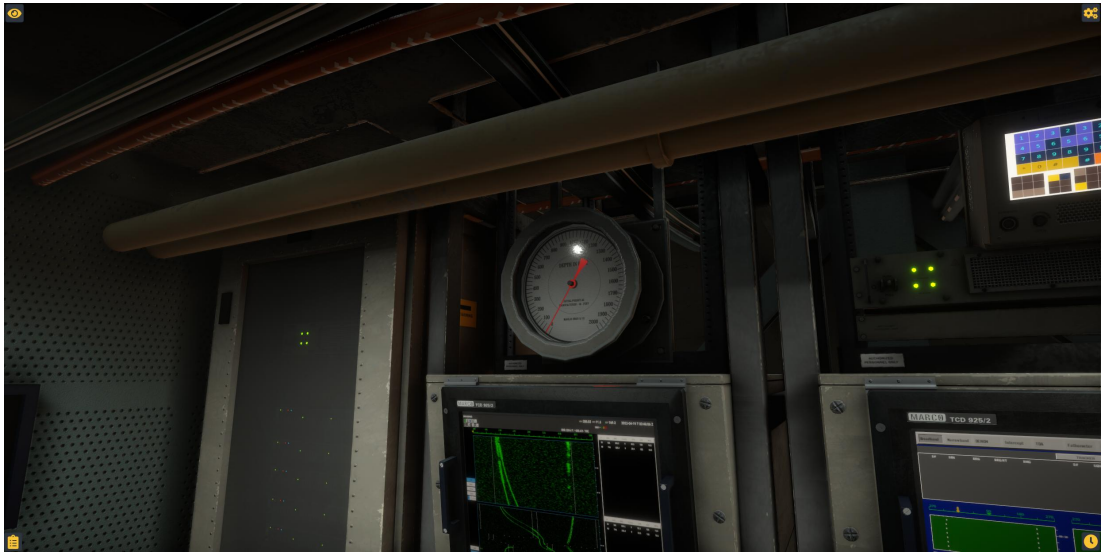


Figure 35: Depth gauge

- **Compasses**

Yet again analogue backup instrument that displays the current heading (not course) of the submarine. (Note: They are only available on some blocks.)



Figure 36: Compass

■ Light Controls

One of the many things we have control over in the submarine is the lighting. This can be managed from any of the Main Circuits in the submarine (as shown in the picture below). Right-clicking on any of them opens a drop-down menu, at the bottom of which is the Lights Controller. Clicking on it allows us to either turn all the lights off, turn them all on, or access all the lights' presets.



Figure 37: Main circuit

■ How to Receive Messages

One of the most important things to do at the beginning of each mission is to receive the message containing the mission's orders, in order to be aware of what we need to do. To do this, we first need to ensure that the submarine is, at most, at Periscope Depth. This is because the submarine's antennas have a specific length and, in order to be deployed and receive signals, the submarine needs to be at most at Periscope Depth. Furthermore, to ensure that the antenna does not break, it's safe to order a maximum of 2/3 ahead speed.

After both of these conditions have been met, we are free to go to the Radio Room and open the Radio Station (picture below).



Figure 38: Radio station

After entering the Radio Room and opening the Radio Station (picture above), we are greeted with a panel showing a list of all antennas and their statuses (top-left side), all radios and their statuses (bottom-left side), and the eventual message we'll receive.

Note: The radios can display the following statuses: *Offline*, *Standby*, *Online*, *Receiving* (picture below).

At the bottom of the panel are buttons that allow us to cycle through other panels. The **Antenna Control** panel is where we can raise and retract the antennas in order to start receiving signals, while the *Information* panel contains useful communication codes.

To raise the antennas, simply drag the height slider all the way to the right and click **Raise**. The field on the right, as well as the corresponding antenna on the left, should switch to **Raised**. The corresponding radios on the bottom left should then switch to **Receiving**. This means that a satellite is available and the message is being received (this can take a few seconds).

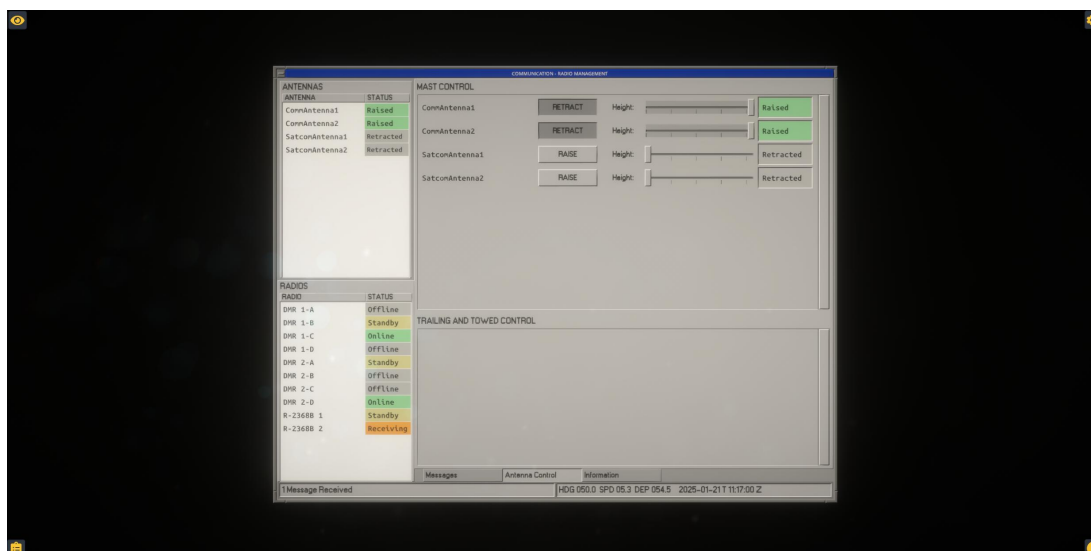


Figure 39: The antenna masts control panel

If at least one of the radios has switched to **Receiving**, we can go to the Messages Panel and click on **SEND/RECEIVE**, at the top of the panel. This will download all the messages and display them in the empty space directly below.

You don't have to keep returning to the station to read the message. Clicking on the **PRINT** button will send it to the **Mission Log Palette** (bottom-left of the screen after clicking ESC or SPACE), where it will remain for the rest of the mission.

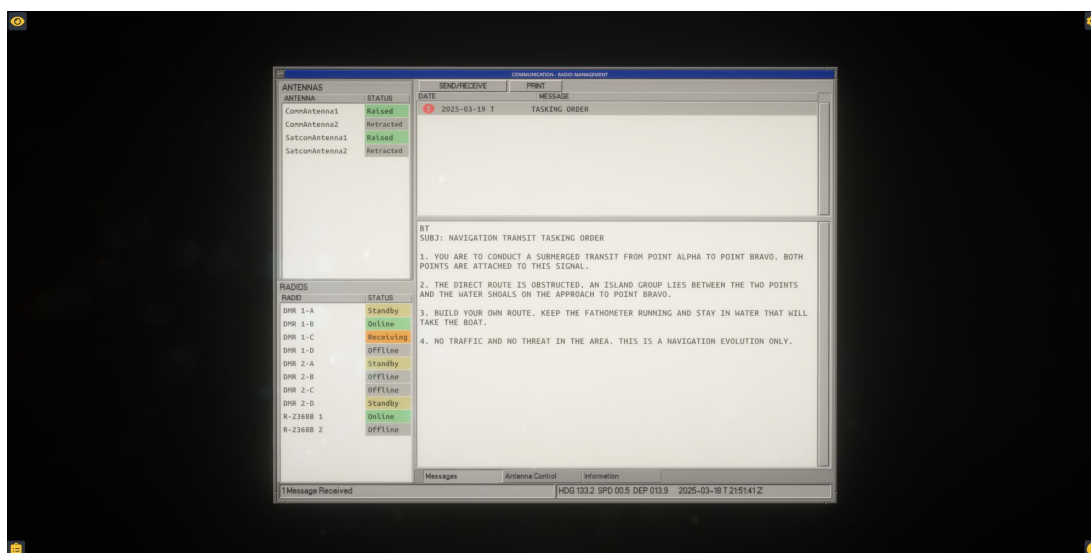


Figure 40: Radio message panel

The Radio Station can also be used during the mission to check whether the *primary* objectives of the mission have been completed and to receive other mission updates (for example, the new location of a target).

WALKTHROUGH

It's time to put everything we've learned to the test. The mission itself does not have any objectives; this means that you can exit it at any point and have it classified as successful. However, you shouldn't move on to the next mission until you are confident that you have understood all the concepts outlined in this guide. For this reason, the next section of the guide is a "checklist," containing all the things you should be able to do, as well as what these actions look like when done properly.

■ Mission Steps

- Set the Large Displays to show the ECDIS Station
- Turn off the Lights
- Go to the Info Screen that displays the depth of the submarine
- Give an order for Periscope Depth
- Go to the Radio Room
- Open the Antenna Control and raise at least one SAT and one Com antenna (for their differences, *refer to virginia_qrh, p1-5*). If done correctly, the antenna statuses on the left side of the screen will switch to *Raised*, and the radio statuses will switch to *Online*.
- Open the *Messages Panel* and press **SEND/RECEIVE**. If everything is set up correctly, the statuses of some radios will switch to *Receiving* and, after a few seconds, the message should appear in the empty space of the panel.

TRAINING BROADCAST ONE

- Send the message to the Mission Log Palette; if done correctly, the message should be displayed on the bottom-left of the screen after clicking ESC or SPACE

MISSION COMPLETION

At the end of the mission, the submarine should:

- Have its large screens display the ECDIS Station
- Have its lights off
- Be in Periscope Depth
- The message should be displayed in the Mission Log Palette

3. NAVIGATION 151

MISSION DESCRIPTION

It is now time to learn how to plot a course to the target coordinates of a mission. By the end of the mission, you should be able to:

- Set POI in the ECDIS station
- Create plots
- Manage the autopilot

- Operate the fathometer

The submarine for this mission is a Virginia Block 3, but the processes are identical for all blocks of the Virginia family. So, let's get started.

MISSION PARAMETERS

- Virginia Class Block 3 ownship
- Deep water location heading to shallow
- 150 ft starting depth
- No civilian traffic
- Dawn
- Good weather
- Reach "Point Beta" winning condition

OVERVIEW

As stated in previous missions, the first thing we need to do is receive a message containing the mission's instructions (refer to Mission 2 for details on this process).

The message we receive (picture below) states that our objective is to conduct a transit from Point Alpha to Point Bravo and to keep the Fathometer running.

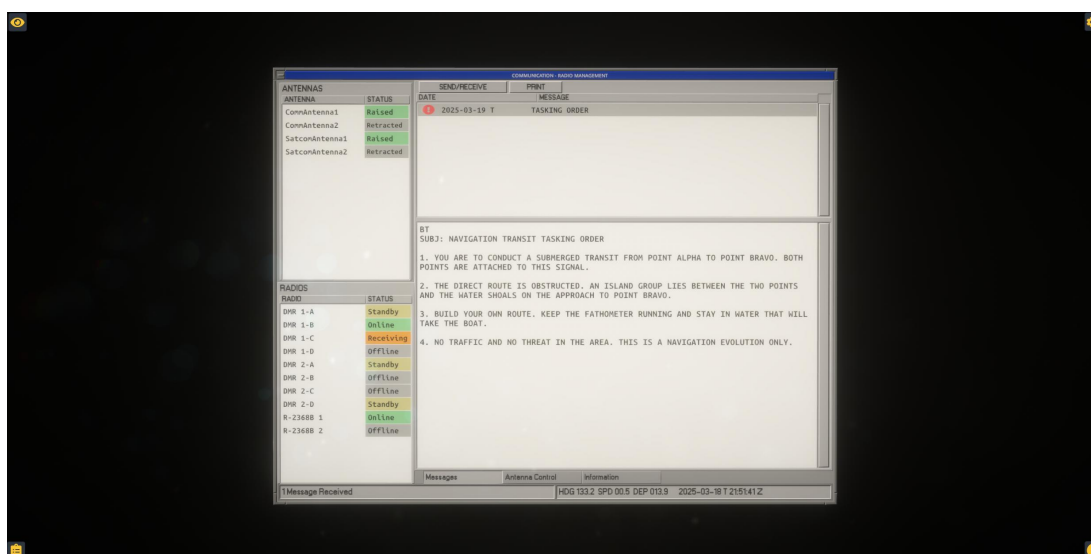


Figure 41: Message

SUBJ: NAVIGATION TRANSIT TASKING ORDER

1. YOU ARE TO CONDUCT A SUBMERGED TRANSIT FROM POINT ALPHA TO POINT BRAVO. BOTH POINTS ARE ATTACHED TO THIS SIGNAL.
2. THE DIRECT ROUTE IS OBSTRUCTED. AN ISLAND GROUP LIES BETWEEN THE TWO POINTS AND THE WATER SHOALS ON THE APPROACH TO POINT BRAVO.
3. BUILD YOUR OWN ROUTE. KEEP THE FATHOMETER RUNNING AND STAY IN WATER THAT WILL TAKE THE BOAT.
4. NO TRAFFIC AND NO THREAT IN THE AREA. THIS IS A NAVIGATION EVOLUTION ONLY.

Since we have received the message, we can retract the antennas and go to the Pilot Station to give an order for a depth of *100 ft* and for *Std EOT*.

■ What is the Fathometer

The Fathometer is the next item mentioned in the message. This is because it is used to measure the depth of the water and ensure that the submarine does not collide with the bottom. To access it, we need to go to the Sonar Station and click on the seventh button on the top-right side of the panel (picture below).



Figure 42: Fathometer (disabled)

■ How to operate the fathometer

Before analyzing the information we can obtain from the Fathometer, it is important to note a few things.

Any depth displayed here is not the actual depth of the submarine, but the total distance from the submarine to the bottom of the ocean.

The Fathometer is not accurate when changing depths. This is because the sound waves need to be vertical to the bottom of the ocean rather than at an angle (which happens when the submarine is at an angle during movements between different depths).

- At the top-middle of the screen, there is a label that shows the current status of the submarine regarding its distance from the bottom.

Secure Deep means everything is within safe limits, *Warning* means the submarine is close to the warning limit, and *Danger* means the submarine is at the dangerous limit.

- Current Depth: Shows the distance between the submarine and the bottom of the ocean.
- Depth Limit: Shows the two depth limits assigned by the user (Warning/Danger), using the selected measurement system.
- Measurements: Shows which measurement system the user has selected for the display and provides a dropdown list for changing it (Imperial/Fathoms).
- Left Graphic: Shows a depth map at a distance of 1,000 fathoms (or 6,000 ft), with the depth limits (the green line is the warning line, and the red line is the danger line). A line is drawn from right to left, showing the Fathometer's echo map of the seafloor and the distance from the submarine to the bottom.
- Right Graphic: Shows the same depth map at a controllable scale, acting as a zoom. The seafloor is always drawn from the middle. The depth-limit lines do not appear in the right graphic.

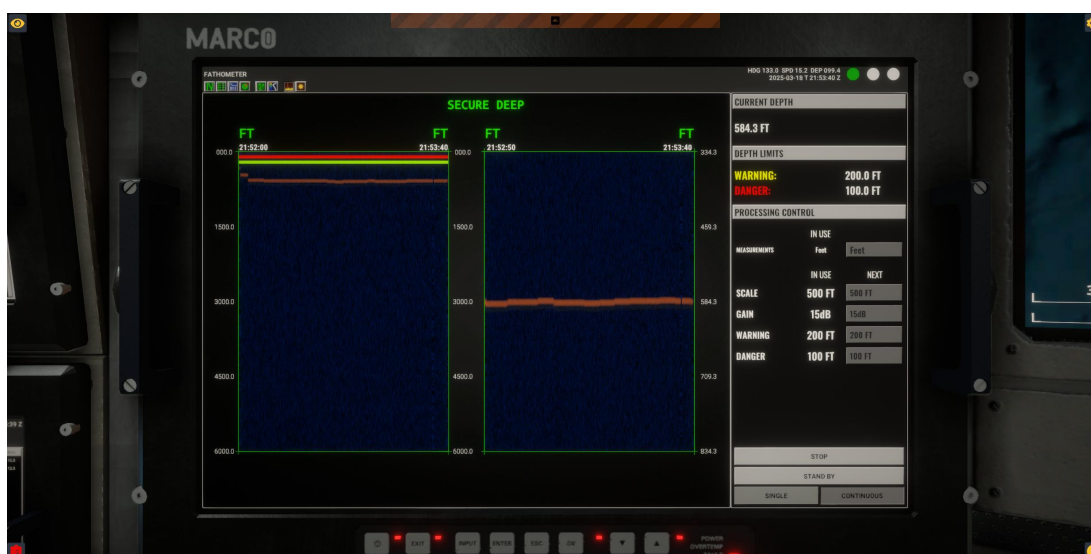


Figure 43: Fathometer (enabled)

- Scale: Shows the scale (zoom level) of the right graph. Changing the scale adjusts the numbers on the right side of the graph. The current depth is located in the middle label, and the distance between the top and bottom labels must equal the selected scale number.

For example: Current depth = 1000 ft Scale = 500 ft

Labels in the order top to bottom: 750, 875, 1000, 1125, 1250 1250 - 750 = 500 which gives us the selected scale.

- **Gain:** Controls the intensity of the sensor. A higher Gain produces stronger returns during the echo-sounding process.
- **Stop Button:** Disables the sensors, unlocks the Processing Control fields, and clears the display.
- **Standby Button:** Stops or pauses the sensors without disabling them and unlocks the Processing Control fields.
- **Single Button:** Activates the sensor returns for 5 seconds and then falls back to Standby mode.
- **Continuous Button:** Activates the sensor returns until the user changes the setting.

The standard presets to use are *Feet* for the measurements, *500 ft* for the scale, and *15 dB* for the Gain.

To enable the Fathometer, simply enter the presets of your choice and press Standby, followed by Continuous. Now, if we go to the Info Screen auxiliary screen, the Bottom Sounding data should be accurate.

■ How to plot a course in the ECDIS

Next, we need to head to the ECDIS Station. Once we arrive at the station, we can see a map of the area, which serves as the basis for setting our course. Furthermore, the two points were added to the map when we received the message, as shown in the picture below. The next step is to create a plot from the submarine's current position to Point Alpha, and from Point Alpha to Point Beta.

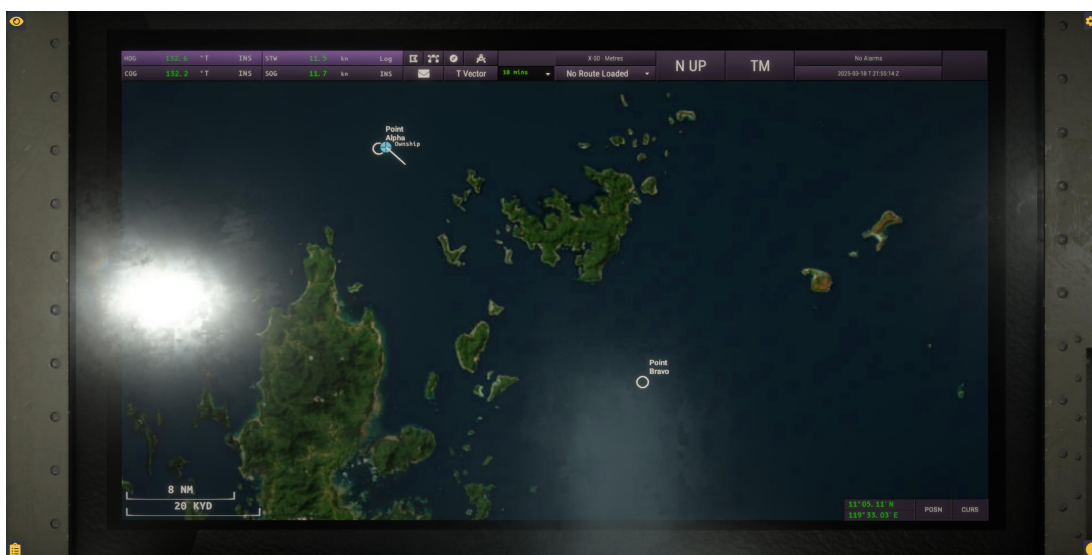


Figure 44: ECDIS points of interest

At the top of the panel is the dropdown responsible for creating waypoints. The button is named *No Route Loaded* (picture below). All we have to do is press it, then press *WPT* and click on the spot on the map where we want our waypoint to be. We can also enter a depth in the *Depth* field, which determines the depth to which the submarine will travel. We can then click *New* to create a new waypoint and repeat the process until the plot is complete. Finally, we click *Save* to create our route.

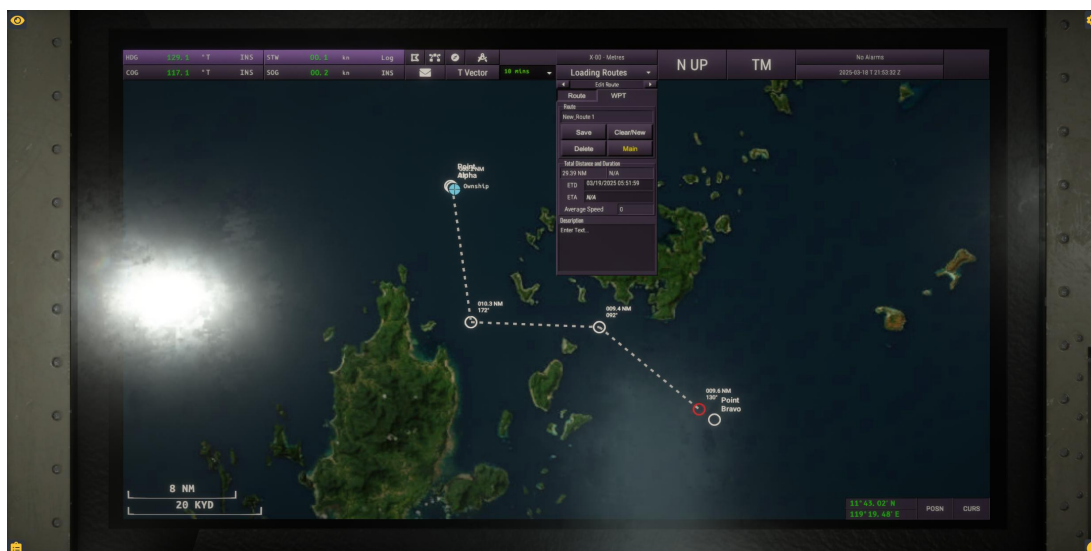


Figure 45: Waypoint dropdown

It's worth noting that if the cursor is placed anywhere on the ECDIS map, the fields at the bottom-left of the screen will be updated to reflect the data (depth, coordinates, etc.) of that specific point on the map. Pressing the *CURS* button will open the *Cursor* panel with additional data about that specific location, such as its depth. Clicking the *POSN* button will open the *Position* panel with data about the *submarine's current position*. Both can be seen in the picture below.

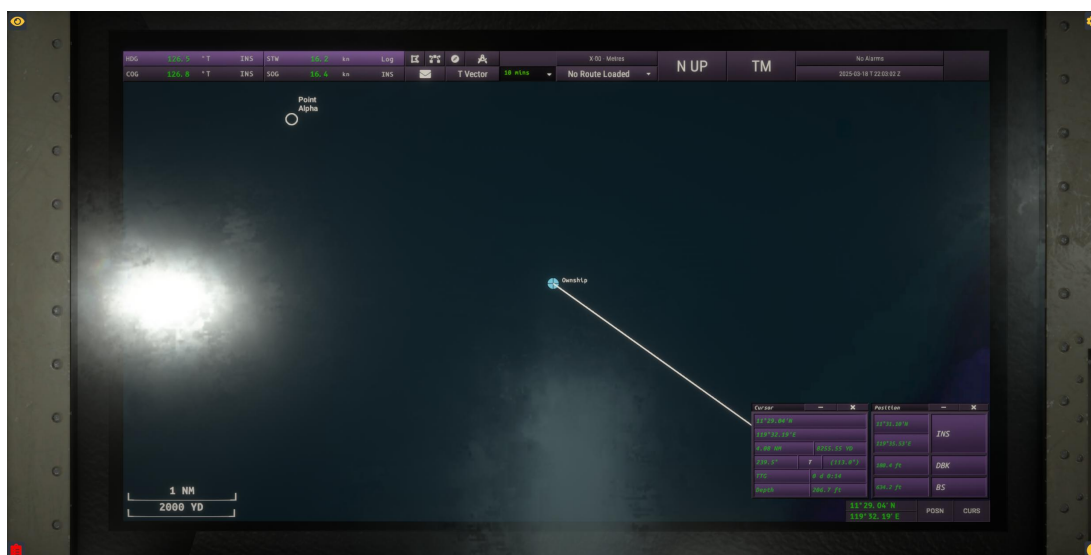


Figure 46: ECDIS Curs & Posn panels

It should also be noted that the ECDIS is interfaced with inertial (INS) and satellite navigational data (GNSS/GPS). The current position of the ownship is always updated in realtime. The accuracy of the position is dependant to the source. INS systems tend to drift if for several days they haven't been realigned with an external source (e.g. GNSS). This happens automatically whenever you raise any mast with GNSS receiver (photonics, satcom, ESM) out of the water.

Looking at the map, we can also notice a white line that starts from the submarine and extends outward. This line is called the **T Vector**, and it indicates where the submarine is headed and where it will be positioned after a certain amount of time (at the very end of the line).

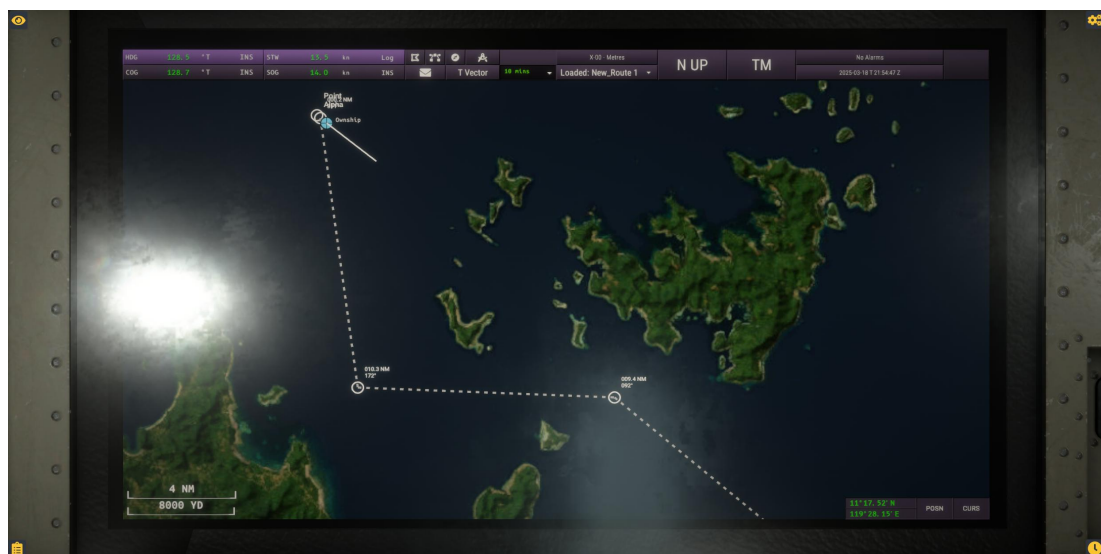


Figure 47: T-Vector 10 mins

This time is set using the button at the top of the screen, next to the **T Vector** field, and is measured in minutes. If we increase the time from 10 minutes to 60 minutes, the line will increase in length, since the submarine will travel farther over a longer period of time (examples are shown in the pictures below).

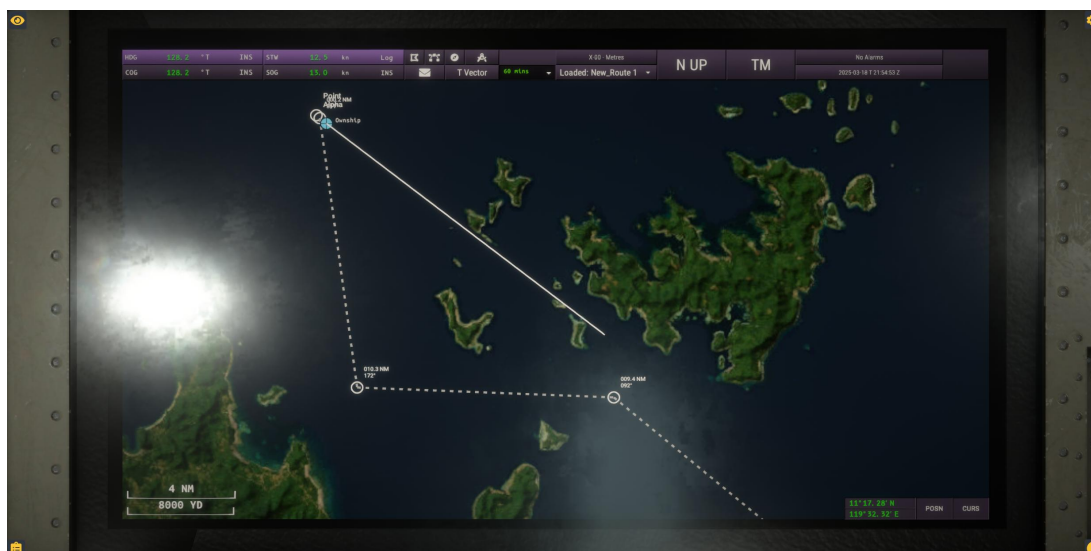


Figure 48: T-Vector 60 mins

■ How to enable the autopilot

In order for the autopilot to interact with the route, we need to make it the *Main Route*. This is done by going to the Route panel and pressing *Main*. We know it worked because the Main button turns yellow. Now that the main route has been saved, we can exit the station, right-click on it, and select **Autopilot** from the dropdown (picture below). Selecting it will show us the autopilot's status:

- Off: It's currently off
- On: It's currently following the main route
- No Main Route: There is no route to follow

It should be noted that if we manually change the submarine's depth or course, the autopilot will be deactivated, and we will need to turn it on again. The same does not apply to manual changes to the submarine's speed.

It should also be noted that the autopilot sets bounds around each waypoint in the shape of a square approximately 1,500 m in length, which is larger than the circle icon on the ECDIS map. As a result, the submarine icon may not reach the waypoint precisely during its transit, and this is intentional.



Figure 49: Autopilot

WALKTHROUGH

It's time to put everything we've learned to the test. As previously stated, the objective of the mission is to reach Point Beta. This means that after reaching Point Beta, we are free to exit the mission, and it will be classified as successful.

■ Mission Steps and Maneuvers

- Give an order for 1/3 Ahead and Periscope Depth.
- Go to the Fathometer and enable it by pressing *Continuous*. If done correctly, after a while, orange horizontal lines should start appearing on the right panel.
- Change the measurements to *Feet*.
- Put the warning depth to 200 ft and the danger depth to 100.
- Put the *Gain* to 15dB.
- After the submarine reaches the speed and depth, go to the Radio Room.
- Raise the antennae and receive the mission.
- Go to the Pilot station and order a depth of *100 ft* and *Std* EOT.
- Go to the ECDIS Station.
- Change the T Vector to *60 mins*.
- Open the *No Routes Loaded* dropdown and press the ****WPT*** button; if done correctly, a panel to create waypoints should appear.
- Create waypoints connecting point Alpha and point Beta and save the route.

Ensure that the waypoints are not too close to the islands, because the submarine will crash in that case. Furthermore, ensure that all waypoints have a depth of at least 100 ft and that the last waypoint has a depth of 300 ft.

- Go to the *Route* panel and make the route you just created the *Main*; if done correctly, the “Main” button will turn yellow and all the waypoints on the map will be white and not red.
- Exit the station, and right-click on it to open the Autopilot overlay; if the route was correctly assigned as “Main”, the autopilot’s status will be *Off* and not *No Main Route*.
- Turn On the autopilot; if done correctly, its status will change and the submarine will start turning to the first waypoint.
- Keep track of the Fathometer and ensure the submarine does not reach dangerous depths; if it does, do to the pilot station and give an order for shallower depths.

Note: If at any point during the transit you give an order for a different depth while the autopilot is on, you should return to the ECDIS Station, update the waypoints’ depths with the new value, and reactivate the Autopilot.

MISSION COMPLETION

At the end of the mission, the submarine should:

- Have an EOT Order of Std
- Be at the depth of the last waypoint
- Be less than 1.5 km away from point Beta; being further than that will count as a mission failure

STATIONS

{Coming Soon}



APPENDIX

GLOSSARY OF TERMS

- **AGI**

Auxiliary, General Intelligence ship. Spy ships (intelligence gathering) sometimes disguised as civilian vessels (e.g. fish trawlers).

- **ASM**

Anti-Ship Missile (e.g. UGM-84 Harpoon).

- **AAW**

Anti-Air Warfare.

- **ASW**

Anti-Submarine Warfare.

- **ASuW**

Anti-Surface Warfare.

- **APP-6**

(See MIL-STD-2525).

- **CO**

Commanding Officer. The leader of a military unit and the one who carries all the responsibility. In the case of ships and submarines he/she is called “the Captain” regardless of the actual rank.

- **COB**

Chief of the Boat. Highest ranking non-commissioned officer on a US submarine and leader of the enlisted men. He is the

senior enlisted advisor to the CO and the XO.

- **ESM**

Electronic Support Measures. Electronic warfare suite used for radar early warning, radar classification, signal intelligence and signal analysis.

- **FLASH message**

A message precedence indicating initial enemy contact messages or operational combat messages of extreme urgency.

- **HWT**

Heavyweight Torpedo (e.g. MK-48 AD-CAP).

- **LAM**

Land Attack Missile (e.g. UGM-109 Tomahawk).

- **LOS**

Line-Of-Sight. A straight, unobstructed path between a transmitter and a receiver.

- **LWT**

Lightweight Torpedo (e.g. MK-46).

- **MIL-STD-2525**

Is the latest NATO symbology standard for tactical computer systems. Most systems currently use this set. In MNW we feature only a small subset of the full specification.

- **NTDS**

Naval Tactical Data System. Is a symbology design for use on the system with the same name back in the 1960s. Some older consoles still use it today.

- **ONI**

US Office of Naval Intelligence.

- **Optronics**

(See Photonics).

- **PD**

Periscope Depth. A preset depth for a submarine where the periscope and other masts can be raised out of the water.

- **Photonics**

Also known as Optronics. A modern version of the periscope where digital cameras are placed at the top of a retractable non-hull penetrating mast.

- **PLA**

People's Liberation Army. The Chinese Army military branch.

- **PLAN**

People's Liberation Army Navy. The Chinese Navy. Uncommonly it is not a separate branch but a service under the command of the PLA.

- **PRC**

People's Republic of China.

- **SAM**

Surface to Air Missile (e.g. MM-104 Patriot or RIM-161 SM-3).

- **Screw**

Propeller, pump-jet or other similar rotating propulsion method for ships.

- **SEAL**

United States Navy Sea, Air, and Land (SEAL) Teams are the US Navy's primary special operations force.

- **SINKEX**

A naval exercise where an obsolete or captured vessel is used as a target for testing various weapons systems.

- **SLEB**

Submarine Launched Emergency Buoy. A self contained canister launched when a submarine is in trouble. It transmits emergency signals to assist any rescue efforts.

- **SLMM**

Submarine Launched Mobile Mine (e.g. MK-67).

- **SLOT**

Submarine Launched One-way Transmitter. It is used to transmit low priority messages without revealing the position of the transmitting submarine.

- **Sonar**

Sound Navigation And Ranging. A system that uses sound propagation for navigating, ranging and detecting objects underwater. It is the primary sensor for any modern submarine and the main tool for ASW.

- **SSBN**

Nuclear ballistic missile submarine. Also called Boomers.

- **SSN**

Nuclear attack submarine. Also called as Fast-Attack submarines or Hunter Killers.

- **STW**

Strike Warfare.

- **TLAM**

Tomahawk LAM (see LAM).

- **Weaps**

Weapons Officer. The department head responsible for sonar, fire control, and all

weapons systems (torpedoes and missiles) on a US submarine.

- **XBT**

Expendable Bathythermograph. It measures water temperature (and sometimes other parameters) at different depths.

- **XO**

Executive Officer. Second in command of a military unit and usually responsible for every day operations and all the officers.

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